Design of Equipment Remote Monitoring System Based on Embedded Web

Yong-tao ZHOU, Xiao-hu CHEN, Xu-ping WANG, Chun-jiang YAO

Staff Room 501, Second Artillery Engineering College, Xi'an 710025, China

Email: zhouyongtao2002@163.com

Abstract

In this paper, we combine the mature technology of Web with the embedded and fully utilize the advantages of both. Applied the embedded Web technology in the field of equipment condition monitoring, the equipment remote monitoring system is designed based on embedded Web. Firstly, the function and structure of the system are designed. Based on ARM9 technology, the hardware part of system is designed by using of Samsung's S3C2410, ADC0809 and DM9000 chips. Secondly, based on the commonly Web design technology, the embedded Web server is designed by integrating embedded CGI (common gateway interface), ActiveX and Java Applet technology. Finally, the problem of communication security is considered. The System can complete the remote access, monitoring and maintenance operations of equipment through the network and Web browser. Practical operations show that the system can decrease system running cost and improve maintaining efficiency. It has wide application prospect and great popularization value.

Key Words: *Embedded Web, Remote Monitoring, ARM9，Embedded CGI， Java Applet*

1. Introduction

With the growing popularity of Internet and the development of embedded technology, Web technology has been extended to the development and application of embedded system. It is the end of the network era which takes PC equipment as the basic network node. Besides PC equipment, the network nodes include various types of embedded devices. How to use Embedded and Web technology to performance the remote monitoring, diagnosis, management and maintenance operation of embedded devices which from different subnets and physical areas, is a problem need to solve.

Embedded Web based equipment condition monitoring system directly connects the equipment to network as a node. Using B/S model, it provides the equipment condition information by Web page form for user browsing. The clients do not need to install special software and may monitor the current condition of equipment through browsers. This structure has the following advantages: It truly realized seamless connection between equipment and management. It requires no intermediate gateway conversion; by using of the mature Web technology, it greatly decreases the system building cost; with the development of industrial Ethernet technology, the real-time performance of system is improved further.

Integrating Web and embedded technology, this paper realized the embedded equipment monitoring system based on web management. Managers can remote access, monitor and maintenance the on-site

equipment through the network and using a Web browser without the limit of region and time. It can realize the inter-access between the heterogeneous equipments.

2. The Function Design of Remote Monitoring System

The function of Web-based equipment monitoring system is to collect real-time data information of the on-site equipment, publish it through a Web form, and remote send the data in the form of the user-defined data transmission style. It should provide flexible rich remote monitoring and diagnosis function combining the configuration software based on standard browser. Monitoring system includes the basic functions as follows:

Dynamic publishing real-time data and historical data: The embedded Web server publishes and dynamic refresh the real-time data and historical data in Web page form. Remote clients browse the Real-time information through network.

Remote parameter setting and real-time control: The parameters include operating and equipment condition parameters. The Web server executes the writing operation after received the parameters setting request from remote clients. The control functions include remote measurement, remote regulation, remote control and remote communication. After received the remote control operation request, The Web server order the control command to drive the corresponding implementing agencies of monitoring system.

Download and upload document: The document refers to the configuration parameters information of system and modules. The download function is the ability of download the parameters files from the Web server. The upload function is the ability of upload parameters files from the customer to the Web server.

E-mail alerts: The monitoring system analyzes and processes the collecting data. It shows that the equipment is in abnormal condition if the data appears overrun and exception. In this time, the Web server send the corresponding alarm email automatically via network and notify the manager to maintenance the equipment timely. During designing alarm functions, their own characteristics and priority level of the monitored object should be considered. It should do the weighted processing of multi alarm signal to ensure that all important alarm can be handled in good time. In addition, during the system normal operation, it can send the system running log to the designated email address based on user's setting.

Access level setting and authority authentication: Access level setting is not only in the traditional page-based form, but also in the flexible Object-based form. A single device and data collection point may become the Object. Thus, different important levels data point can be configured of different access level in same Page. Only the client which has the access level no lower than the level equipment required can performance the monitoring operation within its limits after the authentication of web server.

Multi services supporting: Flexible query and rich report is expansion of the basic functions of the monitoring system. Giving the comparing analysis between real-time data and historical data, it can provide equipment operation and maintenance information for managers from different angles. It also can provide the reliable basis for equipment's maintenance, overhaul, renewal and transformation.

3. The Structure Design of Remote Monitoring System

Remote monitoring system consists of the data acquisition equipment (for multiple devices), the local Web server and remote monitoring host. The embedded remote monitoring system completes the data collection in the embedded platform and provides the data to remote host through the TCP/IP protocol from

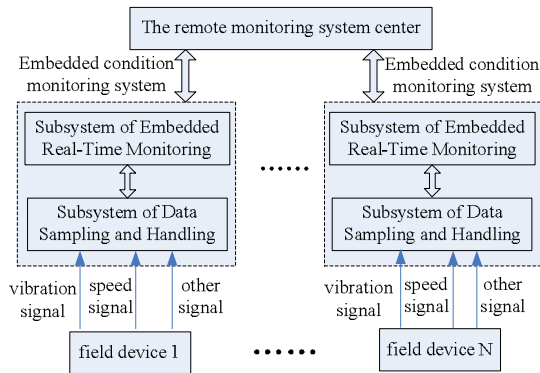Web server. It creates condition to realize unattended management.

Figure 1. The structure of embedded web based remote monitoring system

4. The Hardware Design of Remote Monitoring System

The hardware part of system consists of ARM9 core board, CPLD, A/D, LCD, touch screen, signal conditioning, sensors, SD card storage systems and communications interface. The basic architecture is shown in Figure 2.
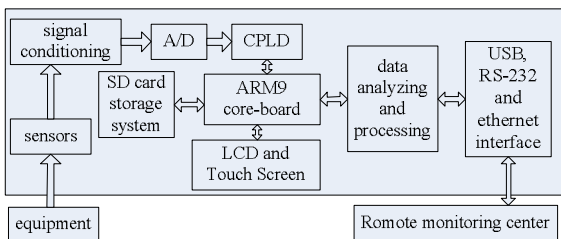

Figure 2. The hardware architecture block diagram

The ARM9 core board consists of S3C2410, FLASH and SDRAM. Samsung's S3C2410 16/32-bit RISC is a microprocessor with the characteristics of high cost-performance, low power, small size and high integration. The S3C2410 is developed using an ARM920T core. To reduce total system cost, the S3C2410 includes the following components: separate 16KB instruction and 16KB data cache, MMU to handle virtual memory management, LCD controller (STN&TFT), NAND flash boot loader and system

manager. The core board constructs flash memory system using the 28F128J3C chip which has 8 M×16 bit data widths. It constructs the SDRAM memory system using two HY57V561620BT chips which is 16 bit data width and single-chip capacity of 32 MB. The 64 MB SDRAM space can meet the requirements of embedded operating system and the various complex algorithm operations.

The hardware platform extended a 10/100 adaptive Ethernet interface by connected a DM9000 chip which is an Ethernet MAC chip. The Platform also has two serial ports, USB HOST and USB DEVICE interface, audio interface, SD card interface and so on. The USB HOST interface can connect USB removable storage devices and other USB devices, such as USB mouse, USB keyboard. USB DEVICE interface can communicate with upper PC. For easy operation and debugging, Platform equips LCD and touch screen.

The various signal of equipment are picked up by sensors and converted to digital signals by the A/D converter chip ADC0809 after Signal conditioning. The programmable control chip controls the A/D collection and the data transmission with ARM. The data can be published through web page form by embedded Web server, saved in SD card and displayed by LCD. For the purpose of providing equipment operating condition information facilitate, the system designed RS-232, USB and Ethernet data communication way.

This part can be embedded in the devices as an independent hardware module. It can collect equipment status information through A/D interface card, then establish the equipment running database records after analysis and processing. It sends alarm messages according to the equipment running status through the network and provides the function of historical data query and information document management.

5. The Design of Embedded Web Server

The thinking of Web-based embedded equipment monitoring is to realize the HTTP service in the embedded equipment and transform the equipment to Web server to embed into controlled equipment. Through providing Web-based graphical management interface for the Internet or LAN users, it eliminated the special client management software and realized unified management of various equipments in the network. Through existing public communications networks, without geographical restrictions, using a standard Web browser, Users can directly access to the Web server in embedded devices and performance remote monitoring, diagnosis and maintenance of all nodes on the network.

Embedded system is a kind of special computer system which has limited resources and functions. To implement Web server in embedded system is characteristic of itself. Considering the need of large dynamic data exchange during equipment monitoring, using Samsung's S3C2410 as the platform, the paper proposed a solution to implement embedded Web server in the embedded Linux operating system environment. The solution takes the general Web design technique as foundation and combines embedded CGI (Common Gateway Interface), ActiveX and Java Applet technology. It can well meet the application requirements in the equipment monitoring domain. The structure of embedded web system is shown in Figure 3.
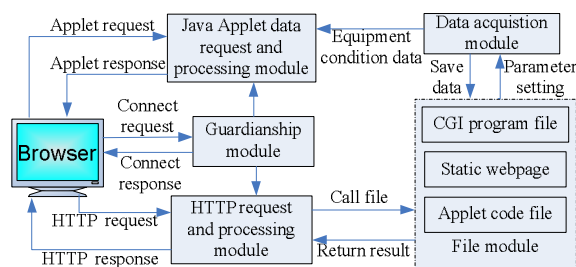

Figure 3． The structure of embedded web system

5.1 Embedded CGI

When http request URL is the external extended program, Web server puts the client side input's form data in the environment variable. And then server start external extended program to call the parameters of environment variable in the implementation process. The results will be returned to the Web server in HTML document form. This process exchanges data between Web server and external extended program. CGI is the standard of their dynamic interactive interface.

According to CGI interface specification, the communication methods between application and Web server have environment variables, command line, the standard input and output. The transmission has GET, POST and HEAD method.

Different to standard CGI, the implementation of embedded CGI often aims at specific applications based upon the consideration of the characteristics of embedded systems. In the embedded Web based equipment condition monitoring system, CGI has two main functions: Implementation of user authentication security mechanism; when the user setting equipment control parameters (such as data acquisition parameters) through the browser, the parameters can be analyzed from http message and handled correctly. Because of the function be greatly simplified, the solution of embedded CGI has the following characteristics: it does not involve complicated process in the embedded CGI program, so it is no necessary to design it as a separate process. It is called as a sub-function of the HTTP request handling process; after analyzed the form data from HTTP messages, the embedded CGI program create a dynamic memory area for writing form data, but not to use the environment variables. And then the dynamic memory address will be passed to CGI procedure as the called parameters; the results are directly passed to the client browser, but not to the Web server according to standard output method. This method increases the efficiency greatly.

5.2 Make Dynamic Monitoring Webpage Using ActiveX or Java Applet

Using Java Applet, we can write the executable program embedded in the webpage. The Applet has two methods of acquiring data from the Web server. The first is joining Socket in the Applet and obtain the results after the interaction between Socket and program on the Web server. That must be pay attention that Socket only can interactive with the Socket in Web server. The second is that Applet can operate the data from the Web server where the own URL on.

Java Applet is the program by a .class ending, which can be operated on the web pages. It can respond all events on the interface of Applet. For example, it can show the current rate and the frequency through moving mouse after left-click or right-click. Thus the user can have a better understanding about the analysis results.

ActiveX is the expansion of OLE technology. Through ActiveX, you can call this standard interface not only from the local environment, but also from the network. In fact ActiveX component can be inserted into webpage or other applications. It is functional and reusable component.

The equipment running information returned from monitoring nodes includes the signal waveform of temperature, voltage, current and vibration. It also includes graphic information which reflects the equipment deterioration condition and tendency. The information can be displayed by embedded Java Applet or ActiveX control in webpage.

It generally gets the same effect embedded these two kinds of control in the Webpage. The difference is that Java Applet could not operate the computer's hardware and has weaker Control function. Applet has high security and can prevent malicious damage procedure. ActiveX can operate the computer's hardware, but has stronger control function. Moreover, ActiveX has lower security and exists the danger of transmit viruses and damage the computer.

Java Applet or ActiveX controls embedded in webpage is a HTTP client procedure like the browser. It directly acquires waveform, trends graphics and other data from monitoring node via GET command. Then the data can be analyzed, processed and graphic displayed. Figure 4 shows the working principle block diagram of Applet/ActiveX controls.
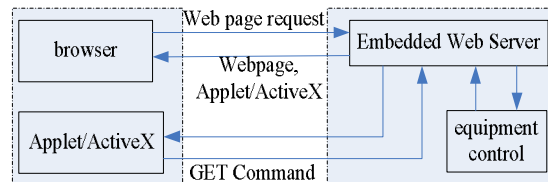

Figure 4.The working principle block diagram of Applet/ActiveX control

The browser accesses the embedded Web server to download the webpage which including Java Applet or ActiveX control. Then System gives the domination control to Java applets or ActiveX control. Finally, the embedded controls exchange data with the monitored node directly. For distinguishing with the GET command of browser, we can add "#" or other identifier into the GET command of controls.

6. The Issue of Communication Security

Web has many unsafe hidden dangers. Safety is a very important issue in a military remote monitoring system. VPN (Virtual Private Network) technology provides a powerful and reliable security platform for remote diagnosis system. Its implementation mainly use of IPsec protocol. The data security solution of VPN technology includes three aspects as follow: authentication, data confidential and data integrity. It integrates the tunneling, encryption and decryption, key management, authentication technology of user and equipment and can meet the security requirements. The processing speed of containing complete encryption and decryption can achieve 70 Mbps. At the same time, it can create and manage a large number of VPN tunnels. Remote monitoring system is a distributed

computing system and VPN is an extension of the outside world. According to the need and security level, it can ensure data security by using specialized VPN equipment or client software. Those can provide equipment technical support and management tasks to troops safety and quickly.

7. Conclusions

Embedded Web is a new technology which base on thin-server and fat-client model. It greatly decreases the building cost. With the rapid development of industrial Ethernet, applying embedded Web technology to the equipment condition monitoring field, it can meet the requirement of intellectualization, web centric and decentralization. It has broad application prospects.

The monitoring system based on the embedded platform has advantages of small size, longer work time and stable performance. It is widely recognized and becoming the main flush of network remote monitoring system. This article designed a solution of remote monitoring base on embedded and web technology. The solution is more integrated and practicality. Finally it is implemented and proved that it is successful and has achieved better results.

8. References

[1] WU Hao, JING Bo, LI Jin-liang, "Research of the Military Aircraft's Remote Diagnostics Technique Based on Web", Journal of the Academy of Equipment Command & Technology, P69-P73, April 2005, Vol.16 No.2

[2] LEI Zhi-xiang, Huang Xiao-yan, WANG Nian-cong, "Design of Equipment Monitor System based on Web", Railway Computer Application, P38-P41, May 2006, Vol.15 No.5

[3] LAI Yu-shu, LI Xun-bo, DU Ping-an, "Design of Multi-channel Hygrothermoscope Based on Embedded Web Serve", Instrument Technique and Sensor, P16-P18, May 2006, No.5

[4] HE Ling-song, ZHANG Rong, WANG Jun-feng, "The Establishment of e-diagnostics Agent by Using Embedded Web Serve", J. Huazhong Univ. of Sci. & Tech., P21-P23, Dec 2001, Vol.29 No.12