DESIGN OF CONTROL SYSTEM FOR SAGA SYNCHROTRON LIGHT SOURCE

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Abstract

A control system for SAGA Synchrotron Light Source has been designed. The system consists of PC-IOC with off-the-shelf IO devices, console computer, and network. Industrial IO device, FieldPoint (National Instruments) and PLC with Ethernet module (Yokogawa, FA-M3) will be employed as the off-the-shelf IO devices. Ethernet channel access for PC, ActiveX CA, will be used for the network protocol. The server-client applications will mainly be developed by LabView. Field tests for prototype systems have been done in the KU-FEL Linac at IAE, Kyoto University and the storage ring TERAS at National Institute of Advanced Industrial Science and Technology (AIST). Those tests show that the system is suitable for a small-to-medium size control system.

INTRODUCTION

The SAGA synchrotron light source (SAGA-LS) is the light source, which is designed and constructed by a local Japanese government [1]. The construction has been started, and the main components of the light source will be installed during the year 2003. An important issue on this facility is its tightly restricted budget and, hence, the limited number of staff in the facility. Thus, the control system for SAGA-LS should be simple and robust, while inexpensive, easy to develop, maintain and expandable. The use of the off-the-shelf products and PC brings us a solution to this problem.

The PC control system is widely used in many facilities [2] because of a very high cost performance of PC. On the other hand, there are sophisticated and well-established control systems based on workstations, such as EPICS, which have been used in many accelerator facilities. Because a large number of hardware drivers and utility software are available for EPICS system, it is an efficient way to use those resources to design a control system. Since EPICS also runs on a PC-UNIX system, a PC-based EPICS system is one of the solutions. However, it is difficult to modify and expand the EPICS system with the limited number of the staff. Fortunately, the number of the control items of the SAGA-SL is about 500 and there are very few demands for real-time control. So, we designed a Windows PC-based control system which only uses the EPICS channel access (CA). There are many excellent works to develop CA components for the PC-Windows environment [3]. ActiveX CA [4] is one of such component. PC running the ActiveX CA server with off-the-shelf IO devices works as a PC IO controller (PC-IOC) [5]. Because the data communication protocol is EPICS CA, we can use the existing EPICS tools and, off course, in-house applications.

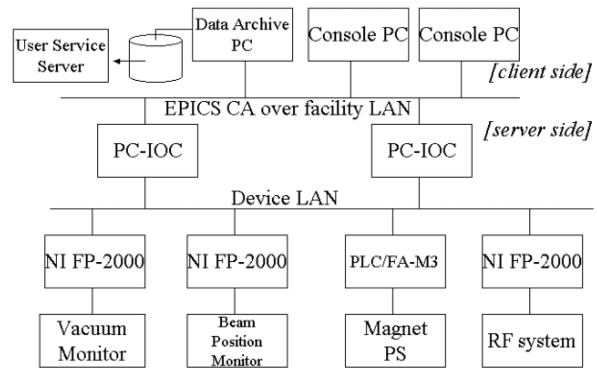

Figure1: Schematic drawing of the SAGA-SL control system

In this paper, we will describe the system design and the field tests of the prototype systems in KU-FEL facility [6] at IAE, Kyoto University and in the storage ring TERAS [7] at National Institute of Advanced Industrial Science and Technology (AIST).

SYSTEM DESCRIPTION

The system consists of PC-IOC connected to the off-the-shelf IO devices (CA server), console PC (CA client), and Ethernet LAN. Fig.1 displays the schematic drawing of the system.

PC-IOC

A PC with slot IO cards is a cost effective off-the-shelf IO device [7]. However, there are problems on this configuration: the reliability of the IO card is not so high, and that the system operator has to keep up with the speed of the update of version of the OS and the hardware drivers. So, we chose the industrial IO devices, because the industrial IO device is reliable, and the product lifetime is longer than the PC IO card. Recent industrial IO devices have their Ethernet modules, and this means that we can construct the IOC only with such off-the-shelf devices. Then, the control system will be free from the PC update problem. However, we put PCs between the console computer and the IO device because:

1) PC can be used to convert the IO device parameter into the physical one.

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2) PC can be used as a local monitor during installation and maintenance.
3) PC works as the IOC for GPIB and non-Ethernet devices.
4) The device LAN should be separated from the facility LAN to secure the network.

FieldPoint (National Instruments) is a candidate for the IO devices, because of its reliability and hot plug and play operation. While a severe real-time control is not required for the SAGA-LS, a synchronous control is required for the magnet control of the storage ring during the energy ramping. We will use FA-M3 PLC (Yokogawa Co., Ltd.), which can perform the preloaded ramping pattern via Ethernet command [8], for the magnet IO device.

There will be about ten Windows 2000 PCs for the PC-IOC that are equipped with ActiveX CA servers. The server applications will mainly be developed by LabView (National Instruments).

LAN

The data communication between the PC-IOC (server) and the console PC (client) is done via 100 Mbps LAN, which will be installed in the whole facility (facility LAN). On the other hand, the data communication between the PC-IOC and the IO device is done via 100 Mbps LAN which is locally wired in the machine room (device LAN). Thus, the PC-IOC acts as a gateway machine between two different LANs. The facility LAN is connected to the Internet passing through a router which protects the facility LAN from the outside. The SR users can get the machine status from a data archive system which periodically records the CA Process Variables (PVs). An intra-web server and web browser will be used to extract information from the database. Undulator user will be able to access to the undulator PVs, corrector magnets and tune correction quadrupoles.

Console PC

Since EPICS CA will be used as a communication protocol, both UNIX workstation and PC can be used for the console computer. But we will mainly use Windows PC which has high cost-performance and familiarity for un-trained operators. The ActiveX CA client will be used to access the PVs. Console applications are developed by LabView and some other GUI tools, i.e. Delphi, MS-Visual Basic. The data archive system, which records control parameters and delivers the machine status, will be installed in the system. MS-Access is a candidate of the system. A small look-up table, which stores the latest snapshot of the control devices, is also put in the database.

FIELD TESTS

The prototype systems have been tested in two accelerator facilities, KU-FEL facility and AIST storage ring facility.

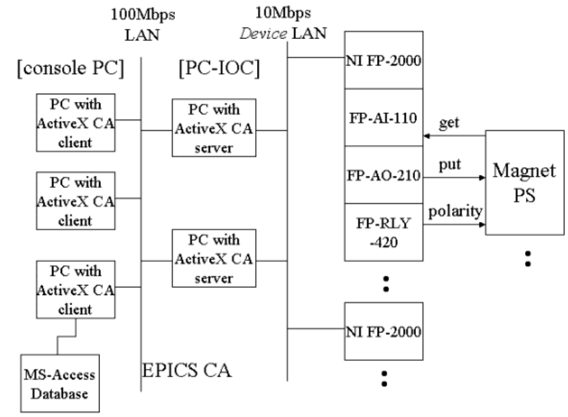

Figure 2: Block diagram of the IAE magnet control system.

KU-FEL facility

KU-FEL is a compact and economical FEL facility in the Institute of Advanced Energy, Kyoto University. The purpose of the KU-FEL is to establish Linac-FEL techniques for industrial and to explore new application fields especially in advanced energy science. The machine is under construction, and the electron beam of 20 ~ 40 MeV will be provided by an S-band linac with an RF gun in this year. A control system using the ActiveX CA has been developed as a prototype system of the SAGA-SL. The system has been installed on a gun cathode, magnets, and vacuum monitors. The block diagram of the IAE magnet control system is shown in fig.2. FieldPoint Ethernet modules (FP-2000) and analog AI/AO modules (FP-AI-110/AO-210) are used as the IO devices. Relay modules (FP-RLY-420) are also used for polarity control of the steering magnets. The number of PVs is about 100. The PV server and PV client applications have been developed by LabView. The 'PV get' frequency of 4 Hz and 'PV put' frequency of 2 Hz are easily achieved by using 200-300 MHz Windows machines connected to 10 Mbps LAN. The maximum transmission rate is almost 250 Hz for one PV channel. These response is enough fast for the daily operation. A data archive system has been installed in the system, and MS-Access database is used for this purpose. LabView database connectivity tools add-on is employed to archive the PVs. The historical trend charts generated by MS-Access are available on any network PCs. The look-up table which shows the latest control parameters for the magnet is also drawn by the MS-Access database.

AIST storage ring TERAS

The storage ring TERAS at AIST is a small synchrotron radiation source. Electron beam is injected by a 300 MeV linac. The storage ring is operated from 200 MeV to 800 MeV depending on the user's request. The electron orbit is sometimes tuned to fit to a specific operation mode. The PC based distributed control system has been

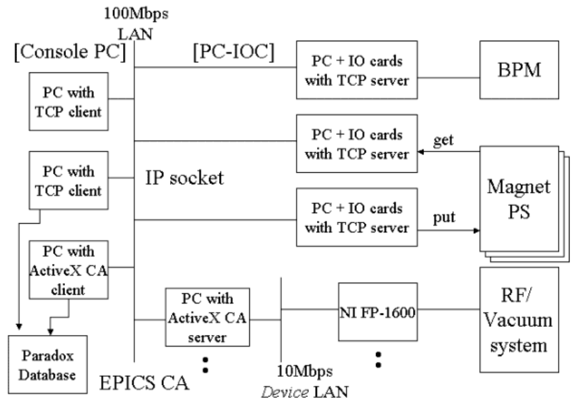

Figure 3: Block diagram of the AIST control system at the present stage.

developed [6]. The system consist of PC-IOC, console PC, and LAN. Figure 3 shows the block diagram of the AIST control system. The PC IO card, which is directly inserted in the PC expansion slot, is used for the IO device. IP socket is used for the client-server communication protocol. Because the system has been developed since 1997, several PCs are already out of date. We have to re-calibrate the DAC and ADC on PC IO cards when they are replaced, because low-cost PC IO cards do not certify the AD/DA values, and that process affects significantly the accelerator operation. So, we upgrade the vacuum monitor, and the RF control system using FieldPoint modules. AcitiveX CA system has also been tested for the data communication between the server and the client. Two PC-IOCs have been installed with two FP-1600 Ethernet modules. The RF control system has a feedback loop to stabilize the intra-cavity RF power. The updated control system works for 5 Hz feedback-loop which is fast enough for a stable operation of the storage ring. The vacuum monitor runs in 2Hz updating frequency, which is also fast enough for a practical use. A PARADOX database has been used for the original control system because the applications were developed by DELPHI. Since the ActiveX CA is also available in DELPHI, we continuously use the PARADOX for the data archive system.

CONCLUSION

The control system of SAGA-SL has been designed. We will be able to develop a simple and robust control system with a reasonable cost by using ActiveX CA component, LabView programming environment, and industrial IO device. Easy development, maintenance, and expansion of the control system, will also be achieved, at the same time. The total number of control items will be about 500, and most of them do not require the severe real-time control. Thus, the system consists of PC connected to off-the-shelf IO devices (PC-IOC), which communicates via EPICS CA, console PC, and Ethernet LAN. The prototype systems, which consist of the ActiveX CA and FieldPoint, have been tested in IAE Linac and AIST storage ring. The result of the system test shows enough performance in each facility. So, we will try to use this configuration in the commissioning of the SAGA-SL. However, we will need further tests and discussions about the communication protocol and the database system for the routine operation of SAGA-SL, because the number of the control items is larger than that of these two test facilities. We tried another approach, OPC (OLE for process control), to the network communication. OPC is widely used in industrial field [9]. FieldPoint and FA-M3 have ready-to-use OPC server and we can access to the device directly from network. In a preliminary test of the OPC server with LabView client, we found a very smooth response between them. The other candidate is TACO developed in ESRF [10]. Several accelerator facilities adopt the TACO system [11] and one can develop an appropriate system with the common control resources.

The authors would like to thank H. Nishimura (LBNL) for his helpful advises on this work. A part of this study was financially supported by the Budget for Nuclear Research of the Ministry of Education, Culture, Sports, Science and Technology, based on the screening and counselling by the Atomic Energy Commission. A part of this study was also financially supported by the Budget for the 21st Century COE Program (E-3) of the Ministry of Education, Culture, Sports, Science and Technology.

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