The Use of PCs in Controlling DESY Accelerators

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Abstract

PCs now play a dominant role in the control of the HERA, PETRA and DORIS machines at DESY. Initially (1992), the control system employed made use of MS-DOS Front ends and MS-WINDOWS Consoles. Today, the HERA control system supports a number of platforms, the preferred configuration using LINUX Front ends and Windows NT Consoles. A handful of front ends are not PCs at all, however, necessitating an interface between the PC and the non-INTEL world. This has been by and large unproblematic, and over the years the PC itself has proven to be a surprisingly robust and versatile element in the control system. Nevertheless, one must contend with frequently changing tools and components, both hardware and software, in an area where the ″State-of-the-Art″ looks different every six months. We report here on the experiences at DESY concerning the PC as a system choice.

1 Introduction

The Intel-based PC has been integrated into a number of modern control systems. Recent workshops at PCaPAC [1] (DESY) and ESONE [2] (CERN) have in fact focused entirely on PCs. At DESY HERA, PCs have been employed in machine control since the 1992 run. Now, five years later, virtually all HERA consoles are PCs as are more than three quarters of the HERA front ends. Recently, the smaller PETRA and DORIS machines have been converted to all PC control. At the TESLA Test Facility (TTF), PCs are also being employed, albeit on a much smaller scale (but also using much different control systems). Throughout this span of time and range of machines, a wide spectrum of Operating systems and PC hardware has been/is being used.

2 The operating system

The operating systems employed on PCs used in accelerator control at DESY encompass MS-DOS, Windows 3.X, Windows 95, Windows NT, Linux,, VxWorks, and NetWare. For the sake of simplicity we shall not be concerned here with version information. That is, Windows NT will be referred to as Win NT (and not 3.51 or 4.0) and Linux is Linux regardless of whether it is the Slackware distribution with kernel 2.0.7 or the SuSE distribution with kernel 1.2.12). OS 2 was briefly tested in 1993, and although found to be (at the time) one of the best operating systems for the PC, it was later dismissed as a dead-end.

Tables I - IV will help to illustrate the distribution of OSes on PCs at DESY. The primary control system for the HERA machine is TINE (Three-fold Integrated Networking Environment) which has been described elsewhere as MCS1 [3]. TINE is PC-biased, but as can be seen from the Table I below includes many non-PC components. Subsystems controlled by other control systems include Cryogenics (soon to be EPICS), Power and Cooling (EPICS), and Proton Vacuum (a DOOCS[4] predecessor). Of these, PCs are used in the Power and Cooling subsystem and are included in Table I.

Also shown in Table I are the IP and IPX stacks used for each platform (note that TINE supports IPX where available). Of particular interest are the last two columns.

By ″software reboot events″, we refer to workstation conditions arising from commercial software (be it the operating system, device drivers, or other third-party packages) which require a reboot for recovery. The distinction here is between problems of my own making (which I can find and correct) versus those of the software components I′m dependent upon. The two events concerning the Win NT consoles were due to PCI bus-mastering problems for the 3COM ethernet card then in use. This problem was acknowledged by 3COM, the work-around being to turn the bus-mastering off. From 1992 to 1996, Win16 consoles were in common use in the control room, and suffered such reboot events at the rate of approximately one per console per month. This was largely due to the nature of the Win16 operating system, where starting and stopping applications over a long period of time can sometimes leave resources (such as GDI handles) in a fragmented state (or not cleaned up at all!). The only other OS to have entries in this column is Netware, which is an unprotected operating system. Both events reported in this column occurred in 1996 and were unexplained. However, since applying the most recent patch level, no further events have been seen.

As to hardware faults, all of the entries shown refer to disk problems, with the exception of the Win NT consoles. In this latter case the cooling fans had ceased to function. Following this discovery, the cooling fans on all the consoles were replaced with higher quality fans equipped with an audible alarm in case of malfunction. Note that under MS-DOS, the disks are not used at all, unless the front end program explicitly uses file IO. This explains the astonishing stability of the DOS platform shown above.

The primary control system used in PETRA and DORIS is MCS2 (Machine Control System-2)[5] and is based exclusively on PCs using the IPX protocol. As can be seen in Tables II and III, the software and hardware

Table I: PCs in HERA
Control System: TINE

OS	TYPE	IP Stack	IPX Stack	No. Units	SW Reboot events (2-7)	HW faults (2-97)
Win NT	Console	WINSOCK	WINSOCK	20	2	2
Win16	Console	WINSOCK (LWP)	NOVELL	6	Many	0
DOS	Front End	LWP	NOVELL	40	0	0
Win16	Front End	WINSOCK (LWP)	NOVELL	20	0	1
Linux	Front End	BSD	BSD	3	0	0
Win NT	Front End	WINSOCK	WINSOCK	2	0	0
Win 95	Front End	WINSOCK	WINSOCK	1	0	0
Non-PC	Front End	BSD	-	17	0	1
Netware	File Server	Novell	Novell	2	2	1

Control System: EPICS

VxWorks	Front End	BSD (WindRiver)	-	3	0	0

Table II: PCs in PETRA
Control System: MCS2

OS	TYPE	IP Stack	IPX Stack	No. Units	SW Reboot events (6-7)	HW faults (6-97)
Win16	Console	-	NOVELL	7	Many	1
Win16	Front End	-	NOVELL	28	0	0
DOS	Front End	-	NOVELL	4	0	0
Netware	File Server	-	NOVELL	1	2	1

Table III: PCs in DORIS
Control System: MCS2

OS	TYPE	IP Stack	IPX Stack	No. Units	SW Reboot events (1997)	HW faults (6-97)
Win16	Console	-	NOVELL	7	Several	0
Win16	Front End	-	NOVELL	20	0	0
DOS	Front End	-	NOVELL	3	0	0
Netware	File Server	-	NOVELL	1	0	0

Table IV: PCs in TTF
Control System: DOOCS

OS	TYPE	IP Stack	IPX Stack	No. Units	SW Reboot events (6-7)	HW faults (6-7)
Linux	Console	BSD	-	1	0	0
Linux	Front End	BSD	-	3	0	0

events parallel what has been observed in HERA.

In the TESLA Test Facility (TTF), the principal control systems are DOOCS and EPICS. Presently EPICS PCs are not being used at TTF. DOOCS was originally designed to run on SUN workstations, but has been ported to Linux, and in the case of TTF, four such machines have been in use over the past two years, all without incident, as noted in Table IV.

3 Development environment

Beginning with Turbo C from Borland in the late 1980s, the user-friendly, intuitive integrated development environment (IDE) has been the forte of the PC. In the 16-bit world of DOS and Win16, the C and C++ compilers of both Borland and Microsoft are in common use, almost always in the context of their IDEs as opposed to the command line. In the 32-bit world of Win NT and Win 95, the Visual C++ compiler of Microsoft is used exclusively. Under Linux, the Gnu compilers are frequently used at the command line. However the ″X Windows Programming Environment,″ xwpe [6], IDE is also used by those developers who want the feel of

Borland 3.1 on Linux. Indeed, it is hoped that the transition from DOS front ends to Linux for front end developers can be made palatable through this tool.

Much of the high level (GUI) development on the consoles (and sometimes on the front end) is done using Visual Basic. As is known to most users of Visual Basic, programming at this level can be very simple, i.e. merely putting together components in a meaningful manner.With Visual Basic 5, the programmer can create a native-compiled executable, rather than the interpreted ″executable″ of versions past. This means that the programmer could in principle write long algorithms in Visual Basic without concern that they might be too CPU-intensive. Nonetheless this practice is still discouraged, i.e. writing code to do say matrix inversion is better left to C or C++ and called from a Dynamic Link Library (DLL). Visual Basic has proven to be an invaluable tool for ″part-time programmers″ such as machine physicists and engineers.

At HERA, Linux is used only in the capacity of TINE Front ends and as such does not require GUI development tools. At TTF, Linux is used both at the front end and the console end, and in the latter case the DOOCS Display Data (DDD)[7] graphics display package is used.

The possibilities of JAVA are also being investigated at DESY. Almost all development work in JAVA has so far occurred on Win32 platforms, using either Visual J++ or Symantec Caf ,both of which appear to be viable development tools.

4 PCs and Real-Time

For most aspects of accelerator control in HERA, PETRA, DORIS and the TTF, real-time is not an issue. Where it is an issue, ″traditional″ solutions involving (Motorola) VME CPUs running a real-time OS such as VxWorks are typically used. Recently, VxWorks has been deployed directly on industrial PCs in the context of Power and Cooling controls for HERA. This has so far (since July 1997) proven to be a stable platform.

Other real-time operating systems which apparently work well on standard PCs (OS9, LinxOS) have not been tested at DESY, but were reported on at the recent PCaPAC workshop[8], all with positive results.

The real-time add-ons to DOS, RTK [9] and RTX [10], have been tested at DESY. Both of these products were found to be stable but could not guarantee hard real-time when file IO was underway. In the case of the electron RF, RTX was in fact used for several years, not because of the need for real-time, but in order to provide a pre-emptive multi-tasking environment.

The real-time capabilities of Windows NT have not been investigated at DESY. At the recent ESONE workshop, Win NT was reported to have no hard real-time capabilities, but there were several third-party add-ons which did.

Linux also offers a real-time kernel [11], but this has not been tested at DESY.

5 Hardware/Software considerations

Putting together the finished PC Workstation from hardware components has the distinct advantage that there are generally many vendors vying for market share, driving prices down and offering greater choice. The disadvantage is that finding an acceptable combination of say graphics cards, ethernet cards, mother boards that works well for the targeted operating system(s) can be a research project in itself. Furthermore, PC distributors sometimes skimp on ″non-specified″ components such as cooling fans or power supplies, which can contribute to maintenance problems if faulty. Nonetheless, after a modicum of experience, so-called ″noname″ PCs can be obtained with the same stability and longevity as their more expensive counterparts.

Linux on the Intel platform reaps the benefits of hardware market for PCs as well. Consider that X graphics on a Linux station with an accelerated SVGA card will generally have much greater performance than on commercial UNIX workstations. In one benchmark test Xfree86 on a 486DX2-66 PC with 20MB RAM plus VLB s3-864 graphics card with 2MB DRAM was found to be seven times faster than a Sparc IPX workstation[12].

IO cards in general tend to be much cheaper on the PC than their equivalent VME counterparts, sometimes as much as a factor of 10. The bus architecture on the VME crate is much more sophisticated than the ISA bus common on PCs (and perhaps more so than the PCI bus as well). However, this extra degree of sophistication has turned out to be completely unnecessary in a large number of cases concerning IO in the HERA, PETRA, and DORIS subsystems.

The PC market is such that PC components undergo dramatic improvements every 12 to 18 months, often giving the impression that one is constantly trying to stay up to date. There is in fact (justifiably) some concern regarding ″platform stability″ over the longevity of an accelerator. In other words, if I need replacement parts in five years, can I get them? For instance, the transition from the ISA to the PCI bus has been underway for the past three years or more and already it is difficult to find ISA bus ethernet cards. In perhaps as little as two to three years, standard PCs may no longer offer ISA slots! Generally we have to accept the fact that these transition periods exists and take advantage of them to 1) stockpile replacement parts (such as ISA ethernet cards) or 2) upgrade the PC as a unit. What has also been true at DESY is that as staff members ″rush to obtain the latest Pentium-pro″, the pool of ″unwanted″ i486-vintage equipment has continued to grow and to be absorbed into either the control system proper or the spare-parts department. In general, the 5-year transition period which appears to be accompanying the change in bus standard on the PC (a major change) has not brought with it any undue expenditure in either time, manpower, or equipment regarding HERA controls operation.

Likewise, the software which one runs on the PC seems to undergo dramatic improvements at an even higher rate. Of course, ″Service Packs″ and ″Patches″ are necessary for virtually every operating system. In Windows systems, however, the concept of network administration becomes very important, where say a system of 20 consoles consists of 20 individual workstations, as opposed to 20 X-terminals attached to a high-end central work station. The administrative effort to guarantee that all stations are configured identically should not be underestimated. To this end there are various tools on the market, including Microsoft s own Zero Administration for Windows (ZAW). At DESY the product NetInstall [13] is currently being tested in order to meet these requirements.

6 Conclusion

The overall experience in using PCs in accelerator control at DESY has been quite positive. In particular Windows NT appears to be well suited as a control system console. At the front end, PCs provide ample power and stability in many circumstances. Here, Linux would seem to be the favored operating system, since the hardware requirements are not so extensive as in Windows NT, and it is relatively easy to write device drivers for Linux. Nonetheless, the availability of software development tools under Windows NT (in particular Visual Basic) makes front-end development for Windows NT attractive as well. There are also several real-time operating systems which run directly on a standard PC, but with the exception of VxWorks, these are not used on PCs at DESY.

PCs are by no means regarded as a panacea for all front-end problems at DESY, and in several (mission-critical) cases are not used at all. Nevertheless, the case for using PCs in some capacity in accelerator control is a strong one. There are now several examples of small and medium scale accelerators being controlled exclusively by PCs.

References

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