SUPPORTING MULTIPLE CONTROL SYSTEMS AT FERMILAB

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Abstract

The Fermilab control system, ACNET, is used for controlling the Tevatron and all of its pre-accelerators. However, other smaller experiments at Fermilab have been using different controls systems, in particular DOOCS and EPICS. This paper reports some of the steps taken at Fermilab to integrate support for these outside systems. We will describe specific tools that we have built or adapted to facilitate interaction between the architectures. We also examine some of the difficulties that arise from managing this heterogeneous environment. Incompatibilities as well as common elements will be described.

MOTIVATION

The primary motivation for utilizing foreign controls system elements within Fermilab is to take advantage of contributions of collaborators. One example of this collaborative effort affecting the controls is the Fermilab/NICADD Photo-injector Laboratory (FNPL). FNPL uses the DOOCS control system from DESY as its main control system. Operations of FNPL are relatively isolated from Fermilab's main Tevatron accelerator sequence, but FNPL does use cryogenics supplied by the Tevatron system and FNPL also uses several Fermilab-standard data acquisition crates called IRMs (the name derives from Internet Rack Monitor) which communicate via Fermilab ACNET protocols.

Further collaborations which grew out of the FNPL-DESY connection are low level RF (LLRF) controller boards with DOOCS software interfaces. These DOOCS LLRF boards are used in the Fermilab superconducting RF cavity Horizontal Test Stand (HTS) and a related conditioning system for couplers for superconducting RF cavities.

LLRF controls for Fermilab's High Intensity Neutrino Source (HINS) is another example of adapting outside systems for Fermilab experiments. SNS provided Fermilab with a LLRF system, consisting of a VME crate and controlling PC running EPICS software.

EPICS EXPERIMENTS

For a variety of reasons, but chiefly to facilitate collaboration, EPICS was selected as the primary control system for the HTS and HINS experiments. These are both housed in Fermilab's Meson Detector Building. Additionally, EPICS provides a global interface to the cryogenic APACS control system for HTS. For the first couple of years of their existence, HTS and HINS have both been pretty much stand-alone experiments with nearly all the operations occurring in the immediate proximity of the experiments. As expected, EPICS has proven very good at providing all the elements these projects required. We were able to use EPICS to quickly build IOCs, PV databases, and EDM displays to enable initial operations. We also added tools such as alarm handlers, save/restore, auto-restore, archiving, browser-based archive viewers, and an IRMIS PV database, while growing a good base of expertise with EPICS at Fermilab.

While this EPICS infrastructure was being created, some interaction with common Fermilab ACNET tools was required. One relatively simple tasks was to make an EPICS IOC which could read and set data from the IRMs (and the similar HRMs). This was straightforward to implement and a great boon to sharing data between ACNET and EPICS.

Another of these interactions involves getting data from EPICS into an ACNET Parameter Page. Parameter Pages are an ubiquitous aspect of Fermilab control system operations, and are text-based lists summarizing device names, readings and settings. Since many people at Fermilab like Parameter Pages so much, it was necessary to be able to import EPICS data into a Parameter Page. Using our Java-based Parameter Page, an extension of its protocol for importing foreign data, known as the Secure Controls Framework (SCF) [1] was built to access EPICS channel access data.

DOOCS EFFORTS

Our efforts to integrate DOOCS into the greater control system at Fermilab have been constrained by a lack of local experts in DOOCS. Our DOOCS system was initially set-up by experts from DESY and there is only a small handful of software engineers familiar with DOOCS at Fermilab.

As a result, DOOCS has not been integrated into the overall controls system which is used by our main control room, and is only used locally at the photoinjector lab or for the local LLRF controls of the other experiments.

There are two bridges between DOOCS at other control systems. The architecture of DOOCS intrinsically allows collecting data from devices communicating with other protocols. So we have a DOOCS module which communicates via the ACNET "classic" protocol that the IRMs use to make readings and settings on the IRMs.

We also implemented a DOOCS to EPICS bridge (again, adapted from source code from DESY) which

allows EPICS to access DOOCS devices in the LLRF controllers used in the HTS experiments.

EPICS INTEGRATION

As mentioned earlier , the EPICS control systems for HTS and HINS were developed as stand-alone, locally operated systems. As the years have gone by we have grown to want more integration with the mainstream Fermilab operations group, and hence needed to integrate with the Fermilab control system. The motivation of this integration comes from the maturing of these experiments and from the commencement of work on the NML SCRF cryomodule staging area. Similar technologies are required for NML that were used in HTS or HINS, but with a larger degree of involvement from the Fermilab community. Gone are the days of HTS being a relatively small experiment that could operate with just a few people in any manner it wanted to. This expansion must eventually include involvement of the lab's main control room (MCR).

Early Bridging

One of our first efforts at merging EPICS and ACNET was upon learning that the 'E' in EDM (an EPICS GUI builder) stands for *extensible* and that it really does work. We were able to extend EDM so that it was able to read ACNET devices. This extension to include the ACNET I/O libraries went relatively smoothly and let us have our mostly EPICS EDM screen, but with the addition of one or two ACNET devices that someone wanted to monitor. Although possible, we really haven't taken the stop of developing many all-ACNET-device EDM screens.

The next step in bridging EPICS and ACNET is to import EPICS PV readings into ACNET. Duane Voy at Fermilab wrote code in the ACNET MOOC front-end environment that uses channel access to read or set EPICS Process Variables. To use this, you have to tell this front-end code which PV is connected to which ACNET channel/device. We are still working on integrating this connection into the ACNET central device database so that it can be downloaded automatically to the front-end after device definition.

This EPICS-ACNET bridge has worked well for us. The fact that channel access is able to automatically manage a connection across times when the remote device is unavailable (e.g. rebooting) made the implementation of the bridge software easier. One difficulty in merging EPICS and ACNET has always been their differing philosophies for data sampling. In EPICS, a particular input channel is generally assigned a fixed sampling frequency (or event) at initialization time. In ACNET, a common model is to have a general purpose input channel which can be dynamically configured to sample at different rates or be triggered by a dynamically specified Tevatron event. The way our EPICS-ACNET bridge handles this is simply to attach a Channel Access monitor to the PV. If an ACNET client requests the data at a faster or slower rate than the PV supplies, the pooled PV data is simply over or under sampled.

Environmental Integration

All these varying bridging strategies allow us to pull data from one control system to another, but skirt around real issues of incorporating elements of a foreign control system into the core ACNET environment. ACNET application clients are primarily driven by a set of textual *index pages* where the operator selects the desired application from a mouse-sensitive list of application names. While some newer Java-based applications can be run from a browser and have been made web-start-able, running applications from the index pages remains the primary means for most control programs.

Some aspects of pulling EPICS features into the ACNET console environment are straightforward. For instance, we compiled EDM for our console computer environment and we have made index page entries which launch various EDM displays.

ACNET's index page applications are run in one monolithic environment without individual-user customizations, although it is possible to save operator generated files from certain clients. However, most client files (e.g. a list of devices for a save-restore file) are only saved in proscribed locations. This contrasts with the much looser way we had gotten used to operating with EPICS. While certain files accessed through our common EDM screens were saved in standardized directories, many individual operators were in the habit of saving other files in their own personal sub-directories. Examples of these files include archive viewer plot setups, StripTool setups, and alarm limits. We are still in the process of sorting out what to do with all these files, trying to impose some discipline while also giving the users flexibility.

LESSONS LEARNED

The experience gained by the continuing work with multiple control systems has been very valuable for the members of Fermilab's controls department. The perspectives have taught us a lot about our own control system, validated some of the features that are built into ACNET, and suggested many improvements using features noticed in DOOCS or EPICS.

EPICS Wins (ACNET Deficiencies)

Most of the operations staff for HTS and HINS have liked some of the aspects of working with EPICS. Some items considered an improvement by most were:

- Using a graphical display manager such as EDM over the text-based index pages of ACNET.

- Longer device names
- Easy and intuitive plotting software
- Ease with which a control system for a new experiment can be implemented without a connection to a core existing system.
- Ease with which a collaborator's contribution can be integrated.

Within the Fermilab control system, we are already implementing some improvements related to these findings. For instance, longer device names are now partially supported (although we also find, without a comprehensive naming strategy and hierarchical name search software support such as provided by DOOCS, longer names just become harder to remember). While Fermilab already had a Synoptic Display Builder, we recognize the need to enhance and publicize it (within our own division) more. The ability to provide a "control system in a box" (to simplify standalone development) is also on our longer term wish list for features of an enhanced ACNET.

ACNET Wins (EPICS Deficiencies)

Some features of ACNET that we preferred to EPICS include:

- Don't need to know the network topology (no gateways required to cross subnets)
- A central device database is very useful
- The ACNET client's ability to select parts of an array for reading or setting.
- The ability to acquire or trigger the same device at multiple frequencies or events.

This is not a full list by any means, but it should give you some feel for the type of issues we have been looking at.

Personnel Constraints

The technical challenges of supporting multiple control systems have not been insurmountable by any means. What is harder to maintain is the staffing requirements to support EPICS, ACNET, and DOOCS simultaneously. For instance, to support both an EPICS and an ACNET archiver requires a lot more effort than just having one ACNET archiver and a bridge to acquire EPICS devices into the ACNET archiver.

System administration has been another issue in terms of available manpower and expertise. Since our Linux-based EPICS console environment is different than the Windows PCs used as desktop clients for ACNET consoles, administration is another area where more people (with different skills) have been required.

Because of issues such as these, we have begun trying to find ways to bring EPICS systems and applications into the ACNET console environment.

SUMMARY

Developers and users of any control system can gain from exposure to other systems. At Fermilab, we have learned a lot about the other control systems by actually using them in experiments. We are using this knowledge to make improvements to our own system. There has been some duplication of effort along the way (i.e. implementing some front-end or GUI in both ACNET and EPICS), but the knowledge gained has been worth it. Our usage of EPICS is converging to a approach similar to the way we treat Labview. It is allowed, it is deployed to control several key instruments, but using Labview applications is largely confined to engineering experts and Labview devices are bridged into the ACNET system for access by the main control room.

REFERENCES

[1] A. Petrov, "Overview of Secure Controls Framework Implementation". 22 June 2004, http://beamdocs.fnal.gov/DocDB/0010/001040/002/SCFOverview2.pdf