DEVELOPMENT OF A MONITORING SYSTEM FOR THE FL-net PROTOCOL

M. Ishii#, T. Masuda, S. Ueda, JASRI/SPring-8, Hyogo 679-5198, Japan
T. Fukui, RIKEN/SPring-8, Hyogo 679-5148, Japan

Abstract

FL-net is being used as a communication protocol between the front-end computers and PLCs in several control systems at SPring-8 and SACLA. It is an Ethernet-based open standard protocols used for a factory floor networks. Furthermore, it is an UDP/IP-based master-less token passing protocol and supports cyclic transmissions. SACLA has experienced certain problems in terms of data acquisition when using FL-net for a beamline machine protection system. To resolve these problems, we developed a monitoring system for the FL-net protocol that captures and analyzes all packets of an FL-net network segment, detects protocol failure events, and stores the event information in a relational database. We can easily refer to the stored information in the database using a Web browser. The software-based monitoring system is highly portable and does not require a dedicated hardware-implemented protocol stack. This paper presents the monitoring system design for FL-net.

INTRODUCTION

FL-net was first introduced at SPring-8 in 2005 as a field-bus for the communication between the VME system and PLCs. The control systems using FL-net are as follows: a status monitoring of linac interlock system at SPring-8 [1]; a vacuum, RF high-power, and low-noise power supply control system; an undulator control system; a precise water temperature control system at SACLA [2]; and a facility control system at both SPring-8 [3] and SACLA [4]. Figure 1 shows a schematic view of a typical control system using FL-net at SPring-8 and SACLA. In our control system, FL-net shares Ethernet switches through the use of virtual LAN technology (VLAN). The SACLA control system currently utilizes 45 types of VLAN segments for FL-net. Packet capturing and protocol analyses are helpful for troubleshooting the network. On the other hand, analyzing a very large amount of captured data requires a lot of time and effort. In addition, since problems may occur at any time, we have to monitor the packets over the long term. For the SACLA control system using FL-net, a problem occurs at least once a month. While an FL-net protocol analyzer has been released on the market, it was not designed for a long-term monitoring.

We therefore developed a monitoring system for the FL-net protocol in March 2012, and started monitoring the system in May. Herein, we describe the design of the system and the effects of its installation.

ishii@spring8.or.jp

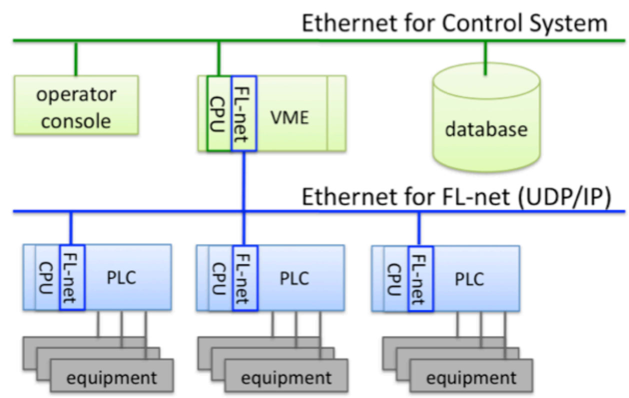

Figure 1: Schematic view of a typical control system using FL-net at SPring-8 and SACLA.

FL-net

The FL-net protocol was authorized by the Japan Electrical Manufacturers' Association (JEMA), and was established as a JEM standard in 2000 [5] and as a Japanese industrial standards (JIS) in 2004 [6]. Since several PLC vendors provide FL-net interface modules, we can build a control system using multiple vendor products. The FL-net protocol has the following features.

- The standard UDP/IP Ethernet communications protocol is used. Cables, hubs, and other networking components are readily available.
- The network operates at 10 Mbps (version 2.00).
- Up to 254 nodes can be connected to the physical network layer.
- Message transmissions for asynchronous data communication and a cyclic transmission are supported.
- Message transmissions sends/receives up to 1024 bytes of data.
- A cyclic transmission uses the common 8-Kbits and 8-Kwords memory shared by all nodes.
- Nodes can be automatically connected to or disconnected from the FL-net network by adopting a master-less token method.

SYSTEM DESIGN

Our design policy was to capture and analyze all packets flowing through the Ethernet of the FL-net network, and to record all problematic events. In FL-net, network packets continuously flow at a rate of ~ 4 Mbps. If all packets of the captured data are saved as files in pcap format, which is a standard format treated by open-source network analyzers such as tcpdump [7] and

ISBN 978-3-95450-124-3

Wireshark [8], the disk usage reaches up to ~ 30 GB/day. We therefore have to store only the necessary data to save disk space. Our requirements for the monitoring system are as follows:

- The system automatically saves only several 10-s long data packets including the problem event as a pcap format file.
- We can select parameters such as the type of detection events, and save directory using a Web browser.
- The system stores information on a problem event with a time stamp in a relational database. We can easily refer to this information using a Web browser.
- The system has no influence on the operation of the FL-net system.
- The system monitors several FL-net network segments, and we can access the monitoring system through the Ethernet.
- The system has the highly portability and is independent from the hardware.

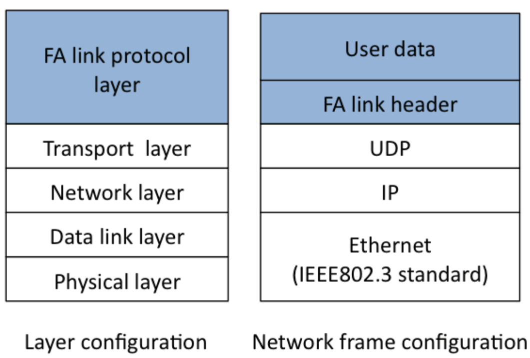

Figure 2: The layer configuration and network frame configuration of the FL-net protocol.

We developed a software-based monitoring system running on a Scientific Linux. In the FL-net protocol, the FA link protocol layer, including the FA link header and user data, is located above the transport layer. The monitoring system analyzes only the FA link header. Figure 2 shows the layer configuration and network frame configuration of the FL-net protocol.

Figure 3 shows a schematic view of the monitoring system. The black line indicates a data flow, and the green line is a process management flow. The monitoring system consists of an administration process (Admin-proc), a packet capture process (CP), a protocol analysis process (AP), a MySQL database, and a Web server in a computer.

The CP captures all incoming packets and saves them as a temporary file with 3 to 4 MB in size for each 10-s of data, and writes the temporary file name to the database. The file size depends on the packet capture period. From the database, the AP acquires the file name of the temporary file to be analyzed. The AP then analyzes the temporary file according to the detection events such as the participation and removal of a node, a token skip, and the duplication of the node address. If the AP detects an event, it saves the packet data including the event as an archive file and writes the event information with a time stamp to the database. The AP then sets an analysis complete flag for the temporary file to the database. The CP acquires the temporary file name set the analysis complete flag from the database, and deletes the

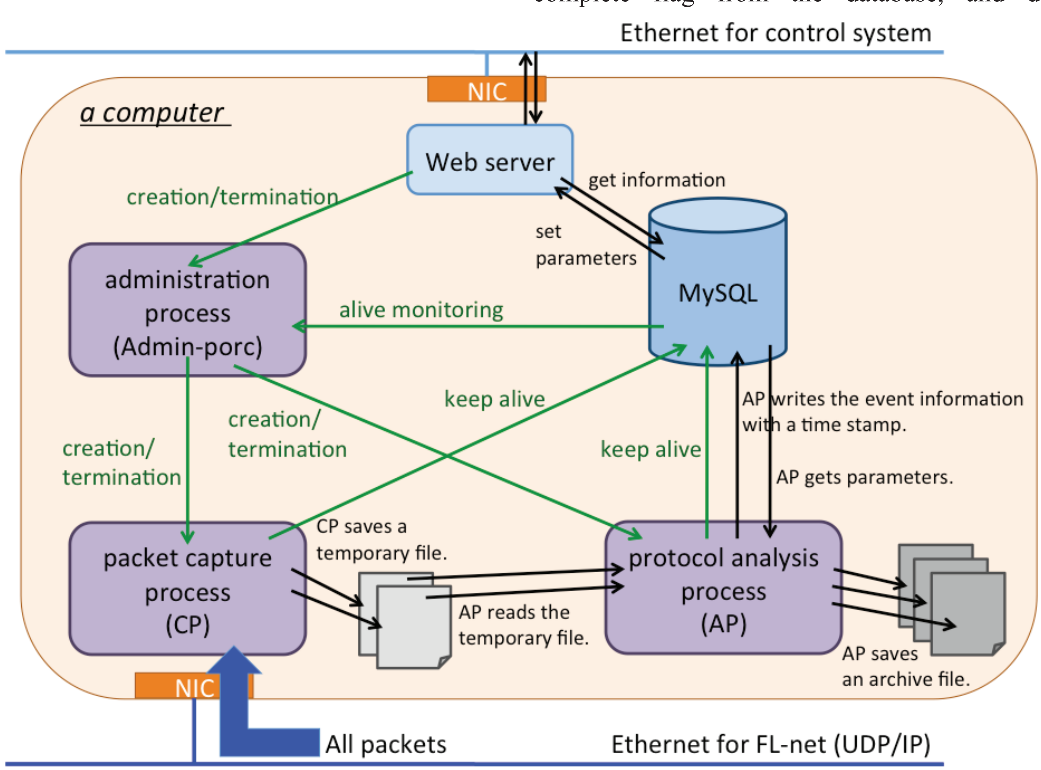

Figure 3: Schematic view of the monitoring system for the FL-net protocol.

ISBN 978-3-95450-124-3

temporary file. We can check the packet flow before and after a problem event off-line using the archive files. If the FL-net is normal, an archive file is not generated.

The Admin-proc manages the creation, termination, and alive monitoring of the CP and AP. The CP and AP update a time stamp as keep alive to the database.

A Web server creates and terminates the Admin-proc, and displays lists of information, such as the node status, event history, and saved archive files from the database. Figure 4 shows the main page on a Web browser. We can access the connection history, archive file list, timer information, event history, parameter configuration, process status, and help from the menu bar. In addition, we can obtain the node number, connection status, 4th octet of the IP address, the offset address and size of the allocated common memory, and the token watchdog timer for each node.

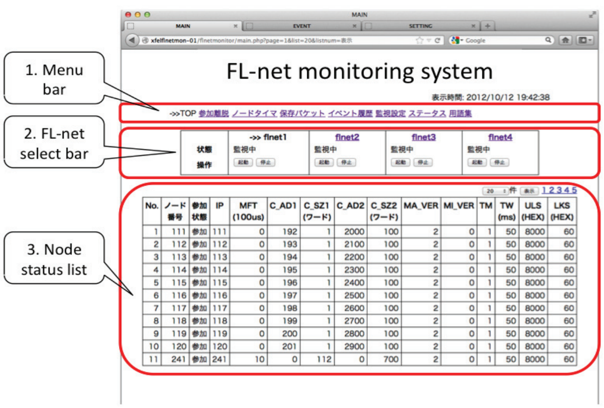

Figure 4: The main page of the Web browser. The language is set to Japanese. The red line around the box No. 1 area indicates the menu bar used for browsing The No. 2 area is the FL-net select bar, which can start/stop the monitoring by the click of a button Finally, the No. 3 area shows the node status and configuration list.

APPLICATION

We built the monitoring system on a computer with a quad core Xeon 2.4 GHz CPU, 16 GB of memory, a 1 TB HDD, and five Ethernet ports. One Ethernet port is for Web access and the other Ethernet ports are for monitoring four FL-net network segments. The average CPU load is less than 0.1.

From the start of the SACLA operation, there were problems with the status monitoring of the beamline machine protection system (MPS) during data acquisition, such as the status of the main beam shutter opening/closing, and the gate valve status at the front-end and transport channel vacuum system. The MPS is consisted of PLC modules. The VME system acquires data from the PLCs using FL-net (Fig. 1). On one occasion, the VME FL-net board was suddenly blocked, and data acquisition was ceased. Before the installation of the monitoring system, we were unable to determine whether the source of the problem was a network switch, VME computers, PLC modules, an application running on the VME system, the PLC ladder software, or burst traffic. After its installation, the monitoring system detected that the source of the data transmission blockage was the VME FL-net board. We then examined and upgraded a firmware of the VME FL-net board. Since this firmware upgrade, the data acquisition of the MPS has been running stably.

Data acquisition for precise temperature control system of undulators at SACLA also involved some issues. The VME system acquires data from the PLCs through FL-net as an MPS. By using the developed monitoring system, we found that many token skips had occurred, and the token cyclic time exceeded the token watchdog timer set for each node. We were able to determine the setting configuration of each node based on the node status and configuration list of the monitoring system. We will modify the configuration to the appropriate token watchdog timer during the next shutdown period.

SUMMARY

Several control systems using FL-net have been built at SPring-8 and SACLA. We developed a monitoring system for the FL-net protocol, which captures and analyzes all packets of an FL-net, detects problem events, and stores the event information into a relational database. Through the installation of this monitoring system, we have resolved certain issues in data acquisition for the beamline MPS and precise temperature control system for undulators at SACLA. The monitoring system is effective in identifying the source of system problems.

REFERENCES

[1] T. Fukui et al., "Development of a communication with PLC by using the FL-net as an open standard PLC link," Proc. of PCaPAC2005, Hayama, Japan, 2005.
[2] R. Tanaka et al., "First operation of the SACLA control system in SPring-8," Proc. of IPAC2011, San Sebastian, Spain, 2011, p. 2325.
[3] M. Ishii et al., "The Gateway of Facility Control System for SPring-8 Accelerator," Proc. of ICALEPCS2011, Grenoble, France, 2011, p. 473.
[4] T. Masuda et al., "Facility Utility Control System of XFEL/SPring-8," Proc. of ICALEPCS2009, Kobe, Japan, 2009, p. 286.
[5] http://www.jema-net.or.jp/Japanese/standard/opcn/opcn07.html
[6] http://www.jisc.go.jp
[7] http://www. tcpdump.org
[8] http://www.wireshark.org

ISBN 978-3-95450-124-3