EPICS BASED VACUUM CONTROL SYSTEM USING ETHERNET MULTI SERIAL DEVICE SERVERS FOR PAL STORAGE RING

J. C. Yoon, J. W. Lee, J. Choi and S. H. Nam

Pohang Accelerator Laboratory, POSTECH, Pohang 790-784, Korea

Abstract

A vacuum control system has been developed for use Ethernet Multi Serial Device Severs (EMSDS) on the Pohang Accelerator Laboratory (PAL) storage ring. There are 124 Sputter ion vacuum pumps at the storage ring. It was a very important problem to solve the problem how to control such a large number of vacuum pumps distributed around the ring. The cost of interfaces is also a large problem. After discussions, we decided to develop a serial to Ethernet interface device sever that will be mounted in the control System Rack. It has a 32-bits microprocessor; Embedded Linux, 16 ports RS485 (or RS232) Slave interface, one channel 10/100BaseT Ethernet Host port, one channel UART Host port, and 8 Mbytes large Memory buffer. Evacuation of gases in the storage ring is done by control the current in the titanium filaments in the vacuum pump. These vacuum pumps are connected to Ion-Pump Serial Controllers, which chop the AC current so as to control the current in the pumps. The EMSDS connect either 100BaseTx or 10BaseT Ethernet networks to asynchronous serial ports for communication with serial device. It can simultaneously control up to 12 Ion-Pump serial controllers. 12 EMSDS are connected to a personal computer (PC) through the network. The PC can automatically control the EMSDS by sending a set of commands through the TCP/IP network. Upon receiving a command from a PC running under Windows2000 through the network, the EMSDS communicate through the slave serial interface ports to Ion-Pump Controller. We added some software components on the top of EPICS (Experimental Physics and Industrial Control System) toolkit. The design of the vacuum-pump control system is discussed

INTRODUCTION

The Pohang Accelerator Laboratory (PAL) is a 2-GeV third generation light source that has a 150-m long 2-GeV injector linac and a 280-m circumference storage ring. Its construction was completed in December 1994 and normal operation for beam-line users started in September 1995. The computer control system for the PLS 2-GeV storage ring has distributed control architecture, has three layers of hierarchy; operator interface computer (OIC) layer, subsystem control computer (SCC) layer, and machine interface unit (MIU) layer. The OIC layer is based on Sun Microsystems' SPARCstation with UNIX (SunOS 4.1.3) and X-terminals. The SCC acts as a data gateway between the OIC layer and the MIU layer. The MIU layer is directly interfaced to individual machine devices for low-level data acquisition and control. The SCC and MIU layer is based on VMEbus standard with OS-9 real-time operating system. Executable application software modules are downloaded from host computer at system start-up time. There are 4 SCCs and 24 MIUs. The MIU and host computer is linked through Ethernet (TCP/IP)[1]. The control system now shows very stable and reliable characteristics enough to meet our control requirement. However, the control system is continuously being upgraded to accommodate additional control requirements such as vacuum ion pump devices. Some parts of the vacuum system have been modified for easy access to a mobile pumping unit, and for quick and easy operation of a chamber bakeout process in the maintenance shutdown periods. Some of the cold cathode vacuum gauges have been replaced with Bayard-Alpert ion gauges due to the bad signal caused by either gauge head corrosion or breakdown. Some control requirements of the vacuum gauge controllers were changed when the undulator was installed at the storage ring. We use the EPICS tool kit as a foundation of the control system. The Section 3 briefly summarizes architecture of the EPICS and related topics. We developed a vacuum control system for use Ethernet Multi Serial Device Severs on the Pohang Accelerator Laboratory (PAL) storage ring. It uses MODBUS TCP as a communication interface and reduces cost and space of cabling for 120 vacuum ion pumps of the PLS storage ring. During the maintenance period, vacuum control system was upgraded. And control software was modified to support these changes. Application software for vacuum gauge & ion-pump device and operator interface software are being developed. The overall development of the EPICS based vacuum control system, field installation, and integration test will be completed by the end of January 2003.

SYSTEM CONFIGURATIONS

Vacuum system consists of 124 ion pumps, 36 penning ion gauge, 18 Bayart-Alpert ion gauges, 240 photon-stop temperature sense, and 15 gate valves. These components have their own local controllers are interface to the machine interface units called the VMMIU. Each of pump and gauge controllers has an RS422/RS232 type serial communication port. Each of gate valve controllers has a relay type I/O port. There are total 124 vacuum ion-pumps for two types in the storage ring[2].
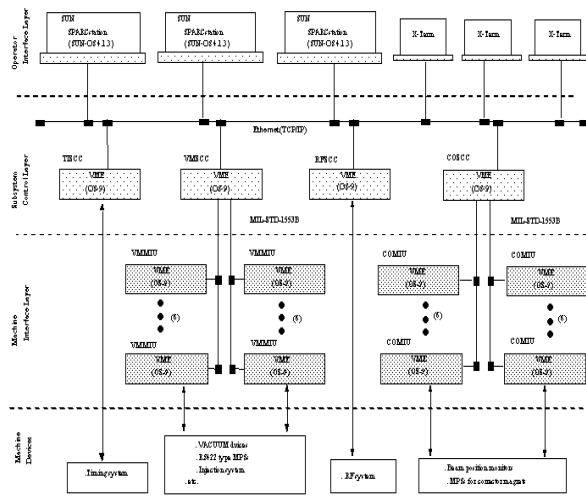
Figure 1: Configuration of the control system for PAL

A EMSDS has a 32-bit CPU (StrongARM RISC, 206MHz), a 32 MB SDRAM, 16MB FLASH, 256B EEPROM, a 10/100BaseT Ethernet network port (1 Chip Ethernet controller used), 2 channel UART (RS485 HALF, FULL and RS232) port, JTAG port for upgrade on-line firmware and 12 channel UART (RS485 or RS232) slave ports connected to 12 ion-pump controllers. The EMSDS can simultaneously control up to 12 ion-pump controllers by serial communication. These vacuum pumps are connected to the ion-pump controllers that chop the AC current so as to control the current in the pumps. To operate the pumps, the pump current must have a trapezoidal shape. The EMSDS is configured so that the current in the pumps has a trapezoidal form associated with the warming-up phase, evacuation phase, and cooling-down phase of the pump The EMSDSs are connected to an Industrial personal computer (PC) through the Ethernet network. The connection between the PC and the EMSDS is established using the MODBUS TCP/IP socket mechanism. The PC is a client and the EMSDSs are servers. The EMSDS has only a simple connection mechanism i.e. the "socket mechanism" rather than Remote Procedure Call (RPC) that supports rich client-server mechanism[3]. Thus, communication between the EMSDSs (servers) and the PC (client) is established using the socket. Fig.2 Structure of vacuum control system .The PC can automatically control EMSDSs by sending a set of commands through the TCP/IP network. Sending commands does control for the titanium-getter pumps; for example, the execution command specifies the duration of the current form. The EMSDS listens to the TCP/IP port to receive a message or command from the PC through the network. Upon receiving a command from the PC running under Windows2K through the network, the EMSDS serial communicate through the slave UART serial ports to ion-pump controllers in association with the operating vacuum pressure. A command includes an ID number, which specifies the ion-pump as well as the duration of evacuation, and vacuum pressure time in seconds. Upon

receiving a command, the EMSDS initializes its timers associated with the command parameters, and starts triggering the gate of the ion-pump controllers through the slave UART serial port
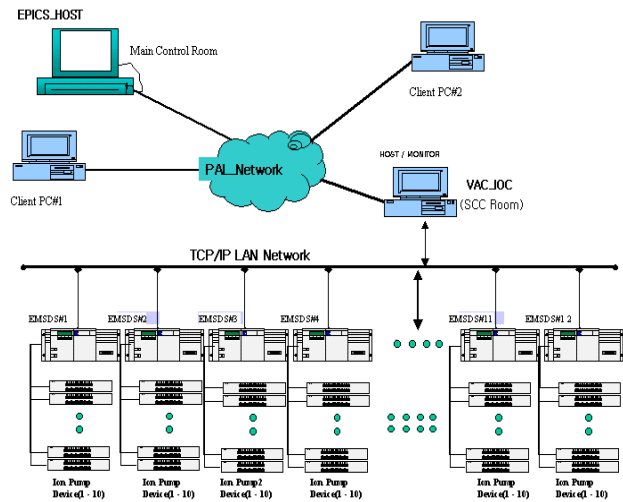

Figure 2: Structure of vacuum control system

SOFTWARE

The system consists of VAC_IOC (CA server) connected to the IO devices (EMSCS), console PC (CA client), and Ethernet LAN. The Modbus TCP Server based on the TCP Socket Channel Access Server has been used to develop of the SDDS/EPICS toolkit. VAC_IOC assumes that the control system is consists of 1) Distributed intelligent socket Input/Output TCP server, 2) High-speed network based on Modbus TCP/IP EPICS Core and 3) Windows NT host computers for various high level control applications including human interfaces and data logging. EPICS run-time database on the IOC and CA constitute the core of the EPICS software. EPICS client software accesses the record in this run-time database using the logical name of the record. Read and write accesses to the EPICS run-time database from the EPICS client software triggers the access to the hardware from the IOC. User of EPICS only needs to supply hardware specific routines, hardware driver and device support routines. EPICS core software also includes programs such as 1) Scanner to scan the status of hardware in the way specified by the user, 2) CA server to handle the database access request from the client program. Configuration files prepared by the user define the actual behaviors of these programs (Figure 3). User can also extend the EPICS core software using the hooks in itself. For example, user can add a support of a new device to the EPICS by supplying a device driver and/or device support routines. EPICS CA applications such as MEDM (Motif based Editor & Display Manager), ALH (Alarm Handler) and Arcmd (EPICS Archive) run on the host computer. Configuration files drive these

applications user can build a basic control application without any programming. We use Industrial PC as the host computer in the PAL accelerator control system. The host computer also serves a development environment for VxWorks, which is the operating system of IOCs. X-terminals are used as an operator interface in the PAL accelerator control system. We currently use the version R3.14 of EPICS on this host machine. A test of the latest release of EPICS software, R.3.14 .1, is under way.
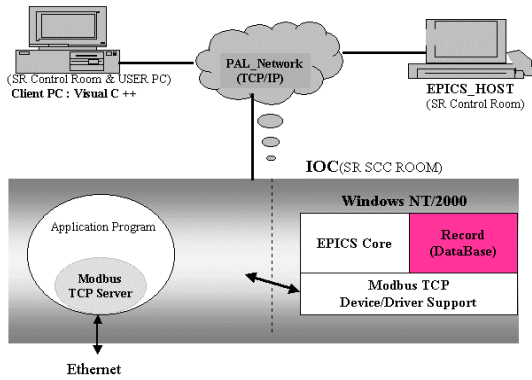

Figure 3. Structure of Control Software

CONCLUSION

A basic set of the PAL accelerator vacuum gauge monitoring control system was installed and has been working. We developed a vacuum control system for use Ethernet Multi Serial Device Severs on the PAL storage ring. The EMSDS design was fixed and the end of this fiscal year will deliver the EMSDS for the vacuum ion pump control system. Industrial PC based IOCs will be also installed in the system in this fiscal year. Software development/improvement will be continued until, long-term operational experiences even after it. Designing the EPICS database template for each hardware device will be the major effort in the software development. We are upgrading and modifying the control system to accommodate new control requirements and to apply long-term operational experiences.

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