Data Exchange from Allen–Bradley PLC–Based Systems to EPICS at the Advanced Photon Source*

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ABSTRACT

The Advanced Photon Source (APS) uses Allen–Bradley Programmable Logic Controllers (PLCs) in a number of applications including equipment protection and personnel safety systems. It is necessary to report the operating status of these systems to the main control system, designed using the EPICS tool kit. This paper discusses the method used at the APS to transfer data from a PLC–based subsystem to the EPICS–based control system.

I. INTRODUCTION

Traditionally an EPICS database communicates with the outside world via a number of interfaces - one being the Allen–Bradley Remote I/O link. This link consists of an Allen–Bradley VME scanner card (SV-6008) that resides in a slot in the Input–Output Controller (IOC) and is connected via "Blue Hose" (twinax cable) to a "Remote I/O Adapter". The Remote I/O Adapter resides in slot zero of the Allen–Bradley 1771 backplane and functions as a bus arbiter but contains no user code. All of the intelligence is contained within the IOC (usually a MVME167 processor running an EPICS database). With proper configuration, an EPICS database can access a variety of Allen–Bradley 1771 I/O cards including binary, analog and a few special cards (thermocouple, strain gauge, etc.). This method was used for many years as it was a cost-effective way of adding many remote I/O points to an IOC with little effort.

Within the last few years, however, it was determined that another method of acquiring data from an Allen–Bradley system was needed – a passive method that would grant an EPICS database the ability to view the status and I/O map of an autonomous PLC–based system. This was born from the need to monitor the status of two large safety systems at the Advanced Photon Source (APS) which use PLC processors running ladder logic (a graphical–based control language). Since the PLC processor resides in slot zero of the Allen–Bradley backplane, the remote I/O adapter is not an option. This paper discusses the hardware and software used to communicate information from a PLC control/interlock system into EPICS.

II. OVERVIEW

As mentioned in the introduction, the standard connection from an IOC to a Remote I/O adapter is not valid. Instead, the use of the Allen–Bradley Direct Communication Module (DCM) is appropriate. The DCM is meant to be used as a method of data transfer from one PLC system to another. The DCM resides in any open slot in the Allen–Bradley crate, and the main processor controls reading and writing to it via the backplane. Typically, the DCM is connected to another processor (in a different system) using blue hose. The remote processor believes it is talking to a remote I/O adapter - the communication over the blue hose takes place using the same protocol as the Remote I/O link.

If we replace the remote processor with the VME scanner, we now have the ability to read the status of a PLC system via an EPICS database. Previously it was necessary to "fool" the EPICS device support into reading from the DCM as no specific code was written to talk to the DCM [1]. With the latest

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revision of EPICS however, a specific hybrid record type was included for configuring and communicating with the DCM.

III. EPICS PROGRAMMING

As stated above, the latest versions of EPICS support communication with the DCM via some special record types and device support. A new record type ("abDcm") was created that is used to specify such items as the Link, Rack and Slot address of the DCM, the scan rate and the number of messages that are to be sent from the DCM (1 message = 64 short words) (see figure 1). The Allen–Bradley driver (drvAb) was modified slightly to allow for arbitrary block transfer requests (instead of tying the block transfer to specific I/O modules). Processing of the abDcm record causes a read from the DCM - if a word from any of the messages has changed, a Channel Access monitor is triggered. Typically records are created as INST_IO pointing to the abDcm record and specifying the message number, word number, and bit number (if needed). An example bi (binary input) record is given below (figure 2):

```
record(abDcm,  "TestDCM:SJS")
{
        field(SCAN, "1 second")
        field(UT0, "YES")
        field(UT1, "YES")
        field(LINK, "x")
        field(RACK, "y")
        field(SLOT, "z")
}
```

- The first field specifies that this record be scanned periodically - once per second. Note that the scan rate can be increased or decreased depending on the resolution desired versus the processor load that can be tolerated.
- The second and third fields specify that the DCM will be sending two messages (there are actually six of these fields UT0 through UT5 - if the UT field is not specified, it is assumed to be "NO").
- The last three fields specify the address of the DCM in Allen–Bradley "Link, Rack and Slot" notation.

Figure 1 - Example of abDcm record

```
record(bi, "TestBi:SJS")
{
        field(SCAN, "I/O Intr")
        field(DTYP, "Ab Dcm")
        field(INP , "@TestDCM:SJS.Tx[y,z]")
}
```

- The first field specifies that this binary input record be I/O Interrupt scanned - this record will only process if the word (specified in the INP field) changes.
- The second field specifies that the device type is the AB DCM.
- The last field points to the record name of the DCM record and specifies the message number (the "x"), the word number (the "y") and the bit number ("z"). Note that specifying the bit position within the word is valid only for a binary input record, other record types (namely mbbi and longin) would only specify down to the word number.

Figure 2 - Example of binary input record

The abDcm device support expects to receive at least two messages per data transfer. Each message may consist of up to 64 short words (16 bits), however the first eight words are reserved as described below (see figure 3). The first word is used by the DCM to send status information including buffer state, last transmission success, etc. The second and third words are reserved for future use and the fourth word (word 3) contains an integer value corresponding to the message number (this is the number specified in the Tx parameter in the Param field of the database record). The last four words are also reserved for future expansion. Note that this configuration makes the ninth word the first one available for user data.

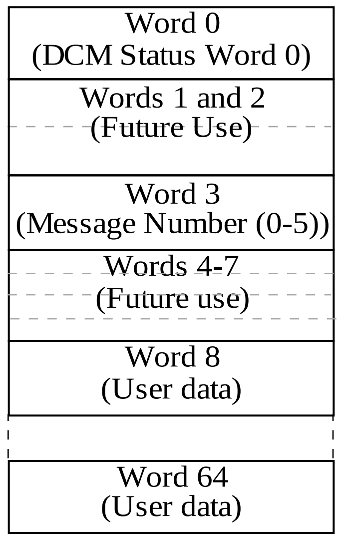

Figure 3 - Message structure from DCM to EPICS

IV. ALLEN–BRADLEY PROGRAMMING

The Allen–Bradley PLC system must be modified slightly to add the monitoring capability. Firstly, the messages are constructed in a certain sequence that is known to both the EPICS and PLC programmer. The messages are then transferred to the DCM via the Block Transfer statement within the ladder logic program. Each message is identified by a unique descriptor (an integer value) which is placed in the fourth word. Each different message is sent in sequence, one at a time. After a message is received in the DCM, block transfers into the DCM are blocked until the message is transmitted over the blue hose. This process is continuous.

V. SYSTEMS IN USE

A variety of subsystems of the APS use the Allen–Bradley series 5 processors for control and interlock functions. In general it is important to be able to monitor the status of these systems from many locations including the Main Control Room (MCR). Below is a short description of three currently implemented monitoring packages at the APS.

V.1 ACIS

The purpose of the Access Control Interlock System (ACIS) is to guarantee that no one is in the APS accelerator tunnels while the accelerator is in operation. Since the APS is composed of several accelerators, there are actually four separate ACIS systems. This allows portions of the APS to be in operation while people have access to other parts. Each ACIS system consists of two redundant Allen–Bradley PLC–5 systems.

EPICS currently is used to display the status of two of the ACIS systems with plans to include the other two systems. For the two systems currently monitored, the EPICS database consists of approximately 1700 records, most of which are binary input records.

In building the EPICS database and the MEDM (an EPICS GUI) displays, extensive use was made of the macro expansion capabilities of dbLoadTemplates and MEDM. The 1700 records are generated from just a couple hundred record templates. Over 100 MEDM displays are available but are generated from just a few medm template displays.

Although the EPICS database has > 1700 records, the CPU utilization is less than 5%. This is because the DCM support provides the ability to process records only when the word containing the records signal changes.

V.2 PSS

The Personnel Safety System (PSS) for the beamlines at the APS is used to provide access interlock and control along an experimental beamline. Each system consists of two independent chains – one of which is based on the Allen–Bradley series 5 processor.

Currently the PSS for the Sector 3 Insertion–Device beamline has a completely functional PSS monitoring package installed. It has been used for a variety of tasks including initial software and hardware debugging, software and hardware verification, on-line diagnostics and fault tracing. At present, the Allen–Bradley chain of the PSS sends two messages at each transfer. Each message consists of a variety of values including the entire input and output image tables, PLC status information (including the current time and date of the PLC clock) and a time–ordered stack showing the first ten PSS faults [1].

A database was constructed that consists almost entirely of binary input records (see figure 1) corresponding to the input and output table of the PLC. Macro substitution was used (via the dbLoadTemplates command) due to the extremely consistent nature of the I/O map. In general each bi record is named in a method that correlates easily to the Allen–Bradley addressing scheme.

Another database was constructed that is used to store “static” records that do not fit into the macro substitution mold. These include a few longin records used to pass time and date, ten records that correspond to a fault stack, and a variety of “analog” PLC status values (scan time, battery status, etc.)

Finally a third database is used solely to service the DCM. It contains one abDcm record (see figure 2) that is periodically scanned once per second [2].

V.3 METASYS

Metasys is a distributed system of intelligent I/O processors used for control and monitoring of environmental and HVAC parameters at the APS. The Metasys Network port is a device that allows monitoring and controlling of the Metasys Facilities Management System from a third party computer system. The Metasys Network Port emulates the communication of a PLC-5 and communicates with other PLC-5 processors via RS232 using the Allen–Bradley Full-Duplex Data Link Layer Protocol (DF/1). An Allen–Bradley 1771 KF2 converts the Network Port RS232 signal to a Data Highway Peer Communication Interface to complete the Network Port to PLC-5 link. This dedicated PLC-5 module is then programmed to act as bridge between the Metasys Network port and EPICS utilizing the DCM device and record support.

Currently, at the APS, a small set of binary and analog Metasys values are passed to EPICS as a proof of concept. This number will increase as more environmental data is incorporated into EPICS displays, alarm handling applications, and data acquisition techniques familiar to the operators and accelerator physicists [3].

VI. CONCLUSION

The additions and modifications to allow communication via the DCM have proven to be invaluable for monitoring PLC–based systems at the APS. The ability to view the I/O and status of these systems has made debugging, diagnostics and fault tracing much easier than previous methods.

Currently there are three systems in place at the APS which use the DCM as a bridge into EPICS. The Accelerator Control Interlock System (ACIS) uses a very large number of records to convey the status of a large system to operators throughout the ring. The Personnel Safety System (PSS) also consists of a large number of records used to report status to operators and, in the near future, APS users. Finally, the Metasys system also reports (indirectly) through a DCM to the main control system a variety of environmental system parameters.

VII. REFERENCES

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