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INTRODUCTION OF CiADS CONTROL SYSTEM

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Abstract

CiADS is a science researching facility, which destination is about energy Providence. The control system of CiADS will have more than hundred types of device, and include more than thousand equipment and sensors. Based on the background of researching and energy project, the control system should overcome two challenges. First is that building a open architecture to face the flexibility of changed requirement. the second is that the flexibility should as less as possible influence the checking result of nuclear law and standard by authority. To meet the requirement, the control system will be divided into 3 levels. Level 2 will provide the OPI, data analysis interface and simulation to all users. Level 1 provides implement of control and security logic. Meantime it will provide an engine and interface for collection and package of some reconstructed data. Level 0 will implement the local control and provide all data and information to other levels. The paper mainly introduces the architecture and some works to build the control system to make it to overcome the two challenges.

BACKGROUND

CiADS (China Initiative Accelerator Driven System) is a large scientific project. It consists of three parts: linear accelerator, spallation target and nuclear reactor. The facility is a complex system, that consists tens of thousands equipment. There are millions of status information, thousands of control points and automated or semi-automated control processes in the control system. As planned. The control system was completed and put into operation in 7 years.

THE ANALYSIS OF REQUIREMENT

As a normal control system, the requirement of CiADS can be divided into two levels. The basic requirements: real-time acquisition of all state information of facility and can remote control various devices. On this basis requirement, it is necessary to provide enough safety and reliability. In addition, the facility will work at complex and various operation modes, the control system needs to adapt and support it. Finally, the control system also needs to provide data and data analysis support to help the operators to achieve the research aims. The following is explained separately.

Basic Functional Requirements

In order to support the operation of the device, the control system needs to implement remote control and reading status information of all devices., which is the most basic functional requirement of the control system. In such a complex system, there are hundreds of different types of devices, which have different control parameters and different operational functions. To reduce the difficulty of system integration, the unified hardware and software interface should be adapted.

In addition, the timing system must be provided for synchronized device operations; the MPS system for protecting the accelerator and the security protection system for nuclear safety. These together constitute the most basic service of the control system.

The timing system. 1. Provide the Trigger signal to synchronize the output or action of the related equipment. 2. Provide time service to the entire facility to achieve strict synchronization of system time to the relevant device, so that the data or status collected by the relevant device can be analyzed and compared on the same time axis. The CiADS control system will use the White Rabbit technology to implement the timing system.

The beam of proton accelerator will be reached mA, and the energy is hundreds of MeV. In this case, a small loss of the beam will cause serious damage to the accelerator, so a machine protection is necessary. The Machine Protection System (MPS) provides the safety to accelerator, while not affecting the availability. How to balance the safety and availability is a challenging task.

As a nuclear-related facility, the control system also needs to equip a high-reliable safety protection system. This protection system is designed on the analysis of all possible nuclear safety accidents which mainly based on hardware system implementation is based on the facility [1]. The device also requires approval of the nuclear safety regulatory agency.

Operation Modes

During the installation, commissioning (step-by-step debugging) and operation, the entire device will face different operating modes [2]. These different modes will involve the parameters of the device, the protection threshold, and the configuration of the protection system and the operating authority. In order to meet the modes of the facility, the databases, device drivers, and applications

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should be used. And then, the design should abstract the equipment and mode and define a sufficiently complete and flexible interface. So that maybe can make it possible.

Archive and Data Analysis Support

As a research facility, in order to achieve the research goal, the collection and storage of the operating and status information is the basis task. For this reason, the control system needs to provide data storage and retrieval functions for this purpose. There are a variety of real-time requirements for each type, which challenges the design of the data archiving engine. On this basis, it is also necessary to provide the necessary platform and technical support for data analysis.

THE ARCHITECTURE OF THE CONTROL SYSTEM

In order to meet the requirements of control system, we need to do related design with software and hardware system. In the design, the architecture (included function block software interface; hardware interface and hierarchical design) must be carefully considered, so that to reduce the impact of changes in demand, because such researching facility is doomed to have many change.

The Design of the Hardware System

The control system interface to most devices is defined as the network interface and the fiber-optic network will be used for the system-level interconnection. In addition, the WR technical solution will be adopted for the timing system, and the Timing system service will be provided to the device through the embedded interface card. In addition, the control system has a unified hardware platform, which is based on PLC, it is used to get the basic temperature and flow valve; control switch; motor control and other functions. The framework of hardware is shown in Figure 1.

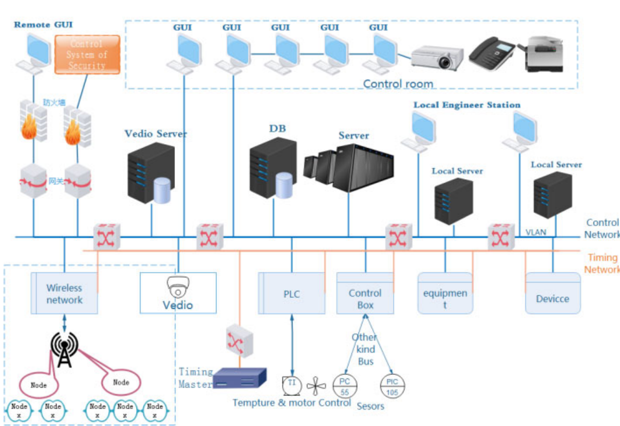

Figure 1: Control system hardware scope of view.

The Framework Design of the Software System

Based on such a set of hardware systems, the software of the control system will use the EPICS system. The control system will be divided into three layers. The view of the architecture is show in Figure 2. The bottom layer is the device driver layer, which is used to operate and read status information of the device, based on EPICS SoftIOC or embedded IOC. In addition, for the convenience of system integration, some software will also support device-level configuration and online software upgrade.

The second layer is the middle layer, which implements all automated or semi-automated control processes; real-time data acquisition and archiving; operation mode change, and modification; security management; alarm systems; physical process simulation and debugging software Support and so on. This layer is the core functional layer of the control system. To this end, it is necessary to standardize the modules and interface as much as possible in order to cope with the changes of subsequent requirements.

The top layer is the interface for all types of operators and management, and in most cases will be implemented by a variety of graphical interfaces. This includes support for data browsing and remote data support for nuclear regulators. This layer is the interface of the control system to the user. For this reason, the control system needs to design a set of GUI writing specifications to control the writing of the interface to realize a unified interface of style and operation mode.

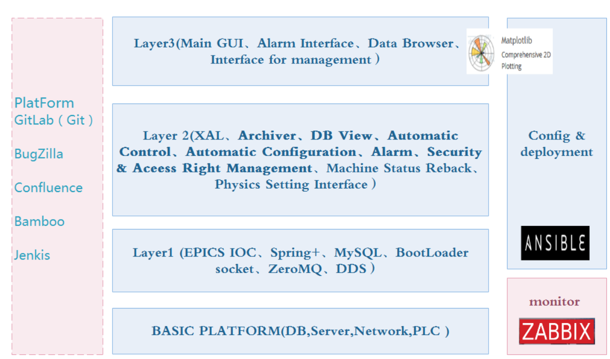

Figure 2: Software architecture of control system.

PROBLEMS AND CHALLENGES

Which Technology is Adopted to Realize the Modification of Equipment Configuration?

In order to help modify the operating mode and facilitate system integration, we need to implement dynamic modification of device parameters and configuration. The current EPICS system can only support a single data type in the V3 version, while the dynamic configuration and

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modification requires the configuration table of the structure type. To do this, the V7 version of the EPICS system or publish-subscribe technology like ZeroMQ may be used to implement such a function. This is a problem that needs to be carefully considered and tested in the next design.

Considerations for Test Environments, Test Packages, and Automated Deployment

As a huge control system, there is a huge number of device interfaces and device access, and a huge amount of code needs to be written or tested. If not fully tested, such a control system must not provide stable and reliable service to the relevant operators of the facility. Therefore, the control system must be tested rigorously and effectively, and the test here will contain the following main contents:

Testing the device interface to check whether the device interface program reads and manipulates the state according to a certain mechanism.

Testing the access of device to check whether every device is to be correctly controlled and read.

Testing of automated or semi-automated operational processes to determine whether the processes themselves operate in accordance with a defined process, and under abnormal circumstances, It will not do any operation that is not allowed.

Performance test to check whether all software systems or hardware systems with performance requirements meet the corresponding performance requirements.

Testing of the GUI, including tests of display, input and output, especially for some important operations and displays, to ensure that the program can run stably, the response of the program must be predictable and deterministic.

Such a series of tests must be done automatically, and each deployed program must be tested, and its own test set must be constantly refined and evolved.

SUMMARY

CiADS control system is a very large and complex system, the current design work is still only in the framework design stage, but has been faced with enormous challenges. Therefore, the design and construction of the whole control system need a lot of serious and meticulous work to achieve a relatively stable, reliable and friendly control system.

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