Design and Implementation of Network Embedded Control System Based on Linux

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Abstract: In order to solve the technical disadvantage of low efficiency and low stability of traditional PLC controllers, this paper proposes to use embedded Linux to design an intelligent control system, and describes the 32-bit high-performance microcontroller based on ARM core combined with embedded Linux control system The design method of the control system, introduces the control system hardware, software design ideas and system network architecture. The operation results show that the overall performance of the control system is good. The touch screen provides users with a friendly human-computer interaction interface, which improves the ease of use of the operating platform. The network camera performs centralized monitoring of the industrial environment, and remote detection and remote control through the Internet network. good application prospects.

1. Introduction

Traditional industrial control methods mainly use programmable logic device (Programmable Logic Controller, PLC) technology. The reheating nature of the production process makes PLC technology reveal many shortcomings, such as the software and hardware compatibility of PLC development tools, and traditional distributed control methods[1]. Aiming at these problems, this paper designs an industrial control system based on embedded Linux, and carries out experimental verification. The industrial control system based on embedded Linux has the characteristics of low cost, low power consumption, easy development and good performance, which enables developers to produce industrial control systems with better performance relative to a given power budget.

2. The overall architecture of the system

This control system design takes embedded technology as the core to realize the general industrial control system[2]. Monitoring, so as to achieve the purpose of monitoring and controlling each equipment node. The design of this system not only considers the reliability, scalability and system cost of the system from the hardware, but also considers the ease of use and real-time performance of the software system. The entire system consists of an industrial controller and an industrial control software platform (Figure 1).

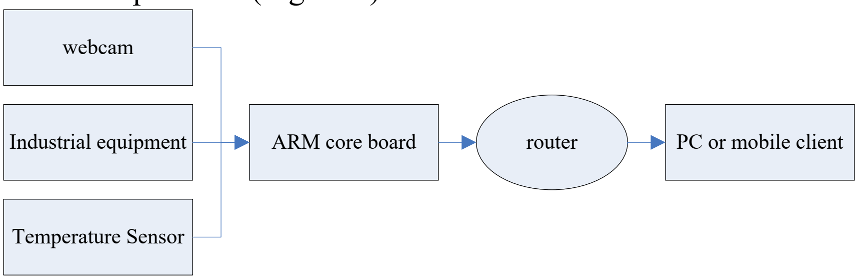

Figure 1 Overall system architecture

3. Hardware Design

In order to ensure the integrity of system functions, the storage module, network camera module,

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Ethernet communication module, human-machine interface module and temperature measurement module are extended on the embedded platform with ARM9 as the core. The cooperation of these modules realizes the whole industrial monitoring and control system. Among them, the storage system includes two 64 MB SDRAM and a 64 MB NAND Flash, and the human-machine interface mainly includes LCD and touch screen (Figure 2)[3].

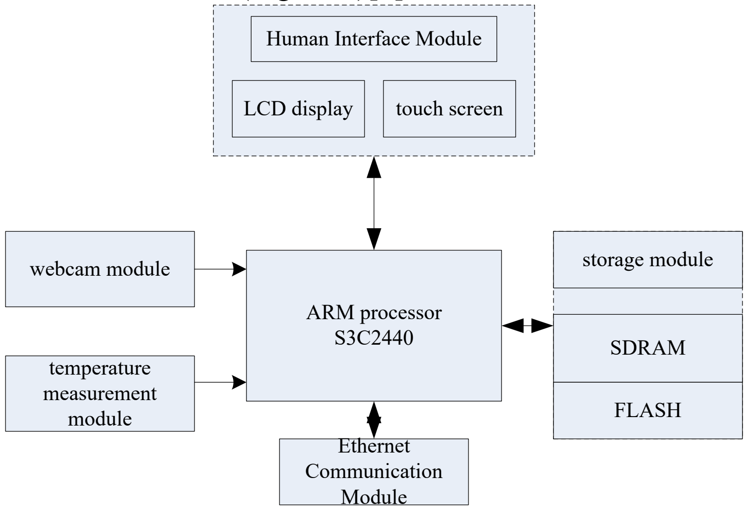

Figure 2 System hardware structure

The hardware design of the industrial control system based on embedded Linux takes the embedded platform equipped with ARM9 processor as the core, and realizes the overall function of the system by expanding the function modules in the periphery. S3C2440 is a 16/32-bit RISC structure microprocessor chip produced by Samsung[4]. It has an advanced ARM920T core and can provide a set of general peripheral interfaces without additional expansion of peripheral devices. Its power consumption is low, simple and convenient., and fully static design, especially suitable for embedded industrial control systems that require high stability and low power consumption. 2-way SPI, IIC bus interface, 4-way DMA controller with external request pins. Depending on the core chip, human-machine interface modules, network camera modules, and Ethernet communication modules can be easily added to the periphery to meet the needs of industrial controllers.

The bottom temperature sensor of the embedded industrial control system selects DS18B20 as the data acquisition device to realize the real-time acquisition of temperature data. DS18B20 is a digital temperature sensor produced by Dallas company, which has the characteristics of small size, wide applicable voltage, economical flexibility and so on[5].

4. Software Design

4.1 Embedded operating system selection

In the realization of the industrial control system of embedded lnlemet, a real-time operating system is needed to manage the system control nodes. Internally, it can manage the operation and coordination of various devices on the control node; externally, it can be connected to the Internet to realize remote control and monitoring of internal devices.

Based on this consideration, the uClinux operating system is selected as the software core of the embedded device. uClinux is a Linux operating system used in the field of microcontrollers and is specially designed for CPUs without a memory management unit (UNMMU). Compared with some other expensive commercial embedded operating systems (such as VxWorks and QNX, etc.), the uCLinux operating system and its corresponding compilation, linking and debugger are free software, which is conducive to reducing system costs, and uCLinux Many microprocessors and a variety of peripherals are supported, reducing the difficulty of system development. More importantly, uCLinux provides a complete TCP/IP network protocol stack, providing powerful network support for embedded systems.

4.2 Features of uClinux operating system

Since uClinux is specially designed for the CPU of UNMMU, and in order to adapt to the characteristics of embedded system applications, it rewrites, compresses and reduces part of the code of the Linux kernel, so that the kernel code is only less than 600 kb, but it still has the advantages of Linux The power of the operating system. Has the following main features[6]:

(1) Kernel loading method. The kernel of uClinux can load the kernel image into the memory and run like the standard Linux boot mode, or it can run directly on the Flash. When running in Flash, the system starts to execute sentence by sentence from a certain address of Flash. This is a more common method in embedded systems, which helps to reduce memory requirements and improve system stability.

(2) Root (root) file system. Using the romfs file system, it requires less space than the general ext2 file system, which can reduce system memory requirements. The romfs file system does not support dynamic erasing and saving. For the data that the system needs to dynamically save, the method of virtual ram disk can be used for processing.

(3) Application library. Clinux rewrites the Linux application library, and uClibc simplifies libc. Based on the needs of memory management, the user program is in the form of static connection, which is also closer to the practice of embedded systems.

4.3 Detailed Design

The main function to be realized by the embedded Internet is to make the system respond to the request of the remote host, complete the specific operation, and automatically send the local monitoring data to the remote host according to the characteristics of industrial control. The uClinux operating system manages the hardware resources of the entire system and provides interfaces to applications through system calls[7]. The application needs to monitor the network port and serial port, collect the data of the peripheral device, and control the corresponding device. Therefore, the application can be divided into two processes, namely the daemon process and the execution process, and the communication between the two processes is carried out by means of pipes.

The system starts from the boot program on the Flash. After completing the initialization of the microcontroller and peripheral chips, start the StartKernel( ) subroutine of the uClinux operating system to start the initialization of the operating system, including the factory Ethernet controller driver, TCP/IP protocol stack, system network configuration, etc. After initialization is complete, the daemon process and execution process are started. The daemon is responsible for the monitoring of the network port. It is realized by programming the Socket when communicating with the remote host on the Internet. It also manages each lower computer on the RS485 bus and communicates with each lower computer. Functionally, a daemon is both a server and a client.

When the remote host sends a request through the Interned network, the daemon acts as a server to respond to the remote request, and when the host computer or microcontroller itself needs to actively send some information to the remote host, the daemon acts as a client to the remote host. Host submits information[8]. To this end, after the daemon is started, two Socket sockets are generated, one as the server port and the other as the client port. The network program running on the remote host also has a corresponding Socket interface to realize the interconnection with the daemon process on the embedded system.

After the interconnection is realized, the daemon starts to monitor the network port. The running process first queries the information of the serial port. If the lower computer has a request to send information, it will extract the sent information and send the information to the remote host through the Socket socket. Otherwise, query the remote host for service requests. If the remote host has a service request, first parse the address of the information frame sent by the remote host. If the requested address is a local address, the information will be sent to the execution process through the pipeline in uCLinux. If it is not a local address, it will be sent to the remote host. The information is converted by protocol and then sent to the RS485 bus through the serial port to be passed to the lower computer, and the lower computer will respond to the remote host. At the same time, the daemon also needs to query whether there is information written by the executing process in the input pipe, and if there is information, it will forward the information to the remote host.

The execution process mainly completes some specific operations, such as data acquisition, keystrokes and display tasks, and controls the actuators connected with the embedded controller. It communicates with the daemon process through the input and output pipes, the collected data is sent to the daemon process through the output pipe, and the control operation is carried out through the information in the input pipe.

5. System test

After the design is completed, a series of tests are carried out to verify the expected design goals:

(1) Network video monitoring test r9) The test connects the USB camera to the ARM development core board through the USB interface, and the PC and mobile clients can obtain video information through the connected wireless router, and realize the remote monitoring of the industrial environment., good synchronization performance, good real-time picture, high resolution, can truly reflect the complex industrial environment.

(2) The touch screen detects the temperature of the industrial environment and controls the cross-cutting machine. Through a good human-machine interface, the temperature of the workshop and the state of the cross-cutting machine can be read out in the interface, and the control of the cross-cutting machine can be realized through the operation of the touch screen, realizing simple macro control, the interface is clear and easy to understand, and the operation is simple.

6. Conclusion

The network embedded control system based on Linux is designed this time. The test shows that the system successfully completes the expected function, and the clarity and real-time performance of video monitoring are ideal. Through network communication, the synchronization between the PC terminal and the mobile terminal is successfully completed. . The monitoring and control of the industrial environment is realized through a friendly human-machine interface. The system software has the characteristics of strong compatibility, high scalability and short development cycle, which greatly reduces the maintenance cost and difficulty of the control system, and can meet the needs of today's society. Increasing demands on industrial automation.

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