MIGRATION OF 1970s MINICOMPUTER CONTROLS TO MODERN TOOLKIT SOFTWARE[1]

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ABSTRACT

Controls for accelerators and associated systems at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory have been migrated from 1970s-vintage minicomputers to a modern system based on Vista and EPICS toolkit software. Stability and capabilities of EPICS software have motivated increasing use of EPICS for accelerator controls. In addition, very inexpensive subsystems based on EPICS and the EPICS portable CA server running on Linux PCs have been implemented to control an ion source test facility and to control a building-access badge reader system. A new object-oriented, extensible display manager has been developed for EPICS to facilitate the transition to EPICS and will be used in place of MEDM. EPICS device support has been developed for CAMAC serial highway controls.

1 PROJECT

In 1992 Oak Ridge National Laboratory began construction of the first radioactive-ion-beam facility in the United States, an innovative fast-paced, low-cost project utilizing existing accelerators of the shut-down Holifield Heavy Ion Facility[1]. The facility housed two accelerators: ORIC, a K=100 cyclotron commissioned in 1964 as a high-current, light-ion accelerator, modified in the early 1970s to accelerate heavy ions and modified again in the late 1970s to serve as a booster, and a 25 MV tandem electrostatic accelerator built in the late-1970s, which could operate stand-alone or as an injector into the ORIC booster.

Work consisted of modifying ORIC to once again serve as a high-current hydrogen and helium accelerator, stripping out injection components and restoring the ORIC internal ion source, constructing a 300 kV platform to house RIB ion sources, constructing a high-resolution mass separator for isobaric contaminant ion beams, building a new beam line from ORIC to the RIB platform and building an injection beam line from the RIB platform to the tandem electrostatic accelerator. At the same time, beam lines were constructed to two new experimental devices.

2 CONTROLS DILEMA

All of the new equipment required controls but provision of controls by extension of either of the existing accelerator control systems proved to be not feasible. In fact, both accelerator control systems were overdue for upgrade or replacement. ORIC's control system was a mixture of a subset of the original hard-wired controls and a MODCOMP-minicomputer/CAMAC system installed as part of ORIC 's conversion to a booster in the 1970s. Because most of ORIC's controls were associated with now-obsolete booster-mode components and because we intended to extensively modernize ORIC, ORIC's CAMAC hardware was stripped out and new controls were implemented with Allen-Bradley PLC hardware. The tandem accelerator's control system consisted of a Perkin-Elmer-minicomputer/CAMAC system designed in 1976. The tandem accelerator CAMAC control hardware would remain but the Perkin-Elmer minicomputer desperately needed replacement. Both accelerator systems were programmed largely in assembly language with some FORTRAN and, as a result, control system extensions were extremely labor-intensive and upgrade of control computers to more modern computers would have required a large programming effort. Our staff did not include a full-time programmer and engineering personnel were extremely busy with facility modifications.

3 SEARCH FOR A SOFTWARE TOOLKIT

We looked outside for a control system software solution and found three possibilities: TACL being developed for CEBAF, EPICS developed at Los Alamos National Laboratory (LANL) and in use at several accelerator facilities and Vsystem, a commercial offshoot of LANL also in use a several accelerator facilities. Vsystem is a product of Vista Control Systems, Inc. The choice quickly narrowed to EPICS or Vsystem. Both systems are "toolkits" consisting of a dynamic, distributed database component (Channel Access for EPICS and Vaccess for Vista), an operator interface component (DM or MEDM for EPICS and Vdraw for Vista) and other tools such as sequencers,

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strip charts, alarm managers, etc. EPICS at the time operated in a UNIX development environment, with VME/VxWorks being required to house the dynamic database. Vista at the time only operated in a VAX/VMS environment with VME/ELN optionally used for the remote portion of the distributed database. EPICS had little support for CAMAC but extensive support for Allen-Bradley which was our preference for beam line and ORIC controls. Vista software included CAMAC support, important for tandem accelerator controls, and Vista was willing to add Allen-Bradley PLC support.

4 ORIC AND RIB PLATFORM SYSTEM OPERATIONAL

A major factor in the decision to use Vista software was superior documentation and ease of installation and use, important because we did not have a full-time programmer, were extremely busy and had short deadlines. Licensing and other costs were not significantly different. Indeed, we had Vsystem running, "out of the box" in a few days and successfully controlled Allen-Bradley PLC components of the RIB platform and beam lines in short order. Ultimately the system controlled 12,057 Allen-Bradley channels and 1,244 serial RS-232, RS-422 and RS-485 channels through VMIC VMIVME-6015 VME serial controllers.

The Vdraw component of Vsystem worked very well and is flexible and easy to use, but we have continued to experience stability problems with Vaccess/ELN related to memory usage in ELN nodes as the number of connections to ELN nodes is increased. The problem is managed by administratively limiting the number of open connections.

Allen-Bradley 1771-series PLC hardware has proved to be cost-effective and reliable at the chassis level. The most troublesome system problems have been in the area of communication to PLC hardware from the Allen-Bradley VME-based AB6008SV remote I/O scanner module which Allen-Bradley has thus far been unable to completely resolve. Controlnet, ethernet and other communication links to Allen-Bradley PLCs will eventually supplant the AB6008SV remote I/O module.

As the time came to upgrade tandem accelerator controls, we were able to add a full-time software developer/system manager to our staff. At about the same time, DEC discontinued development of ELN, which was unfortunate both because of our investment and because in some ways ELN with its protected-memory capabilities was superior to VxWorks. Fortunately, Vsystem version 3.1 had, by this time, been ported to Unix/VxWorks. Therefore, tandem controls were implemented with a DEC UNIX host and a Heurikon VME/VxWorks processor talking with existing CAMAC by means of a Kinetic System 2917/3922 VME-CAMAC interface and we planned to migrate the VMS/ELN controls for the RIB platform and ORIC to UNIX/VxWorks with Vsystem version 3.1. Although we achieved our goal of retiring the aging 1970s minicomputers and the tandem accelerator operated for over a year with this configuration, there were several problems. Throughput between DEC UNIX and our VxWorks node was extremely poor, necessitating development of special "gateway" software to buffer ethernet transactions. In addition, Vista software in this configuration would freeze several times per week and Vista was never able to locate the problem(s). Resulting tandem accelerator downtime (and nighttime trips by members of the engineering staff to restart Vsystem) forced a change.

5 MIGRATION TO EPICS

We decided to move to EPICS after an analysis of the two software architectures[2], and because EPICS will be used increasingly at ORNL following the decision to use EPICS to control the new Spallation Neutron Source (SNS)[3]. However, HRIBF is now in full operation making it a high priority to perform the transition with minimal impact on operations. In addition, operations personnel have grown accustomed to control screens based on Vdraw and desired not to have to find their way around a radically new set of screens. Engineers desired some of the nicer development features of Vdraw, such as symbol support and flexible widget tools. Additionally, MEDM did not work well on our DEC UNIX nodes. For these reasons, a new extensible display manager was developed which is used in place of EPICS DM or MEDM and which can be used to communicate with both EPICS and Vsystem channels, allowing incremental transition to EPICS. The new display manager is also an experiment in object-oriented display manager design; new widgets can be designed as derived-class objects quickly and easily satisfying operator desires for new widgets or special widget behavior. New display widgets are implemented in a manner similar to creation of custom EPICS record support. Anyone familiar with the power of EPICS extensible record support would appreciate the same flexibility in display manager extension. Using this object model for display manager design permits distribution of updates to the object base class without impact on custom widgets developed by users of the display manager. Users of the display manager are able to develop custom widgets which may be shared with other sites.

EPICS driver software was developed to communicate with CAMAC serial highways. Tandem accelerator controls are CAMAC-based with 18 CAMAC crates located on six CAMAC serial highways. The serial highways originate from two CAMAC crates containing six Kinetic Systems 3992 serial highway drivers and the VME-based Heurikon VxWorks processor communicates with these crates through a Kinetic Systems 2917-VME/3922-CAMAC link.

The EPICS portable channel access (CA) server has been used to implement control and monitoring of serial devices using inexpensive PC hardware running the Linux operating system. As a test of the stability of this configuration, a building-access badge reader system was implemented and has been running for many months without the need for a single reboot. Running the portable CA server on Linux was valuable for off-line development of control screens with simulated control channels and the portable CA server on Linux was used to implement assignable knobs and assignable analog meters for accelerator control and PC hardware running VxWorks The EPICS database will similarly be used throughout the facility to avoid the high cost of VME hardware. The primary use of PC/VxWorks will be to interface Allen-Bradley PLC hardware by means of ISA-bus-based Data Highway Plus interfaces, and to control serial devices.

6 REFERENCES

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