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Exploiting the X-Window Environment to Expand the Number, Reach, and Usefulness of Fermilab[1] Accelerator Control Consoles

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Abstract

The Fermilab accelerator operator workstation of choice is now the Digital VAXstation running VMS and X-Window software. This new platform provides an easy to learn programming environment while support routines are expanding in number and power. The X-Window environment is exploited to provide remote consoles to users across long haul networks and to support multiple consoles on a single workstation. The integration of imaging systems, local datalogging, commercial and Physics community's software, and development facilities on the operator workstation adds functionality to the system. The locally engineered knob/pointer/keyboard interface solves the multiple keyboard and mouse problems of a multi-screen console. This paper will address these issues of Fermilab's accelerator operator workstations.

I. CONSOLE HARDWARE

The accelerator console is built around a VAXstation color workstation running VMS and X-Window software. The VAXstation 3200, VAXstation 3520, VAXstation 3100/30, 3100/38, 3100/76 and MicroVAX II are in use as workstation processors. The displays have either 1280 by 1024 or 1024 by 768 resolution with 8 bits per pixel.

Network communication to other accelerator processors is via accelerator-control network (ACNET) software using either a locally designed token-ring card or an Ethernet to token-ring bridge. Communication for system management, accelerator clock, and other purposes is via DECNET and TCP/IP over Ethernet.

A single-screen console provides full functionality, but some control room users require multiple displays. X-terminals using TCP/IP and Ethernet provide these additional screens. The NCD-17c is the preferred X-terminal for this control system.

[1] Operated by Universities Research Association for the Department of Energy

II. EXPANDING THE NUMBERS

The number of consoles connected to the Fermilab accelerators is rapidly growing. Where 20 consoles served Fermilab for 10 years and budgets were prepared for 50 new consoles, the demands for VAXstation consoles are exceeding that estimate. 33 VAXstation consoles are active with 24 additional VAXstations scheduled to be purchased by Spring, 1992.

The increased numbers are due to a variety of factors. Many requests for accelerator consoles were denied over the years due to high cost and difficulty of installation. The new console with symbolic debugging support is a productive rapid cycle development machine. Users want convenient access to accelerator information, often in their office.

However, greater numbers of consoles present larger demands on central services and front end data acquisition nodes requiring consequent upgrades in those areas and the introduction of application program time-outs and other measures to balance high accessibility with overall throughput.

As new models of VAXstations are announced and released, we tend to purchase machines with better performance and value. It is clear that a console supporting a development cycle has an excess of cpu cycles and network bandwith. Utilizing that excess power is possible by supporting multiple consoles on a single VAXstation.

A. X-server consoles

The software architecture of a console is relatively simple. A large shared memory and shared library, several manager tasks and user applications make up a console. Splitting the shared memory region into a global area and multiple console specific area provides the ability to run additional alphanumeric, graphic, and utility managers, and sets of user applications. An X-server console is obtained at the cost of an X-terminal for the window displays. Twenty X-server consoles are in regular use primarily in the offices of programmers and accelerator operations specialists.

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B. Long haul consoles

The X-server consoles were demonstrated on a variety of machines around the lab and at vendors' offices in nearby communities. Sun workstations, Macintoshes, and a variety of X-terminals were compared for capability, cost and performance. Experimenters understanding the capabilities of X, convenience, and travel cost savings requested control system access to allow test and development from their home institution. We currently support occasional long haul access from Pennsylvania and Texas. Peformance of a long haul X-server console is reported as somewhat slower than a local network connection, but acceptable. The suitability and appropriateness of long haul networks for remote control system access may be debated.

C. The numbers

With a full complement of 50 VAXstations, the ability to support three consoles on a single VAXstation, and the trend towards providing office accessibility to all programmers, the total number of consoles supported by this system is expected to exceed 100 within a few years.

III. ADDING VALUE

The tools and services of the accelerator console platform are evolving and expanding at a rapid rate.

A. Console library

The console subroutine library (CLIB) consists of more than one thousand routines available to application programmers. More than half of the routines in CLIB may be classified as value added services not practical on the previous memory limited platform. Programmers have available new data acquisition, file management, and screen management tools. Screen management routines include movable/resizable/stackable windows, scrolling windows, complex menus, dialog boxes, and plotting tools. In addition, many new services for support of tape recorders, sequencer management, error handling, and display of digitized images exist.

B. Datalogging

A distributed, circular datalogger runs on many of the consoles providing datalogging at rates up to 15 Hz (but typically much slower) for a few hundred devices, and plot retrieval rates of nearly one thousand points per second.

The distributed datalogger offers custom features not practical in the sole central datalogger such as dynamically changing collection rates. Current growth of the distributed datalogger predicts up to twenty five such loggers will soon exist, offering datalogging capability for 5000 devices.

C. Supporting development

Users develop applications programs in VAX Fortran or C. The Management Environment for Controls Console Applications (MECCA) is a locally written source code capture system that captures and keeps a public copy of the source code for each application program on the system. MECCA forces users to follow strict conventions controlling the location of include files and user, group, and system libraries. Other facilities exist to build user applications with little restriction for testing without affecting the production versions. These test applications are deleted from the system each evening.

D. Other software

The exploitation of commercial or Physics community software is keenly sought. Mathematica and PAW for example have been installed and demonstrated but have no current operational function.

IV. MULTI-SCREEN CONSOLES

A major requirement of the Accelerator Operations group was that control room consoles have multiple screens and support the knob and the set-in-the-countertop trackball present on the old consoles. The X-terminals which are used for the additional screens come equipped with a keyboard and pointing device. Operating a console with multiple keyboards and pointing devices is unwieldy. This problem, coupled with the strong demand for a physical knob and non-standard pointing devices, resulted in the development of the locally engineered knob/pointer/keyboard box.

A. Control Room Console Configuration

A fully equipped main control room console consists of four physical screens, one 19 inch color VAXstation and three NCD 17 inch color X-terminals. The VAXstation screen

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contains four alphanumeric windows in support of the user's applications, and the utility window. One X-terminal displays the alarm window. The remaining two X-terminals contain the six graphics windows.

B. Knob/Pointer/Keyboard Box

The knob/pointer/keyboard box interfaces the knob shaft encoder, preferred by the operations staff, to the console. It allows a single keyboard and pointing device to provide key input and pointer motion to any of the four display devices. Finally, it supports the Digital and NCD mice and a variety of trackballs as pointing devices. No user consensus can be obtained on the best pointing device. Consequently, up to four pointing devices are ORed together into one logical pointing device which is sent to the selected screen. This allows for left and right-handed trackballs or a variety of pointing devices for the operator. As the pointer reaches a screen edge, software on the VAXstation instructs the knob/pointer/keyboard box to switch the pointer and keyboard to the adjacent display screen.

The box accepts inputs from the following devices:
- Digital keyboard (RS423, Digital protocol)
- Digital mouse (RS232, Digital protocol)
- Mouse-Track trackball (RS232, Digital protocol)
- Set-in-the-countertop trackball (pulse-train)
- NCD mouse (RS232, Logitech protocol)
- Knob shaft encoder (pulse-train)
- VAXstation control port (RS232)

The box generates outputs for the following devices:
- VAXstation keyboard port (RS423, Digital protocol)
- VAXstation mouse port (RS232, Digital protocol)
- 3 X-terminal keyboard ports (PS2, PS2 protocol)
- 3 X-terminal mouse ports (RS232, Logitech protocol)
- VAXstation control port (RS232)

An internal microprocessor accepts keyboard and pointer data from the input devices and sends it to the selected output devices, converting keyboard and pointer protocols if necessary. The VAXstation control port is used to receive screen selection commands from the VAXstation and to send knob changes to the VAXstation.

V. SECURITY

Security for access control to accelerator devices and control programs was an issue long before office and long haul consoles arrived. Increased numbers of consoles called for changes to a nearly wide open system. The strategy chosen attempts to balance protection, implementation cost, and risk, yielding a system that is accessible and accountable.

This control system encompasses and serves several control room environments. Further, setting access is required for engineering test and development, accelerator experiments, and software developers. Tools and applications have been developed to allow the Accelerator Operations group to configure the accessibility of programs and devices.

Each console is a member of one or more classes of consoles that determine what application programs may be run and devices set. Further each console has a setting lock with a variety of privileges determining its behavior. There are four ways that a user is typically denied setting access:

1. cannot run any program. The change-program lock is locked for this console. It must be unlocked by the Main Control Room.

2. cannot run the program. This console is not a member of the classes of consoles allowed to run the selected program.

3. program will run but cannot do settings because this console is not a member of the classes of consoles allowed to set with this application.

4. program will run but cannot do settings because the console's setting's lock is locked, and the user is offered no choices for unlocking, and the Main Control Room elects not to unlock this user remotely or is not able to unlock the user remotely.

When settings are performed, information about the settings are queued, then sent to a central settings logger. Application programs exist to view logged settings with a variety of presentations. An X-server console on the Main Control Room crew chief's desk is normally configured to display in real time the settings performed from consoles not in a control room environment. That number of settings is small, and coupled with the run and set control imposed on applications and devices offers the operating crew the confidence that they are in control of the accelerator.

VI. CONCLUSIONS

The new accelerator consoles are providing greater accessibility to accelerator information to users and richer tools and a more productive development environment to programmers. The growth in numbers and wide geographical dispersion of accelerator consoles present throughput and security problems that require continuous attention.

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