DESIGN OF SPring-8 CONTROL SYSTEM

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Abstract

The control system of SPring-8 facility is designed. A distributed computer system is adopted with a two-hierarchy levels. All the computers are linked by using computer networks. The network of upper level is a high-speed multi-media network such as FDDI which links sub-system control computers, and lower are Ethernet or MAP networks which link front end processors (FEP) such as VME system. Workstations (WS) or X-terminals are useful for man-machine interfaces. For operating system (OS), UNIX is useful for upper level computers, and real-time OS's for FEP's. We will select hardware and OS of which specifications are close to international standards. Since recently the cost of software has become higher than that of hardware, we introduce computer aided tools as many as possible for program developments.

Introduction

The SPring-8 accelerator complex consists a high current electron linac of the energy 250 MeV, an electron/positron linac of the energy 1 GeV, a synchrotron of the energy up to 8 GeV, and a storage ring.[1] As the accelerator equipments are distributed geographically and functionally over the entire accelerator site (about 900 m x 700 m), a distributed computer system is most appropriate for the facility.

From the designer's viewpoint, the control system consists of the following parts:
1) Computer System:
1-1) Computer Configuration.
1-2) Network System:
1-3) Software:
2) Interlock System:
3) Analogue Signal Switching System:
4) Timing System:
5) Television Network System:
6) Links with other systems.

For the design of control system, the following requirements are taken into account:

Distributed processors and local area network (LAN):

Easy Operation:
1) The operator's console should be small and simple, minimizing the number of parameters on regular display.
2) Centralization of operation.
3) Unification of operation and display format.
4) Voice alarm system.

Safety:
Provision of both a hardware (H/W) and software (S/W) interlock system. All accelerator equipments should have individual internal interlock systems. In some instances, a cross-equipment interlock is required, for example between the vacuum and RF system.

Reduction of Human Labour:
Standard and fixed order operations are performed automatically by computers or programmable controller (PC). Operators only perform such operations in which high level judgment is required.

Expandability:
1) Accommodate an increase in and modification of accelerator equipments.
2) Accommodate additional computers or interface H/W.
3) Link with other system such as a radiation safety control system, an experimental system, or a computer center.

Noise immunity:
In order to prevent malfunctions of equipments, or deterioration of exchanged information, optical fiber cables are adopted for long distance signal transfer, and even in short distance communications opto-coupled devices are adopted. Signals of TTL level are not appropriate for transmission between equipments and interface systems.

Radiation Safety:
Selection of the appropriate location for installation of control devices or cables.
Adoption of specially produced cables or devices.

Easy Maintenance:
Adoption of standard modules for H/W and S/W.
Preparation of comprehensive documentation and on-line help systems.

Reduction of Computer Load:
Introduction of microprocessors or programmable controllers at the lowest hierarchy levels.

Easy programming:

Standardization:

Central management of S/W and database:

Computer System

The control system consists of a central control system and several sub-systems for each accelerator. These sub-systems and central control system are linked through computer networks. Each sub-system consists of a host computer, several front-end processors (FEP) and an operator's console. Figure 1 shows schematically the computers and their interconnecting networks.

The functions of each system are:

Central Control System:
1) Selection of operating mode and scheduling (Fig. 2)
2) Monitoring, logging and display:
3) Linking with other computer systems such as that of the computer center, of experimental systems, and of a radiation safety control system:

Program development and Data base:
Central management of application programs and database:

Accelerator Control system:
The control of injector linacs, the synchrotron, and the storage ring. These sub-system controller are loosely coupled, due to the different accelerator construction schedules and the convenience of independent operation and maintenance.

At the lower hierarchy level, some FEP's are linked. These FEP's are microprocessors such as VME systems and programmable controllers. At equipment levels, integrated microprocessors are used. Microprocessors are especially useful for driving motors and the acquisition of beam diagnostic data.[2] When high data processing speed is required, such as by a fast digital feedback system, a VXI system will be selected, since the data transmission rate of the VXI bus is much higher than that of the VME bus.

Workstations (WS) or X-terminals are used as operator's consoles, which perform X-window operation.

The FEP's are distributed throughout the power supply rooms and on the circumference of the storage ring building, and the maximum length of the networks will be about 1 km. Table 1 shows the estimated number of input/output signals. Where LS-BT means beam transport line between linac and synchrotron, and SS-BT between synchrotron and storage ring. More than 200 VME systems are to be used in whole control system.

Table 1. Estimated number of input/output signals.

Parts	Signals DO	DI	AO	AI
Linac	1848	1128	672	96
LS-BT	62	92	0	37
Synchrotron	588	1057	86	203
SS-BT	725	397	63	142
Storage ring	9113	15723	1382	3253
Total	12336	18397	2203	3731

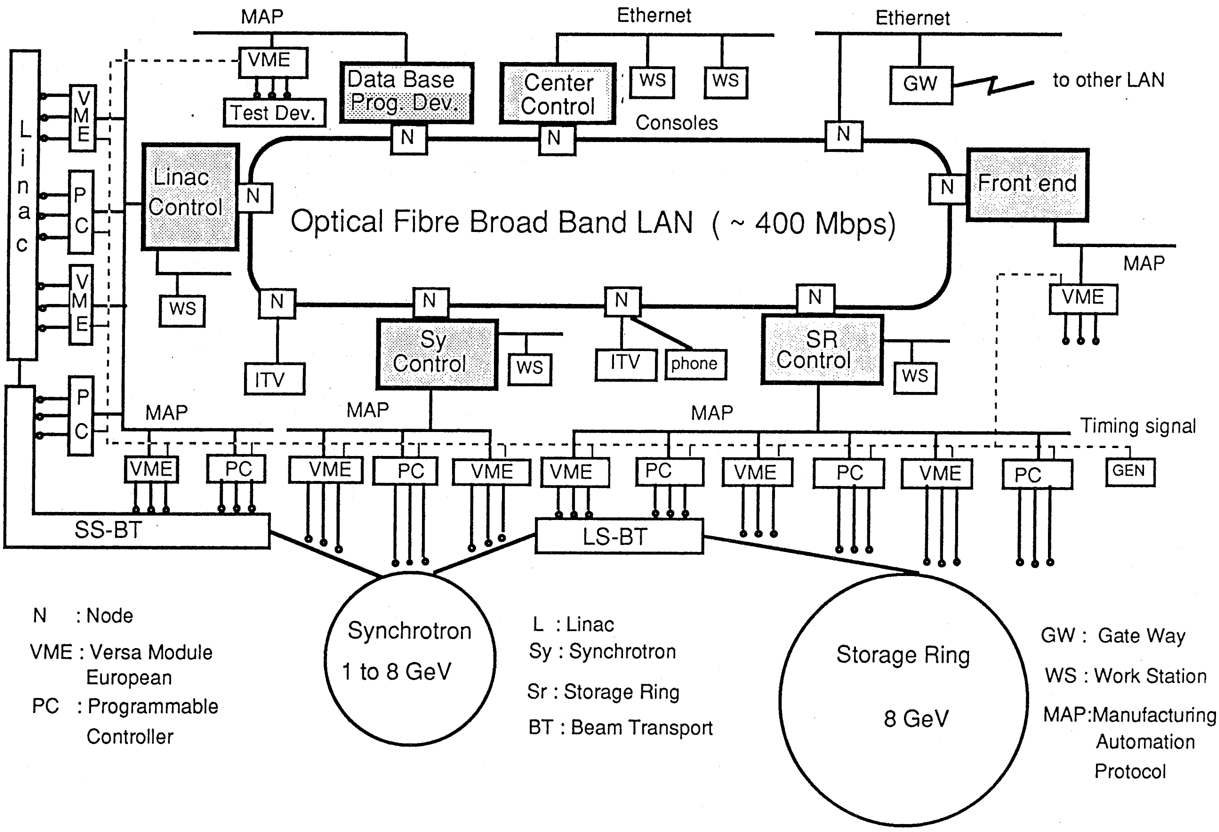

Fig. 1. The computers and their interconnectiong networks.

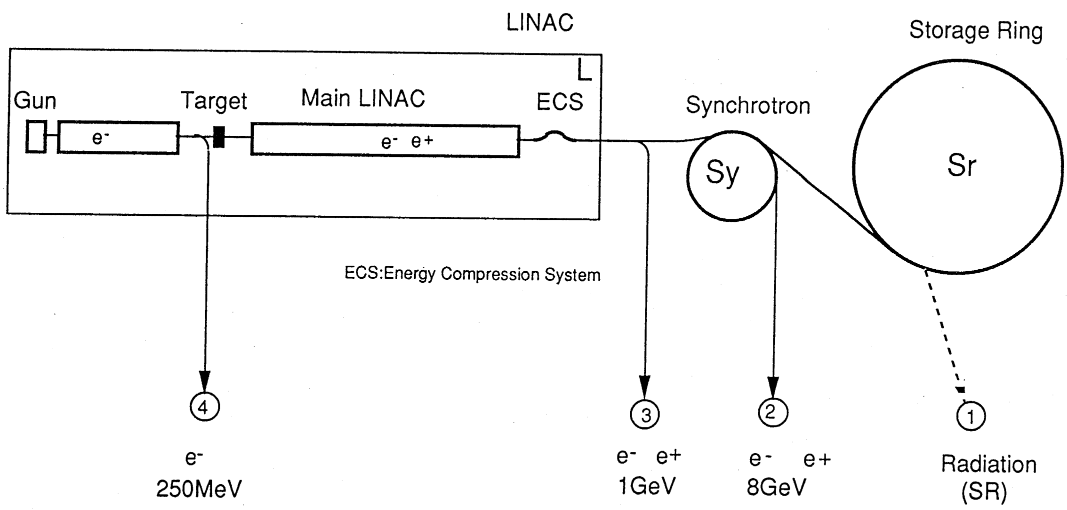

Fig. 2. Usage of electron/positron beam and photon beam.

Network System

Since several kinds of local area networks (LAN) are available, the choice of network is based on the following requirements:
1) The transmission distance is about 1000 m. Hence the transmission and response time must be sufficient for accelerator operation:
2) A standard linking system, between different kinds of computers (including future expansion requirements) must be adopted:
3) The cost/performance should be minimized for linking several computers, workstations, and microprocessors:
4) Optical fibre and coaxial cables can be used:

It is well known that optical fibre cables are damaged rapidly by radiation. However, because all the accelerators are installed on the surface, there is plenty of space for cabling safely with optical fibres.

As is shown in Fig. 1, a so called multi-media LAN is adopted for backbone control, with full- and mini-MAP LAN's for real-time control. Voice signals and TV signals are also transmitted on FDDI cables. MAP has two advantages over Ethernet (TCP/IP). One is that messages are exchanged by the token-passing method. Hence, even under heavy traffic conditions, real-time response can be maintained. The other is that mini-MAP bypasses the middle 4 layers (3 ~ 6) of the 7 OSI layers. Thereby quick response is achieved.

Software

The Operating System

UNIX and VMS are presently the most popular operating systems. VMS is very powerful, but can only be run on VAX computers. UNIX, on the other hand, is nearly machine independent and has been implemented in many different computers. It is powerful for program development and communication between computers. Although the early version of UNIX had few real-time functions, it has subsequently been improved. One example is the RIKEN ring cyclotron control system, in which UNIX and real-time operating systems coexist in the same computer.[2]

In the present control system different kinds of computers, including microprocessors, are employed. UNIX is too large to be implemented by microprocessors (ROM base), and so is more appropriate for computers at higher level,. For lower level computers, such as VME, real-time operating systems are adopted. The programs are, therefore, developed in UNIX and later downloaded to real time control computers or burned in EPROM.

There are many commercially available real time OS's, which follow the POSIX (portable operating system interface for computer environments).[3] We have introduced LynxOS for R&D study of control of klystron test bench, and OS-9 for that of linac.

Language

The candidates are Pascal, C++, and Ada which are appropriate for object-oriented programming. C and C++, however, are the main candidates because many program developing tools prepare C library functions as application programming interface. FORTRAN is used for large numerical calculation programs, such as COD corrections.

For the effective development of programs, it is convenient to use S/W development tools, such as CASE tool and GUI developer.

Database

A comprehensive database defines all the machine parameters, both real and virtual. This database is edited and maintained in a database computer. It is broken-down, encoded, and separated into parts appropriate for use in the various locations and hierarchical levels. These parts are then downloaded to the various processors where they are used to obtain the necessary information.

Artificial Intelligence

We intend to use expert systems mainly for alarm message handling system, and partly for automatic operations. Introducing an AI tool, "NEXPERT OBJECT", a feasibility study of an expert system for the operation of a test stand of a klystron is started.

Timing System

The timing system supplies synchronization pulses to the gun, linac, booster pulsed magnets, storage ring pulsed magnets, beam position monitoring system, and control-room instruments. It also provides pulses for use by experimenters. The timing signals are lead directly to delay pulse generator in the FEP's. We are developing an accurate delay pulse generator using GaAs preset counter circuits.[4]

References

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