Application of Embedded Web Server in the Design of Ship Network Monitoring System

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Abstract. The frequent cross-ship communication has raised the complexity of ship network, therefore raised the requirements of monitoring system on the complicated local network on board. The traditional monitoring system is expensive and can hardly monitor cross-OS local network. Aimed at the specifications of ship network, this paper puts forward using embedded web server to design monitoring system. Through designing monitoring layer with LibPcap, designing application layer with CGI and designing user layer with JavaScript and REST, this paper finish the complete monitoring system and high improves the performance on latency and threat identification success rate.

Keywords: Ship network; monitoring system; embedded web server.

1. Introduction
With the rapid development of shipping industry and the demand of ship dispatching and inter-ship communication, the medium-sized ships are generally equipped with network communication system. The system can not only provide services for communication within ships, but also provide information exchange services between ships and between ships and public networks. With the increasing complexity of ship network, the stability and security of ship network system has been threatened. The shipping network has gradually become one of the key targets of military enemies, commercial rivals and illegal hackers. At the same time, the unstable state of the ship network system itself will also pose a huge threat to the safety and privacy of ships and their personnel. Illegal elements take advantage of the vulnerabilities, backdoors and system defects of the ship network to place viruses and Trojans inside the network and steal important ship information and personal privacy content [1].

In order to ensure the safety of ships and personnel, it is necessary to establish a monitoring system for ship network. The monitoring system is mainly used for security protection, network security and intelligence acquisition. As the ship network is a typical medium-scale LAN, it is necessary to use mature and complete monitoring tools. The main tool system at present includes Fluke network system analyzer [2]. The analyzer has several test modules, which can be used to measure important information such as network signal, network distribution, network traffic direction, etc. The instrument is portable and easy to operate, but the analysis of potential network hazards is complex and the recognition success rate is low. Sniffer's Sniffer series of network monitoring tools can quickly and accurately identify the
protocols used in local area networks, and real-time monitor the access status of the database to ensure the access rights of the database and resist DDOS attacks.

2. Embedded Network Monitoring System Technology

2.1. Ship LAN system

The ship network system is a medium-sized local area network. Local area network (LAN) refers to a network composed of computers and corresponding communication facilities which are close to each other in physical addresses. It allows data communication between different computers and communication devices, and shares printers and other devices, so as to achieve the goal of cooperative work. The LAN itself is a network, it only provides the communication method for the communication between different devices. In the ship, the power system, electrical system, sensor system and intelligent equipment are interconnected through the network, and work together to form a complex network system.

The shipping network system uses the standard communication protocol stack [3]. The bottom layer of the protocol is physical layer, which implements physical devices such as switches, routers and wires of the network. When data needs to be transferred between two terminals, a network link layer is established on the basis of the physical layer, which uses software method to establish a driver protocol in the physical layer. Data transmission in the network mainly uses the network layer. The main function of this layer protocol is to establish an address system among the nodes of the network. Data is transmitted through the source address and destination address in the network. The upper protocol of the network layer includes the data transmission protocol TCP, which stipulates the data format to ensure that the data sent by the source device can be read correctly by the destination device. The implementation details are hidden between different protocols in the network protocol stack, which can ensure the stability of the network system and the rapid location and investigation of network problems.

2.2. Network Packet Capture and Filtering Mechanism

According to the characteristics of LAN standardization protocol, network monitoring system uses typical standardization protocols, including remote monitoring management information base (RMON, MIB) and simple network management protocol (SNMP), in which SNMP protocol specifies the storage format of network communication and the communication between monitored components and central network management sites. Protocol [4]. SNMP mainly specifies four API functions for accessing information base: GET (Retrieval Management Information), GET Next (Retrieval All Information), SET (Modification of Information Base Variables) and Trap (Report Log).

Since data is in the form of data packets in all protocols, the supervision of the over-traffic LAN is mainly achieved by grabbing network packets. The most important packet capture method is the BPF method on the Unix platform. When the NIC driver receives the data packets transmitted by the network, it is copied to the filter through the BPF and then passed to the upper layer protocol. The filter determines the current state of the ship network by analyzing the selected packets. Current network package capture tools include original socket, WinPcap package capture library, Jpcap package capture library and LibPcap package capture library. The original socket is used to send packets above the IP protocol layer, including ICMP, TCP, etc. WinPcap package capturing library is a package capturing tool based on Windows system, which provides functions such as capturing raw data, filtering custom data, collecting statistical information, etc. Jpcap package capturing library is a package capturing tool for Java programs. We should use the information of the third party library for the network software communication based on Java program.

LibPcap has nothing to do with the system. It uses packet capture tools. It uses a unified interface on different platforms, so it can be applied to cross-platform local area networks. Because the local area network usually uses cross system network, the LibPcap capture tool is used in this paper.
3. Embedded Web server network monitoring system

3.1. Design of Monitoring System
The design of monitoring system first needs to determine the method of collecting network transmission information. In order not to affect the ship network, this paper adopts the bypass connection method of hubs outside critical paths, as shown in Figure 1. On the premise of not affecting the network performance, the monitoring system analyzes the captured data packets and takes corresponding measures, and provides the status information and processing information to administrators through Web. At the same time, it establishes a circular data backup area to provide real-time data query for remote administrators for a certain period of time [5].

![Fig.1 The bypass connection](image)

The whole system is mainly composed of single board PC development system, embedded Linux operating system and embedded Web server software system. The single-board PC development system is a hardware system that integrates the main CPU chip and other hardware through the PCB board. The embedded Linux system includes a tailored operating system including the underlying driver, Linux kernel and communication protocol, which can reduce power consumption on the premise of guaranteeing performance.

Embedded Web server software is a software system developed for ship monitoring system. Its main function is to use LibPcap to capture and process data packages at the software level, and to provide management interface and functional manipulation for administrators.

3.2. Design and Implementation of Embedded Web Server
In order to design and implement an embedded Web server, you first need to specify the workflow of the monitoring system. This article uses the system hierarchy shown in Figure 2. The system mainly adopts the B/S model to complete the design of the webpage-based monitoring system. The data transmission of this protocol is a typical long connection. It takes five steps to complete a communication: establishing a connection, data request, data send, acknowledgement, and close connection [6].
The detection system shares network link layer with ship LAN, so there is no need to redesign. For monitoring layer, we need to use LibPcap capture tool to design network data collection and filtering. Using the Group acquisition strategy and API provided by the tool for function development, the functions and variables used in system design include:

- Char ebuf[PCAP ERRBUF_SIZE]/* stores the string of error information */
- Register char device/* detection device */
- Int snap len/* intercept the maximum length of the packet */

After building the application layer function of LibPcap capture tool, we need to build an embedded Web server.

### 3.3. Implementation of embedded web server

Because in embedded applications, especially in embedded devices, a web server can not be very comprehensive. It must have a small enough capacity without affecting the overall performance of the embedded system, but it must have the characteristics of a web server. A typical embedded web application is shown in Figure 3.
Embedded web servers can run code in HTML files or tables for RAM to read/write data through CGI and other methods. HTML page content is usually generated dynamically by fast-running code through compressed files stored in ROM. Java, JavaScript and other technologies can be used to generate application code on the client side, while Web pages are only published on the server side to reduce the code and capacity on the server side and improve the performance of the server side.

How to transmit information is also the core issue in the design of embedded web server. At present, the embedded application interface is mainly implemented in the form of CGI (general Gateway Interface). Users can submit data to the Web server by filling in a form for an embedded application. The server processes information by running a CGI script (CGI Scripts). The CGI program belongs to an external program and needs to be compiled into an executable file to run on the server. The structure diagram of the application program is shown in Figure 4.

The browser sends the user's input data to the web server, which sends the data to the CGI program using STDIN. After executing the CGI program, it may access the records of the data storage area, and finally use STCOUT to output the result file in HTML form, which is sent back to the browser through the web server and displayed to the user.

This paper uses CGI to call the C language library of Linux operating system itself, which can significantly improve the efficiency of program operation and execute data processing through scripts in HTML web pages. Therefore, this method enables administrators to execute programs locally, thereby reducing the workload of the system server. The development of user interface is mainly for the interface monitoring of administrators. The development of Browser end uses JavaScript and HTML language, which can quickly deploy and implement system management pages, and the development of background through REST on Server end, which can process system data and remote requests.

4. Experimental verification

After the establishment of the ship network monitoring system based on embedded Web server, the monitoring effect of the system is tested by experimental cases. Firstly, each module of the system is tested. The results show that the system achieves the functions of each module. After testing, the whole system is integrated. In this paper, the delay of monitoring system and threat identification of network system are taken as examples, and compared with traditional detection tools. The results are shown in figures 5 and 6. It can be concluded that the Web server monitoring system is superior to the traditional monitoring tools in the two important indicators of system monitoring delay and accuracy. In the whole test process, the return value of embedded web server and the request value of browser are running normally. The browser constantly requests the state value of the programmable controller, while the embedded web server continuously inputs and reads the state command of the programmable controller to the serial port, and sends the return value to the browser. The browser keeps on requesting the state value of the programmable controller. The real-time monitoring of the whole monitoring system is realized by refreshing the picture. It can be seen that the system can run efficiently and accurately and achieve the expected goal.
5. Conclusion
Based on the analysis of the characteristics of ship local area network, this paper puts forward that the traditional network monitoring system can not provide reliable and stable monitoring methods. Through the analysis of the characteristics of low power, easy deployment and high recognition rate of embedded Web monitoring system, a ship network monitoring system is established based on the LibPcap flow packet capture tool, which improves the system delay and recognition success rate significantly, and optimizes the performance of the ship monitoring network system.

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