THE DESIGN STATUS OF CSNS EXPERIMENTAL CONTROL SYSTEM*

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Abstract

To meet the increasing demand from user community, China decided to build a world-class spallation neutron source, called CSNS(China Spallation Neutron Source). It can provide users a neutron scattering platform with high flux, wide wavelength range and high efficiency. CSNS construction is expected to start in 2011 and will last 6.5 years. The control system of CSNS is divided into accelerator control system and experimental control system. CSNS Experimental Control System is based on EPICS architecture, offering device operation and device debug interface, communication between devices, environment monitor, machine and personnel protection, interface to accelerator control system, overall system monitor and database service. The control system is divided into 4 parts, such as front control layer, local and global control layer based on EPICS, database and network service and the others. The front control layer is based on YOKOGAWA PLC and other controllers. EPICS includes local and global control layer provides all system control and information exchange. Embedded PLC YOKOGAWA RP61 and others is to be used as communication node between front layer and EPICS. Database service provides system configuration and historical data. From the experience of BESIII, MySQL is an option. The system will be developed in Dongguan, Guangdong province and Beijing. So VPN will be used to help development. Now, total 9 persons are working on this system.

INTRODUCTION TO CONTROL SYSTEM OF TARGET AND INSTRUMENTS

Neutron scattering becomes a more and more important method probe the structure of the microscopic world. In physics, chemistry, biology, life science, material science, new energy, as well as in other applications, Neutron scattering is the widely used as a complementary way to X-ray in advance research.

To meet the increasing demand from user community, China decided to build a world-class spallation neutron source, called CSNS(China Spallation Neutron Source) [1] [2]. It can provide users a neutron scattering platform with high flux, wide wavelength range and high efficiency. CSNS construction is expected to start in 2011 and will last 6.5 years.

The control system of CSNS is divided into accelerator control system and experimental control system. This paper introduces the design and some test work of the experimental control system.

OVERALL TASKS AND SYSTEM ARCHITECTURE

The main tasks of experimental control system includes: providing the global communication platform for the whole target station and instruments; providing global monitoring and database service; providing TPS(Target station Protection System); providing interface to the front end controls ; fan-out of T0 related signals to where needed; interface with the accelerator control system with their cooperation; coordinating the PPS work for the target station and instruments; local control tasks as required.

CSNS Experimental Control System is divided into global control layer (GCL), local control layer (LCL) and front end layer (FEL), as shown in Figure 1. Global control layer and local control layer are based on EPICS.

In Global control layer, network and database service are main task. Device control and TPS are dominated works for front control layer. Sub-system control is the main task of local control layer. All these are integrated in EPICS system.

KEY ISSUES AND TECHNICAL DIFFICULTIES

In Target and Instruments control system, some difficulties and key issues are focused on.

Stability and Reliability of the Key Path and Devices

Stability and reliability is the most important issue of control system. Control on key path is related to the whole system safety and availability.

To achieve this, system self-check is must. All sub system is required to have self-check ability, and the result of self check can be displayed on the central control room. All the status must be stored in database for historical display and trouble shooting in the future.

*Work supported by Institute of High Energy of Physics
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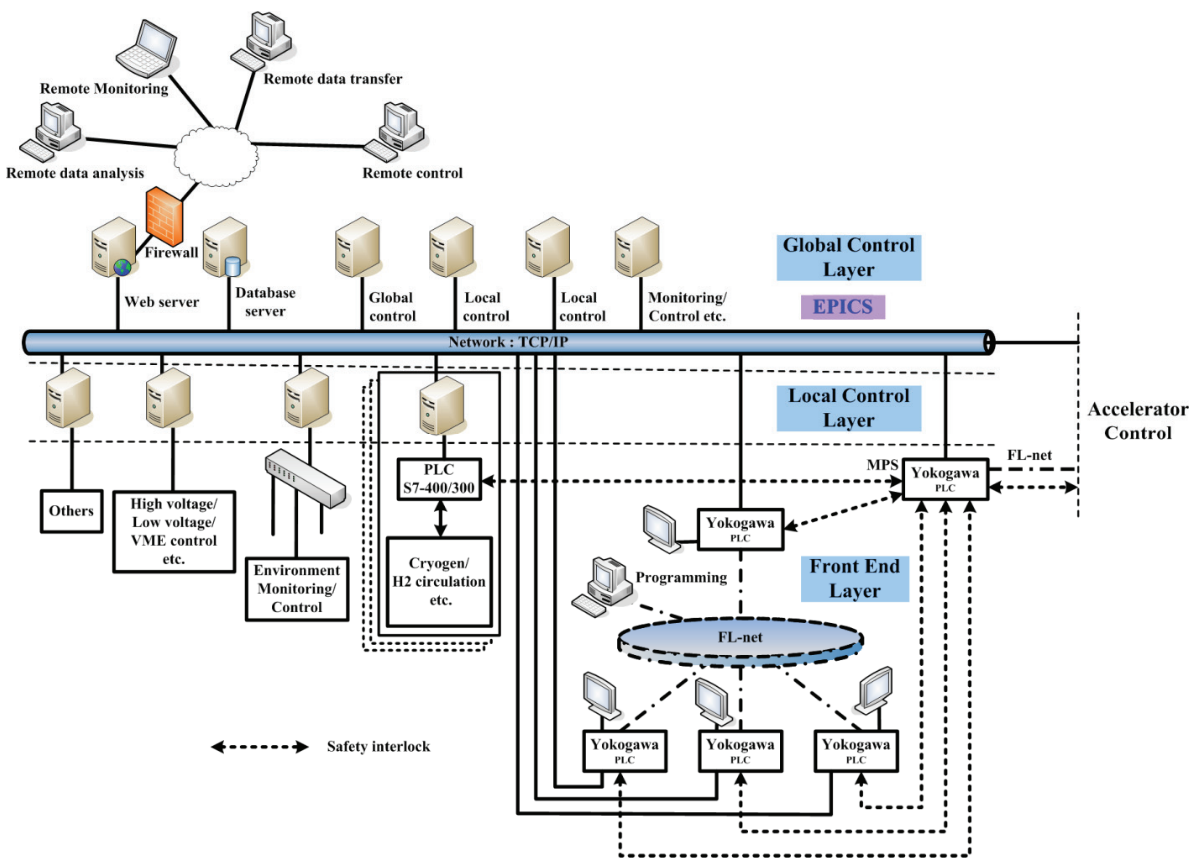

Figure 1: System Architecture.

System Scalability, Maintainability and Configurability

The experimental control system will run for several decades. For long term running, system scalability, maintainability and configurability are main issues that we should be focused on.

Budget

For any system, budget is always an important issue.

Interface with the Front End Control

In instruments, there are always many types of devices for different purpose. So, how to integrate all these devices to the whole control system is a big issue for us.

DESIGN AND TEST STATUS

Epics

CSNS experimental control system is integrated by EPICS control system. To guarantee the Stability and reliability of the system, software version control should be adopted. A software package called CCSP(Control Core Software Package) is created. CCSP includes some selected software, such as EPICS base 3.14.12, Control System Studio 3.0, and some other software. All these software are tested in the function test system to avoid bugs in software version mismatching as shown in Figure 3.

Three kind of IOC is considered to be used in CSNS experimental control system.

The embedded PLC F3RP61 from YOKOGAWA will be used as information exchange and control node in local control layer, between global and front control layer. A lot of test is done on F3RP61. Its performance and role in system is clear.

ARM based IOC will be used in environment monitoring for its low cost as shown in Figure 2. EPICS IOC test is done on a low cost ARM board based on S3C2440 CPU. The results show that illustrates the net performance of this kind board is limited. Graphical interface Qt is developed on this board. This IOC may be used in some device control, and information display.

Blade server or industrial PC is considered to be used as soft IOC to integrate other front layer device into system. Blade server can provide some virtual computers by virtualization software to achieve high reliability, availability and scalability. Soft IOC in virtual computers can provide high reliability data exchange between device and global layer.

Figure 2: IOC based on ARM.

A CA Gateway computer will be placed between experimental control net and accelerator control net to avoid net broadcast storm and increase security of whole system. The test of CA Gateway is also done in function test system, and the policy is decided.

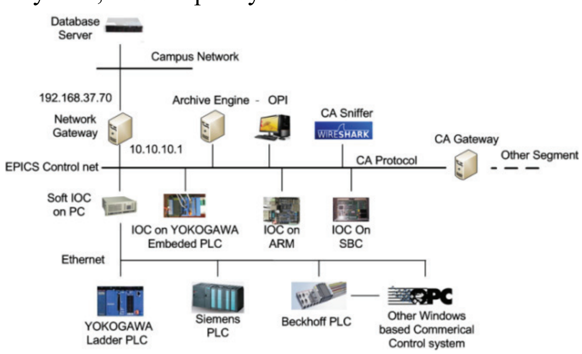

Figure 3: EPICS system architecture. In this figure, all components integrated into EPICS are shown.

Database and Network

MySQL is a choice for the experimental control system, according to its successful application in BESIII. The main advantage of MySQL is free. It can be easily to be developed in distributed environment to achieve database expansion, backup and accessing speed speedup.

Now, MySQL has been integrated into EPICS. Its functions and performance tested is in progress. A long term test and further study will be done next.

The control net spread in 80m x 80m experiment hall. Cables are routed in bridge along the wall. Fibers are used to avoided length limit and interferences Figure 4 shows the topology of the whole control net. Two redundant core switches in control room provide reliable net service. Access switches are placed closed to front device

Front Control

PLC from YOKOGAWA in Japan and Control system from Beckhoff in German are used in front control layer.

The two systems are also test in function test system, and have been integrated into EPICS system.

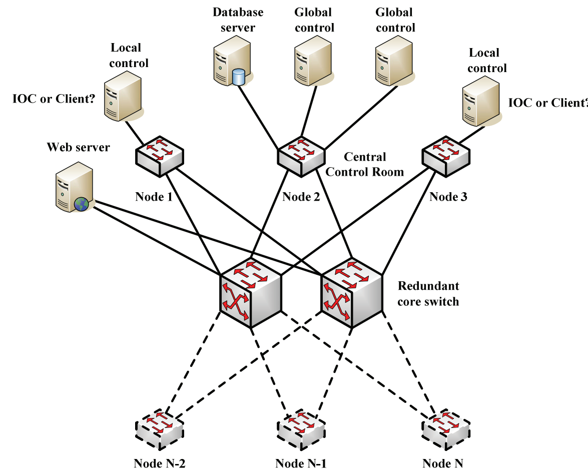

Figure 4: Global control net. The core switch is redundant to avoid shutdown of whole system. And links to core switch is also redundant. The failure of other switch only impact local sub-system.

TPS and PPS

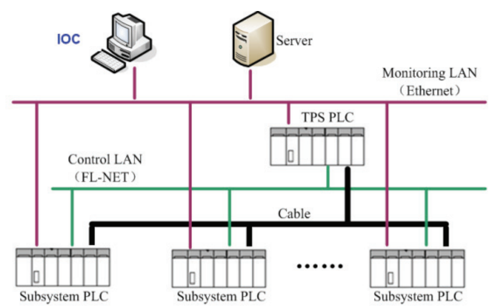

Figure 5: TPS architecture.

Design and technical study of TPS are nearly finished. Figure 5 shows the architecture of TPS. Key interlock signal is routed by hardware, and less important signals are communicated in FL_NET.

A function test system has been established with the heavy water control simulation involved in. A New developing system will setup in Beijing and Dongguan to fulfil the whole system development. Function test system will be upgraded to Beijing segment of the developing system. This function test system is shown in Figure 6.

EPICS software, network, database, archiving and others have all been tested in function test system.VNC, DNS and VPN are also tested which will help integrate the system in two locations into one system.

Function Test System

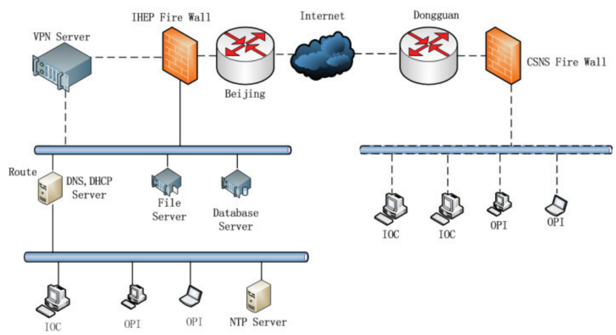

Figure 6: Structure of function test system now and future upgrade. Solid line means what we have already implemented. Dash line means the segment will be build when lab in Dongguan is ready.

Device Control

Some device level control is implemented by control group, which will be help the upper layer test and development. Figure 7 shows the sample platform in HIPD instrument. The platform is driven by 4 servo motors. Servo motors will be controlled by Beckhoff control system through 2 servo amplifier.

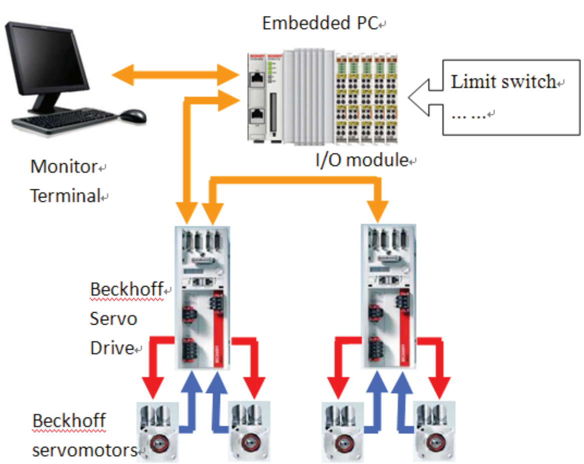

Figure 7: Architecture of sample of HIPD.

Sequence of Events Recording

For control system, sequence of event monitoring is useful for system self-check. On the other hand, sequence of events recording enables rapid root cause analysis after multiple events occurred. Sequence of events is therefore utilized as a diagnostic tool for trouble shooting and minimizing overall downtime. The system structure is shown in Figure 8.

XFC (eXtreme Fast Control Technology) modules from Beckhoff Company are used to build the sequence recording. A test result in Figure 9 shows that this system has a 1us time resolution with some dead time. Next, further study of sequence recording system to achieve higher time resolution to meet the requirements from T0 monitoring will be done.

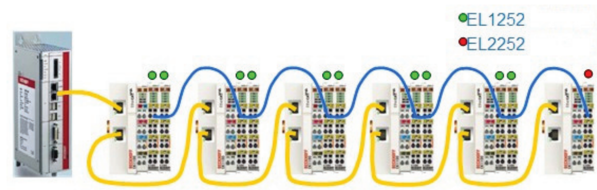

Figure 8: Time resolution test. EL1252 module sends a pulse and all EL2252 measure this pulse and takes a timestamp. The difference of these timestamp is the time resolution of the system.

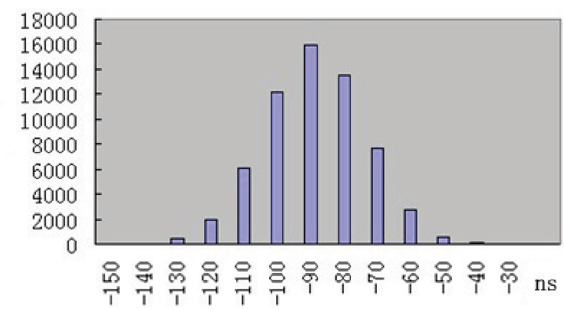

Figure 9: The time resolution of XFC module. X axis means the time difference measured on the same signal. Y axis delegates the sample numbers. The total sample numbers is more than 60,000. And this test also shows there is no big impaction of length of cable and sequence of modules.

NEXT TO DO

In the next two years, setup of the development system, a prototype system of entire CSNS experimental control system is key work. In this system, long-term stability and speed of MySQL; study of CSS and other tools in EPICS further; integration the device into EPICS; design of self-check and alarm system; design of fan-out system of T0 related signals; implementation of TPS and PPS will be done

SUMMARY

In the past, global control layer and some local layer design are finished. Some devices control is under developing now. The function test system is established. EPICS, front controllers and many other techniques have tested.

REFERENCES

[1] Wei Jie et al, China Spallation Neutron Source - an overview of application prospects , Chinese Phys. C, Volume 33, 2009.

[2] http://csns.ihep.ac.cn/english