DESIGN OF THE DISTRIBUTED COMPUTER CONTROL SYSTEM FOR THE 1.8GEV SYNCHROTRON RADIATION SOURCE TSRF AT TOHOKU UNIVERSITY

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Abstract

The control system has been designed for the 1.8GeV synchrotron radiation source at Tohoku-University Synchrotron Radiation Facility (TSRF), Sendai-city, Japan. TSRF is a third-generation synchrotron radiation facility proposed at Tohoku University, Sendai,Japan. The control system comprises three physical layers: LINUX PCs , a high speed network, and VME based field bus. LINUX PCs are employed for the upper layer that provides process control and user interface implemented in JAVA. The physical devices are controlled by using remote object technology developed with the RMI (Remote-Method-Invocation) and JINI in JAVA. The VME crates with high performance CPUs provide access to the remote devices that are interconnected to the magnets, RF, Vacuum, beam-position monitors, wigglers/undulators, beamlines and related components of the storage ring for local process control. The present status of the TSRF control system is discussed.

1 INTRODUCTION

TSRF (Tohoku-university Synchrotron Radiation Source Facility) is a new third generation synchrotron radiation source that is currently proposed at Tohoku University, Sendai, approximately 350km north of Tokyo, Japan. TSRF is planned to be constructed at the site of Laboratory of Nuclear Science, Tohoku University, where a 300MeV-Linac and 1.2GeV Stretcher Booster Ring are currently in operation for nuclear physics experiments [1]. By taking advantage of the existing facility, TSRF employs the Stretcher Booster Ring as the injector for the TSRF storage ring. This can greatly reduce construction cost for the TSRF generation synchrotron radiation source.

TSRF is designed to provide VUV-SX synchrotron radiation to the experimental hall where experiments such as VUV experiments, surface physics, soft x-ray lithography, microscopy and crystal structure analysis, will be simultaneously carried out. The high-power wiggler/ undulator beam lines are simultaneously in operation, producing very intense synchrotron radiation beams [3]. The high-power beam lines are distributed along the long circumference of the storage ring. TSRF has a 1.8GeV storage ring with a DBA(double-bend-achromat) type, third-generation storage ring with emittance of 4.9nm rad, and a circumference of 244m. TSRF has more than ten wigglers/undulators, and thirty beamlines for Soft X-ray and VUV experiments for research. The facility has the 1.2GeV Stretcher Booster Ring and has been already in operation for nuclear physics. By taking advantage of this Stretcher Booster Ring, it will be employed as the beam injector for the Synchrotron Radiation Storage Ring.

The control system has been designed for the 1.8GeV TSRF synchrotron radiation source in order to operate the storage ring, providing stable synchrotron radiation to users at the experimental hall, and to improve the performance of the storage ring. In this study, the design of the TSRF control system is discussed.

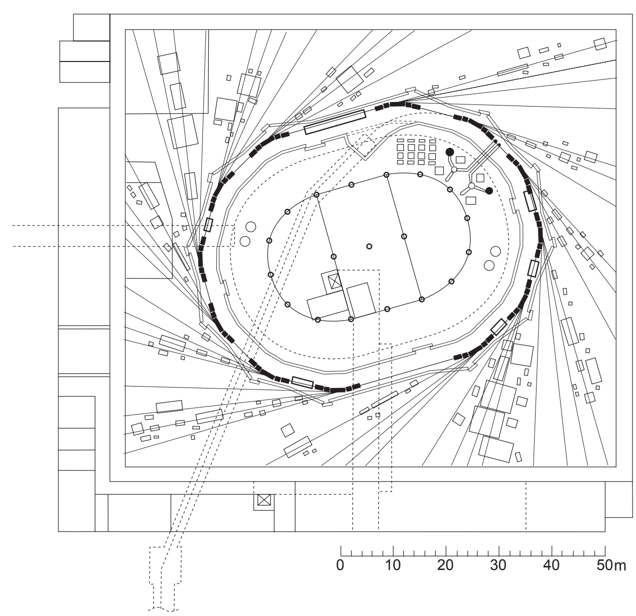

Figure 1: 1.8GeV Synchrotron Radiation Source at TSRF

2 SYSTEM CONFIGURATION

The control system provides two major operating modes at the users' request: multi-bunch beam operation and single-bunch beam operation for time-resolved experiments. In addition, the control system allows an operator to provide both (1) automatic setup-and-go operation of the accelerator for users' experiments and (2) machine-study operation with remote control of the accelerator system in order to improve the accelerator performance and to study accelerator physics.

Table 1 Principal parameters of the synchrotron radiation source at TSRF

Beam Energy	1.8 GeV (Max. 2 GeV)
Circumference	244.8 m
Lattice	DBA×16
Straight Sections	5m x 14, 15m x 2
Emittance	4.9 nm-rad
RF Frequency	500 MHz
Harmonic Number	408
RF Voltage	1.0 MV
Beam Current	400 mA
Beam Lifetime	> 12 hr

The software system which comprises three layers based on a client-server model. In particular, software interfaces for the hardware have been designed with Java Remote Method Invocation (RMI) running under the distributed VME CPU modules on the network as shown in Fig.2 [4]. By taking advantage of Java RMI's capability, many remote accesses are carried out easily without paying a lot of efforts for remote communication as if the remote equipment was residing on the local machine. Note that for very-time critical operation such as a high speed feedback loop, it is implemented in C in order to avoid any time delay caused by garbage collection in the Java environment.

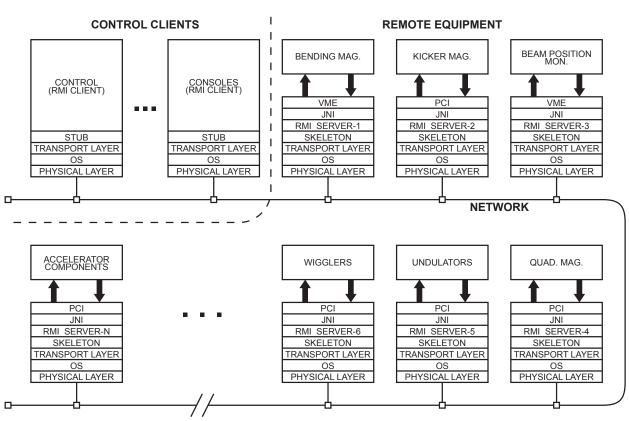

Figure 2: Application program interface using the remote equipment for accelerator components at TSRF

On the top layer, there are Console Managers as clients for operator console management. At the bottom layer, there are Device Servers which actually interface between the physical hardware devices and servers at the upper layers. A Dispatcher is a server in the middle layer, which resides among Console Managers and Device Servers at the lowest level.

PCs are cost effective equipment as operator consoles running at the top layer. Five PCs running under Windows NT are utilized as console devices with a 20-inch bit-map color display, and a trackball used as a pointing device; they are also connected to the network. Under normal operation, two consoles are assigned to storage ring control, and the other to the beam-transport-line, injection-pulse magnets, safety interlock system and the beamline control system. Man-machine interfaces, including graphics status displays, provide pull-down and pop-up menus which are organized in a tree structure. Each branch menu is utilized to specify a device and its parameters. The Console Manager always depicts the present status of the accelerator complex.

There are five LINUX servers at the middle layer for managing VME crates that are utilized for process control. Automatic operation is to setup, in principle, the parameters to devices, such as the bending magnets and families of quadruple magnets, and then to initiate them. This can be carried out by invoking commands defined in a command file, whose file name is specified by an automatic instruction message solicited by an operator. The servers automatically carry out following procedures; (1)Standby-for-beam-injection, (2)Beam-Injection, (3)Beam-Acceleration, (4) Re-injection (to set up parameters for injection of the beam after automatically initializing magnets), and (5)Shutdown.

The LINUX servers, VME crates and PCs are connected to the FDDI (Fiber Distributed Data Interface) high speed network. The FDDI provides a 500-Mbps, token-passing, dual-ring LAN using a fiber-optic link suitable for exchanging control data reliably.

On the bottom layer, there are VME crates with high performance CPUs that are interconnected to the magnets, RF, Vacuum, beam-position monitors, wigglers/ undulators, beamlines and related components of the storage ring for local process control. VME modules in the crates carry out time-critical jobs for the accelerator components: during beam acceleration at the storage ring, a power supply for bending magnets of the storage ring, and power supplies for families of quadrupole magnets are automatically synchronized in order to keep the betatron values constant. In addition PCI modules on PCs Windows NT are also employed to reduce cost. As mentioned these modules are controlled by the Remote Equipment System [5].

There is a shared memory table in which all of operational parameters of the accelerator complex are stored in the relevant data entries [6]. The table is also mapped to the physical memory which can be referenced by any application process. The purpose of the table is to allow all application processes to utilize the operational parameters as well as the present status of the accelerator complex necessary for their specific operation without directly accessing actual physical devices.

There is an on-line database system. The host collects all operational data and control data of the accelerator components. The operational and control data have been automatically stored in the database system to retrieve later specific combinations of behaviors of the accelerator components.

The storage ring has a number of components and sensors to be controlled, including vacuum valves, interlock devices, cooling water flow sensors, fast/slow vacuum sensors, pneumatic-pressure sensors, atmosphere sensors, Open-Request signals from the storage ring /the experimental hall, vacuum pressure gauges of the storage ring and the beam lines, valve driving units. These components are controlled and monitored by a computer of the control system.

For the first commissioning phase, fifteen beamlines will be constructed as shown in Table 2 [3]. To access a number of beamline components, a remote data acquisition system is employed for measuring instruments at the experimental hall [6].

Table 2 Wiggler/Undulator beamlines to be constructed for the first commissioning phase at TSRF

Research fields	Source
1. XAFS	3 Wigglers
2. X-ray diffraction, topography	2 Wigglers
3. X-ray small angle scattering	1 Wiggler
4. Atoms and molecules (VUV-SX)	1 Undulator
5. Surface-solid: PES/fluorescence	1 Undulator
6. Spin polarized UPS	1 Undulator
7. Far infrared	1 Bending M.
8. Millimetre-wave	1 IR wiggler
9. Soft X-ray optics/microscopy	1 Undulator
10. Lithography, Photochemical process and biomaterials	3 Bending M.

3 CONCLUSION

The present status of the control system is discussed for the 1.8GeV generation synchrotron radiation facility TSRF, Sendai-city, where a 300MeV Linac and 1.2GeV Stretcher Booster Ring are ready as the injector for the 1.8GeV storage ring. The control system comprises three layers, and is composed of servers, VME crates and PCs which are connected to the high speed FDDI network. The control system provides automatic operation for users' experiments as well as machine-study operation to improve the accelerator performance and to study accelerator physics.

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