ISBN: 978-3-95450-254-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS1991-S03SRD11

Status Report on Control System Development for PLS*

S.C. Won, S.S. Chang, J. Huang, J. W. Lee, J. Lee, J. H. Kim

Pohang Accelerator Laboratory,
POSTECH, P.O.Box 125,
Pohang 790-600, Korea

Abstract

Emphasizing reliability and flexibility, hierarchical architecture with distributed computers have been designed into the Pohang Light Source (PLS) computer control system. The PLS control system has four layers of computer systems connected via multiple data communication networks. This paper presents an overview of the PLS control system.

Introduction

The accelerator control system provides means for accessing all machine components so that the whole system could be monitored and controlled remotely. These tasks include setting magnet currents, collecting status data from the vacuum subsystem, taking orbit data with beam position monitors, feedback control of electron beam orbit, regulating the safety interlock monitors, and so forth. To design a control system which can perform these functions satisfactorily, certain basic design requirements must be fulfilled. Among these are reliability, capability, expansibility, cost control, and ease of operation.

Considering above requirements, the PLS accelerator topology, available resources, special accelerator hardware requirements and personal preference, we propose a hierarchical system architecture. To implementation of the control system, highly commercial approach should be made because of the tight construction schedule. Using well proven technology will promote reliability, and reduce the development effort. A development environment is set up to develop the prototype of beam close orbit correction system which is to damp up to 15Hz movements. The Beam close orbit correction system will use DSP(Digital Signal Processor) board for the fast computation. All BPM electronic modules and corrector power supply interface I/O modules for one acromat will be put into one VXI crate.

Hardware Hierarchy

To monitor and control the thousands of signals for PLS, it is desirable and cost-effective to establish a distributed control system based upon microprocessors. The PLS control system has a hierarchical structure as shown in Fig.1. The hierarchy consists of four layers, each of which has a different role. The four layers

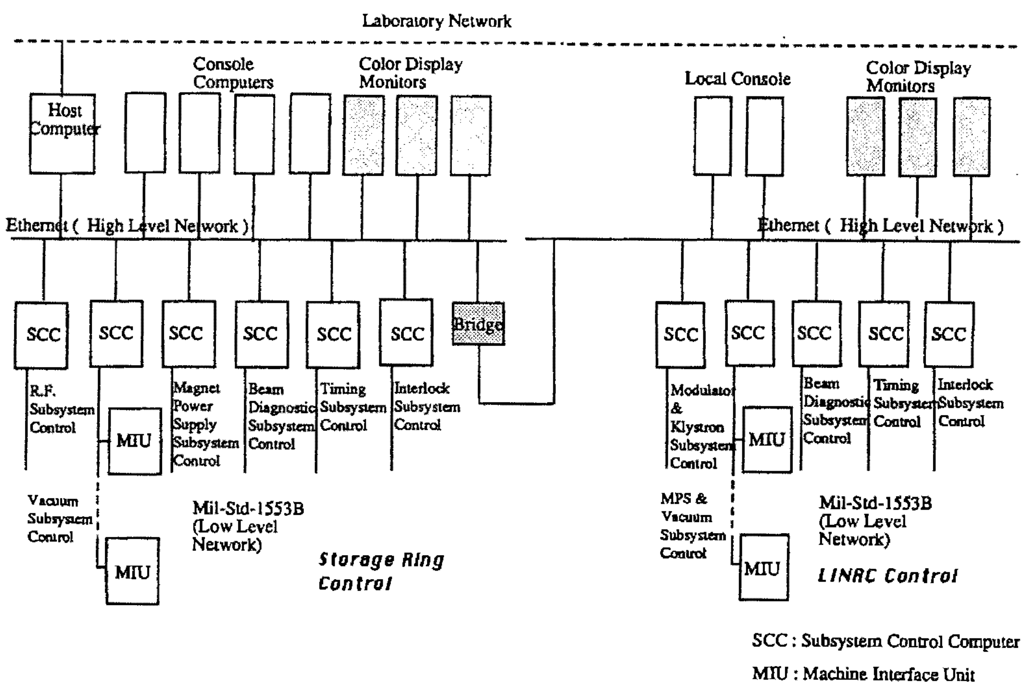

Figure 1. PLS Control System Architecture

* Work supported by Pohang Iron & Steel Co., Ltd. (POSCO) and Ministry of Science and Technology (MOST), Government of Republic of Korea.

ISBN: 978-3-95450-254-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS1991-S03SRD11

are the computing service layer, the human interface layer, the subsystem control layer, and the machine interface layer. The computing service layer is a time-shared host computer in the computer room, and it is linked to various operator consoles which form the human interface layer. These workstations are located in the main control room. The consoles are connected to the master crates which form the subsystem control layer via an Ethernet. These master crates are located in local control stations distributed throughout the machine. The master crates are connected to slave crates, which form the machine interface layer, via a MIL-STD-1553B network. Each slave crate can use a variety of protocols to interface with machine components. Among these are IEEE-488, RS-232, RS-422. New protocols can be added with plug-in modules.

Computing service layer - Host Computer

A host computer with a high computational speed, large memory, and multiple job capability is needed for code and data management, mathematical modeling and simulation, off-line analysis, and for general purpose computing. For a low emittance light source, there are many critical parameters and it is more important to provide good computer modeling or simulation of the beam optics. For this purpose, the computation speed should be fairly high, and the machine should have at least a 32 bit processor with substantial physical and virtual memory space.

The DEC/VAX SYSTEM 6000™ may be a good choice for this as the VMS™ operating system provides an excellent software foundation upon which to run software donated by cooperative accelerator laboratories. However, if we can port the required software to the UNIX™ environment with little effort, a high performance RISC computer might be an alternative.

The host computer will be installed at the end of 1993 after the storage ring building is completed.

Human interface layer - Console Computers

Mid-range engineering workstations will be used as operator consoles to put in the operational parameters and show the operating status. Input parameters will go through some arithmetical processes and be converted into control commands for each affected piece of equipment.

Operating status should be shown on color display monitors in the form of simulation diagrams, various kinds of charts, and other graphical expressions. For this role, an engineering workstation is the best fit due to its high computing power and relatively low cost, high resolution color graphics capability, and high performance multiple window display system.

Currently, several SPARCstations™ of Sun Micro Computer Corp. are being used for console software development since they are well equipped with competitive capability, open system policy, and software availability.

Even though workstations provide excellent graphics capability, typical implementations of easy-to-use man-machine-interfaces have required sophisticated programming effort. However, we expect the use of a GUIDE (Graphical User Interface Development Environment) will be a great help in saving development effort.

DataView™ of V.I. Corp. is a potential solution. DataView™ consists of two components: DV-draw™, an interactive drawing editor for creating sophisticated screens without programming, and DV-tools™, a library of subroutines that connects graphics created with DV-draw™ to an application program. Thus it saves development effort, allows rapid prototyping, and future software interoperability derived from its support for industry-standard platforms. In addition, we will be able to easily integrate with other software environments such as relational databases and expert systems, and effectively develop integrated software by separating the GUI from application code.

A total of six workstations will be used as operator consoles for the storage ring and the linac, and a few additional color display monitors are planned for continuous display of information such as beam current, vacuum status, and magnet power supply current.

Subsystem control layer - Subsystem Control Computers

The Subsystem Control Computers(SCC) are microprocessor assemblies based on VMEbus and Motorola's 680x0 microprocessor. The reason for adopting VMEbus is its reliability and popularity. Each SCC consists of one Single Board Computer(SBC), an Ethernet interface module, and a MIL-STD-1553B network interface module, all of which are put together in a VMEbus crate. Motorola's MVME147™ with 32-bit 68030 CPU and 4 Mbyte memory is used for the SBC of the SCC.

The SCC does many control and monitor functions, such as reading and setting parameter values of machine components, feedback-control, alarm handling, and raw data processing for each subsystem, i.e., vacuum, magnet power supply, R.F., beam diagnostics, timing, and interlock. Each SCC is interconnected to the multiple Machine Interface Units(MIU) through MIL-STD-1553B network. The SCCs are also linked to the high level computers through Ethernet.

Machine interface layer - Machine Interface Units

MIUs are also microprocessor assemblies based on the VMEbus and Motorola 680x0 microprocessor family. Each MIU has one SBC, one MIL- STD-1553B network interface module, and a number of analog and digital input/output modules, all of which are put together in one or more VMEbus crates. An SBC equipped with Motorola's 68000 16-bit microprocessor and 1 Mbyte memory is used for the MIU. In order to handle various types of analog and digital input/output signals, a wide range of standard analog and digital input/output modules as well as home-made or non-standard interface modules are used. MIUs are distributed in local field stations, which are located around the machine, to reduce the length of the signal cables between the MIUs and the machine components and also to reduce electromagnetic noise problems with the cables. There are 12 local field stations around Storage Ring, 3 around Linac and 2 around BTL. Multiple VMEbus crates in the MIU are interconnected with VMEbus-to-VMEbus repeater module.

A development environment is being set up for the development of SCC and MIU. This environment is composed of development hosts and target VME assemblies, which are connected through Ethernet(TCP/IP). Motorola's SYS1147™ VME station, which uses MVME147™ as its single board computer, is used for the resident development host, and Sun Micro Computer Corp.'s SPARCstation/IPC™ is used for the cross development host. Microware's real-time operating system, professional OS-9™, is ported to the resident host and industrial OS-9™ is ported to every target VME system. Initially, this development environment will be used mainly for the development of the beam close orbit correction system and the modulator/klystron control system.

ISBN: 978-3-95450-254-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS1991-S03SRD11

Data Communications Network

The components of the PLS control system are linked via two levels of data communication networks; a low level and a high level network. The low level network is used for data acquisition and forwarding of control commands. The high level network delivers operational setpoint values to the lower level computers and information acquired by the lower level computers to the console computers.

The low level network must be tolerant of electro-magnetic noise because MIUs should be installed close to various noise-generating equipment and cables. Due to this requirement, MIL-STD-1553B specification is used. MIL-STD-1553B is a multi-drop network specification which is operated in a master/slave mode on which one Bus Controller(BC) may communicate with up to thirty Remote Terminals(RT). The SCC acts as the BC and the MIUs as RTs.

For the high level network, Ethernet is chosen because of its popularity which allows cheap and easy implementation for both hardware and software. TCP/IP will be adopted as the higher layer protocol for the same reason. Ethernet is a CSMA/CD network with a maximum transfer rate of 10 Mbps. However, the length of transmitted packet and transmission speed must be carefully selected to guarantee the appropriate transfer delay time and throughput.

Software

System software

A real-time operating system should be used for the SCCs and MIUs because some machine control jobs such as closed orbit correction requires real-time performance. OS-9™ from Microware Systems is selected because of its advanced kernel functions and variety of software development tools. OS-9™ not only provides a real-time kernel and its associated system modules, but all the file managers and device drivers necessary to support integrated i/o processing. The user interface includes an easy-to-use UNIX-like shell, hierarchical directory/file structure and over 70 utility programs to allow simple user access to the operating system's management functions.

The database on the SCC contains all subsystem parameters. It also has a component table which acts as a name sever providing the translation between the different symbolic names allowable at the high level and signal names in the MIUs, as well as linking these names with addresses of the appropriate MIU. The database on the MIU contains component data such as hardware addresses, set values, limits, conversion and calibration factors, and so forth.

Machine control software

Operating status of each subsystem such as vacuum, R.F., and magnet power supply subsystem should be displayed or archived to files, which might be later processed to analyze the operating history.

Desired setpoint values such as magnet power supply current and cavity gap voltage should be set. Setpoint values and other operational parameters might be put into the control system manually by the operator or automatically by the control software.

Intolerable differences between setpoint values and corresponding readback values should be continuously monitored and reported to the operator. These values are archived in files at the same time. The differences might be compensated by a slow feedback control program as long as there is no serious failure in correction. Continuous failure in correction would result in an alarm situation, which would be reported to the operator immediately. Any fault in apparatus should be reported to the operator, who can cope with it appropriately.

A total of 110 man-month is estimated to be necessary to develop the machine control software including the man-machine-interface, for both storage ring and linac .

Database

A comprehensive database defines all machine parameters and device signals. The database is generated in one of the console computers. The generated database consists of two parts: the static and the dynamic part.

The static database includes static machine parameters and device information such as names, locations, and various coefficients which might be used to convert scientific units into actual signal values, and vice versa.

Generated static database should be shared among the console computers by transferring the static part and maintaining consistency between the original and copies. Appropriate portions of the static database should be downloaded to the SCCs to be used to control each subsystem properly. The SCC might download parts of its static database to MIUs under its control. MIUs use this static database to convert scientific setpoint values into actual control signal values or actual monitoring signal values into scientific readback values.

The dynamic database consists of setpoint values such as magnet power supply currents and cavity gap voltages, and readback values such as ion gauge currents, magnet power supply currents and cavity gap voltages.

Dynamic database on a console computer has just a structure at the very beginning. It might be filled with valid data, when a control process which might need appropriate data were spawned. The valid data should be transferred from the appropriate SCC to the requesting console computer on "Supply-On-Demand" basis. Setpointing might also cause updating part of dynamic database with setpoint values.

For the PLS database structure, we took the idea of SPEAR's database system, since it is fairly portable and helped us to save development effort[4]. However, the update policy of dynamic data is quite different between the two database systems. PLS has distributed databases on the SCCs, the data of which can be supplied to upper layer computers on "Supply-On-Demand" basis. On the contrary, SPEAR has centralized database which is continuously updated by the hardware. We expect our scheme to maximize the network throughput by keeping unnecessary data from being transferred via network. Resulting gain in network capacity could be used for faster data acquisition of any particular signal group.

Beam diagnostic software

Knowledge of accurate machine parameters is very important for the efficient operation and study of the machine. We intend to automate all the beam diagnostic processes with various beam diagnostic programs such as beam orbit measurement, real time orbit correction, tune measurement, beam lifetime, beam emittance, and lattice function measurement, etc. Some diagnostic software will be run at the low level control computers for the

ISBN: 978-3-95450-254-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS1991-S03SRD11

real time beam diagnostics and feedback.

Modeling and simulation software

Traditionally commissioning of particle beamlines is a very time-consuming and laborious task. Even in day-to-day operation after start-up, various types of machine and beam errors have to be corrected. To reduce the time and effort for these tasks, fast and easy-to-use computer programs are needed.

Conclusion

An important requirement in designing PLS control system is flexibility. Natural growth of the system will require expansion of the control system or more complex control of the accelerator, and it is often necessary to implement new technology on the existing control system. We have designed a control system which makes substantial use of industry standard components, thus maintaining a very good level of flexibility and expansibility. we expect (and hope!) that industrial development of these standard component will procede faster than the ever increasing requirements on the PLS control system.

References

[1] S.C.Won, Jae W. Lee and Jinwon Lee, "Computer control system", PLS Conceptual Design Report, pp. 2-101, POSTECH, Korea, Jan. 1990

[2] S.C.Won, Jae W. Lee and Juno Kim, "Computer control system for PLS", Proc. of the 4th Asia Pacific Physics conference, Seoul, Korea, Aug. 1990, pp. 1114-1117

[3] S.C.Won, Jinwon Lee and Ji Hwa Kim, "DACS(Data Acquisition and Control System) for PLS", Proc. of the 4th Asia Pacific Physics conference, Seoul, Korea, Aug. 1990, pp. 1139-1142

[4] S. Howry, T. Gromme, A. King, M. Sullenberger, "A portable database driven control system for SPEAR", SLAC-PUB-3618, SLAC, Apr. 1985