INTEGRATION OF INDUSTRIAL PLCS INTO AN EPICS CONTROL SYSTEM

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Abstract

While not yet ubiquitous, EPICS has become the most widely used solution for building new accelerator control systems. Developers using EPICS however, in common with those using home built control systems, are often faced with the necessity of integrating Programmable Logic Controllers (PLCs) into their systems. The most clean solution, that of eliminating the PLC and using EPICS directly, is sometimes not possible due to practical (a subsystem is delivered with a PLC), political (management thinks 'industrial' systems are better), or technical (The PLC components have been pre-certified for safety systems) reasons. Time to develop and test a hybrid system is usually significantly longer than a homogeneous system, and on-going maintenance will cause continuing problems. Integration poses many problems due to the limitations of most PLC systems including: Lack of accurate, system-wide timestamps, hardware triggering and delay modules; Lack fast, high resolution or high accuracy I/O capability; Many restrictions in modifying the system while it is running. Integration, if necessary, has traditionally taken place at a number of levels: Using industrial I/O modules controlled directly from EPICS but without a PLC; Using an EPICS Interface to a Fieldbus supported by the PLC; and interfacing at the supervisory level (normally a PC) using an I/O library provided by the system vendor. At the Swiss Light Source (SLS) we are using a interface from our EPICS control system to a Siemens S7 PLC using a TCP/IP protocol over Ethernet. This protocol, normally used to interconnect Siemens PLC's, is implemented on a VME processor running VxWorks. While the interface could run on the same VME processor running EPICS, it was decided at SLS to use a separate processor with the data blocks written to a shared memory. This interface gives a clean interface which is easy to debug. To the EPICS system the additional processor looks like normal I/O card. EPICS support has been written to support Analogue and Binary I/O. This interface is only loosely coupled to EPICS, and has been adapted for use in the PSI cyclotron control system.

INTRODUCTION

Most new large accelerator projects have avoided the need for home-built solutions for accelerator control and have chosen EPICS[1]. EPICS is a toolkit of pre-built components from which an accelerator control system can be constructed. However, for many reasons it is often required to integrate non-EPICS, particularly PLC, systems into the control system. For these systems EPICS can be seen as a Scada package.

WHY KEEP PLC SYSTEMS

While it might be seen as desirable to eliminate the PLC, and indeed this is often possible, a number of barriers exist:

Subsystems may come with PLC controls

When subsystems are delivered with a PLC control system, there are a number of reasons not to change:

- There may not be time to re-implement the subsystem controls cleanly before the system is needed
- There is not sufficient knowledge of how the subsystem operates or the controls requirements.
- The system vendor will not guarantee the whole system if the controls are changed

Policy decision

There may be a desire by the equipment group responsible for a sub-system, or lab management, to use industrial controls. This may simply be because

- They have always done it that way
- Copy of an existing system
- Knowledge within the equipment group
- Lack of knowledge about EPICS

Technical advantages of a PLC

It may be that the system has to be safety certified, and that the PLC components are themselves certified for use in a safety system. This does not mean that a PLC system is in itself 'safer' than an EPICS system.

DISADVANTAGES OF A PLC

When building a control system with EPICS, integrating non-standard devices such as PLC I/O can take a lot more effort than simply adding analogue and digital I/O to a clean EPICS solution.

Expertise needed in the foreign system

Even if much of the PLC implementation is already done, or will be done by an equipment group, it is almost always necessary to have a good knowledge of the operation of the PLC by the person integrating it into EPICS. It is also not always sure that the persons who implemented the PLC systems, will be available in the future when a problem occurs.

Lack of performance of PLC I/O

PLC I/O modules typically have much lower performance than the equivalent modules used in accelerator systems. Typical PLC I/O analogue input-output modules have less resolution, accuracy, and speed than the equivalent (for instance VME) modules used in modern accelerator control.

Lack of good timestamps and synchronisation

Typically PLC systems lack the basic timing system functions needed for accelerator control. These include

- No accurate, system wide timestamps of measurements.
- No accurate external triggering capability
- No accurate delays

OPTIONS FOR PLC INTEGRATION

PLC components can be integrated into EPICS systems at a number of levels:

Using PLC I/O directly without a PLC CPU

This can be an advantage when simple low performance, robust I/O is needed ut it is not necessary to add the complexity of a full PLC system. This requires that EPICS support is available or can be built for the remote I/O of the PLC vendor. In the past this typically required the complexity of a VME interface to the remote I/O bus, but now it is very easy to run a full EPICS system on PC hardware making it much more likely that the remote I/O interface is available.

Using a Fieldbus

Most PLC systems support one or more Fieldbus interfaces. Interfacing between these and an EPICS system is relatively straightforward, if a VME or PC interface is available for the fieldbus, and has good documentation and libraries to access the data. Generally systems that provide source code for libraries should be preferred. However this does not eliminate the problems of length and speed limitations, generally associated with fieldbuses, which can severely limit their application in all but non-trivial systems.

Using a local area network

This is the approach normally taken at the SLS when interfacing to Siemens PLCs. This takes the form of a dedicated Ethernet link between a Siemens Ethernet communications controller, and a dedicated CPU in the VME crate. The dedicated VME CPU is used to separate the Ethernet traffic for this link from normal control system traffic. Other CPUs now exist with two Ethernet interfaces, and so this could now be achieved on a single board. The data is made available in a shared memory buffer on the dedicated CPU, accessable from the VME bus. In this way it appears to EPICS as a normal I/O card. A simple EPICS driver was written to access the data.

The EPICS driver provides access to data transmitted over the link, both as analogue and binary data. Analogue data is transmitted as 16 bit signed values. Binary data is packed into 16bit words.

FURTHER DEVELOPMENT

The original system described here has been adapted and extended at DESY, and also in the non-EPICS environment of the PSI cyclotron controls. System performance seems at the moment to be well below the possible throughput of the Ethernet link, and the bottleneck is probably the Siemens communications processor. This should be investigated. The approach described here could be adapted to other, non-Siemens PLCs. It might be advantageous to consider a self-describing protocol so that both sides of the interface do not have to agree on the location of every bit or word of data.

CONCLUSIONS

It is not always possible or desirable to eliminate the use of PLCs in an EPICS control system. By understanding the limitations of PLC systems, and selecting an appropriate interface to EPICS the disadvantages can be minimised.

REFERENCES

[1] http://www.aps.anl.gov/epics