NSLS Beamline Control and Data Acquisition Computer-System Upgrade

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The NSLS beamline computer systems have gone through two major updates: (1) a graphical user interface (GUI) was incorporated into the original beamline-control and data-acquisition program ACE to form the new composite program GrACE, and (2) we updated device drivers to run GrACE on a Pentium PC running the UNIX-like operating system LINUX. With a proper PC CMOS setup and a PCI local-bus graphics card, the LINUX X server on a Pentium is dramatically accelerated to run GUI applications. With in-house-designed CAMAC and MCA device drivers and a public-domain GPIB device driver, we can run the original beamline-control and data-acquisition program without changing the computer-interface hardware. The updates produce powerful, low-cost, flexible, and user-friendly computer systems.

1. Introduction

The original NSLS beamline-control and data-acquisition program ACE [1] had enough functions to serve its purpose. However, we recognized that a graphical user interface on top of ACE is necessary to provide a friendlier user interface. GUI applications had tremendously negative impact on program execution speed due to the poor architecture of the software and hardware of the original 486 PC-UNIX platform[2]. LINUX [3] supports a wide range of software, from X-windows to the GNU C/C++ compiler to TCP/IP. It's a versatile, *bona fide* implementation of UNIX, freely distributed by the terms of GNU General Public License. After Intel marketed the Pentium, some developers wrote device drivers for PCI local-bus graphics cards to take the advantage of the local bus system capable of moving 32 bits of data at 33 MHz which accelerates GUI applications dramatically. We updated the original system with low-cost computer systems and in-house-designed software to achieve powerful, reliable, and user-friendly computer systems.

2. Hardware configuration

The PCI local bus greatly improves I/O performance, especially graphics. The PCI bus can transfer data between the processor and the peripherals at up to 132 MB/s, far faster than the ISA bus rate of 5 MB/s. A full-featured PCI-compliant VGA card, with at least 1 to 2 MB of video RAM, will accelerate graphics performance further. We bought several 66MHz, 100MHz, and 120MHz Pentium P5 [4] computers, each equipped with a PCI EIDE hard disk controller, thirty-two megabytes of RAM, a 256 kB cache, an ATI MACH 64 with 2MB of VRAM, and a 1GB hard disk drive. We chose PCI local-bus Ethernet cards [5] for network communication.

Table 1 and table 2 shows the CPU and system benchmark among various computer systems we studied during evaluation. We only compared systems under $12K in price and picked the best values.

TABLE 1. CPU benchmarks [6]

	Pentium 66MHZ	Pentium 120MHZ	HP 715/50	HP 715/80	SUN/SPARC/ 20/50	SUN/SPARC/ 20/61
Cache size	256 KB	512 KB	256 KB	256 KB	256 KB	256 KB
SPECint92	78.0	133.7	49.2	83.5	69.2	88.9
SPECfp92	63.3	99.5	78.8	120.9	78.3	102.8

TABLE 2. System performance using BYTE Benchmarks [7]

	Pentium P5	Pentium P5	Pentium P5	Sun Sparc 10
Kernel	LINUX 1.2.8	LINUX 1.2.8	LINUX 1.2.8	SUN OS
Clock	90 MHZ	100 MHZ	100 MHZ	50 MHZ
Hard disk controller	EIDE	PCI EIDE	PCI SCSI-II	
RAM	32 MB	16 MB	32 MB	128 MB
Average Index	6.6	11.6	11.6	7.9

The system performance was an average index of arithmetic tests, file copy, pipe-based context switching tests, shell scripts and so on.

3. Software development

Some of the source codes of the following software development is sharable [8]. The user manual for ACE is on the World Wide Web [9].

3.1 Device driver development

We wrote a device driver for the AT-bus PC004 PC-CAMAC interface card for a 6001/6002 CAMAC crate controller, available from DSP Inc., and a device driver for the AT-bus PCAII multi-channel analyzer from Nucleus Inc.

We obtained the GPIB device driver for LINUX from a public domain site [10]. One has to modify the kernel to use DMA if the PC has more than sixteen megabytes of RAM. One could leave the kernel untouched by disabling the DMA manager. On the GPIB board [11] we used, the DMA operation is unimportant when a chunk of data less than 32 bytes is transferred and most effective when a chunk of data more than 512 bytes is transferred.

In LINUX, theses device drivers can be installed on the fly without modifying the kernel or rebooting the system.

3.2 GUI development

We wanted to add a GUI on top of ACE with minimum changes in the original structure of the ACE program. We developed three GUI processes to communicate with ACE through pipes. It not only facilitates debugging but also preserves flexibility because each process can run independently. Furthermore, this kind of structure will facilitate further development into a client/server application. Figure 1 shows the current structure of GUI/ACE.

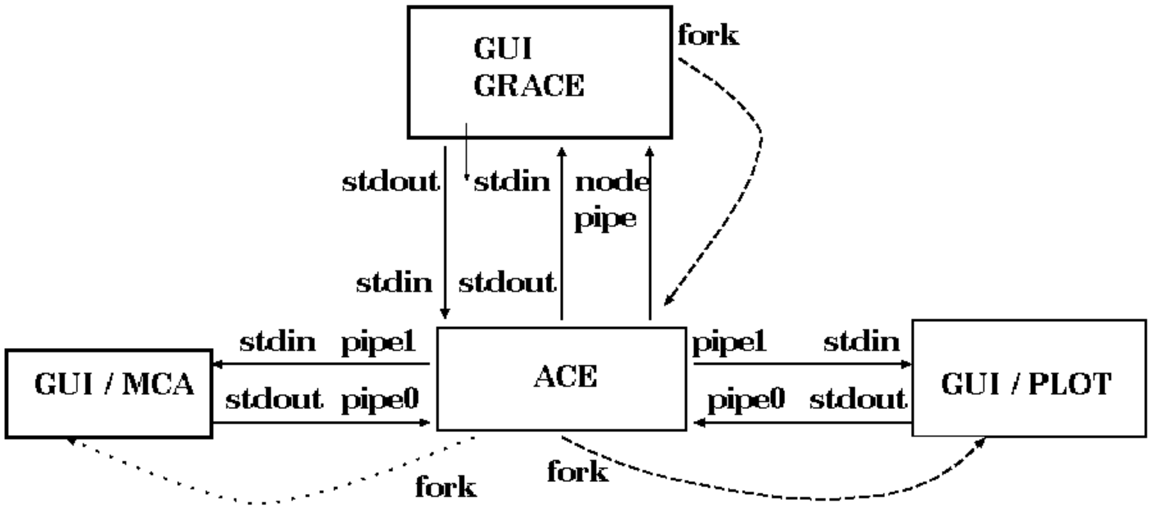

Figure 1: GUI/ACE

3.2.1 GUI/GrACE process

Figure 2 shows one example of the GUI/GrACE which maintains a scrollable window to print out the original screen message from ACE (on the lower left corner). In addition, it shows the GUI for the motor database editing, align/scan and counting. Another innovative design is to use Tcl/Tk to implement a GUI builder to build a user's own macro definitions. GrACE sends strings of commands to the ACE server whenever users click on a GUI as if those commands were typed out by them[12]. The Builder Xcessory[13] was used to build the GUI.

3.2.2 GUI/MCA and GUI/PLOT processes

Figure 3 shows one example of the GUI/MCA and GUI/PLOT called by ACE during a scan. Both processes, capable of running alone, will display the X and Y positions of the cursor in the plotting window interactively. Initially, the Builder Xcessory was used to layout the GUI. Thereafter, a plotting and user-interface library using Motif and X-windows graphics were written in-house to develop GUI processes.

4. Discussion

To integrate the LINUX OS on a Pentium PC demands skillful system administration. Although it is not quite well supported commercially[14], we can fulfill most beamline applications to achieve a powerful and user-friendly computer system.

Acknowledgments

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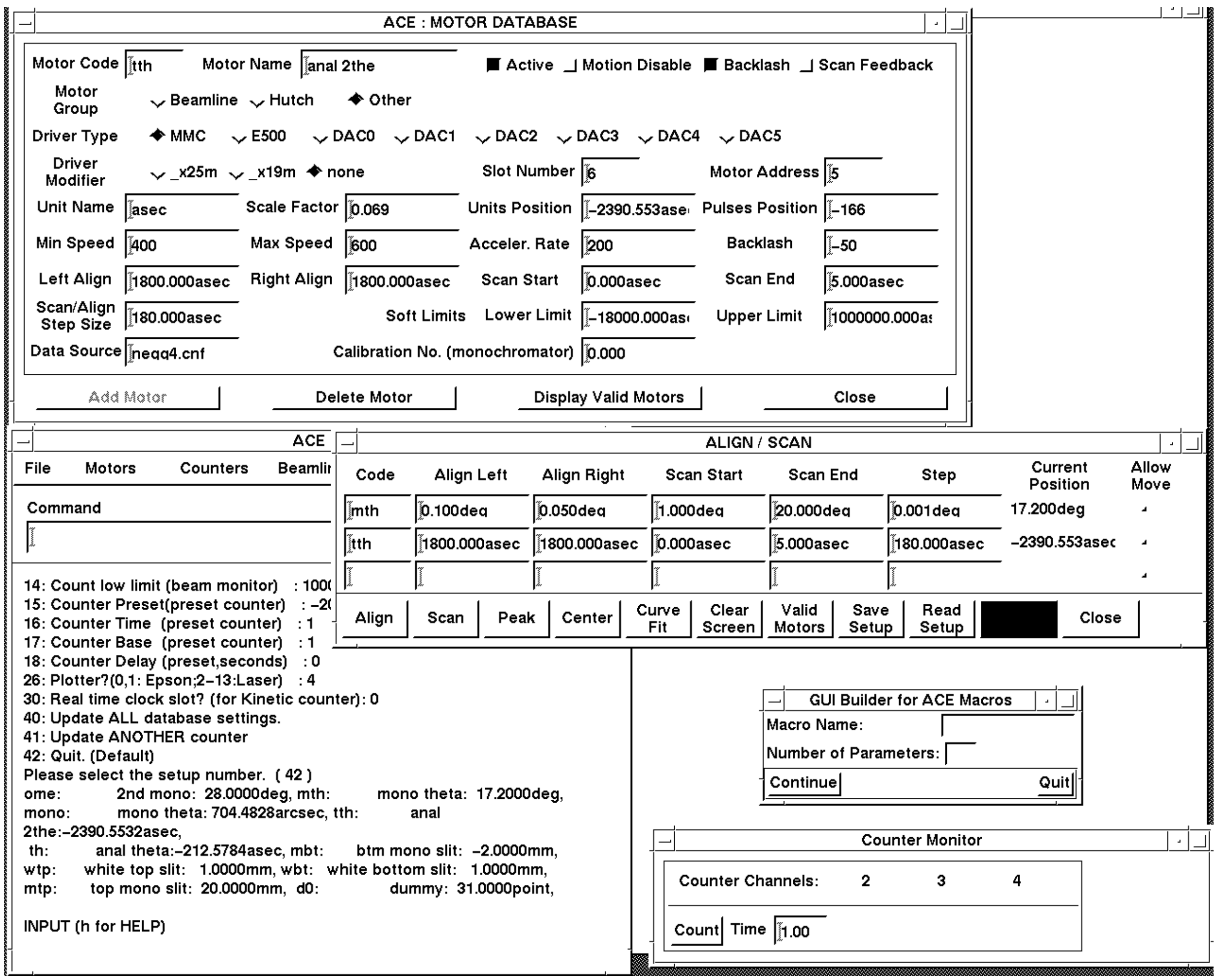

Figure 2: GUI/ GrACE calls ACE server

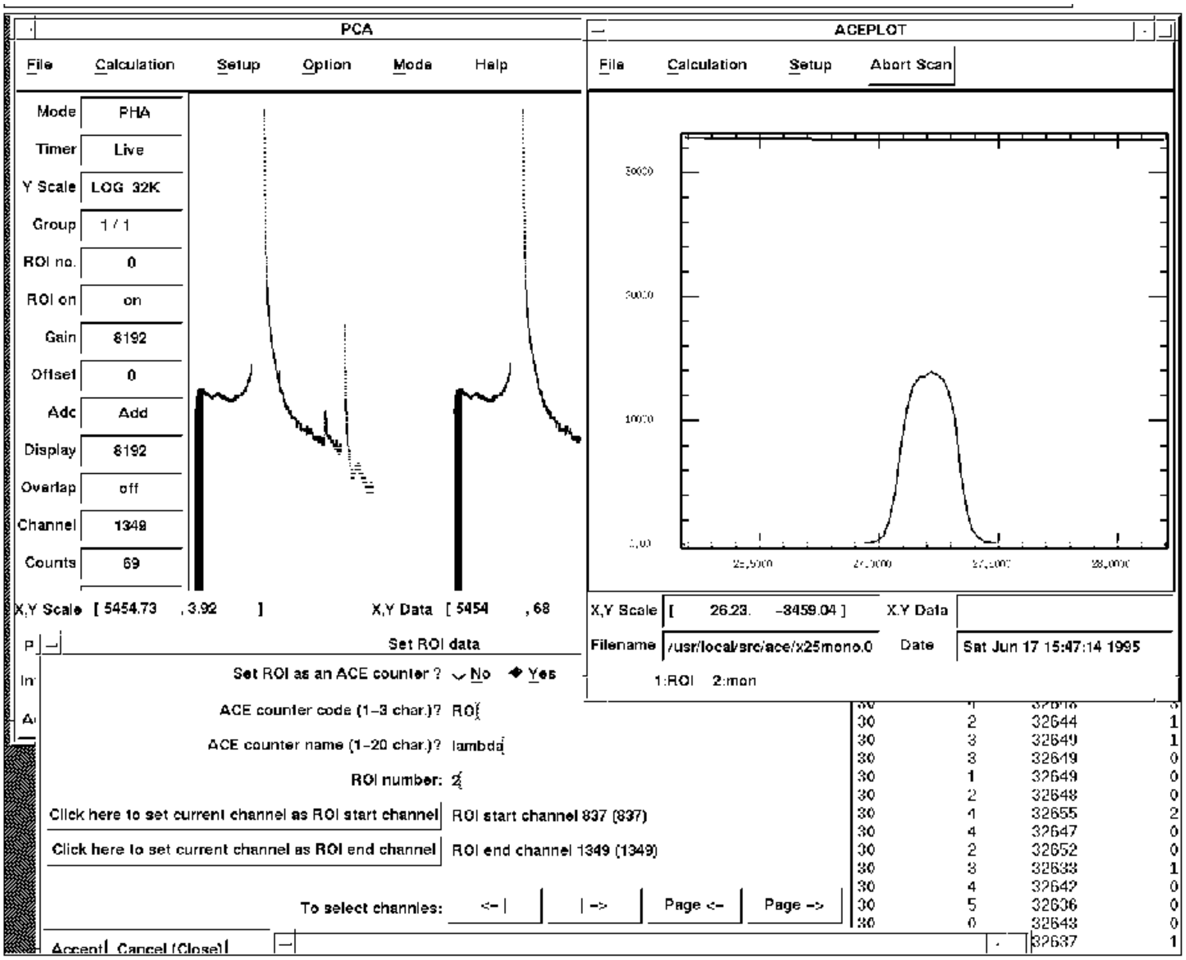

Figure 3: GUI/MCA and GUI/PLOT called by ACE during a scan

References

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[3] Anonymous FTP sunsite.unc.edu:/pub/Linux/distributions, ftp.linux.org:/pub/mirrors/sunsite or other mirror sites.

[4] Gateway 2000 Pentium P5, available from Gateway 2000, North Sioux City, SD, USA.

[5] SMC8432BT ether power PCI ethernet adapter, available from SMC distributor.

[6] Pentium benchmark was obtained from https://webjf.intel.com/procs/perf/bench/spec.html, HP benchmark was obtained from HP9000 Series 700 Configuration Guide, SUN benchmark was obtained from anonymous FTP ftp.nosc.mil in /pub/aburto.

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[8] sharable form anonymous FTP ftp.nsls.bnl.gov in /nsls/pub/beamline.

[9] https://lspc6.nsls.bnl.gov/~giles/man/man.html.

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