The Design and Implementation of Multi-level Communication Network without Bases Stations

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Abstract. This article describes the communication with no fixed centers of base stations, and the establishment of a multi-level communication network via the wireless module,which enables the communication of data between the control center and the front end of two-way transmission. This project uses TDMA communication mechanism. The control center sends commands to each communication terminal, and receives the corresponding data in a fixed time slot. Experiments show that when the communication nodes within a certain amount, the communication system has a better effect on communication, which is suitable for application in underground mining mine, field rescue and other communications without base stations.

1 Introduction

With the development of science and technology, wireless sensor network as a new technology in the field of information technology plays an important role in the world. In regards to manufacturing, Huazhong University of science and technology developed the KDTGMD system based on sensor network and this system was used to check and monitor steam turbines to increase productivity [1]. In civilian aspect, F Chenwei designed a remote monitoring system on the basis of ZigBee and android, which improved wireless sensor network' practical values in environment [2] and helped alleviate environment problems. And in martial aspect, L Xiaowei discussed a remote vehicle monitoring system based on the COMPASS and wireless sensor network [3] and his work proposed a visual system for data collection, which expanded the application range of data acquisition systems. And the downside of this monitoring software is the C/S (Client/Server) structure, which may lead to inconvenient extension and difficult maintenance.

This paper introduced a method of establishing a multi-level communication network without base stations. With the help of wireless module, we can realize the communication between the terminal and control center rapidly and conveniently. As a consequence, this system is suitable for applications in underground mine and field rescue.

2 General Design of System

2.1 Construction of Communication System. The entire communication system consists of communication terminals, a communication relay node and control center. The construction of system is shown in Figure1.

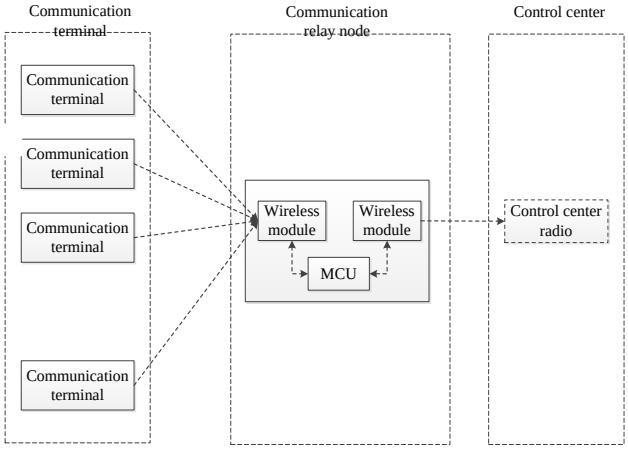

Figure 1. The overall structure of the communication system

Communication terminal is mainly responsible for collecting basic information, and sending it to the communication relay node through the wireless communication module. Communication relay node is responsible for receiving and storing data from the communication node (the control center) and sending it to the control center (communication nodes). The control center consists of a wireless communication module and database servers. It is responsible for establishing and maintaining a wireless communication network, sending data and commands, receiving data from the machine and storing in the database, statistical analysis, etc. It is a bridge between the various parts of the system of information exchange.

2.2 Principle of System. The communication terminal collects terminal information. And in a communication network, communication relay node works as the host, establish a multipoint wireless communication network with TDMA mechanism. Receiving data from communication terminal, processing data and sending the data to the control center. In the network of control center and communication relay nodes, control center controls network traffic as a master, receiving data transmitted by the communication relay node, and storing in the database server. After the completion of the assessment process, the results feed back to the control information communication relay node, after receiving data from the control center and , the relay node transmits the data to the respective communication terminal, and performs specific operations.

3 The Design of Software and Hardware

3.1 Design of Communication Relay Node. Communication relay node is the bridge of communication system, and is responsible for the data transmission between communication terminal and the control center, the communication relay node applies the way of wireless modules and radio work together, the wireless module collects data from terminal and sends it to the control center through radio, the control center communicates with the relay node via radio. Communication relay node consists of core processor MSP430F149 [4], wireless module YL-500IW, Radio WM400, external memory cell and its peripheral circuit shown in Figure 2. The node receives data from communication terminal, and transmits data to the control center via radio. However, since the amount of data needs to be stored in the system, the microcontroller MSP430F149 have more memory space (2KB), it's still not enough to store these data, requiring extended random data memory. In addition, it also requires a certain amount of non-volatile memory devices for storing information used to check later.

The system choose AT24C256 as an external non-volatile data storage.

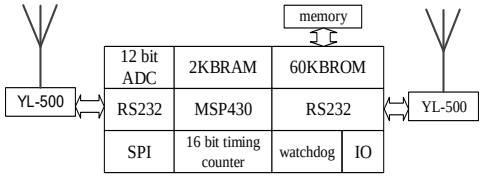

Figure 2. Communication relay node hardware structure

3.2 Design of Wireless Communication Protocol. Wireless network works in master-slave mode, that every communication initiated by the host. When communication is needed, the host sends data request frames to the slave; when the host asks, corresponding slave can transfer information such as working condition, the battery level, address and other status to the host. The data transmission system for wireless communication includs control information and data information [5].

The communication process is shown in Figure 3.

(1) Master and slave power on, the host is in sending state and the slave in the receiving state.

(2) The host sends request frame to the first slave, converts transmit mode to receive mode, and the timer starts working at the same time. The first slave receives request frame from host and converts the receive mode to transmit mode, sends data to the host.

(3) If the host receives data transmitted from the first slave, the data is stored in the memory; if no data is received, the error counter is incremented by one. It works until the end of the timer.

(4) Write the second slave address to the host and convert the receive mode to transmit mode.

(5) Go to the first step.

(6) When there is a command frame from up network, MCU resolves command frame, writes the address to the host and writes the command in the host data request frame in the next polling time slot. After sending those frames, the host restarts polling from the first slave.

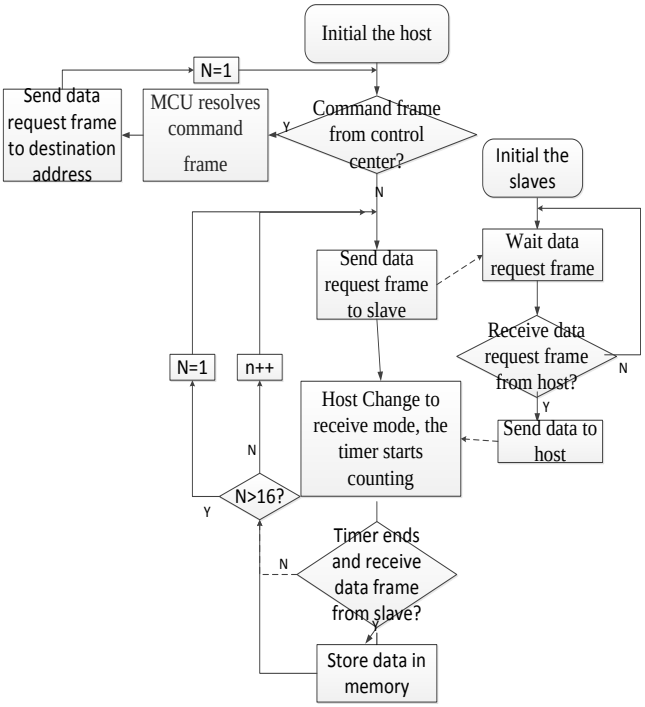

Figure 3. The flowchart of communication

3.3 Design of Frame Format

(1) The command frame and the response frame

Table 1. The format of the command frame and the response frame

7th bit	6th bit	5th bit	4th bit	3rd bit	2nd bit	1st bit	0th bit	Length (B)
The identifier								2
The address								2
The control word								1
The ending identifier								2

The length of the identifier is 8 bit, and we use this identifier to identify the type of frames (if the identifier of one frame is 68H, this frame is defined as the command frame. If the identifier was 69H, this frame is confirmed as a response frame). And we repeat this identifier again after the first one to reduce the misjudgment rate of frames.

The length of the address is 16 bit. If the frame is a command frame, the address suggest the receiver's address. And if the frame is a response one, the address is a sender's address.

The length of control word is 8 bit. It is used to distinguish different control commands from the host and only exists in the command frame. If the value is 01H, which suggest that the host required the slave to reset. And when it is 02H, the host requests the slave to send information. The control word is 03H, suggesting the host forbids the slave from transmitting information.

The ending identifier's length is 8 bit and it suggests the end of a frame. We define its value 34H and repeated the ending identifier to reduce the misjudgment rate of frames.

(2) The data frame

Table 2. The format of the data format

7th bit	6th bit	5th bit	4th bit	3rd bit	2nd bit	1st bit	0th bit	Length (B)
The identifier								2
The receiver address								2
Data acquisition terminal' code								1
Specific data								several
The ending identifier								2

The length of the identifier is 8 bit and its value is 67H. We repeat the identifier again after the first one.

The length of the receiver address is 16 bit. And the address includes the host's address.

The length of data acquisition terminal' code is 8 bit and every terminal has its code to mark the originalities of data.

Specific data include all kinds of information detected by the data acquisition terminal such as humidity and geographical positions of the wireless sensor network nodes.

The ending identifier has the same identification and functions as mentioned before.

3.4 System Test. This system is mainly to achieve the functional data transmission between the communication terminal and the control center. Wireless module baud rate is set to 9600, 8 data bits, 1 stop bit, no check bit, control center by the end of the PC uses serial debugging assistant instead of testing the received data, the cumulative number of transmissions in a communication terminal and compared with received counts found that all data has been received, meeting the design requirements.

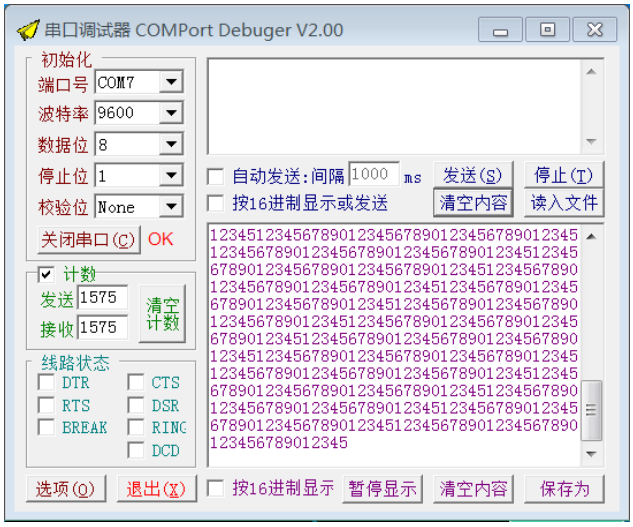

Figure 4. Serial debugging assistant receiving data

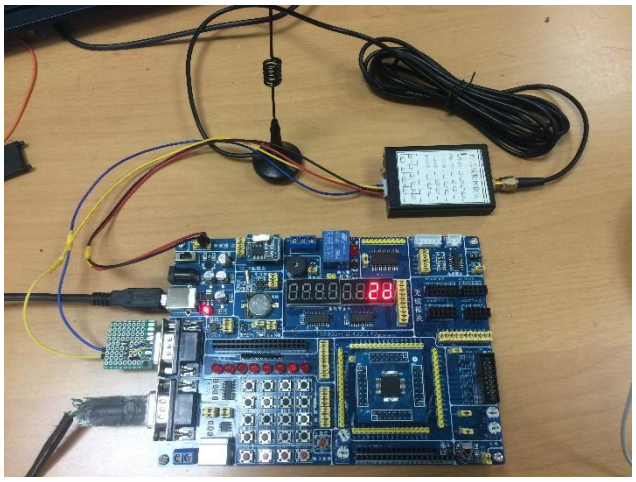

Figure 5. The communication terminal sends data

When the control center requests data from the relay node every fixed period of time, the correct rate of data transmission is limited by communication nodes. When the number of communication nodes are large, the communication between the data relay node and communication nodes will be interrupted by control center's request, thus reducing the accuracy of the data transmission system. Set the experimental parameters the same as above, the control center requests data to the relay node every 5.5s, then waits for data reception. By comparing the received data with the sent data, we get the correct rate of data transmission, as shown in Figure 6. Thus, when the system of communication nodes is within a certain amount, the communication of the whole system will maintain good effect.

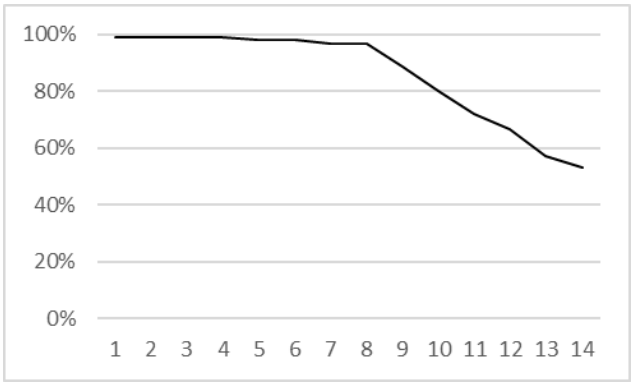

Figure 5. The relationship between data accuracy and the number of nodes

Conclusion

The system adapts TDMA communication mechanism to establish a multi-level communication network without base stations. In the system we defined communication protocol and communicate through micro-power wireless data module YL-500. Its advantages include low cost and mature wireless communication technologies, which make this system easily achieved. And its stable work and reliable transmission have been validated by a specific test. Also the establish of network doesn't need the base stations. In addition, it is convenient for this system to extend when the software is on the basis of B/S structure. Nonetheless, there are many issues worthy of further study such as the data security.

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