Accelerator Control System and VME Front End Computer

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Abstract

An idea for the new control system of the NSRL 800 MeV storage ring is given. The system, based on the ″Standard model″ architecture, consists of the operator layer, communication layer, I/O control layer and device interface layer. As the main part of the ring control system, the main magnet power supply control system is discussed in detail.

1 Introduction

The accelerator control system architecture development has followed the advances in computer technology. The reduction in price of powerful computers have motivated new approaches to distributed control system design. As a result of this new technological support, new designs can be implemented very quickly. Acceptence of the new standard is world wide.

A description of the new NSRL control system which incorporates the universely accepted standards, for distributed processing is given. The implementation of the main magnet power supply control subsystem and its VME front-end computers are discussed in detail.

2 Control system architecture

2.1 Control system function

The new control system should be a reliable, stable, extensible and fully distributed. It must be capable of: (1) providing a friendly graphical user interface, operating all the facilities as machines which have separate missions and controlling devices in the central control room;(2) controlling and monitoring all equipment of the accelerator including various magnet power supplies, RF cavities, vacuum units and beam diagnostic instruments; (3) provide the tools for analysing the running status of the machine and provide tools for calculating the machine parameters; (4) warning and protecting the equipment when accidents happen or equipment fails, protecting the people from radiation.

2.2 Hardware architecture

The control system is based on the ″Standard Model″ architecture of a fully distributed processing system. Logically the system is composed of four levels from top to bottom, which are: the operator layer, the manager layer, the I/O controller layer, and the device interface layer as shown in Figure 1.

The operator layer includes a workstation under UNIX running display manager routines, and several X terminals providing a friendly graphical user interface as operator console. The manager layer includes two powerful workstations under UNIX acting as file server and calculating server. The I/O controller layer includes several front-end computers based on VME system which consist of CPU boards and a variety of interface cards. Data acquisition and open or closed loop control functions of the equipment are handled by FECs. The device interface layer includes a number of single board computers with interface circuits. Signal conditioning, level matching, and A/D or D/A conversion are completed on this layer.

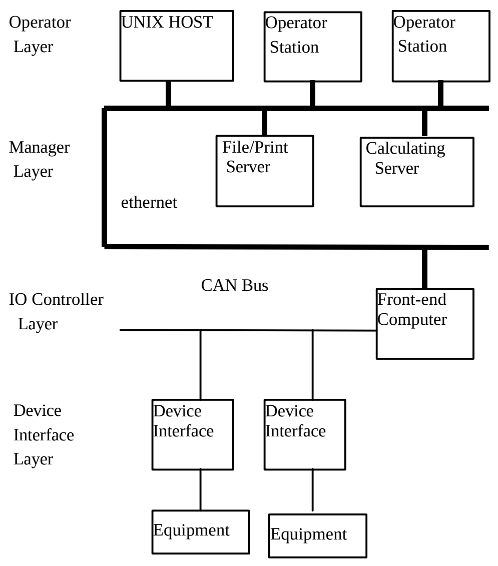

Figure 1. New Control System Architecture

The operator layer, the manager layer and the I/O controller layer are connected through ethernet with TCP/IP. Between the I/O controller layer and the device interface layer, the field bus is adopted as data communication path.

2.3 Software architecture

The EPICS was adopted as the development tool to create the control software. EPICS which is cooperatively developed by the Los Alamos National Laboratory and the Argonne National Laboratory, provides a wide range of functionality, rapid application development and modification, and extensibility at all levels to meet the demands of experimental physics.

The software architecture is composed of the Operator Interface layer, the Input/Output controller layer, and the communication protocol layer. The OPI layer includes the Display Manager, Alarm Handler, Archiver and other configuring tools. UNIX is adopted as the operating system for this layer. The IOC layer includes a Distributed Database, Device Drivers and other applications, and VxWorks realtime operation is adopted on this layer. The communication protocol layer is Channel Access based on TCP/IP which provides the communication between the various subsystems of EPICS.

The main part of the control software can be created rapidly with EPICS and other application development tools. So the major software effort was concentrated in the writing of the I/O device support routines. The communication routine between I/O controllers and Device Interfaces, and other special applications, for example the ramping routine.

3 M.M.P.S control subsystem

Injection into the ring is at the linac beam energy of 200 MeV. After injection the beam energy in the ring is ramped up to the operating energy, which is called ramping operation. In this operation the magnet currents have to track each other in order to keep the ring lattice unchanged. The primary function of the main magnet power supply control system is to assure the synchronization and accuracy of the magnet currents in the ramping operation. Because the ramping operation is a realtime process, this subsystem will be established according to the EPICS pattern. The Distributed Database loaded into the FEC will provide supervision and control for all signals of power supplies. The control current waveforms of power supplies are generated by software. In order to lower the interference of external noise, all remote signals must be converted into digital signals, so AD conversion of readback signals and DA conversion of control signals must be done on the device controller layer.

This subsystem architecture is shown in Figure 2.

3.1 UNIX Host

The UNIX host is a Sun workstation or any other workstation under UNIX. Display Manager, Alarm Manager, Archiver, Channel Access and other managerial tools are running here.

3.2 M.M.P.S. console

The M.M.P.S. Console is an X terminal or an PC with X terminal server software, which employs the M.M.P.S. controlling screen, provides the graphical user interface, accepts commands or parameters input by the operator, and displays the status of the power supplies and the readback data of DCCT, respectively.

3.3 M.M.P.S. FEC

The Front End Computer is a VME based computer with a ethernet interface, CAN BUS interface and other function boards. The M.M.P.S. FEC runs the Distributed Database (DDB) providing local control, employs the ramping routine generating the control current waveform data and sending them to power supply interface through CAN BUS in ramping operation, receives readback data from DCCT interfaces and status data from power supply interfaces and transmits them to the OPI in a event driven.

3.4 Power supply interface

The Power Supply Interface is a single board computer with a CAN interface and A/D, D/A converter. It supports the D/A conversions of control signals, the A/D conversions of readback signals, the level conversion between TTL and power supply signals, and signals condition.

3.5 DCCT interface

The DCCT Interface is a single board computer with a CAN interface and A/D converter. It supports the A/D conversion of readback data from DCCT, the level conversion between TTL and DCCT signals, and signal conditioning.

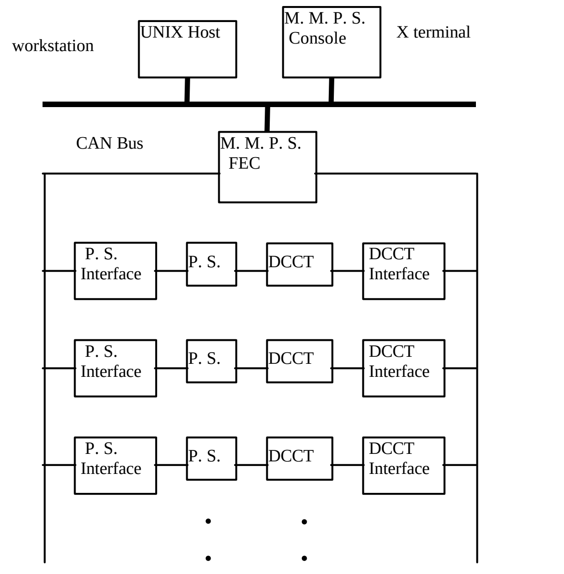

Figure 2. M. M. P. S. Subsystem Architecture

4 Key technology

The reformed NSRL control system will adopt mature innovative technology, and during the process of development, we need to master this key technology such as the distributed database technology, graphical user inter-face technology, network communication technology, the transplanting and improvement of EPICS, composition and development of front-end VME system, development of device interfaces, compilation of I/O device support routines, compilation of ramping routines and etc. Among them, the last four are closely related to the establishment of the M.M.P.S. control subsystem, so they shall be mainly dealt with.

5 Outlook

The reform of the control system of our accelerator will involve the reform of every subsystem, so we chose to start to establish an experimental line controlling the main magnet power supply, and then spread to the reform of the whole control system with this model. The control system will generally realize the integration with international technology after the reform, the mutual cooperation among laboratories will benefit from this. All functional subsystem realize sharing of data, archiving of working parameters and experimental data. With their open structure, all subsystems such as linac, transport line and experiment stations will gradually transit into and finally form a relatively developed computer control system.

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