THE SSRF CONTROL SYSTEM

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Abstract

SSRF(Shanghai Synchrotron Radiation Facility)[1] control system is a large hierarchical standard accelerator control system based on EPICS[2]. The VME 64X system, special embedded controller and PLCs are used for low level devices control or interlocks system. Using a uniform 1000Base-T backbone redundancy control network instead of field bus for mostly device controller with VLAN technique adopted and integrated with EPICS using soft IOC. Digital technology such as digital power supply control system, new event timing system and digital phase control system are used and also integrated with some embedded EPICS IOC[3]. An uniform System development and run time environment of hardware and software is adopted at the whole process. The high level physical application environment using MatLab 2007a with Accelerator Toolbox (AT) & middle layer[4] with MatLab CA (Channel Access) connected component MCA/LabCA. The high level physical application can be integrated with the control system easily and conveniently. With the SSRF centre database, an enhanced distributed archive engine based on RDBS with native XML data type is been testing.

ENVIRONMENT

The development and runtime environment of control system have been set up and used during the procedure of construct and runtime. It composed with the network system, server system and OPI system. A uniform user account system with single sign-on technical is used and the developer or operator can login in on any terminal and share resource.

Control System Network

SSRF using the 1000Base-T control network instead of field bus for mostly device controller, like the PLC and lot of serial based device (using protocol translate: serial to Ethernet translator), most of devices are connected by the control network directly and integrate with EPICS using soft IOC. The backbone redundancy design is adopted to ensure the network reliability with 2 sets of 3 layers main switches. At the access layer, only one type of 2 layers 48 ports switch is used and all the devices are connected through it directly. Various sub systems are running on individual subnet that separated by VLAN (Virtual Local Area Network) and can flexible division and recombine on demand. Figure 1 show the schema of control system network.

Uniform Running and Development Environment

An uniform development environment which base on PC Linux system has been set up for the system development and operations. All of the OPI and the server system are running the fedora 7 and supply the EPICS development and high level physics application environment. NIS and NFS server are used to manage user account and share resource. As part of runtime environment, the database server, boot server, Soft IOC server and EPICS application server such archive and alarm handler are installed at the server room. In order to supply a more stable environment, the server system will move to virtual machine system at summer of this year.

Several versions (from v3.13.x to v3.14.8.2) of EPICS base with cross-compiler support are installed in the runtime environment and the base 3.14.8.2 is confirmed to use at end. Except the Linux-x86 architecture, the mainly target machine we used is Motorola VME5500 and GE7050 which is defined in EPICS as architecture of ppc-604_long.

Also in this environment, the EPICS extensions have been installed includes all the tools we needed. In fact, we install all the EPICS tools like sequencer, ALH, EDM, MEDM, archive engine and so on. Developer can use to development all their applications. A standard directory structure of the entire environment is defined for all users. like "/usr/local/epics/base-3.xx.xxx" for epics base, "/opt/matlab" for the MatLab.

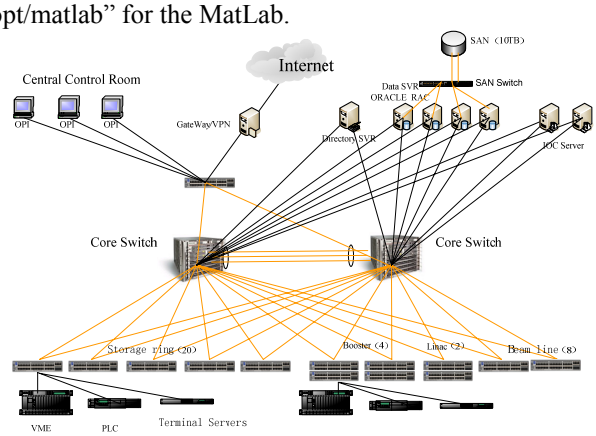

Figure 1: Main layout of control system network.

OPI System

SSRF use EDM for the machine operator and use Matlab version 2007a, Accelerator Toolbox (AT) & middle layer AT for high level physics application. As descript in the section of environment, all the OPI run on the LINUX Fedora 7. The EDM file store on NFS file server and all clients can access it by a start script.

STATUS

The control system is consisted of three parts: 150MeV LINAC, 3.5Gev Booster and Storage Ring sub system with one set of control system environment. The VME 64X system, special embedded controller and PLCs are used for various low level devices control or

interlocks system. Terminal servers were used to connect serial devices and instrumentation to the Ethernet. For reduce the cost and easy to manager, we use centralized IOC server to integrate all of the devices that based on Ethernet. Different soft IOCs can running at a same PC rack server in server room and can managed by a multi-IOC runtime manage system. As yet, the control system has been delivered for operation and works fine.

Table 1 show the IOC and PVs of main sub system. Include hard IOC(VME) and soft IOC(PC Rack Server)

Table 1: IOC List

System	Device	IOC	PV
Power supply	800	26	65000
Vaccum system	730	5	29200
MPS system	25	3	15111
Timing system	16	16	540

Hardware System

For convenience reason of the system management and maintenance, control system hardware system adopt a unitary design, as typical implementation of SSRF control system, it have:

- VME 64x System using GE VMIVME-7050 and Motorola MV5500.
- PLC system: Yokogawa FM3, SIEMENS S300.
- Serial port server MOXA NPort-5610.
- The embedded controller: digital power supply controller, MOXA UC7400.
- VME-EVG-230, VME-EVR-230, EVR-TTB-200, EVR-OTB-200

Software System

The SSRF control system running on EPICS base 3.14.8.2. At OPI part, EDM and some script by Python are used. For high level physics application, MatLab with Accelerator Toolbox (AT) & middle layer is adopted. Runtime data archive system use RDBMS for data storage and data management. For improve the write bandwidth of the database, we using the distribute archive engine and Oracle RAC and Partition technique. The archive engine using native XML data type of database with XML schema for the storage. All the data can be access by the Web Service data access interface. This platform independent data analyse interface can be called by windows client, LINUX client, MatLab and script like python. Now it was already done and in testing process.

Centre Database System

SSRF use Oracle 10g centre database to store the machine parameters and reference information for all stage of machine simulation and running. The database system support access and set various accelerator run time configure parameters, failure report and invalid record of all system. It also store data of accelerator at runtime using channel archive system and can be used for analysis by a stand data access interface. The centre database system integrated with a uniform authentication system, uniform database access rule and data integrity. Remote access from Internet and web based database access also could be applied. The hardware platform use SAN storage system & database server cluster.

DEVICE CONTROL

Device control system in SSRF include mainly are listed below: the power supplies control, vacuum system, injection/extraction system, timing and MPS system and insertion device control.

Digital Power Supply Control

There are over 800 magnet power supplies (PS) in the Storage Ring, Booster, Linac and Transport Lines. For the requirement of control precision, reliability and stability of the magnet power supplies, digital PS control system was used. The typical resolution reaches 1ppm to 10ppm with long-term stability, reproducibility is better than 30ppm. There are two kinds of digital control cards are used: the PSI digital power supply controller[4] and digital power supply controller in house designed. Each PS has a local digital controller and an optical link. The VME-based front-end consists of a GE VMIVME-7050 Single Board Computer, IP carriers and Industry Pack (IP) I/O modules. With EPICS device/driver support routines, runtime database records in the IOC are triggered to process to read parameters from the PS controllers and write settings to the PS controllers.

Vacuum Control System

There are above 730 vacuum device installed at the whole machine. VARIAN Multi Gauge. JJJvac Sputter Ion Pump Power Supply, Vacuum Valve, RGA（Residual Gas Analyzer）, except Vacuum Valve, all of these device are serial port based, the MOXA serial to Ethernet translate be used for serial device and using Soft IOC. All of the vacuum device data can refresh at 10Hz rate.

Timing System

We adopted a new event timing system refer to APS event system, SLS and Diamond timing system. Compare with the traditional timing system, it have obvious advantages:

- Structure is simple used broadcasting method
- Low Jitter with distributed RF clock
- It can be run on the EPCIS environment
- Easy to extend

Now the system integrated with EPICS system is running well for the Linac, Booster and Ring. The figure 2 show the timing system distributed network structure. Timing triggers have been success used for whole machine with low jitter and precise control include e-gun of Linac, kickers, septum and ramping power system of Booster, beam diagnostic system of Ring.

Currently, SSRF timing system can satisfy for all of machine operating modes. The operating status of SSRF timing system proves that event system is a reasonable

selection for timing system. We also developing this timing system integrated with a new data transfer function, Up to now, a new digital timing system with data transfer and hardware timestamp function have been finished in SSRF.

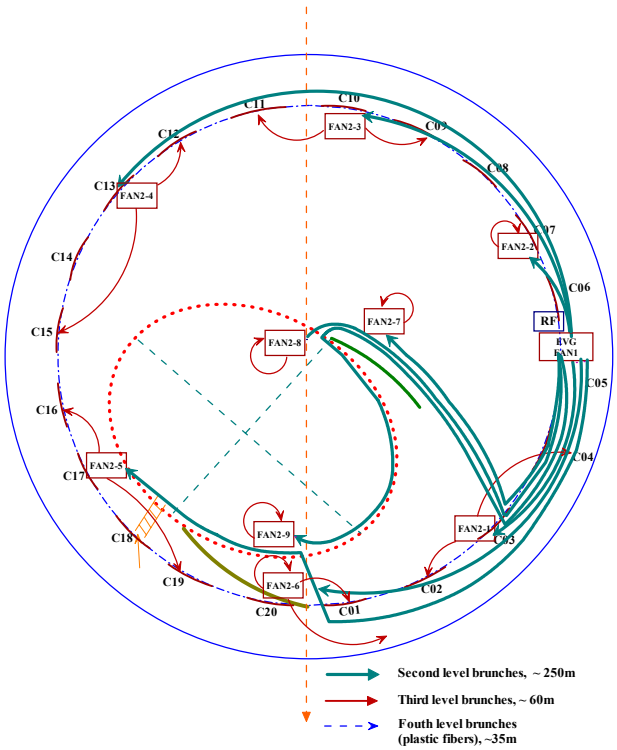

Figure 2: Distribution network of SSRF timing system.

MPS system

SSRF MPS system implement with a PLC system that composed with 25 sets of Yokogawa FM3 PLC. In order to ensure the reliability of MPS system, all the interlock logic run at PLC layer and integrated EPICS for monitor and event record using NetDev[6]. The whole system has 4 layers: Accelerator system layer interlock, Sub collectivity layer interlock, system layer interlock and device layer interlock.

It is easy to achieve a total response time of 30 milliseconds by using three layers of FA-M3R PLC to construct machine protection system, and we also develop a new FPGA based controller for the fast interlock requirement.

Insertion Devices system

There are five inserting devices at first stage in SSRF, including two In-vacuum undulators(IVU25), one EPU(EPU10) and tow wigglers(W80 and W140), have been assembled and on commission in SSRF since Feb.2009. The main parameters are listed in table 2.

Table 2 The main parameters of the IDs

Parameter		IVU25	EPU10	W80	W140
Period length	(λμ)	25	100	80	140
Number of periods	80	42	19	8	
Peak field (T)	0.94	0.6	1.2	1.9	
Minimum_gap	6	30	13	13	

The control systems of these IDs have been divided to two parts: the local and remote controls. The local control parts are accomplished with Simens PLCs to implement motors driving, device interlock and local operator interfaces. About upper layer control, we adopted a kind of embedded EPICS controller to implement the control of correction coil power supplies and PLC. This embedded EPICS controller is based on a commercial Ethernet/Serial converter which running MontaVista Linux as its operation system. Beyond this, EPICS IOC Core program and several kinds of device control drivers were integrated to it. The reliability and performance of this system have been proved good and well suited to our requirements.

CONCLUSION

SSRF control system is large scale(120K PVs over 3000 equipment to be controlled) real time control system running on high interference environment with high reliability and stability over 2 years in success. We set up a distributed controls system based on EPICS. In general, all of function of control have been reached on design goal, The SSRF control system adopted and integrated various advanced digital processing system (such as digital power supplies controller, digital BPM module, digital timing system, digital phasing control etc.) which effectively improve data measuring accuracy without interference. Equipment standard take whole system become more simple and easy to maintain. The precision data are available at beginning of commissioning SSRF at once, so that we save commissioning time.

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