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The Evolution of the ISOLDE Control System.

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Abstract.

The ISOLDE on-line mass separator facility is operating on a Personal Computer based control system since spring 1992. Front End Computers accessing the hardware are controlled from consoles running Microsoft Windows™ through a Novell NetWare4™ local area network. The control system is transparently integrated in the CERN wide office network and makes heavy use of the CERN standard office application programs to control and to document the running of the ISOLDE isotope separators. This paper recalls the architecture of the control system, shows its recent developments and gives some examples of its graphical user interface.

1. Introduction

The ISOLDE on-line mass separator facility [1,2] has been operating on a Personal Computer based control system [3-5] since April 1992 when the General Purpose Separator (GPS) was started. In the autumn of 1995 the High Resolution Separator (HRS) was also implemented into the control system with exception of its higher order beam elements. This article recalls the architecture of the control system, shows its recent developments and gives some examples of its graphical user interface.

2. The control system architecture

The ISOLDE control system, shown in fig. 1, consists of personal computers (PCs) with Intel microprocessors running under MS-DOS or Microsoft Windows. Front end computers (FECs), accessing the hardware for controls and measurements, are controlled by PC-consoles via a local area network (LAN). The general purpose Ethernet available all over CERN is used. The PCs are connected to a file server that provides all necessary programs and data bases. All parts of the control system, file server, consoles and FECs, that are strictly needed to run the separators are protected by a bridge from the rest of the CERN wide local area network. Thus, any LAN problem on the site will not disturb the functioning of ISOLDE.

3. The file server

The ISOLDE file server, SRV1_ISOLDE, has been upgraded to a 486-based, 50 MHz, Netframe model-250 PC computer. It has 96 Mbytes of RAM, 14 Gbytes of disk space and two I/O processors, which make it quite powerful. The operating system is a commercial PC networking product from Novell called NetWare4. This network provides a shared file system and computer to server communication that are used in the control system to share data bases, application programs and hardware equipment between different consoles. It also lets the ISOLDE control system inherit all the security features that the Novell network provides.

Beside being the file server for the control system, the SRV1_ISOLDE is also a complete NICE-server [6] (Novell Integration, Coordination and Evolution). The usage of file servers falls in two categories; software distribution services and home

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directory services. At ISOLDE both services are provided by our file server in different volumes. The control system specific users, referred to as operational users, e.g., the logbooks (one for each separator), the consoles and the FECs, have user data stored in their home directories in one volume on this server. The same volume is also used to store the control system software. This disk volume containing the ISOLDE data files and the control system specific software is automatically backed-up daily under the NICE file server scheme. Other volumes contain the bulk of software available at CERN, e.g., standard office applications like Microsoft Word, Excel and Power Point, as well as standard system software like DOS, Windows 3.1 and Windows 95.

4. The front end computers

The PCs directly connected to the hardware are called front end computers (FECs). Most of the FECs are now 386-based machines, but there are still some models with a 286-processor running. The latter, however, are too slow for modern network cards and need a special driver to be able to run. They will slowly be phased out to get the control system more standardized.

The connections to the hardware are made through CAMAC- or GPIB- buses, by PC/AT cards plugged directly into the PC mother bus or, where a great number of cards are needed in a FEC, through ad hoc extension chassis. Serial communication ports, RS232 and a Siemens communication card between a specific FEC and programmable logical controllers (PLCs) are also used for equipment control. PLCs are used to control the vacuum system and its safety routines for the two separators and the experimental area. Such PLCs are also used to control stepping motors and encoders for the extraction electrode and different slit systems in the separators.

The number of devices controlled is currently around 350 with about 1800 control channels (analog or digital wires) coming into the control system. The number of FECs has been increased to 13 in order to make the running of the two separators more independent.

All front end computers run NODAL [7] for MS-DOS. This local interpreter is used to locally test the connected equipment. The heart of the control system is the communication mechanism between the FECs and the consoles. The RPC (remote

procedure call) server integrated in the FEC system software captures requests coming from the different consoles and executes the corresponding procedure. The result is transmitted back to the client. The concept, however, has been changed with the introduction of the TCP/IP instead of the IPX protocol that was previously used in the control system. In addition to a "direct link", its main feature is the establishment of a "hot link", an automatically refreshed connection, between a FEC and a client, e.g., a console. Instead of having each application program, e.g., a control panel, asking and waiting for an answer from a FEC, as was the case under the IPX protocol, all established hot links are now collectively up-dated by the FEC. At the same time any other console registered as a client by that FEC also receives its requested values. The program code, the RPC server, contains two different modules to serve both console operating systems, Windows 3.1 and Windows 95. The NODAL interpreter and the RPC server form the common part of the executable program running in a FEC.

The software interface between the FEC and the equipment is made by so-called equipment modules (EMs). To every EM belongs a data table with I/O addresses and equipment specific values that is stored and maintained in the equipment data base on the file server as an Excel CSV-file (comma separated values). These hardware specific EMs give each FEC a different software configuration, that is loaded from the file server together with the data table at the start-up of the FEC.

The ISOLDE control system is transparently integrated in the CERN wide office network. Hence, anyone at CERN with a PC can easily look at the system. To avoid that control parameters are accidentally changed, some access security has been installed in the FECs. At start-up of a FEC, another data table with the users having the right to modify the settings of the connected hardware is loaded. The "write" access, i.e., modify a value, is only granted to those users, whereas anyone connected on the LAN has "read" access.

5. The Consoles

The present consoles in the ISOLDE control room are machines with an Intel pentium processor and a 20 or 21 inch colour display. Two separate control desks have been installed with 3 consoles and one computer used as a logbook on each desk. Although

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any console can be used to control either the GPS or the HRS, one control desk is generally allocated to one specific separator.

All of our consoles run Windows 3.1 except for one that runs Windows 95 to test re-written applications. The preferred operating system for PCs with Intel processors by NICE is Windows 95 [8,9]. In order to maintain the integration of the ISOLDE control system in the CERN office network and to profit from the 32-bit environment we have to migrate all our application programs to the new platform . Under Windows 3.1 an ad hoc program, a kind of Windows' client, transmits the RPCs to the FECs. At ISOLDE this program is called the RPC server. The communication between the Windows' client and the application program in the console is done through the Windows Dynamic Data Exchange protocol (DDE) or through a set of functions provided by a Dynamic Link Library (DLL). Several windows open on a console running Windows 3.1 caused the communication speed between the applications and the Windows' client to be rather slow. This bottleneck has been solved in Windows 95 by removing the RPC server program and porting parts of its code into a new Dynamic Link Library. This means that the library contains all low level software (using WINSOCK) to access the FECs directly, and that DDE has become obsolete because of its poor performance. The DLL can be directly implemented in Excel modules, Visual Basic and C/C++ programs, but to make program development easier a new high level OLE (object linking and embedding) object has been created. This object is a piece of software that contains all the properties needed to access the control system. It can easily be inserted into an Excel, Visual Basic or C/C++ application without any programming [10].

In both operating systems an error server runs to whom any anomaly of a RPC is reported. At start-up of a console the error server is loaded together with some Excel data bases that contain all information the application programs need. Hence, the only "hard coded" data in an application are the names of the equipment to control. In a console running Windows 3.1, the RPC server program is also loaded at start-up.

The introduction of the TCP/IP protocol also provided access to the PS control system through the same client interface [11]. This access is currently used in monitoring the proton beam intensity.

The logbook computers are nothing else than consoles running a special application. They are, however, "separator specific". An Excel workbook is used for the

documentation. The logbook includes an automatic data logging feature of any given parameter in the control system. The data logging is done by a Visual Basic module for Excel. Via a control panel the user is allowed to specify equipment properties and the time interval for the data to be read. Normally the target and the ion source parameters are logged for the separator in question at a given time interval. This logfile helps in the understanding of the targets and ion sources. It is also of great value in the analysis of break-downs and abnormal conditions. Time and date are always logged and written together with the specified equipment data on a separate sheet in the Excel workbook. This data logger can be used for a time interval from a few seconds up to several hours. Another spreadsheet in the workbook is assigned for the users to write down any changes during the experiment and to comment on the separator performance. This informs the person responsible for the equipment and allows he/she to take action at an appropriate time. The whole logbook, i.e., the Excel workbook, is also automatically saved on the file server at time intervals as defined in the control panel. An icon in the ISOLDE controls group allows to read the Excel workbook on any office computer on the site without disturbing the functioning of the logbook.

6. The Graphical User Interface

Windows native graphical user interface (GUI) provides a common access for almost any part of the ISOLDE control system on a console. By clicking on an icon the user starts a control application program or a help file. The latter are text files with user instructions and/or equipment descriptions.

A generic program, the synoptic editor and viewer (see fig. 2), has been developed in Visual Basic that permits the creation of synoptic GUIs for equipment control [12]. It loads a bitmap picture as a background onto which objects can be created and positioned by a drop and drag technique. When the complete lay-out has been finished, the picture with its related objects, e.g., equipment names to call control panels, equipment properties to acquire values, is stored as a SYN-file (synoptic data file). The synoptic editor exists in two different versions; 16-bit for Windows 3.1 and 32-bit for Windows 95. The synoptic data file is, however, the same for both versions. When called by its icon the finished GUI is loaded with the relevant synoptic viewer

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together with the SYN-file. The general lay-out of the ISOLDE mass separator facility is created in Autocad and converted to bitmaps. These bitmaps are then used as the background in the synoptic data files. The user recognizes with ease the real equipment and does not have to learn the equipment names by heart. All GUIs for the beam optics, as well as all target- and ion source- applications, are made by this generic program.

The ISOLDE facility has no operators but physicists to set up the beam lines to their experiments. The most used GUIs in the control system are those that give access to the beam elements, e.g., quadrupoles and deflectors, and the adjacent beam observation equipment, i.e., scanners, wire-grids and Faraday cups. When the adjustment of the beam to the experimental set-up is finished, the beam element settings are normally stored in a QP (quadrupole) array. This is an Excel data file saved on the file server in CSV format by a Visual Basic application program. Experiments that require different beam element settings to their equipment frequently share beam time. The control panel for the QP arrays makes it easy to retrieve the beam element settings and transmit the values to the hardware by means of a "mouse click".

7. Conclusion

The ISOLDE control system is a low cost, high performance system based on industry standards.

However, despite the large number of control parameters and sophisticated instrumentation no fast feedback is done through the consoles and all real time aspects are handled by the FECs. The console computers normally only send control values to the FEC.

Beside these remarks, the final result is a highly integrated system that has a very low maintenance cost. This high integration allows fast exchange of information between the control system and the user in order to post-process acquired data on-line. Microsoft Excel spreadsheets with its chart abilities are often used. Performance reports with copy and paste techniques through the clipboard are generated on-line using Microsoft Word. The uniformity of the control system with the office network lets it benefit from all services available from the CERN general infrastructure. This

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includes access from any PC on the CERN site, remote access from home, printing services, e-mail, on-site PC hardware maintenance, user support, cross-platform file sharing and all TCP/IP connectivity.

The ISOLDE control system has proven to be user friendly with self-explaining images on the consoles. The fact that the lay-out of the GUIs corresponds to reality makes it easy to use even for novices.

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Figure captions

Figure 1.   The ISOLDE Control System Architecture

Figure 2.   A generic program, the synoptic editor and viewer, has been developed in Visual Basic. The picture to the left shows the synoptic editor in the creation phase of a GUI. The one to the right shows the synoptic viewer with "hot links" between the GUI and the FECs controlling the beam elements. In addition, control panels for some element types are shown.

Pentium PC Consoles in the ISOLDE Control

Laser Printer

80486 Office PC
Logbook
Statistics
Documentation
Calculation
Control

RS232 Communication

File Server
SRV1_ISOLDE

GPIB Instrumentation

PC/AT Add on Boards

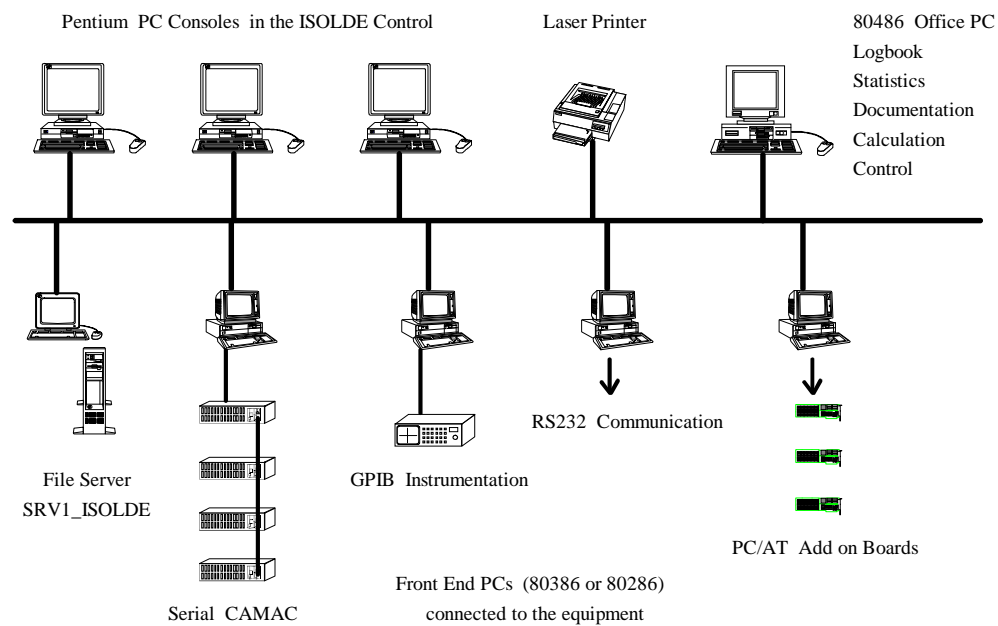Serial CAMAC

Front End PCs (80386 or 80286)
connected to the equipment

Figure 1

The Evolution of the ISOLDE Control System

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