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A PC BASED CONTROL SYSTEM FOR THE CERN ISOLDE SEPARATORS

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Abstract

The control system of the two isotope separators of CERN, named ISOLDE, is being completely redesigned with the goal of having a flexible, high performance and inexpensive system. A new architecture that makes heavy use of the commercial software and hardware available for the huge Personal Computer (PC) market is being implemented on the 1700 geographically distributed control channels of the separators. 8 MS-DOS™ i386-based PCs with about 80 acquisition / control boards are used to access the equipments while 3 other PCs running Microsoft Windows™ and Microsoft Excel™ are used as consoles, the whole through a Novell™ Local Area Network with a PC Disk Server used as a database. This paper describes the interesting solutions found and discusses the reduced programming workload and costs that are expected to build the system before the start of the separators in March 1992.

I THE ISOLDE PROJECT

The ISOLDE project consists of the move of CERN's Isotope Separators and their experimental area from the recently de-commissioned Synchrocyclotron to a beamline served by the Booster Synchrotron [1] [2]. A new control system was required.

Traditionally, control systems for accelerators have been designed based on specified functionality, and the hardware & software tailored to optimize potential utility. Frequently however, this results in 'home-grown' products which remain incomplete and are overtaken by the rapid advances of the massive industrial base of commercial products.

The ISOLDE Project was taken as an opportunity to explore the extreme opposite approach for the control system. Namely to use 'market-leader' commercial software & hardware available for the huge PC market, with in-house development limited to the necessary software & hardware interconnects. This represents an experiment in providing an inexpensive, user friendly control system, requiring a minimum of manpower both for the implementation & for subsequent maintenance.

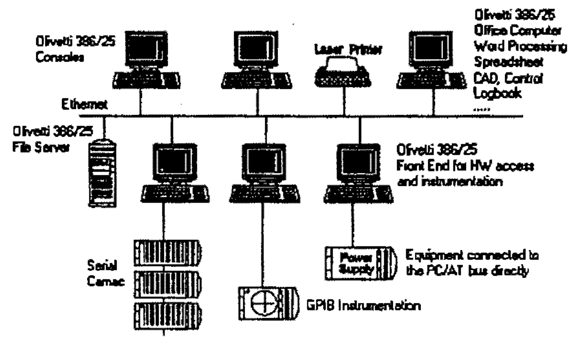
II THE CONTROL SYSTEM ARCHITECTURE

The new architecture [3] [4] [5] being installed reuses the old camac hardware while allowing an evolution of the system towards modern solutions.

Computers, Network and Control boards

The Isolde Control system is simple. It has Olivetti personal computers (PC) at all levels connected using the general purpose Ethernet network available side-wide.

As console in the control room, Olivetti 386/25 are used. i486 based PCs may be introduced next year. The console computers are equipped with 21 inch monitors providing a graphic resolution of 1024 x 768 pixels on 16 colors. Apart from high resolution monitors, the console computers are identical and fully compatible with the several hundred PCs available in the offices as local workstations [6].



The Isolde control system architecture

The personal computers connected to the equipment are called *Front End Computers* (FEC) and are also Olivetti 386/25. The performance of these computers is entirely satisfactory and 80286 PCs have enough CPU power to drive the equipment. In fact for some FEC applications, old IBM AT computers are used, recuperated from the initial Large Electron Positron Collider (LEP) front end controls, now replaced by faster Olivetti PCs. The Front End PCs are identical in configuration to the Office PCs except that they have additional boards for control.

The kind of control/acquisition boards supported in this architecture are:

- CAMAC, to allow the recuperation of all the hardware in the existing control system.
- GPIB to drive sophisticated instrumentation
- Industry Standard Architecture (ISA), alias PC/AT, boards that plugs into the PC directly or in ad hoc extension chassis.

A wide offer of this last type of boards exists and it has, for the moment, being restricted to Analogue to Digital converters (ADC), Digital to Analogue (DAC), Digital Input and Output (DIO), timer interrupts and external interrupt boards and RS232.

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Operating Systems and File Servers

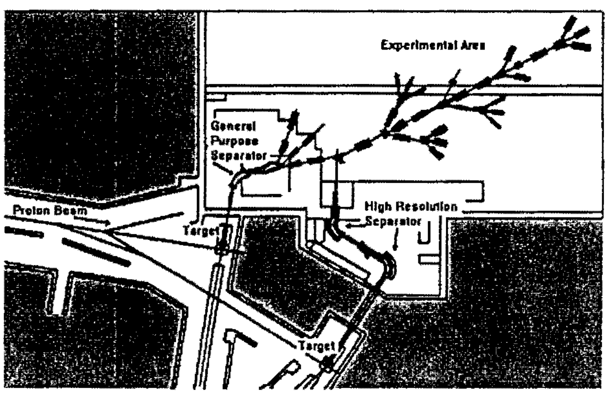
The whole system is built on a commercial PC network, Novell Netware™/386. This network provides a shared file system, shared printers, peer to peer and peer to server communications that are used in the control system to share databases and to share the hardware equipment between different consoles. The FECs are in fact just seen from the consoles as *equipment servers* to which client requests can be sent.

These FEC, alias hardware servers, are running MS DOS and the Nodal for DOS program. The Nodal for DOS program is an environment that provides:

- An equipment server to all consoles. The built-in network listener allows the consoles to access the equipment attached to the FEC.
- A local nodal interpreter that allows access to the equipment from the FEC. This is used mainly by the equipment engineers to test modules locally.
- Local alarm treatment

The Netware file system can be mounted also from Macintosh via Appletalk as an Appleshare file server and from Unix workstation via TCP/IP as a NFS server. All the Isolde databases or documentations in Word™ or Excel™ format can then be retrieved.

Numbers, manpower and financial resources



The CERN Isolde Facility

To quantify the dimension of the project, the control system comprises: 2 Faraday cage 60 Kv power supplies, 6 Extraction electrodes, 27 Faraday Cups, 5 Slits, 5 Lens Collimators, 15 Beam Scanners, 5 Wire grids, 6 Thermocouples, 18 Target power supplies in 60 Kv faraday cage, 9 Beam gates, 3 Separator Magnets with gauss meters, 58 Quadrupoles, 25 Steering Quadrupoles, 8 Kickers, 7 Benders, 4 Correction Plates, 3 Multipoles, 5 Deflectors and the Vacuum system. This gives roughly 300 devices (elements) and 1700 analog or digital wires (control channels) coming into the control system on three buses (CAMAC, GPIB, ISA).

More than 80 ISA (PC/AT) boards are being installed in different PCs or PC expansion chassis. 8 FECs are necessary, controlled by 3 consoles in the control room (or any office PC).

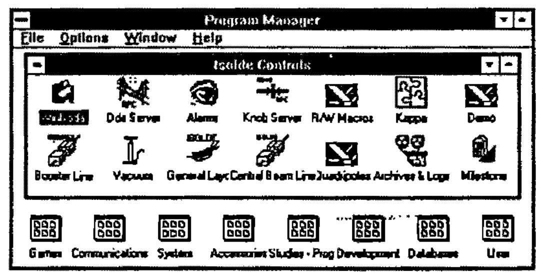
The manpower necessary to design and install the whole system is about 3 man*year.

Costs are equally divided between acquisition boards and computers. About 100 KCHF have been invested in PCs and the same amount in ISA boards. Wiring costs, 50 KCHF, are not included.

III BASIC TOOLS

Graphic User Interface (GUI)

The graphic user interface is Microsoft Windows™ and it provides a common access to all applications. The shell to start the different applications is the default *Windows Program Manager*.



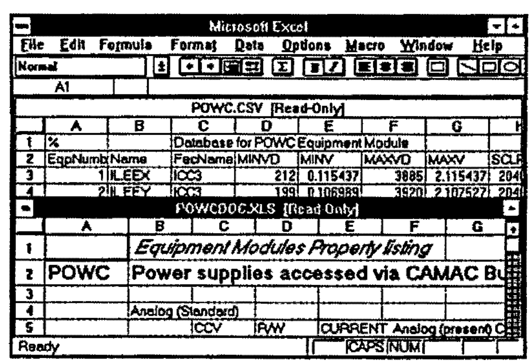
The program manager - Icons and menus oriented shell

Documentation

All documentation is produced using Microsoft Word™ for Windows, and is available on-line on the Isolde Server.

Databases

Databases are built using Microsoft Excel™. Database are stored in the native Excel format (BIFF) or in *Comma Separated Value* (CSV) format when they must be accessible from C or Nodal programs. The system is entirely database driven using Excel.



On-line databases

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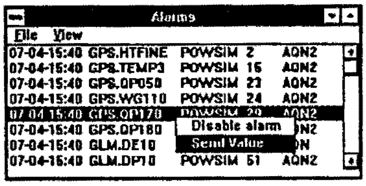
Alarms

An alarm process is running in all Front End Computers and systematically checks for inconsistencies in the element status or in the difference between acquisition and control values.

The alarm process has a list of active alarms that are polled by the alarm program running in the console. The Alarm program in the console is normally minimized in a green icon that becomes red when there are active alarms.



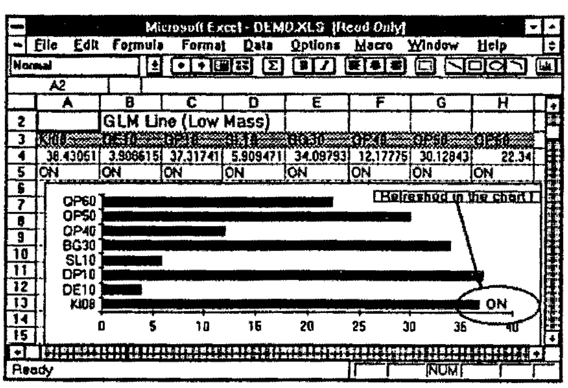
The Alarm eye

Applications

Three environment are available to develop applications. The first is Windows Nodal that provides a Nodal language interpreter with graphics capabilities that emulates the existing Isolde console.

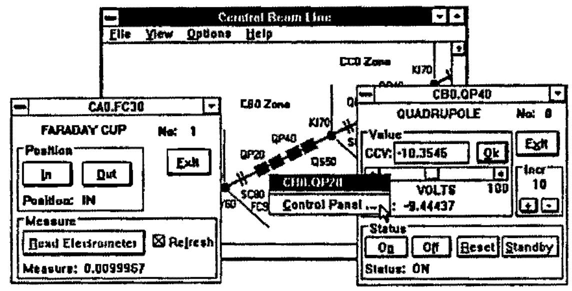
Using Nodal for Windows it is possible to run all old applications developed in the Isolde history. The existing isolde console is made of a keyboard, a track ball, an alphanumeric display, a graphic display, two hardware knobs and a touch panel. Nodal for Windows emulates all these peripherals and permits reuse of the old software (see next section).

The second environment where control applications can be developed is in any application that supports Windows' dynamic data exchange (DDE). Several high level applications with programming facility could be used, for example Actor™, Toolbook™, Microsoft Word™ and Microsoft Visual Basic™. The recommended tool of this level is Microsoft Excel™. The Spreadsheet facility can be used to correlate physical quantities to control parameters and vice versa.



An Excel based application

The third environment where control applications can be produced is the Microsoft Windows Software Development Kit™ (SDK). Any application can be written in this environment and high performance and acquisition rates can be achieved.



An SDK application

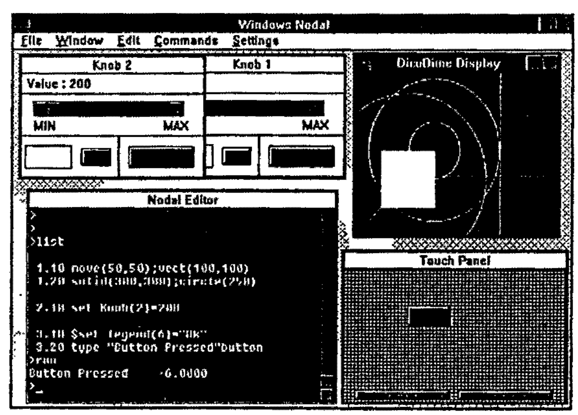
Security

Any application accessing the hardware must be attached to the Isolde Disk server where the client applications are stored. To attach a Netware file server a username and an encrypted password must be provided. In this way the Isolde Control System inherits all the security features that the Netware environment provides that are widely used by banks and other commercial Networks. In particular, it is possible to account the usage, to restrict the hours or days of the week a particular user can attach, to limit concurrent connections, force systematic password changes and several other features.

IV DEVELOPMENT TOOLS

Windows Nodal

The Nodal for Windows interpreter allows to run all existing Isolde software and permits the development of new applications. Interaction with the user is done using the two knobs and the touch panel. Data are presented in the alphanumeric and graphic displays.



Nodal for Windows

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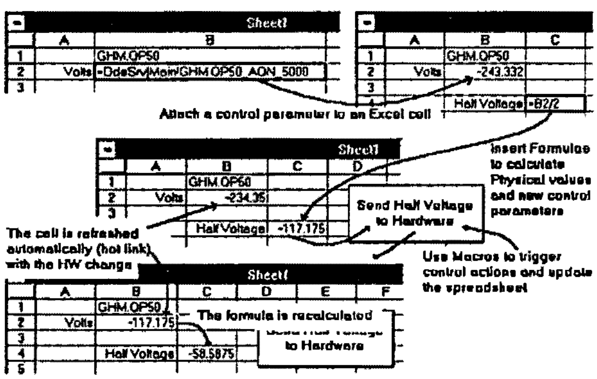
Programming in this environment does not require any particular skill beside having read the Nodal manual.

Microsoft Excel™

Excel in addition to its database facility, provides spreadsheets, charting, database and advanced macro programming facilities.

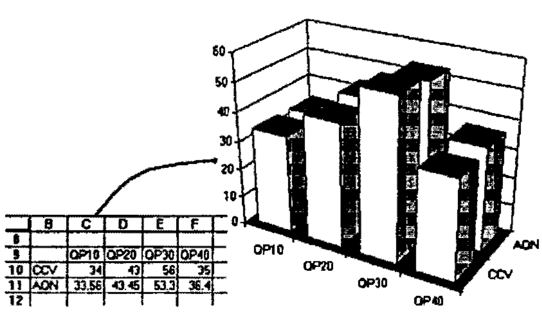
The spreadsheet facility provides the possibility of having hot-links, i.e. dynamic links between a cell in a spreadsheet and a particular property on a particular equipment, for example the acquisition of the current in a magnet. The spreadsheet cell is updated automatically whenever the physical acquired value changes. Formulae can be used to calculate from control parameters acquired with hot-links any physical quantity related to the parameter. All calculated values are, of course, also automatically updated when any quantity in the control system changes.



Example of application development using Excel

Basic macros, usually written automatically by the Excel Macro Recorder, allows to execute complicated algorithms. When attached to push buttons on the spreadsheet, macros allow to trigger complicated measurements, start optimization processes or to write calculated values to the hardware.

The Excel charting facility is used to produce graphics for analog presentation. Charts are normally also dynamically linked to the hardware properties and dynamically updated in real time.



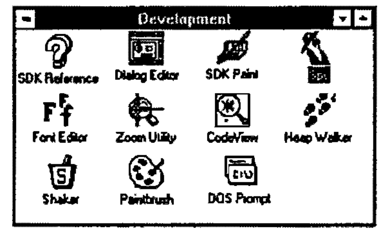
a dynamically refreshed chart

An Excel course for beginners is enough to allow a physicist to start building the applications himself.

Advanced Excel features can be used to produce applications with their own pull down menus and dialog boxes. The Excel Dialog Editor can be used for this purpose.

Windows Software Development Kit™ (SDK)

There are different tools available to design Windows applications, for example, the Dialog, font and Bitmap Editors, or the CodeView Debugger for Windows.



The SDK tools as example.

Writing applications using the SDK gives very high performances but a good knowledge of the C programming language and of the Windows architecture is necessary.

Microsoft Quick C™

The major tool used to develop Equipment modules is Microsoft Quick C. Beside providing an interactive Edit-Compile-Link-Debug environment as if C was interpreted, it has also on-line the complete C language reference. This context sensitive hypertext documentation provides also ready to run examples of all C library functions.

V CONCLUSIONS

Simplicity

Using the same type of computer (ISA PC compatible) at all levels of the control system leads to uniformity and simplicity. This advantage is reinforced by using the same operating system as the office machines.

All the persons involved in the design of this control system master it completely and are able to solve any problem at any level, front end or console. This global view on an uniform system reduces the skill necessary to cope with different parts of the system, because the approach is always the same, data driven from the Excel Database.

Development time

The use of well tested, market leader products (hardware and software) has reduced the development to a strict minimum. The very few necessary development done with the available tools have shown that:

- Development is very quick because of the user friendliness of the tools and because the SDK, the Microsoft C and QuickC compilers offer

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incremental link and compilation options and run time dynamic link.

- Informatic skills are not necessary: Physicists and engineers can write their own programs after very little training.

In particular, the time to develop the application programs, normally the stumbling block in most control system is very significantly reduced: for example, it does not take more than 10 minutes to build a simple application using Excel to display graphically several parameters acquired from the separator.

Integration

The Isolde control system, although completely independent in case of problems, is transparently connected to the office network and all its services are available.

Beside providing an access to the Isolde control system from nearly 1600 points at CERN (the number of PCs installed), it is in the user culture by providing the same user interface to control applications as to any administrative or scientific applications. It is of course possible to Copy/Cut/Paste between any applications, for example, the Excel chart acquiring the status of the Isolde magnets can be pasted into Microsoft Word to produce a written report. Development of control application from any office is possible without the installation of additional hardware.

All A3/A4 laser printers (including the color ones), plotters, scanners, disks, software and data of the office network are available, including the support.

By relying on this infrastructure, the information can be easily distributed cern-wide as Statistics and/or electronic Logbook, as it is done now for the PS accelerator complex. As the file base is shareable between different platforms and operating systems (Macintosh, Windows, Unix), all data in Excel format can be retrieved from any user on the site.

Speed

The benchmarks done with the Olivetti 386/25 computers have shown that these computers are fast enough to control large processes where dozens of parameters from different FECs are involved. The margin can be enlarged in this area by using i486 based 33 MHz machines that are much faster.

The speed of the control system is often limited by the network used. The Novell network based on ethernet give us a performance of more than 100 Kbytes/second transfer rate on the busy CERN ethernet. A typical Remote Procedure Call with a search in the element database to find which FEC and which equipment module to call takes less that 30 milliseconds.

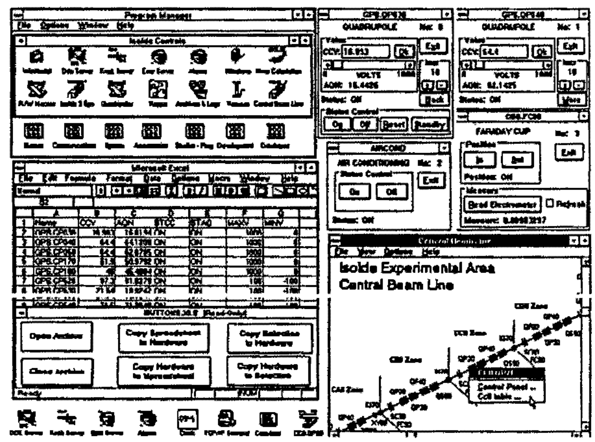
Cost

The market of Personal Computer in the world is roughly of 80 Millions units and with a strong competition between manufacturers. The PC production is more than 10 Millions/unit per year with performances increasing by a factor of 2 every year.

It' s a world wide standard, with binary compatibility, with major European involvement such as Olivetti, Philips, Bull and Siemens. A chassis, made in Europe, to control 48 power supplies (48 ADCs, 48 DACs, 288 digital I/O) cost about 12 KCHF. The cost per control channel is 9 CHF per digital bit, 55 CHF per ADC channel and 155 CHF per DAC channel.

Limits

There are no limits to the numbers of control channels the system can handle. If more are necessary, just add more FEC and more consoles.



A typical console screen

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