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IMPLEMENTATION OF THE EPICS DEVICE SUPPORT FOR NETWORK-BASED CONTROLLERS

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Abstract

In the control system of the JAERI-KEK joint project (High Intensity Proton Accelerator Facility), it is planned to employ network-based controllers such as PLC's and measurement stations instead of using other field control networks, since the network hardware and software can be standardized and they have been successfully utilized in other accelerator control systems in KEK.

EPICS software support for those controllers was designed paying special attention to robustness and has been implemented and applied for the accelerator test stand. Basic functionalities were confirmed and miscellaneous functions such as diagnosis of the software itself would be added.

Since many kinds of network-based equipment such as oscilloscopes have become available recently, they are considered to be integrated as well. They may enable more manageable controllers.

1 INTRODUCTION

Phase 1 of the JAERI-KEK joint project for high-intensity proton accelerators was recently approved for construction. The control system is being designed in detail. The overall conceptual design is given elsewhere [1]. The EPICS control software environment [2] will be used in the system after having investigated several options. The main reasons for EPICS are the recent success of EPICS in the KEKB ring controls [3] and the feasibility to share software resources of accelerator controls with other facilities.

In the linac part of the project it has been planned to employ controllers based on the IP (Internet Protocol) network instead of using special field networks if they meet the performance requirement. And the selection of such network-based controllers are being extended to the whole project. The reasons why we intend to use them are that we successfully utilize hundreds of such controllers in another accelerator at KEK [4, 5] and that we need only standard IP network software and infrastructure for both controls and management [6].

In this article the usage plan and the software implementation of such network-based controllers under EPICS in the joint project are described.

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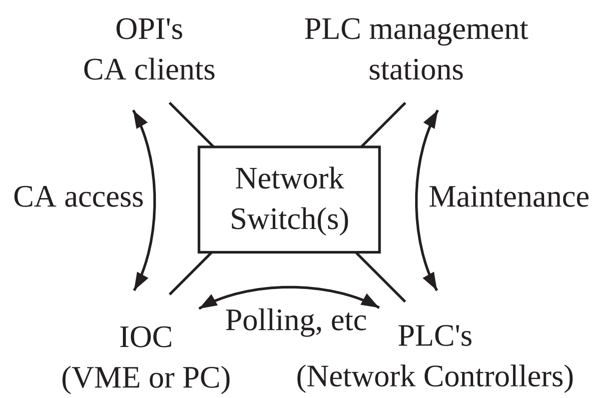

Figure 1: The same network is shared between different purposes between network controllers, EPICS IOCs, EPICS OPIs and management stations.

2 CONTROLLER USAGE UNDER EPICS

A network-based controller and an EPICS IOC[1] may be connected with IP network as shown in Fig. 1, with a PLC[2] as an example. (Other network-based controllers act the same way.) There are five components in this scheme and their tasks are listed below.

- A PLC controls local equipment and carries local processing. It is mostly designed by an equipment expert and it may have a simple local-operation panel. It may be tested by a management station without EPICS environment. Sometimes such an autonomous controller is useful when a robust control is required.
- An IOC may covers several PLCs and others. And it processes logics between several PLCs and keeps their current status on memory. It may be designed by an equipment expert or an operator.
- An OPI[3] sees such an IOC as an ordinary IOC. It does not notice the existence of network-based controllers.
- A management station is utilized to develop ladder software which may be downloaded to a PLC, and to diagnose it. If some mistakes exist in EPICS database

[1] IOC: input output controller.
[2] PLC: programmable logic controller.
[3] OPI: operator interface.

or programming, it is useful to test from outside of EPICS.

- Network hubs between them should be based on switch technology not to be suffered from message collisions. The design of the network topology is relatively flexible compared with other field networks because of the IP network. A connection to OPIs may be isolated by a network router to limit the communication to PLCs locally.

Figure 1 is symmetric between them since it shows the physical view. Logically PLCs are on local network and OPIs are on global network. They communicate in three ways.

- A PLC communicates with an IOC in its own protocol, since it cannot use the EPICS channel access (CA) protocol. While it is based on polling, an important PLC may send urgent information to IOC without being asked.
- An IOC communicates with OPIs through the CA protocol in normal way.
- A management station maintains PLCs during maintenance time. It is important to manage them over IP network, since the number of PLCs may become hundreds.

3 NETWORK-BASED CONTROLLERS

In the project these kinds of network-based controllers are considered to be used.

- Programmable logic controllers (PLC) for simple and medium-speed controls.
- Measurement stations (Yokogawa's WE7000) for medium speed waveform acquisition.
- Plug-in network controller boards for relatively large power supplies for magnets.

Although we use VME modules installed in EPICS IOCs for other purposes, new network equipment may be added. Measurement equipment such as a network-based oscilloscope may be especially useful.

3.1 PLC

At the electron linac in KEK, about 150 PLCs are used for rf, magnet and vacuum controls, which are managed through central computers. A PLC called FA-M3 (Factory ACE) from Yokogawa Co. was chosen because the network software was relatively reliable and the management of the PLCs could be carried over IP network. Even the ladder software can be downloaded into a PLC over network. Such functionality was not available from other venders. Thus we decided to use the same type of PLCs at the joint project as well.

The communication and control routines for PLCs were originally developed for Unix environment. While they were designed to access the shared-memory registers on the PLCs, they can also directly access I/O modules over network.

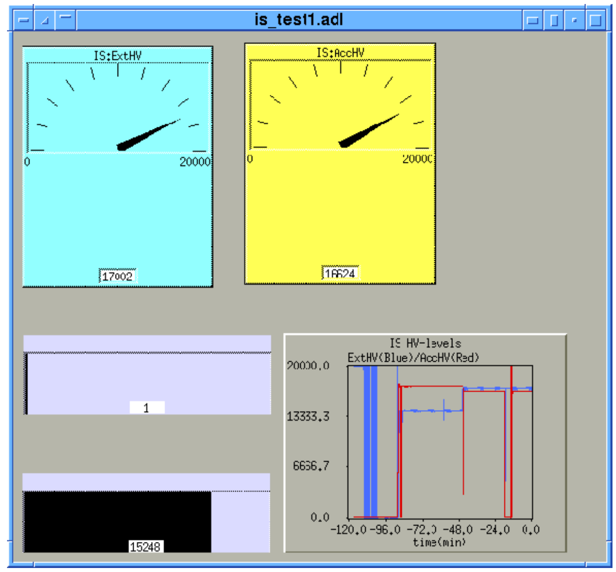

Figure 2: An example panel for testing the ion source of the linac, which utilizes the EPICS PLC records.

Since the routines were written with a generalized IP communication package [7], they were easily ported on to VxWorks and Windows operating systems. The routines on Windows machines are often useful for developers of ladder software of PLCs even without EPICS environment.

EPICS device support software was written utilizing those routines on VxWorks, providing EPICS standard access methods which could be called from any channel access (CA) clients. It basically reads and writes registers on PLCs, each of which is specified by an INP/OUT field of an EPICS record using an IP address or a host name and a register address.

As an example of CA clients, a MEDM panel is shown in Fig. 2, which includes current values and strip charts of high voltages of the ion source which was being conditioned at the linac.

Although such an application can be handled by current software without any problems, the current implementation of the device support software is not optimal yet and a conditional write function, which is described later, may be necessary. Thus the software is planned to be upgraded soon.

3.2 Measurement Station

A waveform acquisition is often essential in beam instrumentation and microwave measurements. In this area, a measurement station called WE7000 from Yokogawa Co. seems to be promising when cost performance and electromagnetic noise elimination are taken into account. And it was well adopted in beam instrumentation at KEK [8].

Three types of waveform digitizers, 100ks/s, 100Ms/s and 1Gs/s, are currently considered to be employed. For the

EPICS device support software, we thought that it would be a good example of out-sourcing. Thus we asked a company to build software. Although it took some time for them to understand the EPICS software environment, waveform records were built using disclosed information from Yokogawa. We are now evaluating the performance of the software.

3.3 Plug-in Network Controller

As we designed the magnet power supplies for drift-tube linac (DTL) and a separated DTL, we realized that we'd better develop a specific controller, since power supplies were intelligent and had many functions.

Thus we designed a plug-in-type network controller board, which transfers information and commands between IP network and a local processor inside a power supply. The number of registers are about 50, half of which are utilized for network communication and include registers for diagnostic purposes such as the last IP address accessed.

The controller boards are being built with the power supplies and will be evaluated soon. The software will be almost compatible with PLC's.

4 CONSIDERATION

Since network-based controllers may reside on global network, we should be very careful about programming and configuring them. Although the number of persons who access such controllers were limited in the previous project, we don't know it in the new project now and some misunderstanding may occur easily. Thus we decided to make several rules to use it.

- We will put an unique identification number (ID) to each PLC and plug-in network controller. Since it will be written in hardware or ladder software, a mistake in the configuration of the IP-address may be found from a management station.
- A clock counter of the controller should be consulted routinely from a management station to monitor that it works properly.
- While read functions are not restricted, write functions should be limited to some range of register addresses. For important controllers a value should be always written indirectly with a value and a address.

5 CONCLUSION

The combination of EPICS toolkits and network-based controllers may enhance the manageability of the control system. The software for EPICS toolkits has been developed and are being tested. They will be used in commissioning of the first part of linac soon.

6 ACKNOWLEDGMENTS

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