CURRENT STATUS OF THE CONTROL SYSTEM FOR THE RIKEN ACCELERATOR RESEARCH FACILITY

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Abstract

The control system of the RIKEN Accelerator Research Facility (RARF) has been completed in the summer of 2002 using EPICS [1]. We expanded it in this summer gazing at the RIKEN radioisotope (RI) Beam Factory (RIBF) [2], which is under construction, by introducing a new server computer which has a new version EPICS base on it.

INTRODUCTION OF ACCELERATORS

The RARF has an accelerator complex consisting of the RIKEN Ring cyclotron (RRC) as a main accelerator and its two different types of injectors, frequency-variable RIKEN heavy-ion linac (RILAC) and AVF Cyclotron (AVF). The facility provides heavy ion beams over the whole atomic mass range and in a wide energy range from 0.6 MeV/nucleon to 135 MeV/nucleon. One of the remarkable features of this facility is capability of supplying light-atomic-mass radioisotope beams with the world-highest level of intensity.

To boost the RRC beam's output energy up to 400 MeV/nucleon for light ions and 350 MeV/nucleon for very heavy ions such as uranium, the RIBF project is now under construction. Having the RRC as an injector, a new cyclotron cascade consisting of three ring cyclotrons will be commissioned in 2005.

CONTROL SYSTEM

Control System of RARF

The structure of the RARF control system is shown in Fig. 1. EPICS base R.3.13.8 has been running on the server computer whose OS is HP-UX 11.0. Five VME single board computers are used in our system as Input/Output Controllers, and they communicate with the server computer through the Ethernet.

As a main feature of our control system, it is based on a CAMAC serial crate network and is supported by two types of modules, communication interface modules (CIMs) and device interface modules (DIMs). These modules were originally developed by RIKEN about twenty years ago in order to assist the main computer in its tasks. CIM is a CAMAC module which has twelve pairs of serial I/O ports, and it executes the message transfer between the VME and DIM. DIM has 32 DI/DO ports and 16 AI ports, and it executes a local sequence

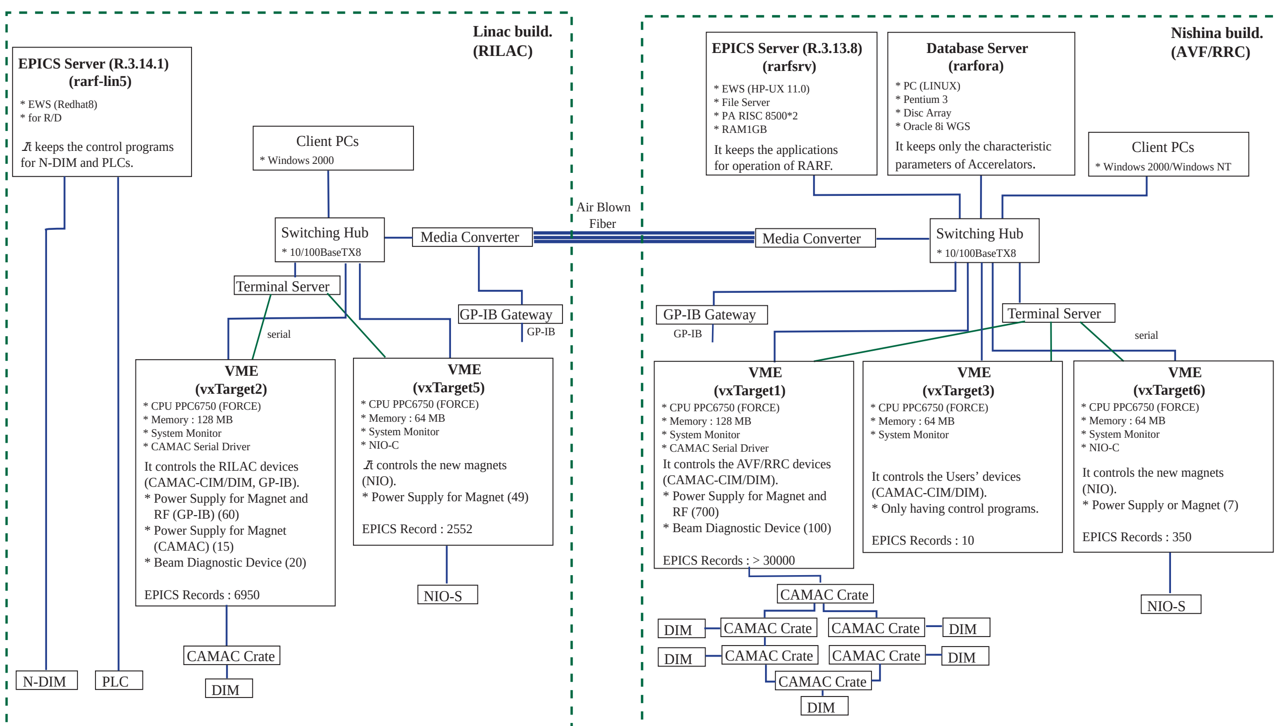

Figure1. Structure of the RARF Control System

control, local surveillance, function generation and testing. Information is transferred serially between these two modules through a pair of plastic optical fibre cables. Almost all magnet power supplies and beam diagnostic devices are controlled by them.

Another control devices are also used in the RARF; such as a GP-IB, a network I/O (NIO) system [3], and a programmable logic controller (PLC) and a network-DIM (N-DIM). GP-IB controls mainly measurement instruments such as a vector-voltmeter and 20-year-old power supplies in RILAC.

Our EPICS control system already includes two sets of CAMAC-CIM/DIM interfaces and the GP-IB interface. Most of the basic operations of RARF are currently carried out without any serious problems.

System Expansion to RIBF

The system expansion of RARF has always been required for the RIBF. New components have been introduced into the cases such as the upgrade project of RILAC, renewals of very old components and so on. There is a demand that the system expansion should be carried out only by adding the parameters of new components into the EPICS database, if they are controlled by either the CAMAC or the GP-IB. On the other hand, in investigation of a control system of the RIBF, it may be the easiest solution to expand the current system to the next one because the RIBF is a cyclotron facility as well as the RARF. However, both the interfaces have already become old and it is not a good idea to employ such old ones for the control of new components. Then it was decided to introduce three types of new control interfaces into the EPICS control system. The first one is NIO interface, which is used for new magnet power supplies. All magnet power supplies in RIBF will be controlled by NIO. In the RARF, we have already controlled the power supplies with NIO in the extended beam line of RILAC in the EPICS control system by making the device support for it. The second one is PLC, which is used for a new RF system and so on. The third one is N-DIM, which is our original control device developed to substitute for the CAMAC-CIM/DIM system. In the RIBF control system, N-DIM is used for a various purpose; to control all beam diagnostic equipment, all vacuum systems, driving system for deflectors and so on. Furthermore, it is also planned to replace the CAMAC-CIM/DIM in the RARF with N-DIM gradually. Table 1 shows the relation between an interface device and a component of RARF and RIBF.

Table 1. Interface Devices in RARF/RIBF

	RARF			RIBF						
	RILAC	AVF/RRC	BT (existing)	fRC	BT (in Nishina)	BT (in new building)	IRC	SRC	Injection Line for Big-RIPS	Big-RIPS
Ion Source	Hard wire /WE 7000 (Yokogawa)	WE 7000 (Yokogawa)								
RF	PLC (Omron)	PLC (Sharp)	DIM	PLC (Omron)	not fixed	not fixed	PLC (Omron)	PLC (Omron)		
Magnet Power Supply	GP-IB/NIO/DIM	DIM	DIM/NIO	DIM/NIO	NIO/DIM	NIO	NIO	NIO	NIO	NIO
Beam Diagnostics	DIM/N-DIM	DIM	DIM	N-DIM/DIM	N-DIM	N-DIM	N-DIM	N-DIM	N-DIM	not fixed
Driving Controller	DIM	DIM	DIM	N-DIM/DIM	N-DIM	N-DIM	PLC (Omron) /N-DIM	PLC (Mitsubishi) /N-DIM	not fixed	not fixed
Vacuum	N-DIM	PLC (Omron)	DIM	Local only	N-DIM	N-DIM	PLC (Omron)	PLC (Mitsubishi)	N-DIM	not fixed
Beam Interlock	Hard wire /PLC (Mitsubishi)	DIM	DIM	not fixed	not fixed	PLC (Mitsubishi)				
Cooling	Local only	Local only	Local Only	Local only	Local only	PLC (Mitsubishi)				

: controlled by the existing EPICS system

: will be controlled by the expanded existing EPICS system

: will be controlled by the CORBA system

: stand alone system
some systems has connected and send the data to the EPICS system

Development of N-DIM

For measuring a beam in RIBF, we improved the beam diagnostic hardwares to fit a high energy and high intensity beam. However, the basic driving mechanism is same as the equipment used in the RARF. Thus, we had to develop a control device like CAMAC-CIM/DIM to control them. NIO was a candidate of it and we examined its performance. However, it was developed specially for magnet control and it was difficult to convert it like CAMAC-CIM/DIM. On the other hand, PLC is another candidate of the control device and it can be used instead of CAMAC-CIM/DIM, however, the cost to compose the system becomes high. Considering these facts, we have started to develop our original device substitute for CAMAC-CIM/DIM since two years ago, and we named it N-DIM. The important features of N-DIM are as followings;

- N-DIM is a network-based intelligent controller.
- Each N-DIM has an IP address.
- Each N-DIM controls a beam equipment such as a beam profile monitor.
- N-DIM plays roles both a server and a client in the control system.
- Control commands are written in ASCII code.
- N-DIM is a radiation-resistance device.

Its more detailed characteristics are shown in Table.2.

The prototype was completed in last fall and we have tried to use it in the existing EPICS control system since this summer for checking its performance.

Table 2. Main characteristics of N-DIM

CPU	SH4 (HITACHI)
Memory	6MB (S-RAM), 1MB (EP-ROM)
OS	μITRON 2.0
Protocol	TCP/IP, UDP/IP
Service	FTP, Telnet
Port	10/100Base-T, RS-232C
power supply	5V/1.5A, 24V/1A (for I/O)
Size	320(W) x 210(D) x 30(H)
I/O	DI : 32 (Isolated)
	DO : 32 (Isolated)
	AI : 16
	another DI : 8 (Isolated)

Control of N-DIM and PLCs

As shown in Table 2, N-DIM has a CPU on it and the CPU has about thirty kinds of the original control commands and their programs. Any computer can communicate with N-DIM through TCP/IP and UDP/IP. Thus, we have developed the software to control it with the control group of KEK since last summer and it has almost completed [4]. Some new type records were created to suit for the N-DIM commands such as 32-bit MbbiDirect record, 32-bit MbboDirect record, the record to receive a 4-cloumn matrix data, and the record to store 32-bit binary data and 16 analog data temporary.

One remarkable feature of this software is that it can work both on EPICS base R.3.13 and R.3.14 by the common program. Thus, we newly introduced R.3.14 into the EPICS control system in this summer for R/D of the system. We installed it on a new server computer whose OS is Redhat 8. It is confirmed that N-DIM works in both systems by the same software except one part; that is for the mechanism of time out detection in a beam measurement. In the system of R.3.13, the watchdog timer of vxWorks is employed for it, thus, this part must be changed when we use it on Linux.

The Linux server PC controls nine N-DIMs installed in the new vacuum system in RILAC. Any communication troubles have not occurred under the condition that all N-DIMs are scanning their all DI/AI ports every 0.1 second.

The PLCs are also controlled by the Linux server PC. There are the switch box controlled by Yokogawa PLC, FA-M3, and the new RF system in RILAC controlled by Omron PLC, CS1. The software for the CS1 was prepared very easily by using that for FA-M3 as a template. As for N-DIM, the software was developed from scratch, since it adopts the ASCII code, which was not used in any other software.

In the RIBF, more than one hundred N-DIMs will be used to control the accelerator components. There are two candidates of their server computer in current status, the HP-UX server and Linux server. Advantage and disadvantage of both systems are followings;

Advantage of HP-UX server with EPICS R.3.13.8:

- Easy. Only adding another VME to the existing control network does the system extension.

Disadvantage of HP-UX server with EPICS R.3.13.8:

- When we add a new VME into the system, licence cost of the vxWorks is very expensive.

Advantage of Linux server with EPICS R.3.14.1:

- Cost-effective.
- It is able to construct independently from the current HP-UX system. In other words, plural control networks divided into control blocks can be existed in the system independently.

Disadvantage of Linux server with EPICS R.3.14.1:

- Hard to maintenance it. It is difficult to follow the high pace of its kernel version up.

We have to select it carefully by considering its ability, its stability and its future maintenance.

Database

The Oracle database in the existing EPICS control system keeps only the characteristic parameters of accelerators. The parameters obtained in a beam operation such as a current of a magnet are written only into files and stored in the server machine. To know such data easily without looking for a file, we decided to send the data to the database server in the CORBA system [5] for the magnet control in the RIBF. Since the RARF and the RIBF are not stand alone facilities, it is better to keep all parameters obtained from them in a common database server. The interface between EPICS and CORBA must be developed and we have started it since this fall.

REFERENCE

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