© 1991 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE.

Modern Operators' Consoles for Accelerator Control at Fermilab

P. Lucas, K. Cahill, R. Peters, and J. Smedinghoff
Fermilab
P.O. Box 500
Batavia, IL 60510

Abstract

Since the construction of the Tevatron the Fermilab accelerator complex has been controlled from operators' consoles based on PDP-11 computers and interaction with display hardware via Camac. In addition the Linac has been controllable from microprocessor-based local consoles. The new generation of console devices is based on VAXstation computers, networked by Ethernet and Token Ring, and utilizing the X-windows protocol. Under X the physical display (server) can be driven by any network node, and need not be part of the console computer (client). This allows great flexibility in configuring display devices - with X-terminals, Unix workstations, and Macintoshes all having been utilized. Over half of the 800 application programs on the system have been demonstrated to work properly in the new environment. The modern version of a Linac local console runs in a Macintosh. These are networked via Token Ring to Linac local control stations. They provide color graphics and a hard copy capability which was previously lacking.

I. INTRODUCTION

Since the advent of the Tevatron in the early 1980s the operator interface to the Fermilab accelerators has been via consoles consisting of PDP-11 computers driving Camac links to hardware, which in turn control multiple screens and pointing devices. The number of such installed consoles peaked at twenty - with about half clustered in the Main Control Room area and the remainder distributed throughout the site. These consoles now are obsolete due to the difficulty of maintenance, the expense which precludes construction of further instances, and a restrictive software environment which greatly limits potential usefulness. It is well known in the controls community that the appropriate functionality for operating an accelerator can be found in a modern engineering workstation, and such devices are being implemented at Fermilab as replacements.

The Fermilab H^- Linac, for which the controls preceded those of the Tevatron, has been operable either from the Control Room via an early LAN (Local Area Network) (SDLC combined with Ethernet and gateway software running in a PDP-11) or locally at the accelerating station. The local operation is through small monochrome character cell screens. These local consoles are being phased out in favor of ones based on Macintosh personal computers with color graphics and a Token Ring network.

No accelerator downtime has been scheduled to accommodate console conversion; thus both for the Linac and for the rest of the complex it has been necessary to install the new console types and have them operable simultaneously with old ones. In particular for the workstations this has required the vast majority of roughly 800 application programs to be operable with identical code on both new and old machines.

II. LINAC MACINTOSH CONSOLES

The most frequently utilized applications at the local control stations are the generic Parameter Page (important on all Fermilab console types) and a memory dump page used for diagnostic purposes. These have been duplicated in the Macintosh environment together with a full featured plot package and a standard text window for error reporting. These features are generated by a single application program written in C, developed under MPW, and operating under standard Mac OS. Since performance is an issue, the Macintosh IIci system with cache has been selected. In addition a 13" color monitor, Apple Token Ring card, and 8 MB RAM are configured. Figure 1 shows a typical display on one of these consoles.

III. WORKSTATION CONSOLES

A. Hardware

The remainder of this paper will discuss the replacement of PDP-11 consoles by workstations. The platform chosen for this console implementation is the VAXstation. This choice was dictated by software considerations, mainly that the central node host for our control system is a cluster of VAX machines so that all of the networking and data acquisition codes have long been operable under VAX/VMS. As advances in the VAX line have occurred the specific model of choice has progressed from MicroVAX II GPX through VAXstations 3200, 3100/30, 3520, and 3100/76. All such stations are equipped with 19" 8-plane color graphics, 32 MB RAM, and 600 MB external disk. The cost of a complete single screen console at present is $16K.

All consoles have Ethernet connections for remote system management functions and accelerator clock distribution. However our control system backbone LAN is not Ethernet but Token Ring, and it is desired to have the appropriate connection for all nodes. We have succeeded in constructing a network interface for the Q-bus backplane machines, in particular the 3520, but do not yet have the required Token Ring/SCSI (Small Computer Systems Interconnect) connection for the 3100 devices. A commercial solution is being sought, but at present some Q-bus machines are serving

*Operated by Universities Research Asociation, Inc. under contract with the U.S. Department of Energy.

0-7803-0135-8/91$01.00 ©IEEE

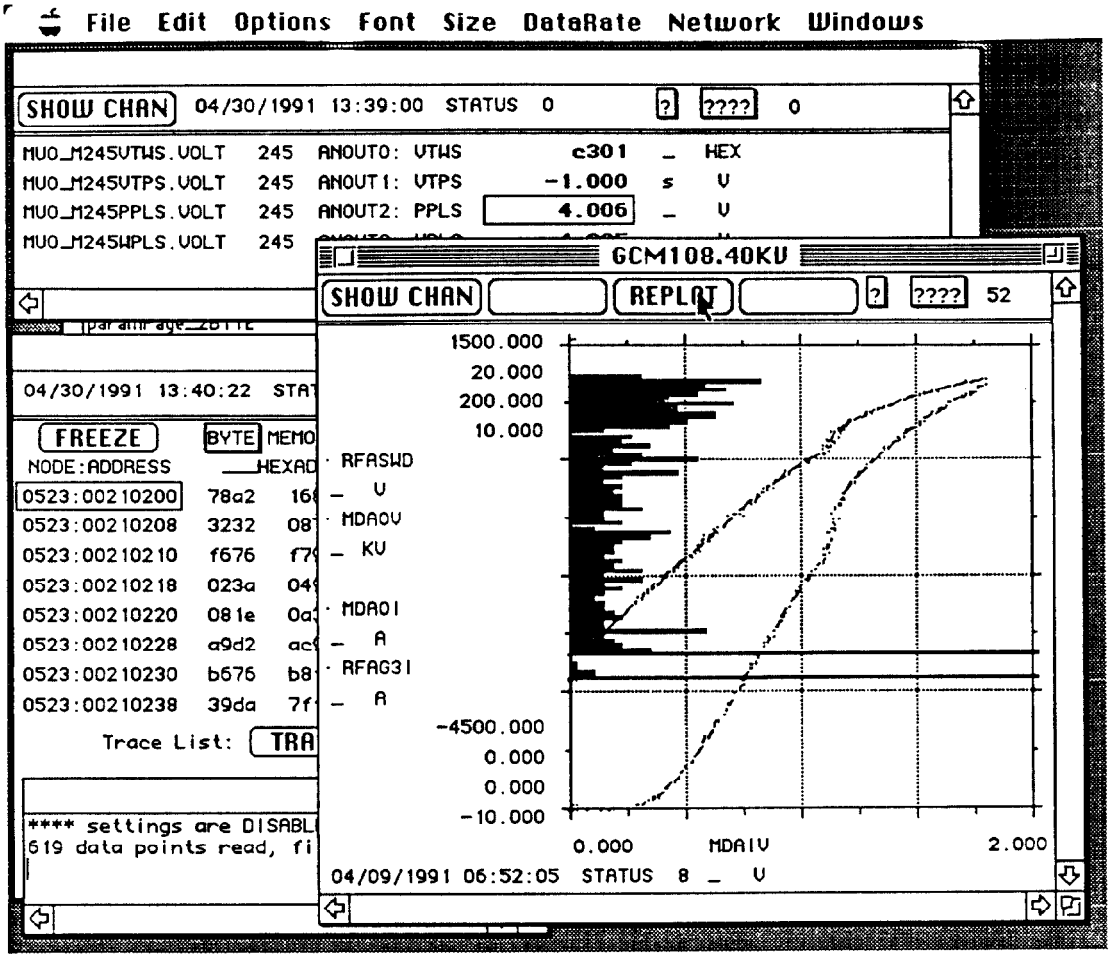

Figure 1. A multi-window display on a Linac Macintosh console.

as Token Ring/Ethernet gateways with the 3100s actually networked only via the latter.

An important aspect of our progress is represented by the installation of X-servers or X-terminals. The windowing system chosen is X11, which specifies network transparency of a display, i.e. the display for any given computer can appear on any other computer or appropriate terminal on the network. The terminal of choice at this time is a 16" color NCD device (cost of $3800). We have demonstrated single screen consoles with either the main workstation screen or an X-terminal, and multi-screen consoles utilizing both.

B. Software

As was noted above, the X11 windowing system was chosen for this work. The means of implementation was to map the display on each of five screens of the old consoles into corresponding windows on the new. Since all I/O is done through library calls from (primarily) Fortran application programs, a separate library for the workstations utilizing X, rather than Camac, operations has been created and has permitted the migration to be surprisingly straightforward. On the VAXstations this library of console routines is implemented as a VMS shared library so that changes to it can be made without relinking any application programs. Figure 2 shows a typical display.

The number of windows allotted to a single new console provides a display capability roughly equal to twice that of an old one. Additionally it has been found practical, due to the compute power of the newer workstations, to run more than a single console instance from a given computer. So far no more than two instances have been run, but three seems a realistic possibility under some circumstances. In the case of more than a single instance running in one computer, all beyond the first utilize remote X-servers. Any device capable of working in this capacity is acceptable, and, although X-terminals represent the obvious choice, a Sun Unix workstation and a Macintosh personal system have also been utilized successfully. Indeed since the X-server can be on any node which is reachable via the workstation's Ethernet connection, there is no technological limitation that the server reside at the laboratory. Thus live console information has been examined to advantage on screens at the University of Pennsylvania, at SSCL in Texas, and at Maxwell/Brobeck Laboratories in California.

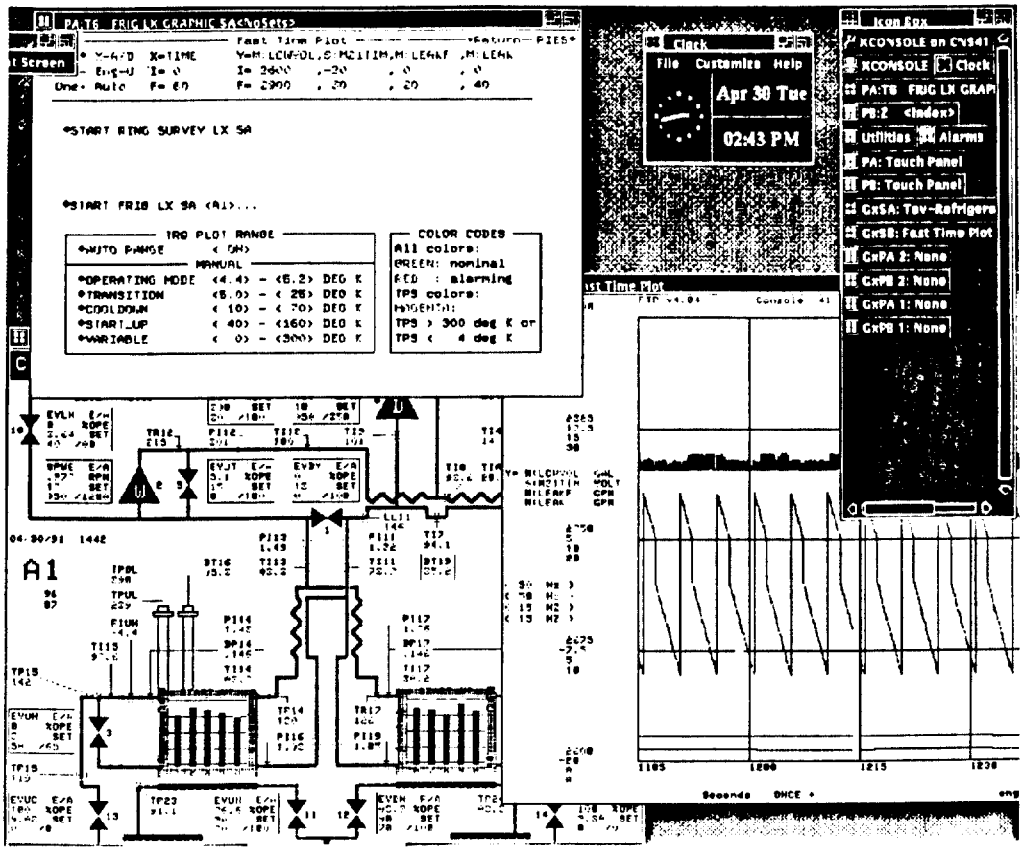

Figure 2. A VAXstation display with several active X-windows.

Due to the obvious potential security problem, secondary console instances are allowed readonly access to the accelerator data and operating parameters.

The duplication of the PDP-11 programming environment on this new platform represented a first phase of the project. Furthermore, until this phase was completed, we worked under a self-imposed restriction of not creating any operating software which was incompatible with the old consoles. However, now that new consoles outnumber old, we are able to take advantage of the compute power, memory and disk capacity, and graphics capabilities of our new equipment to improve markedly the services provided to machine operators. Among the features added thus far or under consideration:

• An efficient datalogger operational totally within the console. The performance of this product surpasses that of the standard logger running on the host;
• Security and accountability features. Most consoles initialize with settings disabled; the user must explicitly allow them on a given machine, and a time limit will be imposed on this activation. Additionally all settings are logged so that activity which might affect operation can be monitored from the Control Room;
• A large software package for colliding beams operation. The Tevatron control system is given its most severe tests when protons and antiprotons are accelerated simultaneously and brought into collision. Previously this process was orchestrated by a program running in a PDP-11, a situation which severely restricted operational flexibility. New software,designed from the beginning for VAXstations, is being created and already represents several person-years of effort;
• A console based image library. A library of scanned photographs, in particular of the site and of inaccessible areas of the tunnel, is available for viewing on the console during operation. This library is originally envisaged as a training tool for operators;
• Alarm display. Display of alarm information, as done by PDP-11s, represents one of the weakest aspects of our control system. A new display, having many advanced features and utilizing the capabilities of the workstations, is being created.

IV. CONCLUSION

In the past our accelerator consoles have been extremely specialized devices, configured from hardware specific to the task. However, with modern advances in computing, the capabilities of reasonably priced desktop systems far exceed those of yesterday's consoles. It is quite imaginable that, based on the configurations presented here, any staff member with a need for real-time accelerator data will be able to have a console equivalent on his/her desktop soon. This happy situation of course creates a new set of problems - throughput limitations in the rest of the control system due to so many requestors of data, and possible security, manageability, and data integrity concerns.