Control System

Takeshi WADA
Shigeki FUJIWARA
Toru FUKUI
Takemasa MASUDA
Atsushi TAKETANI
Ryotaro TANAKA
Weimin XU

Introduction

The control system for the SPring-8 is under construction. It consists of UNIX engineering workstations (EWS), UNIX based VME systems, and optical fiber network (FDDI) system. The remote I/O systems (RIO) are adopted as field bus systems[1]. The EWS's are used as operator consoles and database server. The VME system are used to provide reliable device control with reasonable real-time capability operated by the UNIX based real-time operating system (HP-RT). These workstations and VME's are directly inter-connected by the backbone FDDI network system. These control computers communicates with remote procedure call (RPC) with TCP/IP protocol.

The storage ring is planed to be commissioned on February 1997. The design of control system has been finished. This system is constructed in two phases. As the first phase, the contracts for FDDI network, two magnet power supply control systems, and one RF control system were finished on March of 1994. They was estimeted to be about 30 percent of total system. The second stage consists of the control system of three RF stations, vaccum control, and development of control software. The number of persons in the control group is now seven.

Design & Construction

1. Design Concept

The followings are the design concepts of the control system.

(1) Distributed processors are linked with each other by high-speed network.

(2) Sub-system (linac, synchrotron, and storage ring) control computers are loosely coupled due to different accelerator construction schedules and for the convenience of independent operation.

(3) All the accelerators are operated at one control room by small number of operators.

(4) VME system is used as the front end controller with real-time operating system.

(5) For high productivity of application program, computer aided program developing tools are used as much as possible.

2. Architecture

Figure 1 shows the control system architecture[2]. In the storage ring control system, the network structure is designed as simple as possible. All VME's and EWS's for the storage ring machine control are directly linked with each other by FDDI network with a transmission rate of 100 Mbps. A FDDI interface board is installed in each VME and EWS. The FDDI optical fiber cables are laid around the maintenance corridor of the storage ring and to the injector building. The total length of the cable is about 4500 m. On the way, almost all of the fiber are laid in a pipe of the air blown fiber system (ABFS) as shown in Fig. 2. We use the fiber bundle of four fibers with 62.5 micro meters of core diameter. The FDDI node systems are installed in six places, those are, control room, injector room, and four places, the A to D zone between RF station and Electrical/Mechanical building. Each node system consists of a FDDI concentrator and a Ethernet router. In the injector control room, only a router is installed. We use HP 9000/700 series EWS with HP-UX operating system as operator's consoles and database server. The CPU board of each VME system is HP9000/742rt or 743rt with PA-RISC7100. The HP-RT operating system is down loaded at the first time from EWS or flush ROM.

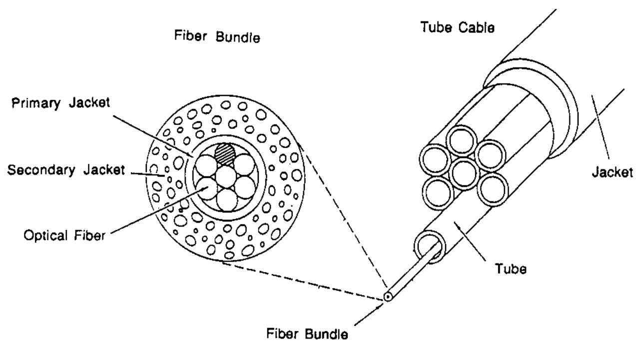

Fig. 2. Air Blown Fiber System

The RIO system is used as field bus[2]. One RIO system consists of one master card (VME board) and 62 slave cards (not a VME standard) at maximum. They are linked with optical fiber cables (or copper cables) with the transmission rate of 1 Mbps, it guarantees reliable control of the equipments in the environment of high electromagnetic noises. Five types of slave cards are available, depending on the number of interface signals of the equipments.

3. Software

The main concepts of the software system are network transparency and device abstraction. The network transparency means program independence of control system from the network system. In the device abstraction concept, the application program controls accelerator components without knowing low-level physical device configuration. These concepts provide flexibility for the application programs running on both EWS's and VME's. We will introduce two kinds of processes, a message server (MS) and an equipment manager (EM), in the EWS and VME system, respectively. The MS manages the command exchange between processes, such as name server, application programs of machine operations, a database manager, GUI's, and a data poller. The connection between abstracted devices and physical devices can be realized at the EM which is running on the front end CPU board. The EM resolves physical configuration of devices from device configuration table which includes every attribute of available devices. The device access control such as exclusive access can be managed at EM, that is, it prevents inconsistent access to the one equipment at the same time.

4. Database

We are planning to make two kinds of database, one is archive database and another is on-line database. The machine database is stored in hard disks which is archiving of logging data and fixed data such as operation parameters, equipment location, calibration constants, etc. The on-line database will keep equipment configuration tables and current status and data of equipments. The performance of on-line database is expected to be fast enough because quick access from many processes is the key issue of real-time machine operation. The equipment configuration tables are down-loaded from archive database and stored in RAM area of EWS.

There are many commercially available database management systems. The decision of the choice will be made soon.

5. Graphical User Interface (GUI)

In order to perform the easy operation and quick understanding of the results, GUI's are important. Most of the operation commands are expected to be specified through GUI, however it may be useful that in some limited cases the commands can be specified through a text string from keyboard or ASCII text files.

R&D

We have introduced a SASD method for the analysis and design of control software by using a CASE tool, "teamwork".

The computer network system is one of the most important parts of the SPring-8 control system. In order to estimate an effective transmission rate through network, we have measured the time to send/receive a block data between EWS and EWS, and EWS and VME. Since the FDDI systems are not installed yet, the time is measured using Ethernet by changing the block size to be sent at a time. We are going to introduce a building tool to develop graphical user interfaces (GUI). We investigated the specifications and performance of several commercially available tools, such as DataViews, SL-GMS, UIM/X, X-Mate, and XRT. The X-Mate is the main candidate of our GUI builder because of cost performance. We have installed a LynxOS operating system on the VME system with a CPU board of MC68030 (25 MHz) in 1991. Some device drivers were developed[3] and used for the test of RF klystron facility with a real-time operation[4]. A new VME system of CPU board of PA-RISC7100 (50 MHz) with HP-RT operating system was installed in 1993 because of higher reliability and performance. We developed the device drivers and measured the performance between the old operating systems and the new one. The processing times for device open+close are about 14 msec and 0.3 msec, for LynxOS and HP-RT, respectively.

Since we use about seven hundreds RIO slave cards, it is important to prepare testing systems for the quality control of massive production and trouble detection and shooting. A simple system which consists of a circuit board and software is primarily developed for a type-A slave card. It is convenient if CAD data can be utilized as a part of GUI or database. A software which reads the DXF type data file of CAD system and draws them by using Xlib was developed[5].

Because digital signal processors (DSP) offer more computational power and faster data acquisition, it may be useful for fast local feedback systems of beam orbit and image processing for beam shape. R & D on the DSP has been started.

Some of the control group staffs have visited the large accelerator facilities in Europe and USA, such as ESRF, CERN, APS, FNAL, SLAC, and ALS, to study the machine control system. We appreciate Drs. G. Mulhaupt, C. Serre, W. McDowell, K. Cahill, S. Howry, and H. Nishimura, and many staffs of above laboratories for helpful discussions and advices.

References

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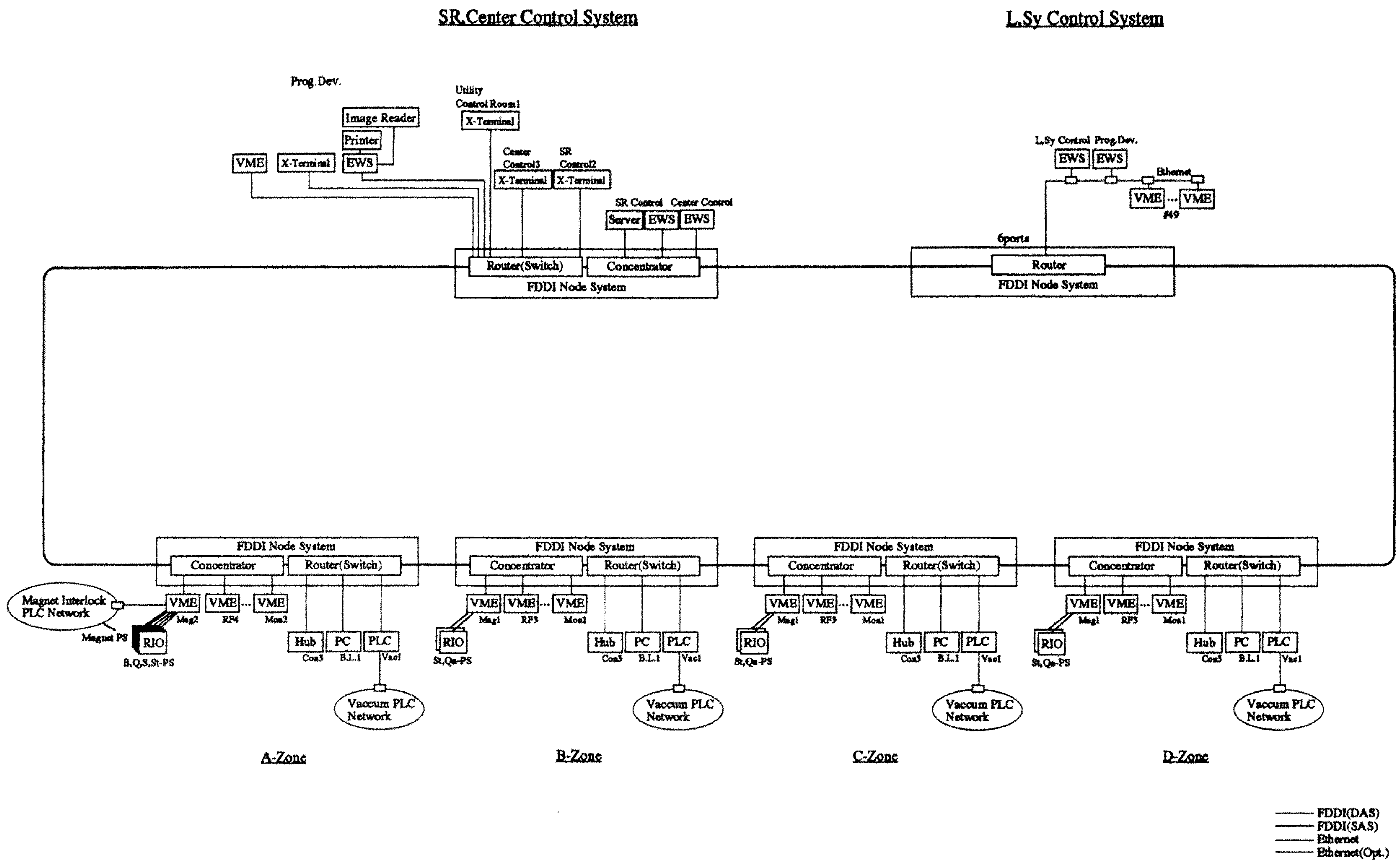

Fig.1. Spring-8 Control System Architecture.