Control System of PLS 2-GeV Storage Ring

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Abstract

A real-time computer control system is developed and used for the remote operation of the Pohang Light Source (PLS) 2-GeV storage ring. It consists of three layers of computer systems; console computer for operator interface, subsystem control computer (SCC) for front-end data processing, machine interface unit (MIU) for low-level data acquisition. The console computer is Sun Microsystem's SPARCstation with UNIX. It uses X-Window/Motif for the GUI (graphical user interface) tool. The SCC acts as a front-end data processing between the console computer and the MIU. There are 24 MIUs placed in the storage ring building. The MIU is directly connected to individual machine components to do low-level data acquisition. The SCC and MIU are based on VMEbus standard and use Microware's OS-9 real-time operating system. Console computers and SCCs are connected through Ethernet (TCP/IP). SCCs and MIUs are connected through MIL-STD-1553B fieldbus.

1 Introduction

The Pohang Light Source (PLS) is a 2-GeV third generation light source that has a 150-m 2-GeV full energy injection linac and a 280-m circumference storage ring. Its construction was completed in December 1994 and normal operation for beam-line users started in September 1995.

We have developed a large-scale computer control system for the PLS 2-GeV storage ring. The control system was completed in August 1994. After minor system modification and upgrade works during machine commissioning period from September 1994 to July 1995, the control system now shows very stable and reliable characteristics which meet our control requirement. However, the control system is continuously being upgraded to accommodate additional control requirements such as insertion devices. With better operational experiences, we are also doing research and development work according to the advance of computer technology such as multimedia system [1].

The computer control system for the PLS 2-GeV storage ring has a distributed control architecture, and has three layers of hierarchy; operator interface computer (OIC) layer, subsystem control computer (SCC) layer, and machine interface unit (MIU) layer. The OIC layer is based on Sun Microsystems' SPARCstation with UNIX (SunOS 4.1.3) and X-terminals. X-Window/Motif is used for graphical user interface tool. The SCC acts as a data gateway between the OIC layer and the MIU layer. The MIU layer is directly interfaced to individual machine devices for low-level data acquisition and control. The SCC and MIU layer is based on VMEbus standard with OS-9 real-time operating system. SCC and MIU are OS-9 ROM-based system. Executable application software modules are downloaded from host computer at system start-up time. There are 4 SCCs and 24 MIUs in total. The OIC layer and SCC layer is linked through Ethernet (TCP/IP). They communicate with each other in the form of client-server. The SCC layer and MIU layer is linked through MIL-STD-1553B fieldbus. They communicate with each other in the form of master-slave.

2 Machine components under control

The 2-GeV storage ring consists of various kinds of machine components which need remote control. Major components include magnet power supplies, vacuum devices, beam diagnostic devices, RF system, and timing devices. These components are placed around the 280-m circumference storage ring building. The number of control points from these components amounts to about 6,000 in total.

There are a total of 215 power supplies for various magnets in the storage ring. These power supplies are placed in two locations: 6 units in the linac power substation and other units in the 12 local control sheds around the storage ring building. Each corrector magnet power supply unit has a digital type I/O port that is connected to the machine interface unit called the COMIU. However, each unit of remaining power supplies has a RS422 serial communication port that is connected to the machine interface unit called the VMMIU.

The vacuum system consists of 123 ion pumps, 53 ion gauges, and 15 gate valves. These components have their own local controllers placed in the 12 local control sheds. These local controllers are interfaced to the machine interface units called the VMMIU. Each pump and gauge controller has an RS422 type serial communication port. Each gate valve controller has a relay type I/O port.

For beam diagnostic purpose, there are 108 beam position monitors, 1 DCCT system, 3 screen monitors, 1 tune measurement system, and 1 beam scraper system. We have developed in-house VXI-type electronic modules to process electric signals from beam position monitors, and these modules are installed in VXI crates. The VXI crate is linked to the machine interface unit called the COMIU via VXI-to-VME repeater. The subsystem control computer, the VMSCC, is used for low-level data acquisition for the rest of diagnostic systems.

The RF system consists of various components such as klystron, cavity, high voltage power supply, circulator, low -level RF electronic system, etc. These components are placed in the RF building. For low-level data acquisition

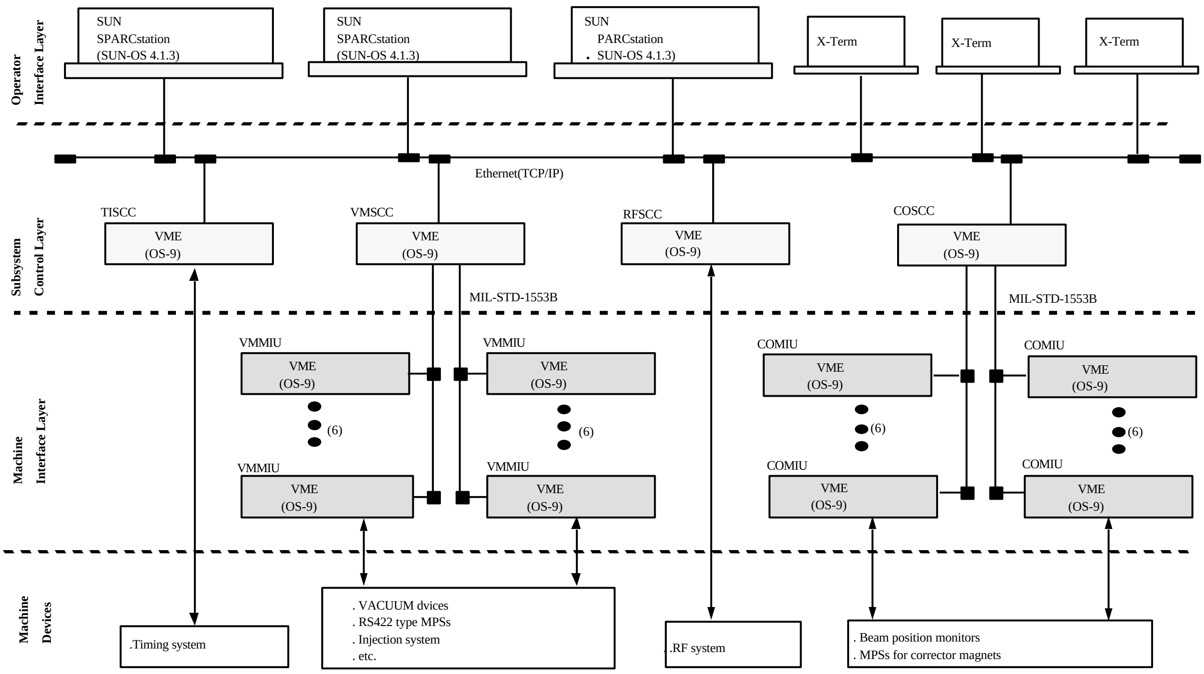

Fig. 1: Schematic diagram of the PLS 2-GeV storage ring control system.

for these RF components, we have assigned a subsystem control computer (RFSCC) placed in the RF building. Various types of commercial VME I/O boards are used to interface with these RF components [2].

We have also developed in-house electronic modules for machine timing and synchronisation system. All these modules are based on VXI, and installed in a VXI crate together with VME type CPU board to form a subsystem control computer (TISCC).

3 Hardware of control system

The schematic diagram of the PLS 2-GeV storage ring control system is shown in Fig. 1. There are three layers in the control hierarchy; Operator Interface Computer (OIC) layer, Subsystem Control Computer (SCC) layer, and Machine Interface Unit (MIU) layer.

3.1 Operator interface computer (OIC)

The OIC layer provides various kinds of graphical user interface windows for the operator to control and monitor the storage ring machine. In the OIC layer, there are three SUN Microsystems' SPARCstations and three X-terminals, which are placed in the main control room. Each SPARCstation has 64MB main memory and 4.4 GB hard disk.

We have assigned a dedicated function to each of OICs for the operator's convenience. SPARCstation #1 is used for the control and monitoring of the RF system. SPARCstation #2 is used for the magnet power supply control. Third SPARCstation is used for the timing control. X-terminal #1 is used for the beam position monitor data display. Second X-terminal is used for the vacuum profile displays. Third X-terminal is used for the beam current and lifetime display. All graphic user interface programming has been done with X-Windows/Motif.

3.2 Subsystem control computer (SCC)

In order to reduce work load on OICs, we have divided the control system into five subsystems according to the similar functional characteristics in the control point of view; vacuum system and RS-422 type magnet power supplies (VMSCC), beam position monitors and digital I/O type magnet power supplies (COSCC), RF system (RFSCC), and timing system (TISCC). The VMSCC has twelve machine interface units named VMMIUs and the COSCC also has twelve machine interface units named COMIUs. These MIUs are multi-dropped from SCC through MIL-STD-1553B. The RFSCC and TISCC are directly interfaced to devices to do low-level data acquisition. The SCCs use Motorola's MVME147SB-2 as their CPU board. MVME147B-2 has 16MB DRAM with 33 MHz CPU clock. Each SCC is a diskless ROM-based system. The ROM contains OS-9 real-time operating system and other necessary application modules. The SCCs and the OICs are connected through Ethernet (TCP/IP) for data communication between them.

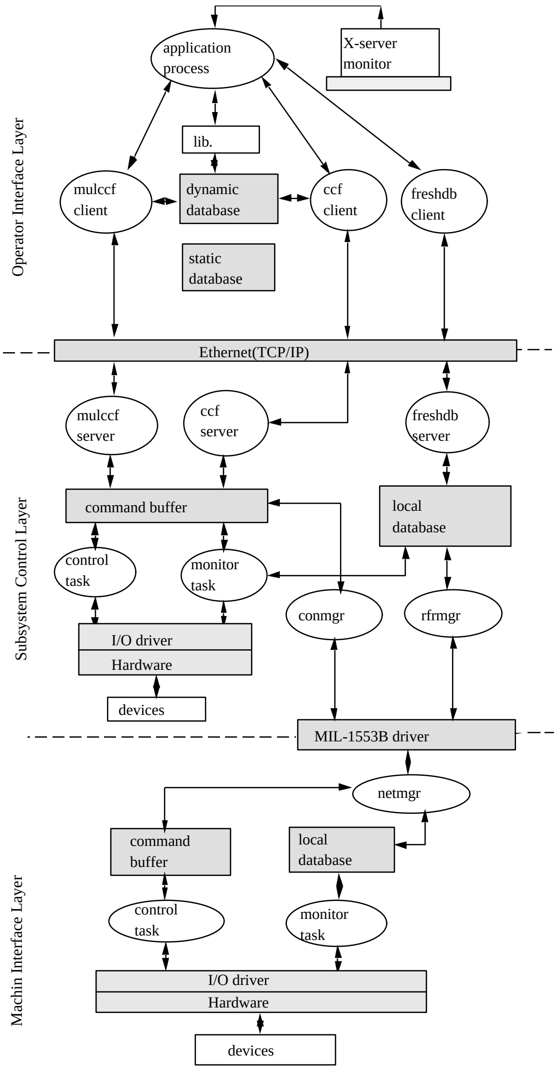

Fig. 2: Software structure of the PLS 2-GeV storage ring control system.

3.3 Machine interface unit (MIU)

The MIUs are directly connected to individual devices and performs low-level data acquisition. There are total 24 MIUs; twelve VMMIUs and twelve COMIUs. VMMIUs are interfaced to vacuum devices and RS-422 type magnet power supplies. COMIUs are interfaced to beam position monitors and digital I/O type magnet power supplies. All VMMIUs and COMIUs are placed in the 12 local control sheds around the storage ring building. Each MIU uses Motorola's MVME147S-1 as a CPU board. MVME147S-1 has 4MB DRAM with 25 MHz CPU clock. Each MIU is a diskless ROM-based system. The ROM contains OS-9 real-time operating system and other necessary application modules. We can remotely control and monitor the power and reset of each MIU crate from the control panel placed in the control room. The MIUs and the SCCs are connected through MIL-STD-1553B for data communication between them.

3.4 VME boards

Most of VME boards used in SCCs and MIUs are commercial products. A summary of commercial VME boards used for SCCs and MIUs are shown in Table 1.

Table 1: Summary of VME boards used

Model	#	Description
MVME147S-1	24	SBC, 25 MHz, 4MB DRAM
MVME147SB-2	4	SBC, 33 MHz, 16MB DRAM
BUS65522II	28	MIL-STD-1553B Interface
AVME9510-I	20	32 digital input/output, 16 ADC, 2 DAC
AVME9330	1	16 ADC
AVME9470	3	80 digital input/output
AVME9210	4	8 DAC
AVME9450-I	4	32 digital input/output
TSVME630	1	Image Processing
TSVME500	2	4 x RS422
ESD-ASIO16	25	16 x RS422
ESD-DIOC0/40	48	48 digital outputs
ESD-DIOC48/0	48	48 digital inputs

4 Software of control system

In parallel with the hardware structure, there are three layers in software structure. The software structure of the PLS 2-GeV storage ring is shown in Fig. 2. There are three important features in the storage ring control software; the client/server model to exchange data between operator interface layer and subsystem control layer, the master/slave model to exchange data between subsystem control layer and machine interface layer, and the separation of control and monitor tasks.

4.1 Operator interface computer layer

The major role of operator interface software in the OIC is to provide operator with various tools to monitor and control the machine. The major components of the OIC software are database, graphical user interface software, and communication software.

The database consists of static database partition and dynamic database partition. Dynamic database stores set-point and read-back values for the control signals. Static database stores all sorts of static information to manage machine control signals. Current set-point values of the machine components and their read-back values are updated in real-time basis.

We have adopted a client-server model for communication between the OIC and the SCC. Client tasks running on the OIC send service requests to server tasks running on the SCC. Then, server tasks execute services and return results to the requesting clients. There are three clients for communication in the OIC; dynamic database refresh client (*frshdb*), single control command forwarding client (*ccf*), and multiple command forwarding client (*mulccf*). The *ccf* is for setting a specific signal to some value. The *mulccf* is for setting multiple signals to corresponding values at once. The *frshdb* is for updating specific parts of the dynamic database with the present machine data stored in the SCCs.

Graphical user interface software is provided to the operator to use operating environment easily. We have used X-Window/Motif for the GUI (Graphical User Interface) programming. All graphical user interface processes may ask *frshdb* to update the corresponding dynamic database for the signal group they are interested in. They use database access subroutines to get the interesting real-time data from the dynamic database and display the machine status on the computer screens. They also instruct *ccf* to set some control signals to the desired set-point values.

4.2 Subsystem control computer layer

The SCC software acts as data gateway between the OIC layer and the MIU layer. Network task (*rfrmgr*) gathers the updated device data from attached MIUs through MIL-1553B network, and stores them in the local data buffer (*sccddb*). Upon request from the database refresh client of the OIC, database refresh server sends the requested data in the *sccddb* to the OIC through Ethernet. Upon device control request from the control command forwarding client or the multiple control command forwarding client of the OIC, the control command forwarding server transfers the control command to network task (*conmgr*), which finally transmit this command to the proper MIU through MIL-1553B network.

4.3 Machine interface unit layer

Major function of the MIU software is to directly monitor and control individual devices. The monitor task monitors attached devices regularly and stores updated *hhhdata* to data buffer (*miuddb*). The network task (*netmgr*) sends the data stored in the *miuddb* to the SCC upon its request. Upon receiving device control command from the SCC, the network task (*netmgr*) stores the control command in the command buffer (*cmdbuf*). For the fast action, the network task notifies the appropriate control task of the arrival of the command through the software interrupt called signal. The control task finally controls the designated device through the appropriate I/O driver and hardware.

5 Current status

At present, we have a reliable control system for PLS 2-GeV storage ring. Recently, timing software has been modified for the uniform bucket fill function for the fast ion instability experiment. We are upgrading and modifying the control system to accommodate new control requirements and to apply operational experiences. Here are some of the major activities which are currently being done.

We are preparing one more duplicated operator computer system in addition to the main one. This duplicated system will be used for research and development works in the normal situation. In case of main system failure, this system can be used as backup. In this way, we can smoothly apply research and development results to the real system. We are also building a database server environment by using ORACLE. This server environment will be linked to the on-line database of the operator computer. This will provide physicists and engineers with uniform and integrated environment for the storage and analysis of the operation and machine dada.

We are also developing the data acquisition system for the undulator U7 in the storage ring, which was installed in August 22, 1997. We have completed local level control test. The integration into the present control system will be done by the end of this year.

Acknowledgements

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References

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