EXPERINCE OF DEVELOPING BEPCII CONTROL SYSTEM

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Abstract

The project of upgrading the Beijing Electron Positron Collider (BEPC) to the BEPCII was started in 2001, and the goal is to reach a higher luminosity, $1*10^{33}cm^{-2}s^{-1}$. The BEPCII control system has rebuilt with EPICS, which has 20,000 channels and about 30 VME IOCs for equipment controls. The control system was put into operation in November 2006, and system construction has followed its schedule and finished on time. This paper describes what we have done, the experience and lessons of developing the system, including design considerations, selection of standard hardware and software, build of the development environment, people training and collaborations.

INTRODUCTION

The BEPCII project is for upgrading the BEPC and the luminosity will be100 times than the BEPC. The BEPCII is designed as micro-ß plus multi-bunches with double rings schema and adopted super-conducting equipment, which serves high energy physics and synchrotron radiation experiments. The project was started in August 2001, and the first beam was stored in the storage ring in November 2006 using normal magnets in IR region. Recently the e+/e- beams have successfully collided with 20 bunches and 100*100mA beam current in each ring and the machine was run in synchrotron mode several months with beam current 250mA at 2.5GeV energy.

The BEPCII consists of a 1.55-1.89 GeV injector Linac, two transport lines and 1.0-2.8GeV Storage Rings. There are 1900 devices should be controlled and about 20,000 channels in control system. The BEPCII control system adopts distributed architecture and it was developed with EPICS. The event timing system is to synchronize all the relevant components of the BEPCII.[1] The figure 1 shows the system architecture.

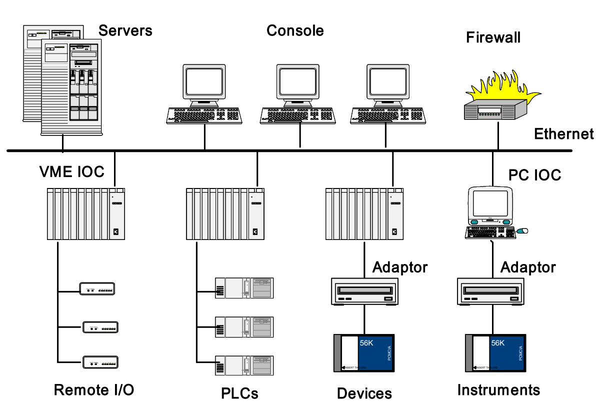

Figure1 Architecture of BEPCII control system.

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Since 2001 we went through the design stage, R&D stage and the system development, installation, test and commissioning stages, the system was put into operation in November 2006 and recently it runs well.

SYSTEM DESIGN AND DEVELOPMENT

The BEPCII control system has to be delivered on time within its budget, and it should meet the requirement of accelerator physics. From designer's viewpoint, the following design philosophy should be considered, including adopting the distributed architecture, using commercial products as many as possible, selection of standard hardware and software, considering system extension and the cost-performance etc.

System Integration

To develop a control system, the system integration tools should be used. Currently there are many comercial SCADA products in the world market and most of them are running on the PC and Windows platform, which mainly support PLC hardware. The EPICS provides the software architecture and many development tools, which was first developed by LANL and ANL and now is widely used in the accelerator area. After evaluation of the SCADA products and EPICS, the BEPCII selects EPICS to build the control system. The benefit of using EPICS is that it is an open source and strongly supports the VME hardware and we are easy to get technical support from HEP institutes in the world, especially the high level applications for accelerator commissioning could be shared. The some kinds of SCADA products are used for cryogenic control and beam line controls.

Standard Hardware and Software

The standardization is very important for the system development and maintains, [2] and we should select standard hardware and software as early as possible. During the design stage we spent a lot of time to learn the control system of world accelerators and investigated the market for hardware and software products.

For the host computers, we have chosen SUN V880 cluster as the EPICS boot server, NFS system and high level application compute engine. Two PC servers serve the Oracle database and data archiving. The console was build with SUN blade 2000 workstations and Linux PCs.

In the hardware side, BEPCII has chosen MVME5100 as EPICS IOC, adopts Cisco C4506 series products to build control network, which is a redundant system. The AB-PLC ControlLogix5500, ControlNet are used for Cryogenic and vacuum controls, after comparing the Simens PLC, Profibus and CANbus. The major reason to select AB products is that has a high quality and there are EPICS communication drivers for both of VME-PLC adapter and Ethernet with a good support from EPICS world, when we design the system.

Considering the software standard, it is complex. We have spent a time to select the EPICS version and its development tools, as well as the third party software. The SUN Solaris 8 and Linux Redhat 9 are for host machine, the VxWorks 5.4 reai-time operating system is chosen for VME IOC. Crrently EPICS BaseR3.13.8 are installed in VME IOCs, and EPICS BaseR3.14.7 running on Linux PC IOCs.[3] The EPICS provides plenty of toolkits for system development, we have to select some of them to build our control system. Many discuss have been made with experts from overseas laboratories. Finally we adopt EDM, VDCT, SNL, Tcl/Tk, Channel Archiver, ALH, Cmlog, Prob, Striptool as the standard tools to develop BEPCII control system. The NFS and CVS are for files and application management. DESY's Archiver Viewer and e-logbook DESY-IHEP are also used in BEPCII commissioning. The history data are stored in Oracle database. The record naming convention of database and GUI standard have been defined before the system development.

The high level applications for BEPCII commissioning were considered to transfer from another HEP laboratory for the limited man-power and tight schedule. We have discussed the issue with people from SNS, KEKB, APS, PEP-II, in year 2001 and 2002. At that time the XAL of SNS was under development, the PEP-II applications are based on VMS system, and SDDS of APS is mainly for synchrotron radiation facility. The KEKB is a collider machine which is similar as the BEPCII, so we decided using SAD environment and transfer the high level applications from KEKB first, then modify it and write new code to meet the physical requirement of the BEPCII.

Adopting Advanced and Mature Technology

The accelerator control system is a complex and large-scale system, which deals with variety of technologies and it should has a long life cycle. So we have to consider using advanced and mature technologies in our system to ensure the project successful.

For example, we have built the event timing system based on EVG/EVR 200 modules, which is following the experience of APS, SLS, SSRF and Diamond light sourse. Another example is the interface of power supply controls. Originally, there are several plan could be selected, such as the embedded processor, VME IP modules, and PSC-PSI interface for power supply control. We have built the test bench for the different plan. Finally we have adopted the PSC-PSI mode, which is advanced and it follows SNS and BNL's design.

User Requirement

The BEPCII control group was organized in September of 2001, and the first thing is make user requirement. The control group have sent the working sheet to other groups or divisions, and asked them make user requirement with together control people follows the outline and the device-signal forms. We have discussed the issue with the accelerator physicists, equipment engineers, operators who are working on the design of accelerator and it's sub-systems, including the functionality of the control system, devices working mode, system data (number of devices and channels, requirement of response time, accuracy and stability etc.), timing and synchronization requirement, operator interface requirement and EMI issue and so on, so that the system design could be meet the requirement of the equipment control and machine commissioning.

To finish the work on time, we have arranged contact persons who are from both control group and equipment groups. They work together and exchange ideas so that they could understand each other and know what should do and how to do it.

At same time, we have proposed a database and device naming convention and discussed with our users, which is very important for system development and maintains.

Interface Definition

During the design stage, we have also made interface definitions between internal components and to other systems, such as physical detector and BSRF facility. The duty partition for each group or division needs the help of project leaders. Both of user requirement and interface definition is the base of system design and cost estimation.

R&D

The purpose of R&D is to build a prototype system, solve key technology and select hardware interfaces. The prototype consists of a Sun Blade 2000 workstation, VME-64x crates with PowerPC750 IOC and different I/O modules. On the prototype, we have set up an EPICS environment and have developed all of I/O drivers and communication drivers that the BEPCII need, including the I/O drivers of VME IP module IP235-8, IP330, IP440 and IP445, PSC-PSI driver for power supply control, VME-ControlNet driver for PLC control, VME-CAN bus driver for linac control and VME-RS232 driver. Some of these were downloaded from EPICS web site and were modified to fit BEPCII hardware.

We have also built two prototypes for power supply control. One is use of the PSC (Power Supply Controller) and PSI (Power Supply Interface) modules, another is with VME IP modules and both of them have been tested with individual power supply to compare the cost and performance. A SAD environment was installed on SUN Solaris during the R&D.

Construction and Test

After one year R&D, the system development has been started in January 2004, including the host computer system and its services, networking, timing system, machine protection system and sub-systems of power supply, vacuum, RF, cryogenic controls.

Firstly, we built the sub-systems in laboratory and made the off-line test and on-line test with individual devices, such as a set of power supply, vacuum gages, pumps in Laboratory. In the spring of 2006, all of equipment moved to the BEPCII site and have been installed. After test the sub-system locally, we started to integrate and test whole system in central control room, including start up control system on central console, accessing remote IOCs, debugging applications, test data logging, alarm handler, GUI applications and machine protection system. Then we have fixed all of software and hardware configurations, save IOC database and applications. In November 2006 the BEPCII control system put into operation successfully.

MANAGEMENT ISSUES

People

In the beginning of the BEPCII project, we short of man-power and most developers are young people who were just got their Bachelor or Master degree. So training the young staff became an important task. The major effort is provide EPICS training for them. Two Asia EPICS Seminar were held at the IHEP, Beijing, which was hosted by IHEP and KEKB, on the meetings there are EPICS training courses and we also hosted an EPICS training course with Chinese language. More than 150 people attended the training courses, our young staff have learnt EPICS. Except the training course, we have sent 12 young people go abroad working at KEKB and DESY to learn EPICS for 1-3 months each. To spread the EPICS in China, we have translated most of EPICS documents to Chinese language, including IOC reference Manual, Record Reference Manual and user manual of MEDM, ALH, VDCT, Burt, Channel Archiver, Python, Tcl/Tk etc. We have built a Chinese EPICS Web page at IHEP, so that our colleagues could learn EPICS easy.

During the project development, we have discussed the progress and technical problem on the group meeting, and we also discuss young people one by one to find problem and give them advices, so that the development could be on schedule.

Collaborations

There are many HEP laboratories have good experience to develop an advanced control system. We have made effort to communicate with them and built collaboration relationship. Science 2001 we have invited more than 20 experts from overseas laboratories to discuss the system design and development issues, which is very helpful for us.

The collaboration between KEKB and IHEP control group went through 10 years. Except exchange visit scholar, KEKB gave us many help, they provided us the most of source code for accelerator commissioning, which have speeded development of the BEPCII control system.

The BEPCII cryogenic control system is a first system in accelerator field of China and we have no experience to build this kind of system. It is too bad for the tight schedule, and we have to build the system in half year. The DESY cryogenic control group gave us valuable help. They gave us many advices when the system design and construction, translated source code to us including new PID record of IOC database. [4] Finally the cryogenic control system has been done on time with high quality.

We also collaborate with the domestic laboratory SSRF, when we develop the timing system. The expert of SSRF suggested us to adopt the event timing system in the BEPCII, and they lent us EVG/EVR modules to build a prototype, we learn each other to developing the timing systems.

Any way, the overseas and domestic collaboration is very important for succeed of the BEPCII control system.

LESSON

For the reliability and maintenance reason, the number of device type and protocol should be reduced in a control system. Unfortunately, there are two kind of PLCs are used in cryogenic control system. One is Siemens PLC S7 with Profibus and WinCC to control compressors and turbines, which was developed by Linde company, the other is AB-PLC, ControlNet and EPICS system for valve box, tanks, dewars and cooling pipes control developed by IHEP. The problem is data exchange between the systems and it increases the maintenance cost. To solve the problem we have to develop a communication driver between WinCC and EPICS.

The reason for this is the communication was lacked between cryogenic group and control group, when the contract was discussed with Linde company. The lesson is the control people should pay attention to every part of controls even for sellers developed systems, to insure uniformity of whole control system.

SUMMARY

Since September 2001, the BEPCII control system has gone a long road for system design and construction and it is successful with good quality and reliability, which contains our painstaking effort. Thought of what we have done, the major experience includes following concept of software engineering and adopting EPICS to build the system, using standard hardware and software, good collaboration with overseas and domestic laboratories and adopted their advanced and mature technologies. The team and staff training are also very important for system construction.

The author would like to thank all of our colleagues in control group and the people who gave us many help during the system construction.

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