Real-time Data Acquisition and Control System for the PLS Storage Ring

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Abstract

The PLS computer control system has a fully distributed control architecture. It consists of three layers of computers and two levels of networks linking the adjacent layers. The first computer layer is involved in the graphical operator interface. On the other hand, the two lowest computer layers and the low level network are involved in the execution of the real-time data acquisition and control tasks. In this paper, we describe the implementation details of hardware, software and network of the real-time data acquisition system.

1 INTRODUCTION

The PLS storage ring consists of various machine devices such as magnet power supplies, vacuum controllers, beam diagnostic monitors, etc.. Most of these devices are geographically distributed around the storage ring. The total number of control points is about 5000. The real-time data acquistion and control system, real-time control section of the PLS computer control system, controls and monitors these control points on real-time basis. It is made of two layers of VMEbus-based field computers with OS-9 real-time operating system. The upper layer consists of Subsystem Control Computers(SCC) and the lower layer consists of Machine Interface Units(MIU). These two layers are linked each other with MIL-1553B network. Figure 1 shows the computer control system structure.

The MIU is directly interfaced to the individual machine devices and is in charge of perfoming real-time data acquisition, closed-loop control and monitoring of the hardware devices.

The SCC acts as front-end for its connected MIUs. Its main tasks are to provide a standard access to the controlled devices and supervise MIU operations.

The relationship between SCC and MIU is strictly hierarchical. All the communication taking place between SCC and MIU is in direct consequence of an SCC's request.

2 HARDWARE

The SCCs and MIUs are field computers based on the VMEbus and the Motorola's MC68030 CPU. They are equipped with the same Microware's OS-9 real-time operating system which is a multi-user, multi-tasking UNIX-like operating system with a versatile re-entrant, position independent memory module design.

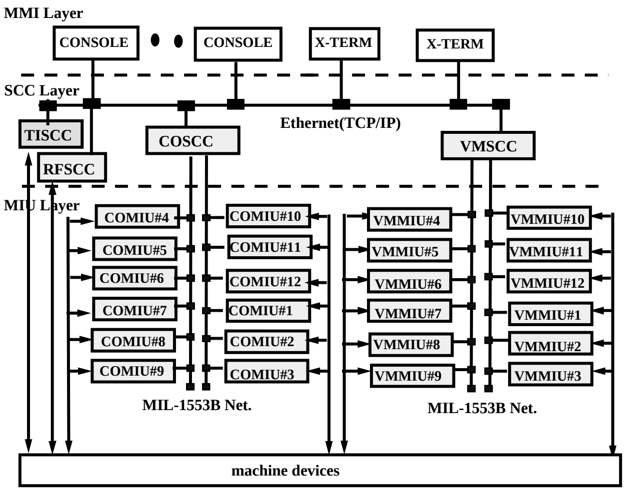

Figure 1: Computer Control System Structure.

2.1 Machine Interface Unit(MIU)

There are 24 MIUs: 12 VMMIUs and 12 COMIUs. They are distributed in 12 local control sheds around storage ring to reduce the complexity of device cabling and to increase system maintenability. They use Motorola's MVME147S-1 as their single board computer. MVME147S-1 has 25-MHZ MC68030 CPU and 4 MByte DRAM.

The COMIUs control beam position monitors and corrector magnet power supplies. We use digital I/O(ESD's DIO-48) for the interface to the corrector magnet power supplies. We use special lab. developed electronic boards for beam positon monitoring. These boards using VXI standard are installed into a separate VXI crate. All other boards are installed in a VME crate. These two crates are linked each other using VME-to-VME repeater (BIT3's 412).

The VMMIUs control machine devices such as vacuum devices, power supplies for all magnets except correctors, injection system, etc.. We use RS422 serial communication protocol(ESD's ASIO16) to interface to these magnet power supplies.

2.2 Subsystem Control Computer(SCC)

There are 4 SCCs: VMSCC, COSCC, RFSCC, TISCC. The VMSCC is front-end for 12 VMMIUs which control vacuum devices, magnet power supplies, LCW and injection system. This system also controls directly some beam diagnostic monitors such as DCCT, screen monitor, etc.. This syetm uses a image processor board(TSVME630) for the processing of image data of screen monitors. The COSCC is front-end for 12 COMIUs which control beam position monitors and corrector magnet power supplies. The VM-SCC and COSCC are located inside a small room which is next to the main control room. In this room, there is also a host VME computer. This is used for the application downloading, the software development and the system diagnosis. The RFSCC controls directly RF devices. This is located inside RF buliding. The TISCC generates all timing signals needed to synchronize machine operations. The TISCC uses VXI standard and uses lab. developed electronic boards for timing function. This system is located inside the No. 1 local control shed. All SCCs use Motorola's MVME147SA-1 as their single board computer. This board has 32-MHZ MC68030 CPU and 8 MByte DRAM.

2.3 Network

The multidrop network used for the communication link between the SCCs and the MIUs is based on MIL-STD-1553B standard, originally developed for military systems. This is a master/slave system where one master, called Bus Controller(BC), continuously polls its slaves on the data bus, called Remote Terminal(RT). This standard provides good electromagnetic noise immunity and data integraty, deterministic response time and simple communication protocole which are very important factors for the data network for the real-time data acquisition system operating under severe environment like accerelator. The maximum data bus length used for our system is about 300m and the data transmission rate on the data bus is 1 Mbps. No electronic repeaters are used. The DDC's BUS65522II is used for the interface hardware board. This board provides intellegent interface between the MIL-STD-1553B and VMEbus. Software can control the BUS65522II's operation as either bus controller(BC), remote terminal(RT), or bus monitor(MT).

2.4 MIU Control Panel

For all MIUs and SCCs, we use Wes-Crates's 21-slot VMEbus crate which comply with CERN Spec. V-422. These crates supply with remote control and monitoring function. We use a control panel which can remotely controls and monitors all MIU's system reset, power on-off and fan-failure. This panel is located in the control room. This feature is very important for the easy system debugging, maintenance, and recovery in case of system malfunction or crash because all MIUs are located geographically far away from the control room.

3 SOFTWARE

We use the same operating system, OS-9, for both SCC and MIU. This ensures a sort of symmetry and uniformity in the software design and implementation. This results in drastic reduction of the application and system software development time. A hard-disk based complete operating system package for the SCC and MIU may be oversized for our applications. So, we use diskless ROM-based systems for the SCC and MIU. The system ROM contains OS-9 operating system kernel and other needed system modules. Most of the application software modules are downloaded from the host computer. Thus we can reduce system implementation cost and enhance software maintenabliity. Although the main tasks of the SCC and MIU differ from one another, the data acquisition and control software is basically divided in the following families; device access software, communication software, supervisory software, and utility software. Figure 2 shows the software structure of data aqcusition system.

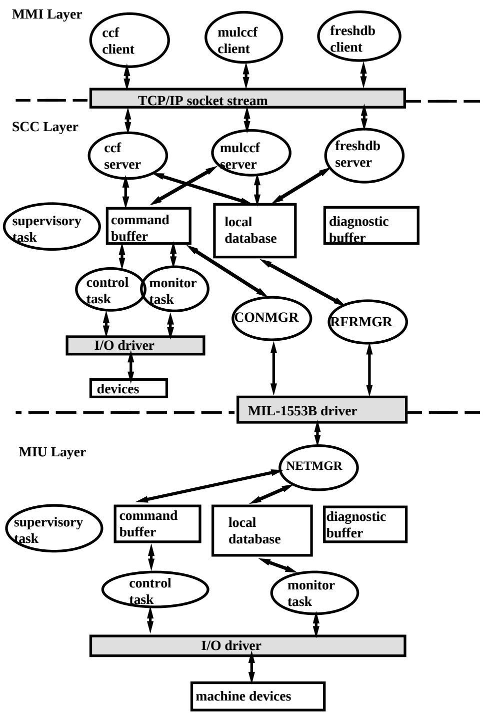

Figure 2: The Software Structure of the Data Acqusition System.

3.1 Device Access software

Device access software allows direct control and monitoring of individual devices. This software delas with the translation between the global device signal identification number(GID) and its asscociated physical address of I/0 point. This software uses various I/O descriptors and drivers to drive hardware I/O ports.

Device access software consists of control software and monitor software. Control software controls the individual devices according to the device control command which consists of GID and set-value. Monitor software monitors periodically the current status of devices and put the monitored data into local database.

3.2 Communication software between SCC and Operator Computer

This software allows message exchanges between the SCCs and the operaotr computers. This software uses a client-server model implemented with Ethernet(TCP/IP) stream socket. The client running on the operator computer makes service requeststo the server running on the SCC and the server provides requested service to the client.

There are three kinds of servers on the SCC; single control-command forwarding server(CCFSVR), database refresh server(FRDBSVR) and multiple control-command forwarding server(IDBSVR). The CCFSVR handles single control-command forwarding service request which need to control a sigle device signal point. The CCFSVR decodes service request messge from the client, extracts GID and set-value, puts them into a small buffer called command-buffer, and sends a wake-up signal to another network task called CONMGR which send the control message to the appropriate MIU via MIL-1553B network.

The FRDBSVR handles database refresh service request. This request is issued when the database of operator computer should be refreshed with that of SCC. Upon receving this request, this server sends requested block of its database to the client in requested interval. The service request message consists of system, class and refresh interval.

The IDBSVR handles multiple control-command forwarding service request. This request is for the simultaneous control of mutiple device signals. The service request message consists of multiple pairs of GIDs and set-values. As with CCFSVR, this server decodes the request message, puts each pair of GID and set-value into the command-buffer and sends a wake-up signal to the CONMGR.

3.3 Communication Software between SCC and MIU

This network software allows the message exchange between SCC and MIU. This software uses simple command-response model implemented with low-level packet transmission scheme. SCC initiates communication session by sending a command packet to MIU. MIU reponds according to the command packet.

In SCC, there are two network tasks relating with MIL-1553B network, called CONMGR and RFRMGR. The CONMGR, which is awakened by CCFSVR or IDBSVR, makes device control command packet and sends it out to the network. RFRMGR, which is periodically awakend by its own alarm, makes database refresh command packet and sends it out to the network. RFRMGR also receives refresh data from NETMGR task of MIU and updates its local database with the fresh data.

There is one network task, NETMGR, in MIU to handle MIL-1553B network communication. This task is normally in sleeping state and is awakened by the command packet sent by CONMGR or RFRMGR on SCC. If this is device control command packet, NETMGR extracts the device set-value and GID from the command packet, puts them into the command-buffer and sends wakeup signal to the appropriate device control task. If this is database refresh command packet, NETMGR makes a response packet consisting of all GIDs and device values of its current local database, and sends it to RFRMGR task in SCC.

3.4 Supervisory Software

Supervisory software checks and gathers various system related information such as application task status, device status, network status etc.. This softare stores all these data into the special local buffer called diagnostic buffer(DIAGDDB) which can be used for the system diagnosis later.

3.5 Utility Program

Utility programs are identified as all the tasks such as off-line test program, simulation program, diagnosis program, calibration program, etc..

4 ACKNOWLEDGEMENTS

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