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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 three-hierarchy levels. All the computers are linked by computer networks. The network of upper level is a high-speed multi-media LAN such as FDDI which links sub-system control computers, and middle are Ethernet or MAP networks which link front end processors (FEP) such as VME system. The lowest is a field level bus which links VME and controlled devices. 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 hardwares 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.

I. INTRODUCTION

The SPring-8 facility consists of an 8 GeV storage ring of 1436 m circumference with a natural emittance of 7.0 nmrad, an injector linac of 1 GeV and an 8 GeV synchrotron. Figure 1 shows the layout of the facility. Construction starts in 1990, and the first stored beam is foreseen in 1998 [1]. The construction of control system will start in 1994.

From the designer's viewpoints, the control system consists of the following parts:

1) Computer System;
 1-1) Host and front end computers;
 1-2) Network system;
 1-3) Software:
2) Interlock System;
3) Analog Signal Observing System;
4) Timing System;
5) Television Network System;
6) Links with other System:

II. DESIGN CONCEPTS

Followings are the design concepts of SPring-8 control system:

1) Distributed processors system which are linked by high-speed networks.
2) Sub-system control computers are loosely coupled, due to different accelerator construction schedules and for the convenience of independent operation at maintenance time.
3) In normal operation, all the accelerators are operated at one control room by small number of operators.
4) VME and MAP for front end processors and networks, respectively.
5) PLC (Programmable Logic Controller) for fixed control sequence.
6) Real-time operating system for VME.
7) For high productivity of application program;
 7-1) Object-oriented programming;
 7-2) Computer aided program developing tools;
 7-3) Computer aided operation tools:
8) Standard hardware and software.

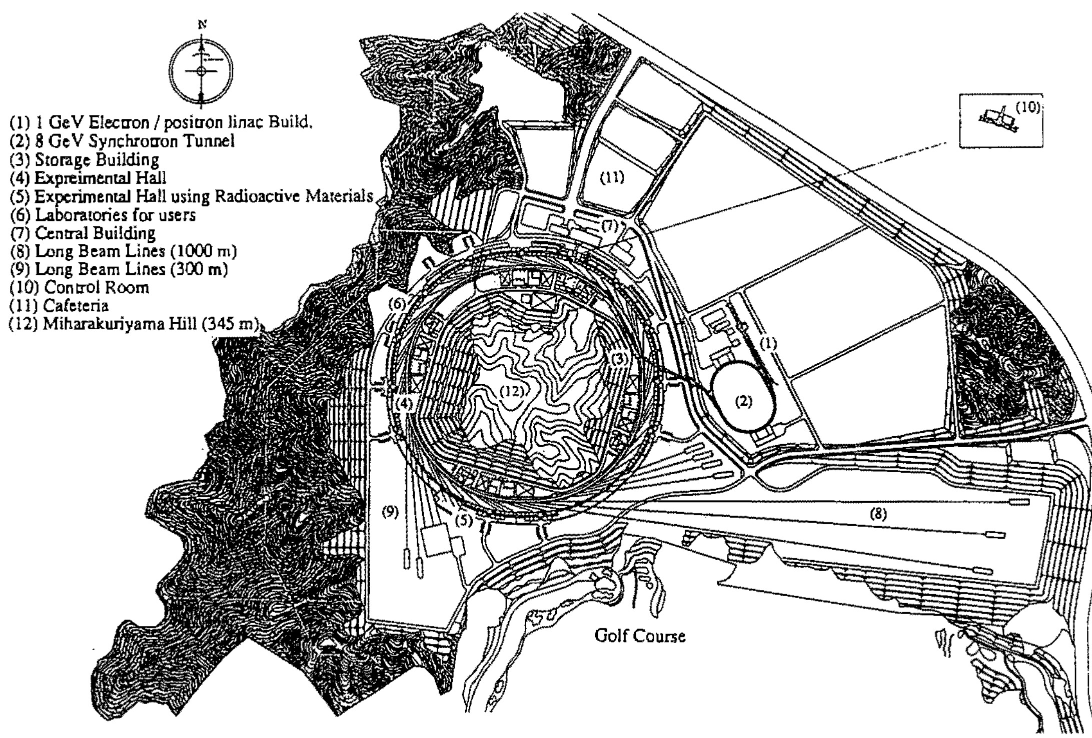

Fig. 1 Layout of the SPring-8.

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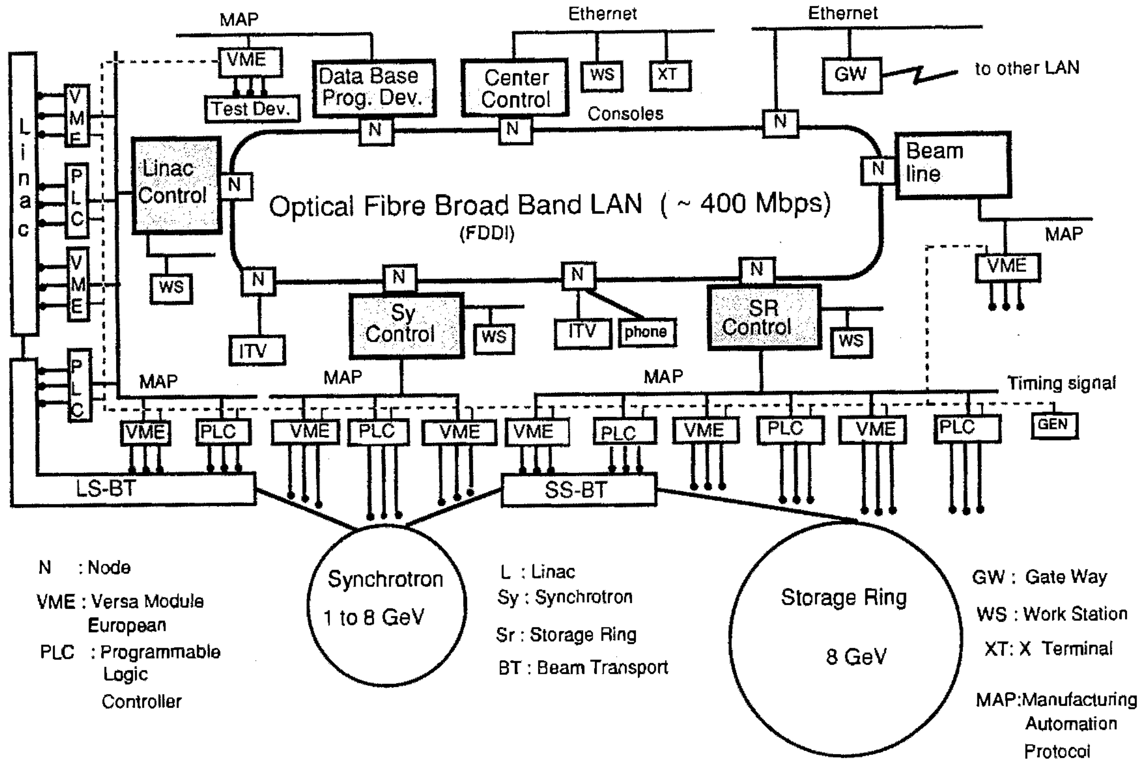

Fig. 2 The computers and their interconnecting networks.

III. COMPUTER SYSTEM

The control system consists of a central control system and several sub-system for each accelerator. These sub-system 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 2 shows schematically the computers and their interconnecting networks. The function of each system are:

A. Central Control System

1) Selection of operating mode and scheduling;
2) Monitoring, logging, and display;
3) Linking with other computer system such as that of the computer center, of experimental system, and of a radiation safety control system.

B. Program development and Database

Central management of application programs and database:

C. Accelerator Control System

The control of injector linac, 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 and programmable logic controllers (PLC). When high-speed data processing is required, such as by a fast digital feedback system, a VXI system will be used, since the data transmission rate of the VXI bus is much higher than that of VME system.

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

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 points, and the comparison with KAON facility [2]. Where LS-BT means beam transport line between linac and synchrotron, and SS-BT between synchrotron and storage ring. More than 200 VME system are to be used in whole control system.

Table 1 Estimated numbers of input/output points.

S P r i n g − 8

Part	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

T R I U M F

	DO	DI	AO	AI
K A O N	7973	16310	2554	10214

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IV. NETWORK SYSTEM

As is shown in Fig. 1, a so called multi-media LAN will be adopted for backbone control, with full- and mini-MAP LAN for real-time control. Voice signals and TV signals are also transmitted on FDDI (Fibre Distributed Data Interface) cables. MAP has two advantages over Ethernet (TCP/IP). One is that messages are exchanged by 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.

V. SOFTWARE

A. Operating System

An UNIX is used for upper level computers, and real-time OS for FEP's. Table 2 shows examples of commercially available real-time OS[3]. Some of them conform to IEEE POSIX (portable operating system interface for computer environments) standard. An actual performance measurements have been reported on four kernels, all running on the same hardware platform [4].

B. 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 useful for large numerical calculation programs, such as COD corrections.

For the effective development of application programs, it is convenient to use computer aided software development tools, such as CASE tool and GUI developer.

C. Artificial Intelligence

We intend to use expert systems mainly for alarm message handling system, and partly 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.

VI. TIMING SYSTEM

The common clock (508.58 MHz) is distributed with temperature compensated optical fibers to the linac, the synchrotron, and the storage ring. Trigger request pulses are to sent from the storage ring to the synchrotron and from synchrotron to the linac. Received devices generate beams after accurate delay time. We are developing an accurate delay pulse generator using GaAs preset counter circuit.[5].

VII. R&D

1). Development of accurate timing system for a 508 MHz clock.
   GaAs preset counter,
   E/O and O/E for optical fiber cable with small temperature coefficient.
2). Development of a pattern generator for the synchrotron operation.
3). Development of a field level bus.
4). Control of a klystron test stand.
   HW: EWS, X-terminal, VME, Ethernet,
   SW: UNIX, LynxOS, C, TCP/IP (socket),
   GUI: Xt, ("SL-GMS"),
   AI: "NEXPERT OBJECT"

VIII. REFERENCES

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Table 2 Examples of real-time operating system.

OS Name		VRTX32	pSOS+	VxWorks	VMEexec	C EXECUTIV	OS-9000	LynxOS	PDOS
Company		Ready Systems	Software Components	Wind River	Motorola	JMI Softwa Consultant	Microware Systems	Lynx Real-Time S	Eyring Research I
Microprocessor		680X0, 80X86 SPARC	680X0 80386	680X0	680X0 88000	680X0 80286	80386, i486	80386, 680X0 i860, 88000	680X0
Bus		not fixed	not fixed	VMEbus	VMEbus	not fixed	not fixed	not fixed	
Network		Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet
Protocol		TCP/IP	TCP/IP	TCP/IP	TCP/IP UDP/IP	TCP/IP	TCP/IP	TCP/IP	TCP/IP
Kernel Size(KB)		8	11.5~ 13	60~ 465	8.5 min.	5~ 10	53	190	25
Task	Max. no.	256	65535	65535	No Limit	32767	No Limit	No Limit	
	Priority	256	255	255	256	32767	65536	32	225
Multi-Processor	Bus	○	○	○	○	×	×	○	○
	Network	○	○	○	○	×	×	○	
File System		MS-DOS	Dedicated, MS-DOS	RT-11, UNIX, MS-DOS	Fast File System	MS-DOS	Dedicated, MS-DOS	i-node	
Exec. Time	Switching	15μ s	19μ s	17μ s	19μ s	17μ s	220μ s	13μ s	26.2μ s
	Interrupt Wait Time	10μ s	7μ s	8μ s	6μ s	NA	40μ s	30μ s	
	Measured Condition	68020, 25MHz 1 Wait	68020, 25MHz no Wait	68020, 25MHz no Wait	68020, 25MHz no Wait	68020, 25MH	80386, 20MHz	80386, 33MHz	68020, 20MHz
AP Language		C, ASM, Ada	C, ASM, Ada	C, ASM, Ada FORTRAN	C, ASM FORTRAN	C, ASM	C, ASM	FORTRAN, C ASM, Ada	FORTRAN, C ASM, PASCAL
Environment for Devlopment		UNIX, VMS	UNIX	UNIX	UNIX	ANY	OS-9, UNIX OS-9000	Self UNIX	Self UNIX, PC