

## SPring-8 beamline control system

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The SPring-8 beamline control system is now taking part in the control of the insertion device (ID), front end, beam transportation channel and all interlock systems of the beamline: it will supply a highly standardized environment of apparatus control for collaborative researchers. In particular, ID operation is very important in a third-generation synchrotron light source facility. It is also very important to consider the security system because the ID is part of the storage ring and is therefore governed by the synchrotron ring control system. The progress of computer networking systems and the technology of security control require the development of a highly flexible control system. An interlock system that is independent of the control system has increased the reliability. For the beamline control system the so-called standard model concept has been adopted. VME-bus (VME) is used as the front-end control system and a UNIX workstation as the operator console. CPU boards of the VME-bus are RISC processor-based board computers operated by a LynxOS-based HP-RT real-time operating system. The workstation and the VME are linked to each other by a network, and form the distributed system. The HP 9000/700 series with HP-UX and the HP 9000/743rt series with HP-RT are used. All the controllable apparatus may be operated from any workstation.

**Keywords:** control systems; interlock systems.

### 1. Introduction

The beamline control system at SPring-8 participates in the control of the insertion device (ID), front-end and beam-transportation channel, with various optics, and all interlock systems, on the programmable logic controller (PLC) of the beamline: it will supply a highly standardized environment of apparatus control for collaborative researchers. In particular, ID operation is very important in a third-generation synchrotron light source facility. Users at the beamline are able to control all of the beamline components through the beamline control system.

It is also very important to consider the security system because the ID is part of the storage ring (SR) and is therefore governed by the SR control system. Considering the progress of the computer networking system and the technology of security control, the development of a highly flexible control system is needed. An interlock system that is independent of the control system has increased the reliability.

The first stage of the SPring-8 beamline control system has been completed and the beamline commissioning schedule is progressing satisfactorily. In the following we give the basic design and the present outline of the beamline control system at SPring-8.

## 2. Beamline control system

### 2.1. Basic design

The beamline control system in synchrotron radiation facilities is the interface between the SR control system and applied research in the experimental station. At SPring-8, IDs are considered to be part of the beamline instead of part of the SR, and researchers at the beamline can use the gap of the ID as a tunable parameter. Free and independent gap tuning is a special characteristic of third-generation synchrotron radiation facilities.

It is important that the beamline control system keeps safety and reliability of the SR control system apart from irregular operation at any beamline. On the other hand, recent progress in network technology offers new solutions for the beamline control system. From any one of the information terminals on the local area network (LAN), one should be able to inspect all beamline information and the SR status.

The most scrupulous attention should be paid to the very high energy photons handled by the beamline. To maintain safety at the beamline, the beamline interlock system must work perfectly. Thus, to increase reliability, the beamline interlock system is made as simple as possible.

The basic design of the SPring-8 beamline control system is as follows: (i) synthesis of the interlock and control systems; (ii) management of all information through safety networks; (iii) GUI-based applications united with 'look and feel'; (iv) sophisticated software design that has high maintainability.

### 2.2. Architecture

The beamline control system requires high flexibility and maintainability. At SPring-8 the special software framework has been designed by the SR control group (Taketani *et al.*, 1995; Tanaka *et al.*, 1995). It consists of UNIX workstations, VME-bus systems and a network system. It has a client/server architecture in order to keep systems robust. In the beamline control system, the network structure is designed so that each beamline is independent of the others. However, each control computer is coupled so that it may read important beamline information from the central control room. Fig. 1 shows the design of the beamline control system. All of the controllable apparatus can be operated from any workstation.

The beamline interlock system maintains human safety and machine safety. In the first place, human safety must be kept independent of irregular operation or instability of the beamline control system.

## 3. Hardware components

### 3.1. Operator console, VME system and PLC

At SPring-8 the main target of the beamline control system is control of the ID gap and the beam shutter, monochromator, mirror and slit components of the beamline, except the experimental station. There are two categories of target equipment. One group comprises the common control system, governing, for example, the actuator and data acquisition. The other group is

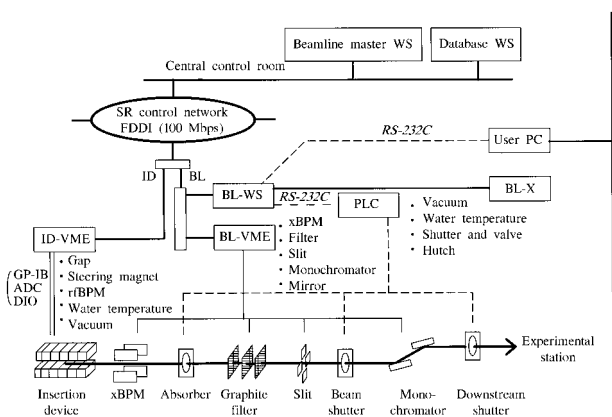
the interlock system for safety, relating to, for example, the beam shutter, vacuum gauge, cooling-water temperature and status of hutches.

The beamline control system was designed by adopting the so-called standard model concept. Expandability and maintainability are most important for the adoption of industry standard hardware. The VME-bus (VME) system is used as the front-end control system and a UNIX workstation (WS) as the operator console. The VME and the WS are based on the RISC processor system, and the VME board computers are operated by a LynxOS-based HP-RT (Hewlett-Packard real-time) operating system. The WS and the VME are linked to each other by a network, and form the distributed system. We use the HP 9000/700 series with the HP-UX operating system as operator consoles and the HP 9000/700rt series with the HP-RT operating system. The CPU board HP9000 743rt/64 powered by the PA-RISC 7100-LC processor with 8 MB memory provides quite a satisfactory performance. It has a 20 MB flash ROM card with a PCMCIA interface which is used as a boot device for the operating system. For system debugging we adopted an SRAM VME board, HIMV-220, made by HSC, as a static memory device. VME I/O modules such as digital input (DI), digital output (DO), analog input (AI), analog output (AO) and GP-IB are used for direct control of the beamline equipment.

BL-X, the operation terminal for researchers with Windows-NT, is connected to BL-WS. Researchers are able to operate whole components on the beamline by using BL-WS or BL-X. In another case, researchers can operate beamline components through the serial communication line of BL-WS. Therefore, researchers can carry out an automatic operation from any user's computer system by on-line software.

The entire interlock system in the beamline is constructed by hard-wired relay or PLC interlock modules as shown in Fig. 2. For human safety, none of the software on the WS or VME intervenes with the interlock sequence. The PLC is made by Toshiba Inc. with a graphical flat display. We use a PROSEC-T3 series and a GP series flat display made by Digital Inc. PLCs are distributed to each beamline and are linked by TOS-LINE, a special network for PLCs standardized by Toshiba, to each other. To supervise all PLCs, we prepared the BL-Master-WS (HP9000 715/64) at the central control room. This WS connects to the PLC, which has an exclusive and independent optical fibre network, by using an SIF station module.

Details of the interlock sequence for human safety will be provided elsewhere.



**Figure 1**  
Schematic view of the beamline control system.

3.2. Network

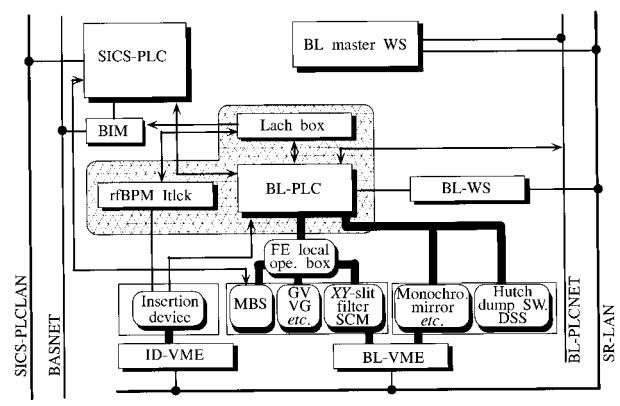
We have three types of network, as shown in Fig. 1. One is BL-LAN, for the beamline control system, which is connected to the duplicated FDDI backbone network (SR-LAN) by the optical fibre network, 10BASE-FX. There are four FDDI nodes for BL-LAN, and network router (3Com NetBuilder-II) is used to connect between SR-LAN and BL-LAN. To reduce the network traffic, a network bridge (3Com LinkBulider-II) is adopted in each beamline. Another type of network is Users-LAN, for beamline users at the experimental station. These networks are separated by only one workstation with two ethernet ports in order to defend the SR and beamline control systems. A third network is the PLC network, TOS-LINE, for the beamline interlock system. TOS-LINE is totally independent of the above two networks.

The UNIX system provides many network protocols. Because of the reliability and the good performance, the TCP/IP protocol was selected for the network communication protocol. In particular, reliability is the crucial feature for machine control.

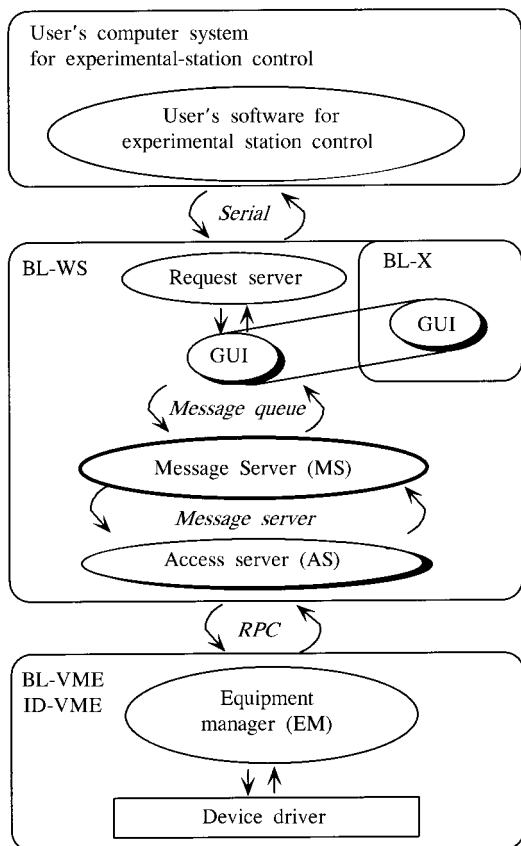
3.3. Data-acquisition system

We adopted a Tsuji Denshi PM16C series as a standard-type pulse motor controller for the SPring-8 beamline control system. This controller has functional switches for local control and a GP-IB interface for remote control. For the GP-IB controller, we are using an EVME-GPIB21 VME board made by ELNIS. A pulse motor controller, potentiometer controller, piezo controller and any other GP-IB modules can be connected. DI, DO, AI and AO VME boards are HIMV-602A made by HSC, VMIVME-3122 made by VMIC, ADVME-2602 made by ADVANET and ADVME-2701 made by ADVANET, respectively. An X-ray beam-position monitor (xBPM) can be accessed by the AI with 16-bit digitizing resolution at a rate of 100 kHz. In the near future, we will be able to support a high-speed feedback system in order to set the steering magnet of the IDs according to the X-ray beam-position monitor data.

The ID control system at SPring-8 is markedly different from that either at ESRF or at APS for various reasons. The manufacturer of the mechanical parts of the device has requested that the gap-related controls, such as the motor, encoder, limit switch *etc.*, be operational without a PC or use of a keyboard. Therefore, we decided to have a company, Tsuji Denshi Inc., make a gap-controller unit, GPC series, which includes a stepping motor controller and encoder reader with GP-IB interface. With this



**Figure 2**  
Block diagram of the beamline interlock system.



**Figure 3**  
Conceptual scheme of the beamline control software framework.

unit, the ID gap can be opened manually in case a VME unit malfunctions. An ADVANET ADVME-2602, 16-bit ADC, has been chosen to monitor the temperature of a standard SPring-8 in-vacuum ID, which has 32 thermocouples. The electron-beam position can be measured with high precision by the RF beam-position monitor (rfBPM), made by Bergoz, using a VMIC VMIVME-3122 AI board.

#### 4. Software design

Kernel software of the beamline control system is designed by the SR control group at SPring-8. This control software is based on the event-driven client/server scheme. Machine control

programs are all written in the language C. On the beamline, however, we have an additional special software frame to serve command requests from the beamline users control system at the experimental station. Fig. 3 shows the software structure of the beamline control system with the command request server on the graphical user interface (GUI) layer.

We are using a commercial GUI builder, X-Mate, for developing the application software with operator interface. The application software for each component has a GUI and a similar 'look and feel' interface. Consequently, whole components on the beamline can be controlled easily.

We will introduce a relational database management system (RDBMS) for the information control of all beamline status, vacuum, temperature and other signals. The conceptual design of the database system has started. In the future, everyone will be able to peruse all the beamline information from any place.

#### 5. Conclusions

The first version of the beamline control system has been constructed at beamlines BL01B1, BL02B1, BL04B1, BL09IN, BL41IN, BL45IN and BL47IN. Despite being built under limited resources, our system is proceeding well and is quite stable in operation. Adjustment and tuning of all beamlines and collection of experimental data in the experimental hutch are provided by this beamline control system. By using many GP-IB modules, however, the system lacks performance speed. Therefore, future upgrades are inevitable in order to improve the system speed. We are planning a second version of the system with fewer GP-IB modules in the near future.

The design and development stage of the beamline interlock system has been completed. Human safety and machine safety have been assured within the PLC system, and so are independent of any irregular operation or instability of the beamline control system.

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