Control System at the Synchrotron Radiation Research Center

G. J. Jan*
Synchrotron Radiation Research Center
Hsinchu 30077, Taiwan, R. O. C.
* also Department of Electrical Engineering , National Taiwan University
Taipei 10764, Taiwan, R. O. C.

Abstract

A modern control system was designed for SRRC to control and monitor the facilities of storage ring, beam transport line and injection system. The SRRC control system is a distributed system which is divided into two logical levels. Several process computers and workstations at upper level provide the computing power for physics simulation, data storage and graphical user interfaces. VME-based Intelligent Local Controllers (ILC) are the backbone of the lower level system which handle the real time devices access and the closed loop control. Ethernet network provides the interconnection between these two layers using IEEE 802.3 and TCP/IP protocol. The software in upper level computers includes data base server, network server, simulation programs, various application codes and X windows based graphical user interfaces. Device drivers, application programs for devices control and communication programs are the major software components at the ILC level.

I. Introduction

The 1.3 GeV synchrotron radiation facility at SRRC has been designed as a third generation synchrotron light source with low emittance and high brilliance. The facility includes a turn-key full energy injector, a transport line and a storage ring with triple bend achromat lattice [1]. The turn-key injection system is composed of a 50 MeV linac and a 1.3 GeV booster synchrotron. The control system of SRRC is cost-effectively designed by using advanced technology. Two level hierarchical computer [2,3,4] systems were chosen to simplify the architecture of the control system. They are console level computers and intelligent local controllers (ILC). The ethernet network is used to link the console level computers and ILCs. The console level computers handle the system wide high level control function and provide a friendly operator interface. The ILC is a field level controller which performs data acquisition and local close loop control for the equipments of various subsystem.

II. Hardware Design Consideration and Configuration

Two level hierarchical control system of the synchrotron radiation facilities at SRRC provide good real time performance with update rate about 10Hz. The architecture is simple and easy to be expanded and maintained. The centralized database structure is implemented. The hardware configuration of the control system is shown in Figure 1. The open system configuration allows the centralized database to be changed into a distributed database easily. Adding UNIX system into the control system is possible after modifying some software components.

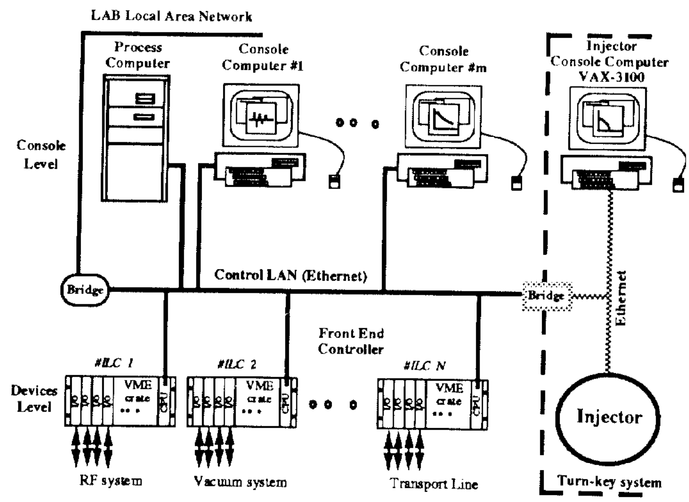

Figure 1. Hardware configuration of the control system at SRRC.

The console level computers are composed of a process computer and several workstations. The process computer will be a VAX 6000 series model 510 which provides a large storage space, computing power and will maintain system-wide resources. The VAXstation 3100 series are chosen as workstations which provide a high performance platform to run graphical or other applications. The workstations are used as operator console. The graphical user interface standard X-Windows and OSF/Motif are used to design a friendly operator interface.

The ILC is a VME crate system which includes Motorola MVME-147 CPU board and a variety of interface cards. The MVME-147 CPU board consists of 68030 microprocessor, 68882 floating point coprocessor, 4 Mbyte on-board memory and ethernet interface. The ILCs are connected to the hardware devices via analog and digital input/output interfaces, IEEE-488 interface and serial communication interface. Data acquisition, closed loop control and monitoring of the equipments are handled by ILCs. Most of subsystems, such as magnet power supply, vacuum gauge controllers, general purpose measurement instruments, provide the IEEE-488 interface. The control and monitoring of equipments can be carried out with the workstation or personal computer through ethernet. The important feature is that the ILC which has a local console can serve as a stand-alone system to commission any sub-system and integrate it into the control system without modification. The RF controller, beam position acquisition

0-7803-0135-8/91$01.00 ©IEEE

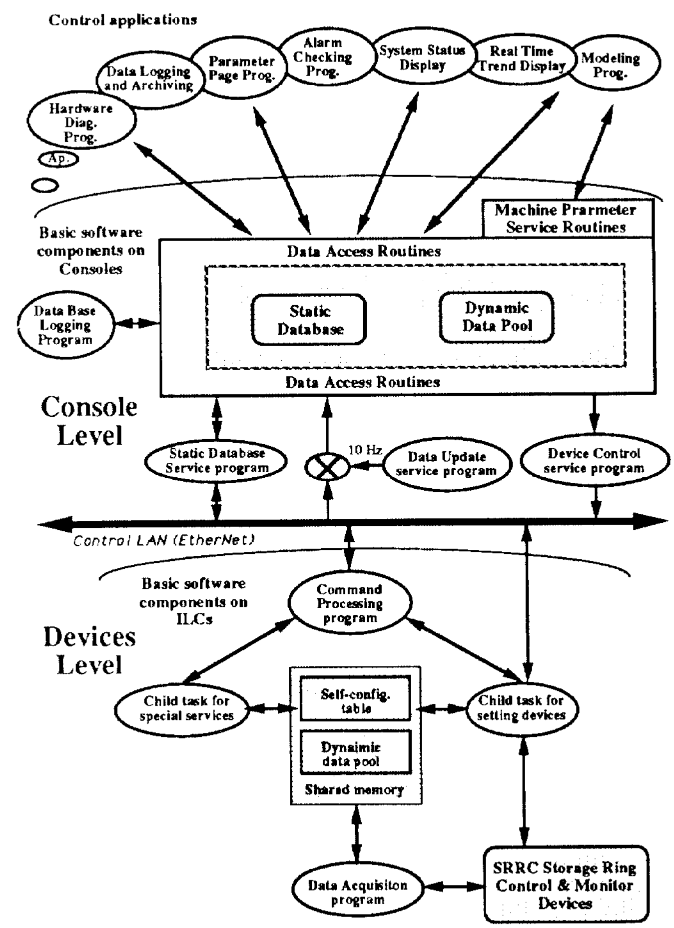

Figure 2. Block diagram of the software system.

system and power supply for correcting magnet are connected to ILCs through the general purpose input/output channel. All ILCs serving for different sub-systems of the beam transport line and the storage ring facility have the same priority level. The dynamic data can be updated into the database of console computers at the rate of about 10 Hz.

The ILC, Micro-VAX II and DECstation 5200 have been set up and linked successfully. The data acquisition system of the control and monitoring has been developed and tested with local console PC/AT-386. This stand-alone system is quite useful in testing the subsystem. The transfer rate of the ILC and DECstation 5200 through the ethernet with TCP/IP protocol was tested. The maximum number of ILC can be accessed from the workstations within 100 msec is about 15 sets. The performance of the ILC and VAX/VMS workstations is going to be tested and evaluated.

III. Software Design and Development

The software structure is divided into several logical layers as shown in Figure 2. There are device access, network access, database management, graphical user interface and applications. The goal to modularize the software into layers is to reduce the development time.

The devices access processes are run on ILC. The pSOS$^+$ real-time kernel provides the ILC with support for task scheduling, memory allocation, event handling and message queuing. The pNA$^+$ network support package provides socket network interface. The control tasks and various input and output tasks are also running on ILC. The hardware dependent device drivers are implemented. In order to test and to commission as well as for diagnosis of the subsystem, the PC/AT-386 is used as a local console to serve control and graphical monitoring system. The PC/AT-386 system is also used as program development station to develop the application programs using C language under MS-DOS environment. The control and monitoring programs for the magnet current power supply and simulator of the low level RF electronics as well as vacuum gauge controllers were implemented and tested successfully. The speed of the dynamic data uploading to console level computers is about 10 Hz. Downloading the database from the process computer into the ILC to form a local distributed database is underway.

The network access software is in charge of the data exchange between console level computers and ILCs. The protocol of the IEEE-802.3 is used to communicate with the turn-key injector system. Thus, the IEEE-802.3 protocol is still developed and coded until the completion of the machine commissioning. The TCP/IP protocol is using at present system and provides an open environment for further expansion. The IEEE-802.2 is also under intensive study, which is considered to be implemented in the control system to reduce the system overhead if needed in the future.

The console level computers are VAX/VMS system. The software package is developed using C language. The function of the process computer and workstations is slightly different. The process computer keeps the system-wide static database and maintains it. At system start-up, each workstation requests and receives a copy of the static database from the process computer. Each console computer then has all the database information necessary to process dynamic database frames received from the ILCs. The workstations are mainly for user interface. The upload sequence is requested by the process computer, the ILCs multicast the dynamic data sequentially. All of the console level computers receive dynamic data and updated into database at the same time. Hence, the console level computers can be expanded easily without increasing the network traffic.

The central database on console level computer is used as a buffer between the low level tasks at ILCs and the console level applications. The application programs access equipments parameters directly form database rather than from ILC. The application programs are devices transparent. The development of the application programs can be parallel with the development of the other programs at ILCs.

There are many applications run at console level computers. The data logging and archiving, alarm checking and machine modeling programs will run at process computer. The graphics-oriented applications such as real time trend display, machine parameters display can run at workstations. Since, the workstation has a powerful processor, some computation intensive tasks can run at workstation also.

IV. Summary

The control system of the synchrotron radiation facility at the SRRC has been designed and the implementation is under way. The two level computer system and ethernet data communication network are configured. The message exchange can be maintained at the 10 Hz transfer rate. The maximum number of the ILC is about 15 sets. The broadcasting mode is used in the ethernet currently.

Acknowledgements

The author would like to express his appreciation for many useful suggestion from Mr. R. W. Goodwin and Mr. M. F. Shea of FNAL, Dr. W. D. Klotz of ESRF as well as Prof. T. Katsura of KEK-PF.

References

[1] "SRRC design Handbook", Synchrotron Radiation Research Center, April 1991.

[2] A. J. Kozubal, D. M. Kerstiens, J. O. Hill and L. R. Dalesio, "Run-time environment and application tools for the ground test accelerator control system", Nucl. Instrum. and Meth. A293, (1990) 288.

[3] B. Robinson, and P. Clout, "Modularization and standardization of accelerator control systems", Nucl. Instrum. and Meth. A293 (1990) 316.

[4] J. P. Stott and D. E. Eisert, "The new ALADDIN control system", Nucl. Instrum. and Meth. A293 (1990) 107.