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MODERNIZATION PLANS FOR FERMILAB'S ACCELERATOR CONTROL SYSTEM

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Abstract

The control system, ACNET, for Fermilab's accelerator complex has enabled the lab's scientific mission for decades. ACNET has evolved over the years to incorporate new technologies. However, as Fermilab prepares to enter a new era with its PIP-II superconducting linear accelerator, ACNET is at a crossroads. There are several components that are either obsolete or outdated, or certainly will be over the long lifetime of PIP-II. We have begun a plan to modernize our accelerator control system. This paper discusses some of the obsolete hardware and software that needs to be replaced and lays out options and technologies that we might adopt as part of this modernization effort.

BRIEF HISTORY

Fermilab's control system, ACNET [1], was developed in the early 1980s for the Tevatron. It was developed as a three-tied system, having 1) front-end systems responsible for the data acquisition from field busses, 2) a central services layer featuring a centralized relational database containing information about all the devices connected through the control system, and 3) the user interface and application layer. A custom, connectionless UDP datagram protocol supports the communication between the computer nodes in the control system. This architecture has proven very resilient over the decades, reliably supporting the physics program of the lab as the set of accelerators and beam lines has grown more complicated over the decades, growing through the Main Injector and Recycler era, to our current set of neutrino, muon, and other fixed target experiments.

MODERNIZATION NEEDS

Hardware and software need updating at all three tiers of the control system. There are a variety of updates that we are beginning to plan, and these can range from a simple upgrade to a more modern computer, to a complete redesign of a particular sub-system.

Front-end and Field Bus

Many of the front-end data acquisition systems are VME-based. Most of these run under the VxWorks operating system, but a substantial number (125) of general purpose I/O units in our linac and elsewhere, known here as IRMs, run PSOS as their operating system. There is very little experience in PSOS at Fermilab (or anywhere), so moving off that platform is a priority. But we would also like to begin moving away from VxWorks to Linux. VxWorks has served our needs well, but with the evolution of processor speed and Linux real-time extensions, we no longer think that VxWorks is providing much benefit for its cost.

Inside these VME crates, we have a substantial number of processor cards based on the 68040 CPU, which came out in 1990. Obviously, upgrading these obsolete processors is a priority. Continued support of these older processor cards means we have to make compromises in rolling out features for our front-end software framework. Beyond the very ancient 68040 processors, we have several systems that rely on end-of-life cards such as the MVMEV2400 series cards. Since we need to upgrade these old processor cards, we are also evaluating other bus architectures to replace the VME bus with something such as MicroTCA.

One priority in the modernization effort is to replace our CAMAC hardware. Fermilab has a lot of CAMAC data acquisition and control hardware. This technology (dating to the 1970s) has not been commercially available for approximately 20 years, and we can no longer buy chips and parts for our custom-built cards. Some of the CAMAC cards could be replaced by general purpose I/O available in PLCs. We have prototype implementations of replacements for some other CAMAC functionality but need to deploy multiple instances across the accelerator complex.

Central Services

One of the key features of ACNET is its central database for information about all the devices and nodes in the control system. The central database is implemented with the Sybase relational database product. The Fermilab accelerator controls department is currently working on replacing Sybase with the open source Postgress.

On the hardware side of our central services we also have aging computing infrastructure. The cluster of computing nodes that run the core software and the operations consoles and user applications are due for replacement.

Applications and User Interface

Our core ACNET user interface is based on X-Windows. While highly functional, this results in a somewhat dated look and feel for our interface, and we need to be cognizant of the possibility that X-Windows may not be supported by the Linux community indefinitely. Since we have over 500 custom applications, porting them to any new technology is a significant effort

Power Supplies

High power (20kW to 500kW) power supplies are another example of our infrastructure that is aging and needs replacement. We have 181 of these power supplies that are over 35 years old. Here again, we can no longer buy parts for these critical accelerator components. These were built on 1960s and 1970s engineering standards and one reason for upgrading them is to get more modern designs with up-

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to-date safety standards built-in. Due to accelerator requirements for fast and precise voltage and current loop regulation, our power supplies require high precision and low noise components, and the regulation and controls for them is developed in-house.

PIP-II AND EPICS

Fermilab is in the process of building PIP-II, a new superconducting linac as the first element in our accelerator chain. Fermilab has decided to use Epics as the control system for PIP-II. Historically at Fermilab, we have benefited from having one unified control system for the whole complex. So, we have several conflicting simultaneous goals:

- Continue normal accelerator operations during PIP-II construction
- Modernize and upgrade the existing controls system
- Have compatibility between PIP-II and the rest of the complex.

It is clear that we will be integrating more closely with Epics and moving the entire system to be more aligned with Epics in the future. For us, this will include investigating which Epics clients/applications we want to adapt, such as for archiving, alarms, or general user interface displays. We expect to implement more "bridging" between Epics and ACNET and we do have some experience with this bridging. For instance, in the past we implemented an ACNET plug-in for the EDM Epics Display Manager, and we currently have software that allows ACNET to read or set Epics Process Variables using Epics' Channel Access [2]. In the future, we plan to more tightly integrate Epics with ACNET by modifying the middle layers of our control system so that, ideally, a client application doesn't need to know which type of device/PV it is accessing.

We are also actively investigating best practices from other labs for managing IOCs, software, and PVs, using applications such as Channel Finder.

SCOPE

Table 1 shows roughly the number of lines of code encompassed by the current ACNET control system. This gives a rough idea of the effort required to modernize and integrate with Epics.

Table 1: Lines of Code in ACNET

Software Type	Lines of Code
Core Libraries	3234k
Console Apps	4122k
SA Applications	264k
Console Service	251k
Java Inf &Apps	1841k
Erlang Frontend	89k
VME Frontend	2993k
IRM VME FE	221k
EE Support FE	105k
Linac VME FE	140k

CONCLUSION

We have identified multiple areas of obsolete hardware and software in the ACNET control system. We have concrete plans for replacing some of these sub-systems, and for others we are still developing a modernization path. Additionally, we are also moving to align our control system more closely with Epics as Fermilab moves into the PIP-II era. The exact extent and speed of our modernization will depend on funding, which is still being negotiated.

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