EPICS-2010 – A VISIOINARY LOOK AT THE EVOLUTION OF A COLLABORATIVE CONTROL TOOLKIT

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Abstract

About two decades ago, the EPICS tool-kit started its development on a short lived project with the goal of reusability. Starting from the control system for the Ground Test Accelerator (GTA-CS) at Los Alamos National Laboratory, the EPICS tool-kit was developed in collaboration with Argonne National Laboratory for the new Advanced Photon Source (APS). Over the years, the tool-kit was installed in other laboratories and has reached now a base of over one hundred EPICS installations. Within this growing collaboration, the software is continually improved. Collaboration meetings every six months are used to coordinate the work between the collaborating partners. This way, the applications and the core software have reached a rich functionality and a mature state. New installations have driven new developments and thus have improved the tool-kit over the years. Each change has contributed to an increment of the successful story. On the other hand, all of these changes give only incremental improvements. Does this adequately resolve the control system issues of the future? How does it miss the control system issues that already face us? In order to tackle this dilemma, the EPICS collaboration has started a series of meetings. The aim of these meetings is to collect ideas for future control systems in general and EPICS 2010 specifically [1]. The groups will be formed by EPICS users, EPICS developers, and by controls specialists outside the EPICS collaboration. This form of brain melting will result in a prioritized list of requirements for EPCIS-2010. This paper presents the results of the first two meetings that took place in June 2003 in Europe and in the week before ICALEPCS 2003 in Korea. The last meeting in this series will take place in spring 2004 at Los Alamos and will result in the final working plan.

INTRODUCTION

Why Consider the Distant Future

It may seem obvious to someone viewing from a distance that it is necessary to look forward to decide what technology advancement and what current limitations need to be considered, integrated, and evaluated. However, when you are responsible for building, testing, integrating, commissioning or maintaining a facility, it is difficult to take a long view on the tools and technology available. In discussing restrictions of the current system and technologies that look promising, the hope is to provide some focus for the developments inside the EPICS community.

Approach

The Experimental Physics and Industrial Control System (EPICS) [2] community consists of many groups over a large geographic area that use the toolkit for a variety of applications. To consider future directions, it is interesting to discuss the shortcomings of the existing tools as well as the emerging technologies that could change the scope of the solution provided. It was decided to organize three small workshops in Europe (June 03), Asia (Oct 03), and North America (May 04). Each meeting would have a local organizer and some representation from the control system design group to solicit input from experts in many different areas of control and, with some consideration to keeping the meeting attendance at around fifteen people. After the final meeting, a group of potential developers will meet to discuss the merit and cost of these ideas in order to create a development plan.

Requirements

In our community, there is a large range of requirements. At one extreme is the control of the RF devices and diagnostics that operate at MHz levels. There is a need to manipulate or view large time intervals of data to support control and analysis. Rings frequently use several hundred kHz feedback loops. LINACs running at up to 120 Hz benefit from pulse to pulse beam steering. 30 Hz control of a secondary mirror supports removing atmospheric distortion. Shutdown latencies of 2 μsec are required to protect machine components. Conventional control for vacuum, cooling and cryogenic plants require 10 Hz standard industrial control. Operators need to see data at only 5 Hz, but this data may include waveforms from RF signals that have been filtered or analyzed. It is easy to envision the need to analyze terabytes of data for machine studies. We currently support a very small subset of the users' needs in an integrated, easy to create and maintainable manner.

Areas of Interest

Areas of interest were used to focus these two day meetings. They included: emerging standards, network communication and objectification, use of web technologies, industrial control system capabilities that are missing in EPICS, and the use of application frameworks to provide a more integrated set of client tools. During the first two meetings, short presentations by the experts followed by group discussions were used to investigate the potential of the proposed technologies along with other issues that needed to be considered. The first two meetings were very successful in expressing concerns, discussing shortcomings of the current system and exploring the possibility of new technology.

ADOPTING EMERGING STANDARDS

In control system design and implementation, some standards to consider are operating systems, programming languages, I/O buses, and communication buses. To consider the emerging technologies, it is necessary to look at the technologies that are currently in use and to determine the benefit of the emerging technologies along with their costs. The last standard that came from our community was CAMAC. Since the days of large control system budgets, we have been adopting technologies from other fields – and creating only those that we need.

Light weight, commercial, real-time, operating systems, such as VxWorks and OS9, are now incorporated in front end processors. Lately, LINUX variants are taking over the workstation with RT Linux and RTEMS taking some market share from commercial operating systems.

At some of the more established labs, FORTRAN still has its defenders. C programming has been relegated to providing code in only the most sensitive performance areas, and all other tool based code is going to C++ and JAVA. High level applications are using higher level languages such as JAVA, PERL, and MATLAB to provide device level abstraction and multiple platform support.

I/O buses from the long past such as CAMAC are still in use at many laboratories today. Serial and GPIB interfaces are fast being replaced by Ethernet. VME and VXI buses are beginning to be replaced by intelligent controllers that are integrated over Ethernet. PLCs are giving up their serial communication buses for Ethernet. Some devices are starting to appear with USB or Firewire interfaces; but this trend has much less momentum. It appears that Ethernet will dominate as the I/O bus within the next few years. The management of thousands of devices, ranging from a low point count I/O multiplexer, to intelligent devices, to high point count PLCs, will need to be considered.

There has never been a clear standard here. Bitbus, serial bus, and GPIB have had many devices speaking a variety of dialects, living a tenuous existence together. These devices have always used standard transport – but never a standard communication protocol. Allen-Bradley supports an "open standard" called Control Net. It has the feel of a Microsoft standard – not as standard as it is claimed to be. The latest attempt at imposing a standard has been OPC. While heavily touted, it is still easier to find devices that speak Modbus over Ethernet. Although Modbus over Ethernet has never been claimed as a standard, its popularity is due to its ease of use.

There are many communication protocols in use in a typical control system, and the most commons implementation is over Ethernet. Some of these protocols include Channel Access or TINE [3]. Some are based on CORBA, such as TANGO [4] or the NIF [5] control system. In addition to these, there are timing networks to distribute data synchronizing signals. There are also networks for providing fast shutdown for machine protection. Systems performing closed loop control in the KHz regime may use shared memory or dedicated links. As we consider new standards such as SOAP, DDS or Universal Plug and Play (UPnP) [6], we need to decide where in the long list of controls functions they may be beneficial. The benefit of using less wire to support more of the functions would simplify the installation. The use of higher levels of abstraction in the communication protocol may simplify the software design.

OBJECT ORIENTED TECHNOLOGY

How can we apply OO technology to take advantage of its benefits while limiting the resulting overhead? If we represent our system as devices instead of channels, we are able to hide much of the complexity of the system and make it easier to manage. Introspection makes systems more flexible and easier to expand and maintain. But, this approach requires more intensive computing. Moreover, there has been no emerging standard for accelerator components. Did OO technology ever delivery on its promise of higher productivity, reuse of code and maintainability?

COMMUNICATION BUSES

Currently accelerators use a variety communication channels for general purpose communication, for transporting timing information and for machine protection functions. They also use various field buses for instrumentation, and high speed or reflected memory for fast global control. There is a definite move towards replacing I/O field buses with Ethernet. Some timing systems are using Ethernet hardware for encoding pulse to pulse beam information such as the quality of the previous beam pulse. Intelligent single purpose networked attached devices, such as BPMs and RF control are becoming more common. At SNS there are over 150 IP addresses dedicated to BPMs – one PC per BPM. Mass market, high speed components are very convenient to use and are becoming fast enough to accommodate more complex functions. Will this trend continue to include their use in high speed closed loop control? How will the explosive growth in the use of the IP address space affect reliability and robustness? Which protocols will need to coexist on the same network – CORBA, SOAP [7], Channel Access, Tango and TINE?

WEB SERVICES FOR EASE OF USE

The use of the WWW has become so common that we expect to have access to data from any computer that is on the network. Operator web-based log books are becoming more and more common. The demand for real-time data on these windows is clear. Can we provide a secure and operator interface with good performance over the web? Will the performance be adequate for interactively viewing archived data? Is the web an adequate technology for providing Global Accelerator Network? There is a lot of promise and a lot questions in this area. UPnP is a technology used for clients and servers to dynamically locate each other and configure integrated components. This is directed more at household automation. Does it have any application here?

ATTRIBUTES OF INDUSTRIAL CONTROL SYSTEM TO EMULATE

Industrial control systems have evolved over the last 30 years to provide a robust solution for a very well defined set of problems. Some of the functionality of these systems is absent from EPICS. For control of high availability systems, such as Cryogenic plants, it would be very useful to have redundant front end computers as well as the ability to add or delete channels during operation. Where EPICS has similar functions, such as state transition control, it may be useful to adhere to industrial standards. This may enable us to use some of the industrial configuration tools. Ease of use and installation that is available from industrial tools would be very helpful for those wanting to implement a small system or to evaluate EPICS. Industry is also adept at providing solutions that are tailored geographically – for language and preferences. Providing an out-of-the-box set of binaries for some common platforms may go a long way in reducing the entry cost for using EPICS.

APPLICATIONS FRAMEWORKS

The need for an application framework to provide consistent look and feel for operator applications, is very important in reducing the frustration of using tools developed in a Bazaar [8] software development environment. This has been obvious to many in the accelerator community. There are frameworks developed for XAL [9], CERN [10] and CosyBeans [11]. The EPICS client environment needs to adopt one of these for its clients. A framework that also supported removing a channel from all client references, or cross referencing the use of a channel in all client programs would significantly reduce maintenance costs. A framework that also managed and monitored all runtime tools would also be very helpful in managing large system.

PERFORMANCE OF HARDWARE AND SOFTWARE

There is a broad range of problems in controlling a large physics experiment. As technology improves, we are able to move more of the solution into more accessible technologies. For example, RF control was originally done with complete analog systems. With DSPs, FPGAs, and fast ADCs and DACs, these systems are now largely based on digital components. There are many areas of control that may still be moved into easier technologies to maintain. For instance, it is now possible to think of placing timing signals and fast control data on the same network using gigabit Ethernet. This greatly reduces the complexity of the plant wiring. Faster processors, allow us to do more signal processing in a runtime configurable environment. These faster processors also allow us to use slower software technology that provides other benefits such as portability. For instance, high speed PCs are able to run JAVA applications at acceptable speed.

BACK ON EARTH

The collection of ideas through this series of meetings has been very useful. Our attempts to build these ideas through the use of a network discussion tool (Wiki) have been less successful. There has been little activity on these Wikis in the six months that they have been available. It would be worthwhile to reenergize the discussions through the assignment of a topic leader. We have one more meeting in this series before the developers meet to discuss the pros and cons of the various proposals. Once we have chosen paths of development or investigation, we will need to device an implementation plan that would be consistent with the collaborative nature of the EPICS development.

ACKNOWLEDGEMENT

It is important to note that the first two meetings were attended by many experts that do not use EPICS. The free exchange of ideas was a very satisfying experience. Thank you for your time and energy.

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