SOFTWARE ASPECTS OF THE LANSCE ACCELERATOR COMPLEX CONTROL ROOM UPGRADE*

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Abstract

The Los Alamos Neutron Science Center (LANSCE, nee LAMPF) Central Control Room (CCR) has been upgraded. The reasons for the upgrade were to move toward a common operator interface, to increase the control room flexibility for simultaneous beam operations and development, to provide a cleaner and more comfortable control room for 24-hour, eight-month-per-year operations, and to improve the reliability and maintainability of the console interface hardware. The three dedicated-function consoles that serviced two separate control systems were replaced by a single multifunction console divided into three stations. Each station is able to control any part of the facility. The new console contains six three-headed Sun workstations and several mainly-display-oriented X-terminals. Each of the three stations of the new console has a single keyboard. To preserve our investment in VAX-based application programs while the VAX and EPICS control systems are being merged, we have provided X-Windows emulators for old hardware interfaces. A recent paper has described the hardware upgrade[1]. This paper discusses the software aspects of the upgrade.

1 INTRODUCTION

The LANSCE experimental programs derive their beams from an 800 MeV proton linac capable of delivering up to 100 μA of H- ions and 1000 μA of H+ ions in beam pulses as long as 1000 μsec at repetition rates of up to 120 Hz. The H- ions can be sent directly to experiments or to a Proton Storage Ring (PSR) that compresses the beam pulse to 270 nsec. The high intensity PSR pulse is then delivered to a neutron production target.

Over the past several years, the focus of LANSCE research has evolved from primarily nuclear and elementary particle physics to include neutron scattering and proton radiography. The evolving requirements for these new applications along with the need to provide safe and efficient operations and high availability drove the CCR upgrade.

During typical operation periods, the LANSCE complex provides beam 24 hours per day, seven days per week. High beam availability is vital to the continuing viability of the facility. Maintenance is usually performed on scheduled two-to-three day maintenance periods that occur every three to four weeks. CCR is usually staffed by a crew chief and two or three operators. During maintenance days and beam development periods a variety of physicists, equipment engineers, and software development personnel may share the control room with the operators.

By 1997, the nearly 30-year-old CCR configuration was reaching the end of its useful life. Communications needs within the control room were changing. The separate PSR control room and control system had been incorporated into CCR[2], but coordination and compatibility issues made the incorporation much less than an integration. The reliability and maintainability of some of the (partially homegrown) operator console equipment were becoming critical issues. Finally, the decision to move toward an EPICS-based[3] control system meant that a common long-term operator hardware interface was important to the efficient running of the facility.

2 BACKGROUND

Before the upgrade, CCR had been organized around three consoles (see Fig. 1). Two of the consoles had general-purpose access to data from the original Linac Control System (LCS) which still controls most of the linac and the experimental area beam lines. The third console was dedicated to tuning and running the PSR and neutron production targets through the EPICS control system.

The original LANSCE consoles had used many different user interfaces since their original conversion to a VAX/VMS-based control system in the early 1980s. But, from the beginning, there were always four primary input/output console devices:

- Color CRT —A CAMAC-based color character-cell CRT at the center of each console. The driver software shared the CRT screen among a program demand line, a message area, and application program displays.
- Graphics scopes —Terminals driven by Tektronix graphics output. These were Tektronix 4014 compatible graphics terminals.
- Touch panels —Originally VT100 terminals with an add-on infrared touch panel interface. These were later replaced by Tektronix compatible graphics terminals using mice or trackballs to emulate touches.
- Knobs —Home-built, CAMAC-based knobs which provided command of analog channels.

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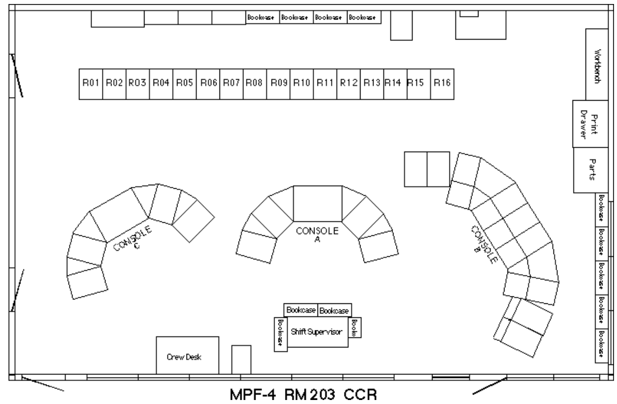

Fig. 1 The Original CCR Layout

A VAX cluster ran the application programs that drove all these interfaces. Each original console supported one color CRT, three graphics scopes, two touch panels, and six knobs.

The EPICS interfaces, which had already been installed on the third console before the CCR upgrade, were EPICS Operator Interface computers (OPIs). In our case, these were Sun workstations running Solaris 2.6. These workstations ran application programs such as the EPICS Display Manager (dm) and Tcl/Tk applications that used the X-Windows protocol.

3 NEW CONTROL ROOM

A process based on operator discussions and a survey of control room users produced a control room layout shown in Fig. 2. In this layout, the three separate consoles have been replaced by a single, large console divided into three console stations. The stations logically mirror the structure of the three original consoles. At the rear center of the new layout is the crew chief s desk. The new configuration improves communication among operators, the crew chief, and other CCR users.

In the new layout, each station contains two three-headed Sun workstations. Each of the six screens can be treated as independent X-terminals. The Sun workstations are either Sparc 5 s or Ultra-Sparcs with at least 64 Mbytes of memory and access to a 76 Gbyte Sun diskserver. Commercially available software[4] allows the two Suns at each station to share a single keyboard. Each console station also contains six LCS knobs.

4 SOFTWARE ISSUES

More than 200 person-years of effort has been invested in the LCS application software that is still needed to diagnose, tune, and run the accelerator. The conversion of these programs to EPICS is expected to take several years. In the meantime, the operators needed to have access to these applications through the new console.

We began our design of software for the new CCR configuration by looking at the application program interfaces (APIs) for handling the old console devices. Our previous experience with changing console hardware taught us to avoid application impact by using well-defined APIs for each type of device. Changes to deal with new hardware were done by changing the API libraries, not the applications themselves. Since EPICS uses X-Windows as its OPI display standard, it was logical to consider using X-Windows to emulate the behavior supplied by the original LCS operator interface hardware.

4.1 Console Hardware Emulators

After investigating possibilities of emulating the old console devices as X-Window displays in the API libraries themselves, we decided to take a different approach. We created new VAX pseudo devices that looked like the old devices to the existing library APIs. We wrote daemon programs which linked the pseudo devices and the X-Window displays. This approach very much simplified debugging the changes, since they were isolated in the new pseudo device daemons and the color CRT driver.

The CAMAC interface for the old color CRTs was a locally written VAX/VMS driver. The CAMAC module provided a "memory map" of the CRT display. Changes to the memory map through the driver changed the display. The driver also picked up keyboard and trackball input, which were then reflected in the display and sent to application programs.

We wrote a VAX-based XRT daemon (for X-Windows CRT) to emulate a color CRT in an X-Window using MOTIF and X-Windows libraries. We modified the CRT driver to read and write a shared area of VAX memory and added a couple of new functions to communicate with the daemon. The XRT daemon was set up to write changes from the driver to the X-Window display, and read changes from keyboard or mouse input back to the driver. There were no changes required to application programs or the color CRT API libraries.

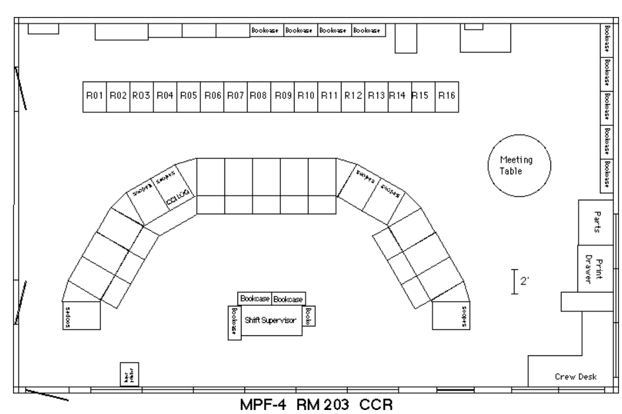

Fig. 2 The New CCR Layout

We followed a similar approach for the Tektronix graphics emulator. We acquired an X-terminal display program (xterm) from a DEC World Wide Web site and made it into a graphics daemon. This daemon creates an emulated Tektronix 4014 display in an X-Window and sets up a VAX pseudo terminal (a standard part of VMS) to act as an interface to application programs. The daemon takes application program output through the pseudo terminal and writes it to the X-Window. In this case, some minor changes were needed in the API library to deal with differences between our real Tektronix terminals and the pseudo terminal.

The touch panel API used the same xterm daemon as for the graphics scopes, but with different setup parameters to use VT100, instead of Tektronix 4014, windows and to communicate mouse and keyboard events back to the application programs. Only minimal API library changes were needed.

4.2 Knobs and Gateways

The analog knobs were controlled by LCS VAX software that we were not ready to move to EPICS. Since the knobs remained on the VAXes, no knob API library changes were necessary. Some system level changes, however, were required to assign knobs on the correct console station when assignments were requested by both VAX- and Sun-based application programs. A VAX server program was created to handled Sun RPC requests for knob assignment. We are now in the process of moving the knobs from the VAXes to an EPICS IOC.

Sharing data between two control systems continued to be a problem. The new CCR configuration made this sharing all the more important. VAX-based gateway programs[5] have been created and expanded to share data and controls between LCS and EPICS environments.

5 EXPERIENCE

With the new control room configuration, the LANSCE operators now deal with a unified hardware interface. Over the next few years we will be able to incrementally convert old VAX applications to EPICS with minimal impact on the operators. At the same time, we are working to improve the overall usefulness of the new interfaces.

We allowed the operators to decide where various programs should be displayed. As expected, the top-level displays (9 heads, three workstations) became comfort displays easily visible from other consoles or from the crew chief s desk. The bottom screens have been the busiest interactive screens. In light of this pattern of use, a reassignment of workstation head coverage on each console station may be possible.

We continue to analyze the performance of the X-Window update loop required by the daemons connected to the emulators. We have made several adjustments to the associated parameters to balance system response with CPU overhead.

We occasionally (a few times per week) get "freezes" on the touch panels where mouse or keyboard events cannot get through to the daemon. The only way to get out of this situation is to restart the X-Window server on the Sun. We think this is connected to a bug in the server code, but we have not been able to resolve the issue yet.

To speed up connections to EPICS channels from LCS applications, we decided to complete the connection before data was likely to be available on the VAX. This caused problems with some LCS applications that expected to read good data immediately. As interim step, we arranged to pre-open a set of commonly used EPICS data channels. Besides improving response for application requests, this change also improved operator alarm notification times. Efforts to further understand connection speeds is in progress.

To improve EPICS screen requests for LCS data, we also optimized and redistributed the VAX-based LCS gateways. We split the gateway into four parts, each running on a different VAX, based on the hardware type of the data and the expected read completion time (fast or slow). Since each gateway polls the data it is interested in, separating the gateway data requests allowed fast data to be accessed very quickly. Depending on the accelerator configuration, slow data may require much longer waits.

6 CONCLUSIONS

The LANSCE Central Control Room upgrade was accomplished during the Fall 1997 — Spring 1998 maintenance period. The new CCR configuration has been in use since April 1998. LANSCE operations have continued smoothly in the new environment. Future control system improvements can be easily integrated into the new control room. It appears that the changes have greatly improved communications, convenience, and operator comfort.

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