Gateway for Inter-Network Connection in the Pohang Light Source Control System

S.C. Won, S. Kwon
Pohang Accelerator Laboratory,
POSTECH, P.O. Box 125,
Pohang 790-600, Korea

Abstract

The control system for the Pohang Light Source(PLS), under construction, is a large scale distributed computer control system which can manipulate approximately 7000 signals. It has a hierarchical structure with two heterogeneous data communication networks. The upper level network is a baseband Ethernet to link operator console computers with Subsystem Control Cpmputers. The lower level network is a MIL-STD-1553B multidrop field bus which connects each Subsystem Control Computer with VME based local controllers. In this control system structure, frequent modification of local control software during system commissioning and maintenance periods requires repeated installations of developed software on the local controllers, which are distributed along the 280 circumference of the storage ring. This paper describes the construction of a software gateway which is a specific kind of network server, to interconnect the two different networks so that an operator in the upper level network is able to access any low level local control computer transparently.

1. INTRODUCTION

The Pohang Light Source(PLS) control system has a hierarchical structure with distributed intelligence and autonomous processing units as shown in Fig.1.

The hierarchy consists of four layers with different roles. The four layers are the computing service layer, the human interface layer, the subsystem control layer and the machine interface layer. The computing service layer is the UNIX based host computers for mathematical modeling system simulation and off-line data analysis. The human interface consists of six console computers equipped as graphical engineering workstations. These console computers are linked with the host computer and the subsystem computers via Ethernet. The Subsystem Control Computers(SCC) are microprocessor assemblies in a standard VMEbus crate and the drive Machine Interface Unit(MIU) clusters through the 1 Mbit/sec MIL-STD-1553B serial multidrop field bus. Each MIU, which is also based on the VMEbus and the Motorola 680x0 microprocessor family, can use various protocols to interface with machine components.

In order to develop an integrated and standardized software for such a large scale distributed control system, a powerful software development environment providing necessary development tools should be arranged.

The software development system consists of a development host, mass storage devices, printers, and communication network to the target systems. The development host uses X-windows as graphics basis, and is equipped with various development tools, utilities, and libraries. All SCC's and MIU's should be able to share these resources

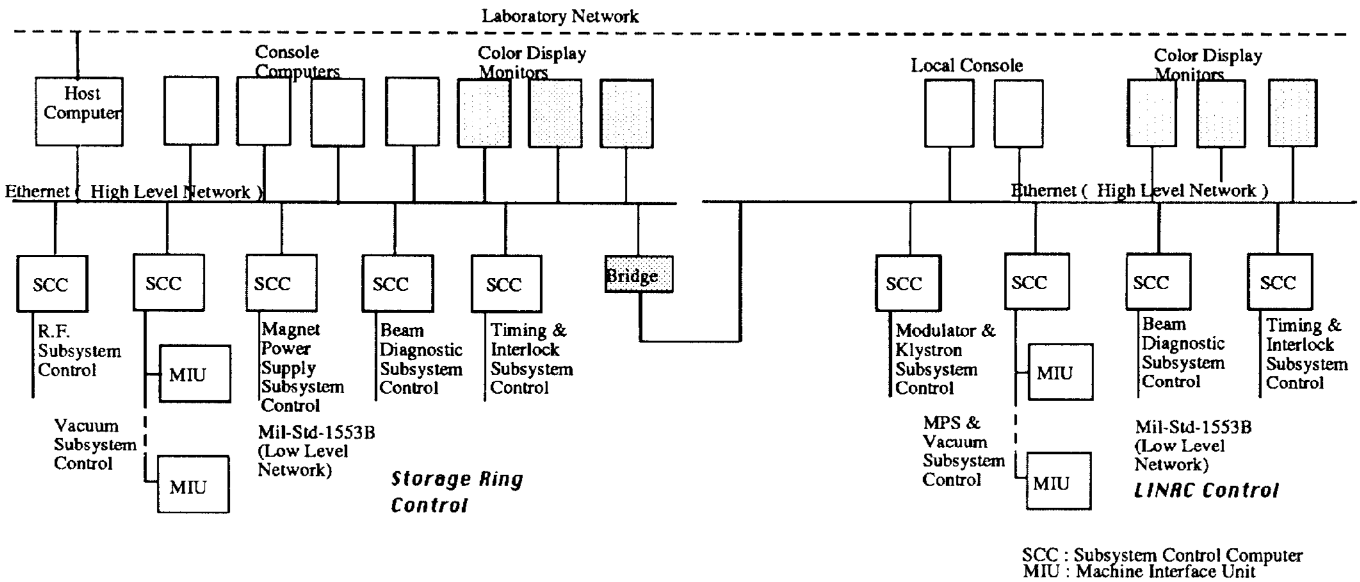

Fig1. PLS Control System Architecture

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through the network, so that developed software can be downloaded to the target system, tested and modified remotely.

However, the PLS control system has two heterogeneous data communication networks. The upper level network uses a baseband Ethernet to link operator console computers and development workstations with SCC's. The lower level network is a MIL-STD-1553B multidrop field bus which connects each SCC with it's MIU's. MIL-1553B is used because of it's deterministic behavior, standard chip, noise immunity and galvanic insulation. Development hosts in the upper level network cannot access MIU's in the lower level network transparently. One way to solve this problem is to construct a software gateway on the SCC to interconnect the two different networks.

2. GATEWAY FOR INTERNETWORK

A gateway is a system that interconnects two or more distinct networks so that computers on one network are able to communicate with computers on another network. Considering the OSI 7-layer model, we have to choose the layer at which a gateway operates,depending on the type of translation and forwarding done by the gateway. In the PLS control system, one of the goals of the internetwork connection is to support remote login and file transfer services from the Ethernet based development host to MIUs on the MIL-STD-1553B field bus. Adoption of a standard protocol suite such as TCP/IP enables us to reduce software development efforts.

Fortunately, the SCC's and the MIU's run Microware System's OS-9 as their operating system. Currently, OS-9 supports TCP/IP protocols and provides an Ethernet network device driver. Furthermore, the UNIX based host computer on Ethernet uses TCP/IP for it's communication protocol. Under the TCP/IP protocol suite, interconnection of two networks is simple and straight forward. If we have an internet of Ethernet and MIL-STD-1553B that both use TCP/IP protocols, no translation of protocols is required. Instead, the gateway only needs to forward packets from one network to another. The IP layer is responsible for this forwarding of packets. Each IP packet contains enough information(*i.e.*, its final destination address) for it to be routed through the TCP/IP internet by itself. Another advantage of a TCP/IP gateway is that OS-9 supports a socket library for network programming,which we can use to develop communication software through the MIL-STD-1553B.

Fig. 2 shows the structure of the TCP/IP gateway which was implemented for the PLS system. The implemented gateway, which was installed on an SCC, has two network interfaces under the IP layer. One is an Ethernet interface and the other is a MIL-STD-1553B interface. The MIL-STD-1553B interface, which corresponds to a data link layer and physical layer in the OSI model, has the hardware characteristics shown in Tables 1 and 2.

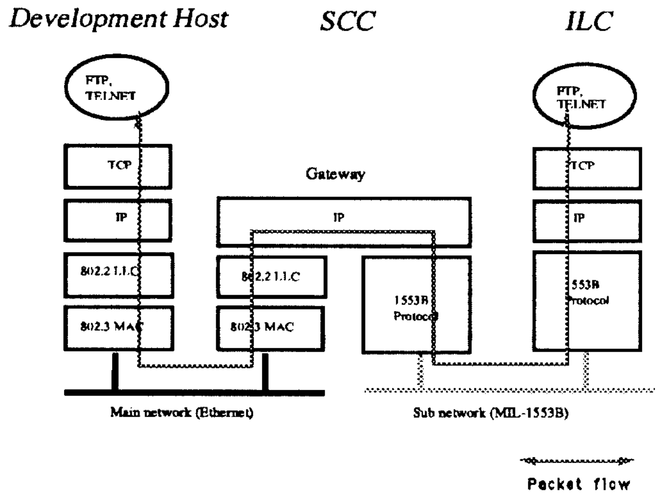

Fig2. TCP/IP Gateway

Framing	Invalid Manchester Coding
Flow Control	Subsystembusy bit in Status word
Error Control	Status Response,Parityu bit for each word
Link Management	Bus Controller,C/R

Tablel. MIL-STD-1553B Data Link Layer

Application	DoD Avionics
Data Rate	1 Mbps
# of Data bits/Word	16
Word Length	20 bits
Transmission Technique	Half Duplex
Operation	Asynchronous
Encoding	Manchester Biphase
Bus Cabling	Transformer
Bus Control	Single or Multiple
Transmission Media	Twisted pair shield

Table2. MIL-STD-1553B Physical Layer

3. NETWORK DEVICE DRIVER FOR OS-9

OS-9 has a modularized I/O structure. It has four levels of modularity including the kernel, file managers, device drivers, and device descriptors. The kernel maintains the I/O system for OS-9. It provides the first level of I/O service by routing system call request between processes, the appropriate file managers, and device drivers. Since the network interface software is embedded in this modularized, layered structure, our major concern was focused on the network file manager, IFMAN, which all the network drivers should interact with.

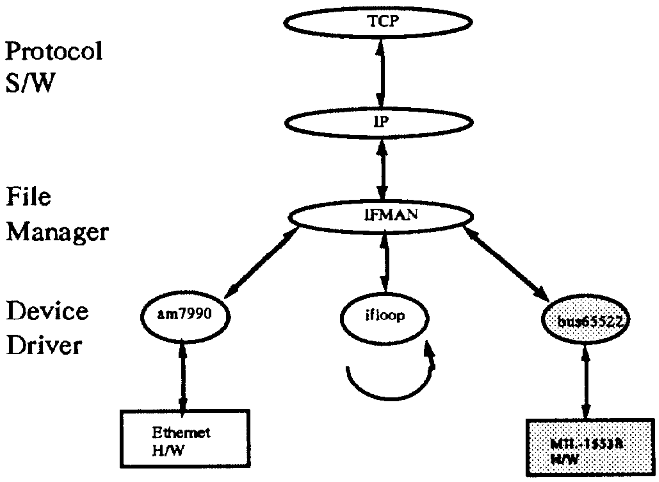

Fig3. OS-9 TCP/IP Software

Fig. 3 shows the network interface software structure in OS-9. IFMAN is below the IP layer and above the NIF(Network InterFace) which correspond to the device driver and the descriptor. In order to interface the DDC BUS 65522 II MIL-STD-1553B network hardware, a device driver, "bus65522", and the corresponding descriptor "mil0", was developed . The device descriptor is a small table which contains network information,such as the Maximum Transfer Unit(MTU), the IP address, the physical address of the port, and initialization data. In Fig. 3, the shaded part represents the new driver attached to the existing OS-9 network system. The major jobs for development of "bus65522" were MIL-STD-1553 bus control, address resolution and packet fragmentation. MIL-STD-1553B consists of a Bus Controller(BC), Remote Terminals(RT) and a twisted shielded pair wire data bus. Unlike Ethernet, on which every node has a unrestricted access rights to the main bus, MIL-1553B reserves exclusive access rights to the BC only. Therefore we must include a polling process on the BC to recognize the individual RT's. The polling process gathers information about bus requests from RT's and maintains this data on it's local table, so that the BC controls data flow for all transmissions on the bus. The other issue during development of "bus65522" was address resolution. Application software such as TELNET uses a logical address(IP address), while the network driver needs a RT address for the actual transmission. We managed this problem by using host ID field in the IP address as the RT address, for simplicity. Another problem we considered was packet fragmentation. The MTU of the Ethernet is 1500 bytes and that of MIL-STD-1553B is 64 bytes, therefore a large Ethernet packet should be segmented into smaller packets for transmission on MIL-STD-1553B. However, fortunately, the IP protocol was developed considering this situation, and we let the IP layer handle packet fragmentation and reassembly internally.

4. CONCLUSION

For implementation of the PLS control system software development environment, a TCP/IP gateway was constructed on the SCC. It interconnects the upper level network, Ethernet, and the lower level MIL-STD-1553B field bus. To check remote login function of the implemented gateway, a TELNET service test was performed. It was proven that an operator at the host computer can access any MIU transparently. Also, the FTP service was tested by sending a 67796 byte file to one of the MIU's. Even though the transmission speed was rather slow due to the protocol conversion overhead, the file was successfully transferred. After the test, the developed gateway was installed on the SCC and has been used by the PLS software team satisfactorily. An operator at a console computer can download developed software to a local controller for remote testing and debugging. Also, using a set of in-house developed local controller access services, we can run application tasks on the console computers. We expect the gateway to serve as a platform for various applications to MIL-STD-1553B internetworking.

5. REFERENCE

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