NETWORK BASED EPICS DRIVERS FOR PLC'S AND MEASUREMENT STATIONS

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Abstract

The control system of the JHF (Japan Hadron Facility) linac is being designed employing EPICS. An overall discussion of the system is provided elsewhere [1]. In the system it is planned to install PLC's and measurement stations for accelerator equipment and beam instrumentation, which are connected via an Ethernet/IP network.

The reason for the choice of network is that modern controllers can be better managed using a TCP/IP network, even for software downloading and debugging and that the IP network and Ethernet are de facto standards. Device support software is being developed in order to integrate these controllers into an EPICS environment.

The use of Yokogawa's PLC's are being considered, since many installations are already running in other accelerators at KEK although not under EPICS. The EPICS software for these PLC's is relatively straightforward.

For measurement stations, WE7000 systems from Yokogawa are being evaluated, which are carefully designed to be immune against accelerator electromagnetic noise, and are also cost efficient. The network driver software was developed at first on Unix, and is now being adapted into an EPICS environment.

1 INTRODUCTION

The JHF project will be carried out in several phases, and the first part, an injector linac, is under construction at present.

We have several control systems at KEK. After studying those systems [1], it was decided to employ EPICS [2], which has been successfully used to commission the KEKB ring accelerator. The main reason to choose EPICS was to make maximum use of the sharable resources among accelerators and laboratories.

During the study, we realized that a number of field networks are being used at these accelerators. Some of them are homemade and others are proprietary products for limited devices. Also, they need certain human resources to be maintained.

At the KEK electron linac, during the rejuvenation for the KEKB project [3], several kinds of IP (Internet Protocol) connected controllers were introduced, and more than 150 controllers are being utilized [4, 5, 6]. Although old homemade networks had to be kept, no new field networks were introduced.

These types of controllers need only IP connections for both maintenance and operation, for which many kinds of commercially available components can be employed. They also have simplified the software development, management and troubleshooting. An IP connection is often the most efficient in speed, cost and manageability amongst other solutions.

Thus, in the JHF project, these controllers are considered to be useful for certain accelerator equipment to ease controller management and to save human resources.

2 NETWORK CONNECTED CONTROLLERS

In control systems choosing the field networks and field buses is a difficult issue. The reliability, speed, maintainability and costs should be taken into account. For medium-to-large accelerators, equipment is spread over a wide area. Thus, we may have to use local networks. Often the maintenance of these dedicated networks needs human resources.

Recently, however, because the cost of human resources is most expensive, we must build and maintain a new accelerator without new resources. On the other hand, the prices of the standard network devices, such as Ethernet including fast 100BaseTx, fiber-optic 10BaseFL, have become very cheap.

If we introduce Ethernet-connected controllers, a selection of standard network device technologies and standard software can be utilized, not only for operating the accelerator, but also for maintaining the equipment controllers. Simple IP packet switching or routing may increase the flexibility in designing the network. In addition people in hardware groups may understand them easily since they use IP network technology in their offices.

If we use the UDP/IP protocol over Ethernet, we only need a standard IP protocol stack and the software can be shared between many environments. If we use TCP/IP, some parts of the error-handling procedures may be platform dependent, since the interface to parameters, such as the timeout values, are not well standardized. Thus, UDP/IP should be applied to critical purposes, while both

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UDP and TCP may be used for other areas. (Nevertheless, an interrupt message through out-of-band TCP packets which is supported by certain network controllers may be employed in some applications.)

3 NETWORK CONTROLLERS IN JHF LINAC

In JHF Linac the following types of network based controllers are planned to be integrated with the EPICS control system.

3.1 Programmable Logic Controller, PLC

Formerly, PLC's had often been used as a simple logic sequencers, and were not considered good controllers to communicate directly with a large control system. Recently, PLC's have powerful and flexible options, and their processing speed is fast enough to be used as remote I/O controllers.

The response time of the PLC's over Ethernet is 5 to 30 milliseconds depending on the processor types. Although this is 10-times slower than the modern VME processors or PC's, it is acceptable for most slow control applications.

Modern PLC's have good processing power, and even scientific functions can be applied to floating-point numbers. Thus, they allow pre-processing of the control variables as well as logic controls if the hardware group prefers to do so.

We are using more than 130 PLC's, called FA-M3 (Factory ACE) series from Yokogawa, at the electron linac [5] and have decided to employ this type at JHF as well. The main reason is that the same Ethernet can be used for their maintenance. That is we don't need any dedicated communication links in order to download software. Most PLC's sold in Japan do not have this capability, without which we cannot maintain a large number of PLC's.

We are currently planning to install PLC's for the control of vacuum, magnets, ion sources and radio-frequency equipment.

3.2 Measurement Station, WE7000

A waveform observation is often necessary for beam instrumentation and microwave measurements. We have been using GPIB connected oscilloscopes or VXI systems in these applications.

At the JHF linac, the pulse width of the accelerated beam is several hundred nanoseconds. Taking cost performance into account, we leave few choices and furthermore electromagnetic noise from modulators makes even some oscilloscopes are inadequate.

We realized that measurement stations called WE7000 [7] from Yokogawa might meet our requirements. Its 100-Ms (Mega-sample per second) waveform digitizer is cheap and reliable. Also a 500-Ms version will be soon available.

Although it was originally designed for a Windows environment, the Ethernet interface was recently developed and its specification have been disclosed. We are evaluating IP communication software on Unix.

3.3 GPIB, Serial and Others

Major measurement instruments still use GPIB or serial line (RS232C) as communication interfaces. Maybe we cannot escape from those devices.

For these interfaces several kinds of gateway boxes to IP network have recently become available [4]. Control systems with EPICS have also started to employ them, since they are often located far from IOC's and any hardware trouble can be easily isolated.

Hardware venders sell equipment, such as oscilloscopes and video frame grabbers which can be attached to an IP network. They can be utilized under certain circumstances, if it simplifies the configurations.

3.4 EPICS Configuration

Since we decided to employ EPICS as a control system for the JHF Linac, we must investigate the proper network structure for combination of EPICS and network based controllers.

Most of the control processing is done on the IOC's (I/O Controller, such as VME or PC) in an EPICS environment, and information is exchanged between the IOC's and OPI's (Operator Interface). Some processes on IOC's may poll network controllers frequently. These access messages on the network may collide with the channel-access messages exchanged between the IOC and OPI's.

The above-mentioned situations can be avoided by using a network switch, as shown in Fig. 1. Since recent network switches are not expensive compared with repeaters, we will install them anyway.

4 EPICS SOFTWARE

Since IP software is standard in a VxWorks environment on IOC's, the implementation of interface software for network based controllers should be straightforward. For synchronous access it is easy to implement device support software.

However, because the response time is slow, about 20 milliseconds with our current hardware, and EPICS does not allow slow synchronous device support, we have to prepare asynchronous device support for these controllers.

Because we are new to writing EPICS device support routines, we tested our software on Unix first, then are im-

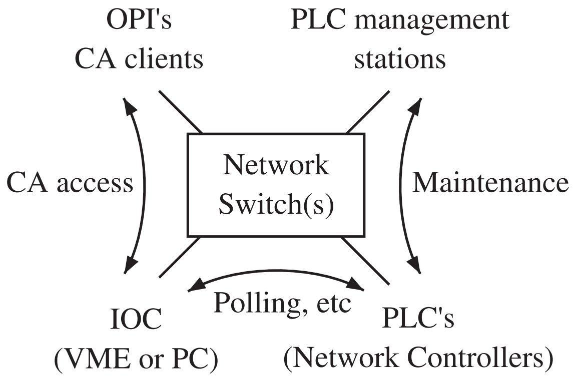

Figure 1: Same network shared among different protocols. Message packets for different purposes are ordered by network switches and do not interfere with each other.

plementing a synchronous device support, and finally plan to achieve an asynchronous device support.

4.1 PLC

At first, PLC access routines that were used in the electron linac were generalized slightly and tested on Unix machines for the JHF controls. This part does not depend on any software/hardware environment.

Then, synchronous device support routines for EPICS IOC's were written and tested. Although the introduction of synchronous device support routines may slow down or even block the processing of other records this step helps us to understand this new architecture.

So far, we have not encountered any difficult issues. Several access methods, which were supported by PLC's, were compared. The on-demand or interrupt protocol is considered to be utilized as well, although the IP-address of the server (IOC) must be hard-coded in the PLC program for this protocol to work.

An asynchronous version of device support routines is planned to be implemented soon after we finish the design of the software interfaces. In this version, a block of memory on the PLC may be assigned as a shared memory between a PLC and an IOC.

4.2 WE7000

The software WE7000 on Unix is now being evaluated and investigated. For a WE7000 station, the status of the station should be managed by the host software, as in VXI. This part is implemented using threads on Windows and Unix.

This software will be ported to VxWorks and an EPICS environment replacing Posix threads with VxWorks tasks. A waveform record that is most required will be implemented first.

5 CONCLUSIONS

IP network based controllers greatly simplify designing a control system, while we must keep our eyes open concerning the effort to standardize other field buses. So far, those types of controllers seem to be promising at least under our circumstances.

Although many pieces of software should be implemented, they are relatively straightforward and will be realized soon.

Perhaps the specifications of variables on PLC's and WE7000's should be generalized to include other types of controllers.

Installation of hardware will start from the beginning of year 2000. We thus hope to finish writing the software and design of record structure soon.

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