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Research and Implementation of Network Communication of Embedded Monitoring System Based on Fieldbus

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Abstract

In recent years, embedded system has been paid close attention by researchers in various fields of science and engineering, and has become a research hotspot. In the development of embedded system, the application of embedded operating system is an important part. It combines with modular hardware to form a reusable software and hardware system platform, which can not only improve the development efficiency, but also improve the reliability and real-time of the system and meet the increasingly complex application requirements. In the field of domestic monitoring, most of them adopt distributed monitoring system. Although it overcomes the shortcomings of centralized monitoring system, there are still some shortcomings, such as low efficiency, weak error handling ability, poor compatibility of equipment, and low real-time and reliability of the system. Using can (Controller Area Network) fieldbus can overcome some of the above shortcomings and significantly enhance the anti-interference ability of the system. The CAN bus is used as the communication network to form the automation system to realize the real-time monitoring of the power supply and improve the safety and reliability of the system. The power monitoring system designed in this subject realizes the centralized management and control of network, improves the reliability, safety and product universality, and eliminates the potential safety hazards of power consumption to a certain extent. The can communication scheme used in this paper has great flexibility, can be easily applied to various measurement and control systems, and has practical application value.

Keywords

Fieldbus; Embedded System; Network Communication; CNA.

1. Introduction

With the continuous development of computer network. As a convenient means to obtain information, the Internet has been gradually recognized by people [1]. Embedded devices with network access function can enable anyone to obtain their operation data and monitor their operation status through the network at any time and anywhere [2]. Embedded operating system is the core part of embedded device software. Because of its existence, the functions of embedded devices have great expansion space and scalability [3]. With the development of information, intelligence and networking, embedded systems have gained a broad development space [4]. In the field of communication, digital technology is completely replacing analog technology; In the field of measurement and control, with the continuous expansion of measurement and control distance and the increasing complexity of measurement and control system, a single data transmission mode is no longer competent, and various data transmission modes must be used together. In the field of consumer electronic products, mobile data processing devices and mobile communication devices mainly use embedded systems [5]. As

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far as the technology and market of embedded systems are concerned, foreign countries are developing very fast, the technology is maturing day by day, and the market structure is basically formed. The domestic development is also very fast, with great market potential [6]. In foreign countries, the hardware of embedded system is updated rapidly, especially the processing capacity of embedded system is improved rapidly. At home, the key hardware of embedded system is mainly imported from abroad, and its technical strength is relatively weak [7].

With the rapid development of computer technology and network communication, embedded systems are everywhere. Real time data processing, network interconnection function, intelligent software and good function expansion have become the requirements of modern real-time measurement and control system [8]. Due to the improvement of economic level, people's demand for automation is increasing, which leads to the increasing complexity of embedded system application, and more and more peripheral devices need to be controlled [9]. If the embedded operating system is not adopted, it is very difficult to develop programs and manage software, so the introduction of embedded operating system is an inevitable trend [10].

Based on the above considerations, this topic mainly studies the software development and application of real-time operating system when developing products with single-chip microcomputer. Compared with the traditional programming mode, the limited hardware resources of the single-chip microcomputer can be used more effectively, the system response speed can be improved, and the real-time performance of the fieldbus communication can be met, thereby saving the development time, reducing the difficulty of system development and reducing the cost of system development; Research on CAN bus can improve the stability and security of system communication, facilitate system upgrade, maintenance, and compatibility with other CAN bus devices, and improve the application level of domestic CAN bus [11].

2. System design

2.1. System Hardware Structure

The design of embedded application system includes two parts: hardware system design and software system design. The design of these two parts is interrelated and inseparable. The design of embedded application system often needs to weigh and compromise between the design of hardware and software [12]. The design of intelligent condition monitoring and diagnosis system should have good openness, scalability, interaction and cooperation. Therefore, the intelligent on-line monitoring and diagnosis system is a multi-sensor system, and its main tasks include three aspects: ① complete data acquisition; ② Complete the fault diagnosis task; ③ Realize the functions of display and alarm output. The working process of the system is as follows: the acquisition module realizes data acquisition and simple processing, and then transmits it to the main control module. The main control module analyzes and diagnoses the processed data. The data communication between the acquisition module and the embedded main control module is realized through CAN bus. The hardware structure of the system is shown in Figure 1.

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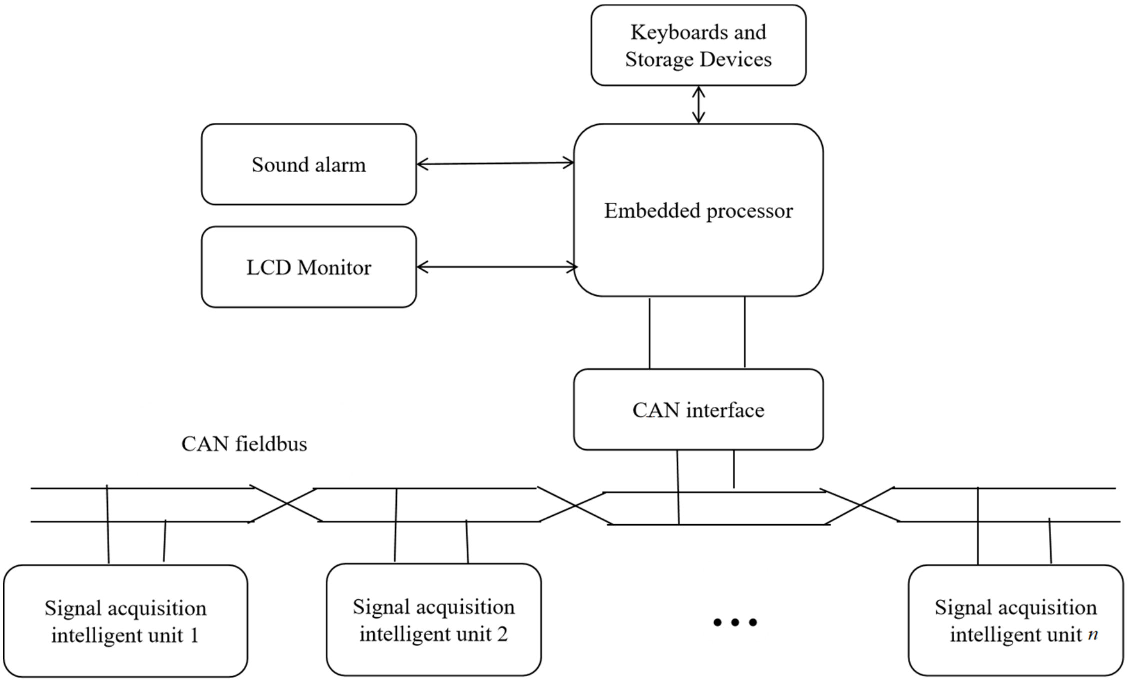

Figure 1/ System hardware structure

2.1.1. Signal Acquisition Intelligent Unit

The function of the signal acquisition unit is to act as an intelligent CAN node to collect status signals with important influence, and to condition, convert and process the collected signals, and then send the processed status information to the embedded master via the CAN field bus The processing unit performs further processing [13]. The structure of the signal acquisition intelligent unit is shown in Figure 2.

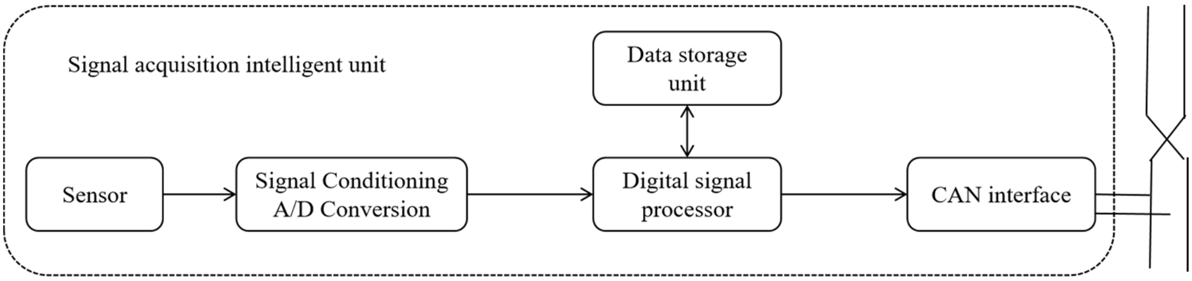

Figure 2. Structure of signal acquisition intelligent unit

The signal acquisition intelligent units are directly installed and fixed on each main part. The signal conditioning and processing device preprocesses the collected data, analyzes it in real time and monitors it online, and sends the processed data to the embedded main control unit through the CAN field bus at the same time. The function of each microprocessor or digital signal processor is to realize some real-time analysis and state monitoring functions by reading the data of its I/O interface and accepting the signal input of the signal acquisition and preprocessing circuit. And send the processed data to the CAN bus through the interface.

2.1.2. The Design of Fieldbus CAN Communication Mode

In order to meet the requirements of fast, reliable and efficient CAN bus communication, the design of the program needs to be able to receive and send CAN messages completely automatically; and fully supports standard identifiers (11 bits) and extended identifiers (29 bits). Through the control, status and configuration registers, the program can achieve: (1) configure CAN parameters (2) request to send messages (3) process message reception (4)

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manage interrupts (5) obtain diagnostic information and send mailboxes. The sending mailbox is set by the program, and the sending scheduler determines which mailbox's message is sent first according to the priority. Set the message filter, 14 bit-width variable/configurable identifier filter groups can be configured, and the software can program them to select the message it needs among the messages received by the pin, and the other The message is discarded.

2.2. System Software

Currently. Most of the network uses a client-server mechanism for communication services. TCP (Transmission Control Protocol) provides a reliable, complex, connection-oriented service. It establishes the connection through a three-stage handshake process. The connection is terminated with a packet-switched sequence. in this mechanism. The client makes a request. The server is required to execute and provide services; the server accepts the request and completes the task required by the client. . Create a socket on the server side. And after assigning it an address, use the listen() function to listen for the client's connection request, and if the connection is successful, call the accept() function to return a new socket descriptor to handle the communication process between the two parties. In order to notify the server to receive the connection request sent by the client, a Socket must also be established first. Then call the connect() function to send a connection request. After both parties end the communication, they must call the close() function to end the Socket communication. The basic communication flow of the embedded server/client is shown in Figure 3.

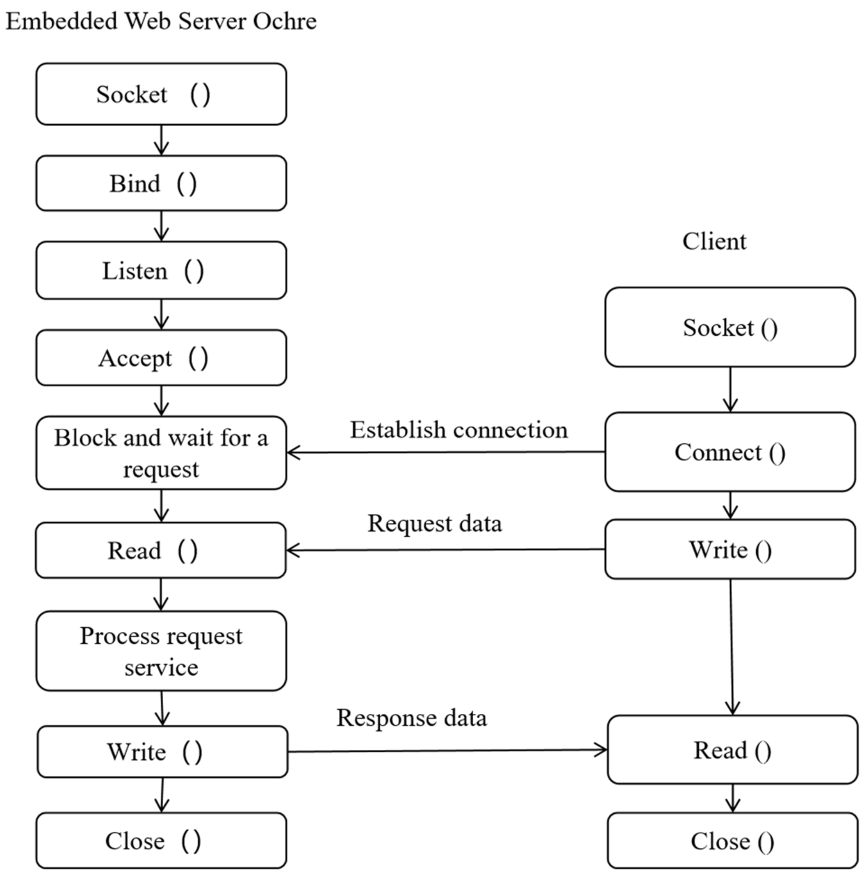

Figure 3. Basic communication flow of Embedded Server / client

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The transmission process of the message is that the main controller transmits the message to be sent to the sending buffer, and then sets the early sending request flag bit of the command register. If the transmit buffer is released, the host controller writes the new message into the transmit buffer and sets the transmit request flag in the command register to start transmission. The received message is placed in the receiving buffer, and then the main controller reads out this information and stores it in the local message memory, and then releases the receiving buffer and processes the message. The receiving process is controlled by the interrupt request method.

2.2.1. Data Collection

In recent years, with the rapid development of power electronics technology, more and more nonlinear electrical equipment is connected to the power grid and put into operation, so that the grid voltage and current waveforms are actually not standard sinusoidal waveforms, but non-sinusoidal waves with different degrees of distortion. Non-sinusoidal waves are periodic electrical quantities, which can be decomposed into fundamental wave components and harmonic components with integer multiples of the fundamental wave frequency according to Fourier series analysis. In this way, the monitoring system should monitor the voltage, current value and its harmonic components of the power input voltage, so that when the harmonic components in the system reach a certain level that may cause harm to power equipment and power users, corresponding measures can be taken to effectively avoid disaster occurs. Let $X(t)$ be a periodic function, containing harmonics and non attenuated DC components in addition to the fundamental component, then $X(t)$ is expressed as:

$$x(t)=a_0+\sum_{k-1}^{\infty}(a_k\cos k\Omega_1 t+b_k\sin k\Omega_1 t) \tag{1}$$

Type: k −−Natural number ,k = 1,2,3,4,B ,

According to the Fourier series principle, a_k, b_k can be expressed as:

$$a_k=\frac{2}{T}\int_0^T x(t)\cos(k\Omega_1 t)dt \tag{2}$$

$$b_k=\frac{2}{T}\int_0^T x(t)\sin(k\Omega_1 t)dt \tag{3}$$

When the voltage signal is input, x_k and φ_k obtained from equations (1), (2) and (3) correspond to the effective value and phase angle of k harmonic respectively. Since the effective value of the periodic function is the square root of the sum of the effective values of DC component and each harmonic component, the effective value of grid voltage can be calculated as follows:

$$U=\sqrt{\sum_{K-0}^{K-\infty}X_K^2} \tag{4}$$

In the program design, for every cycle of electric kitchen current signal, 32 points are collected every cycle, and the collected values are put in the flash of single chip microcomputer for

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Fourier algorithm analysis, and the DC component value, the effective value of 1st-8th harmonic component and the effective value of total voltage/current are calculated by the formula.

3. Research and Implementation of Embedded Network Communication

3.1. Embedded TCP/IP protocol stack analysis

In today's network world, there are mainly two kinds of network protocols being used. The OSI standard proposed by the international organization for Standardization ISO is a 7-layer communication protocol, but the most widely used is TCP / IP protocol. Different from the 7-layer structure of OSI, TCP / IP adopts a 4-layer network structure. (1) The link layer, sometimes called the network interface layer, usually includes the device driver in the operating system and the corresponding network interface card in the computer. (2) The network layer, sometimes called the Internet layer, handles the activities of packets in the network, such as packet routing. In TCP / IP protocol components, network layer protocols include IP protocol, ICMP Protocol, IGMP protocol and so on. (3) The transport layer mainly provides end-to-end communication for applications on two hosts. In the TCP / IP protocol component, there are two transmission protocols to realize point-to-point communication: TCP and UDP (User Datagram Protocol). (4) The application layer is responsible for handling specific application details. Various TCP / IP implementations will provide some general applications.

TCP/IP is usually regarded as a four-layer protocol system, and each layer has a corresponding set of protocols to achieve different functions. The application layer is concerned with a large number of protocols, which can be fully recognized by the application. For example H1] calls are usually associated with web browser applications, but HTrP is also considered an application in many other contexts. It is specifically pointed out here that the application layer is the most general and can be used in a variety of ways for different purposes. The application layer is the demarcation line between private and non-proprietary, and the application layer protocol provides a special purpose, can use the basic protocol to enable it to communicate on the Internet. Most of the work done in protocol development now happens at the application layer. Because nodes on the Internet sometimes lose packets, TCP takes this into account and ensures that the receiver can receive all the data in the order in which the sender sent it. UDP is a connectionless protocol that is believed to provide simple message delivery. UDP does not guarantee the arrival of packets, and packets may even arrive out of order. Even with this shortcoming, UDP is still frequently used by application-layer protocols in situations where data integrity can be easily provided by application-layer timeouts and packet retransmissions. These endpoints can be assigned to client services because, from the user's perspective, all communication takes place on ports, and clients generally create a dynamic port that allows communication with the server.Internet Protocol (IP) is associated with the network layer. The data link layer must respond to asynchronous events from the physical layer, and at the same time manage the packets from the upper layer protocols. For this reason, the data link layer usually divides the rest of the stack according to independent tasks or interrupt-driven entities queuing incoming and outgoing data.

3.2. Simplified design and implementation of TCP protocol

TCP protocol is a very complex protocol. It provides a reliable data stream transmission mode based on connection band confirmation. Its purpose is to enhance the QoS of the network. Because it is very difficult to implement TCP protocol directly on ordinary 8 / 16 / 32-bit processor, it is very necessary to discuss the simplification of TCP protocol in embedded operating system. Like the client host, the server host TCP also experiences various states. The development and design of embedded system is aimed at a specific application, and its purpose

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is to realize a system as simple as possible. After analyzing the connection establishment process, it is found that if the upper layer of TCP layer implements server-side application, the connection establishment state part of the client in the connection establishment process of standard TCP state machine can be simplified. If the developed application is based on the client, the state machine of server connection can be simplified. There are two ways to disconnect, one is to actively disconnect and the other is to passively disconnect. When it is necessary to actively disconnect, send a fin datagram. After receiving the confirmation of fin datagram, send a reset datagram to successfully complete an active disconnection. The workflow of the server-side program is shown in Figure 4.

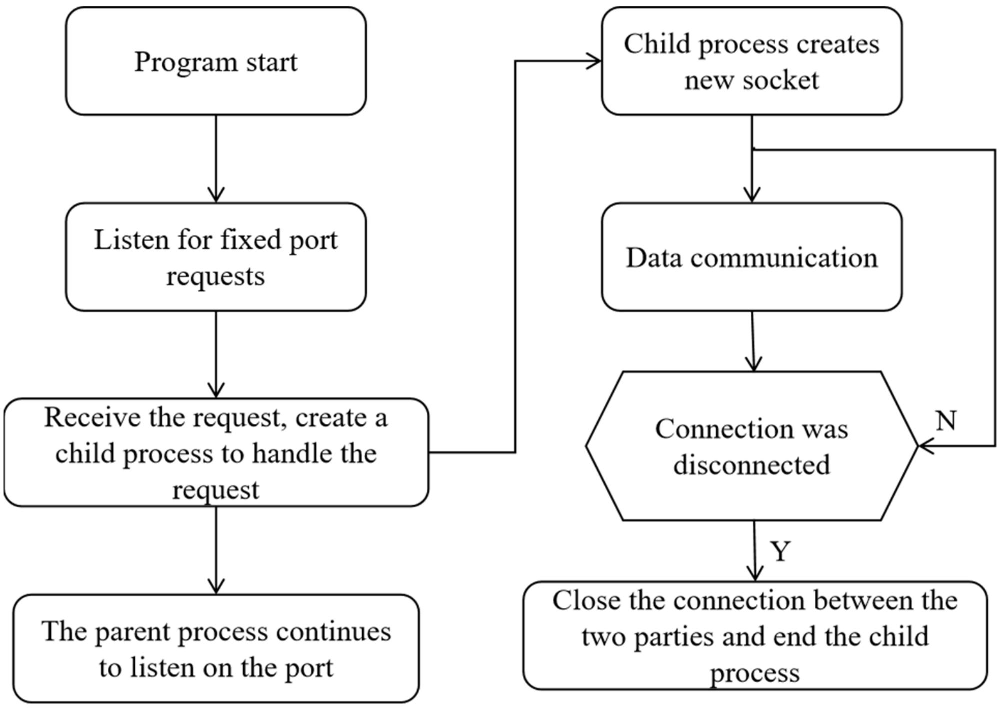

Figure 4. Server-side program workflow

Most of the network uses a client-server mechanism for communication services. TCP provides a reliable and connection-oriented service, establishing a connection through a three-stage handshake process and terminating the connection with a sequence of packet exchanges. In this mechanism, the client sends a request and asks the server to execute and provide services: the server accepts the request and completes the task required by the client. The server program on the PC becomes a server program that can run on the ARM development board. Copy the server and client programs to the ftp shared directory, then download the ftp on the development board, and run it after modifying the execution permissions. Use Makefile to specify two compiled target executables, one for the host and one for the development board.

4. Conclusions

Embedded system has unique advantages and has been widely used in all walks of life, such as industrial control, consumer products, national defense, aerospace and other fields. Programming based on embedded operating system has gradually replaced the bare metal development method, which has become the general trend. Only by using the API provided by real-time operating system for program development can we carry out practical application, improve the portability of the system, reduce the difficulty of application programming, and overcome the lack of software function of traditional single chip microcomputer control system

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Low real-time and reliability. With the development of embedded real-time operating system and the wide application of Fieldbus in the field of measurement and control, in order to deeply grasp the specific implementation of measurement and control system from the bottom, it is of great significance to deeply study a measurement and control system with operating system. Due to the outstanding advantages of high-speed communication rate, high reliability, convenient connection, multiple master stations, simple communication protocol and high cost performance, can bus is recognized as one of the most promising buses. Experiments show that the network communication of the system is effective and accurate, and can realize the reception and transmission of network data. In this paper, ns.2 network simulation tool is used to simulate the transmission rate, throughput and delay jitter of the system. The experiment shows that after using Nagle algorithm, the throughput of the protocol is improved, the bandwidth occupation of the protocol is reduced, and the delay jitter is basically constant, which is very suitable for the transmission of real-time data in embedded system.

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