An Original Approach to Commissioning with the ELETTRA Control System

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Abstract

The ELETTRA third generation Synchrotron Light Source is being commissioned by a distributed control system which relies on a scalable three level hierarchical architecture (presentation, process and equipment interface level). The adoption of new concepts in the user interface design has led to an intuitive interaction with the equipment that requires neither programming nor specific knowledge of the control system. Operators and machine physicists can take full advantage of a broad set of software tools for high level software development and debugging. As a consequence of the extensive software modularisation, specific upgrades can be installed at any functional level in order to balance the overall system performance. The distributed architecture granted both a quick fault isolation and a prompt adaptation to the new requirements rised during the commissioning phase.

1. INTRODUCTION

The ELETTRA facility [1] consists of a 1.5 GeV linac injector, a transfer line and a storage ring with a circumference of 260 m.

The commissioning followed distinct steps: in February '92 the first electron beam from the low energy part of the linac was measured; in June '93 the beam was taken up to the injection point, through the transfer line; on October 4th '93 storage ring commissioning started and the beam was accumulated two days later.

The ELETTRA control system [2] has a distributed architecture based on three computer layers (presentation, process and equipment interface).

High performance UNIX workstations are used as operator consoles. VME based modular microprocessor systems running the OS-9 real-time operating system are installed at the process (Local Process Computers, LPC) and equipment interface level (Equipment Interface Units, EIU). LPCs are placed at three locations, in the linac klystron room and at two opposite sites around the ring. EIUs are embedded in the equipment they control.

A fibre-optic Ethernet LAN which runs powerful communication protocols connects the control room computers to the LPCs. Taking advantage of the high performances of our MIL-1553B based lower level network [3], each LPC and the corresponding EIUs have been assigned to a functional group of controlled equipment: vacuum, injection system, radio frequency plants, transfer line power supplies, storage ring corrector power supplies, storage ring bending, quadrupole and sextupole power supplies, etc. The total number of LPCs and EIUs installed is 15 and 77 respectively.

The machine interlock system, whose operation is completely independent from that of the control system, is based on 7 Programmable Logic Controller (PLC) units geographically distributed around the machine.

2. USER INTERFACE

At presentation level some typical artificial reality concepts were adopted to get an intuitive man-machine interaction [4]. UNIX workstation solid development environment and extensive graphic capabilities best suited the realisation of a point-and-click interface for the equipment access, in which neither programming nor specific knowledge of the control system is necessary. These features, together with a negligible time of training, proved to be crucial in the commissioning phase.

Any equipment is accessed simply by selecting the related icon in a synoptic. One or more control panels are associated to each icon and can be selectively executed. The synoptic representation is intentionally kept very simple to enhance readability. To avoid the need of sub-synoptics that show in higher detail the complex parts of our machine, we added to the graphic database all the information regarding the logical connections between the controlled devices. A parent-child relationship, for example, may be established between an RF cavity and its related amplifier, or between any other complex equipment and its parts.

We used the objects visualised inside the synoptic as entry points to an extended graph structure, in which nodes or new links can be added as needed, simply editing an ASCII file. Users may examine the plant either graphically, using the synoptic, or by the logical connections of its equipment, using what we call the "synoptic browser". They can also execute any program, that may be either a simple control panel or a complex application, just by giving it the same name of a specific node.

A global and unified access to application programs and control panels represents a further simplification in user interaction and guarantees a good level of consistency when maintaining or upgrading the software. The twofold possibility of exploring the system happened to be extremely useful to all users that faced the control system for the first time during commissioning.

2.1 Control Panel Editor

A Control Panel Editor (CPE) [5] was developed to interactively compose widgets inside a control panel. Several features were implemented to fit the editor to our particular needs. A large set of widgets, that we specifically wrote to standardise input/output operations and data visualisation was easily integrated inside the editor. The changeable properties of a widget were deliberately limited, simplifying user operation and avoiding information inconsistency among different panels. Pure Motif source code can be generated by the editor. A large part of the control panels and of the high level software applications have been written using CPE, either for the whole program code or just for the user interface skeleton.

This home-made tool was integrated with a communication library, that transparently decouples the X event loop from data acquisition and handles communication errors. Equipment can therefore be accessed interactively, as soon as a panel is graphically composed.

3. RESOURCES DISTRIBUTION

The hierarchical architecture described above, based on a functional subdivision of resources, optimises operating system and hardware difference in relation to the specific tasks accomplished by each level.

3.1. Software Modularisation

In an accelerator environment, software requirements are never fully specified from the beginning of the control system project. As long as the knowledge of the machine behaviour is refined during commissioning more and more software requests are received by the controls group. With this respect, software modularisation is essential for an easy implementation of upgrades and new features.

Having started with a series of general purpose servers at the process level, more sophisticated procedures have been implemented, for example, for injection magnets and radio frequency start-up, beam position monitor reading, smooth orbit bump creation by a chosen set of corrector magnets, etc. In some cases, like the automatic magnet cycling, processes have been spread among software modules running at different control system levels.

Thanks to the scalability of the logical organisation of control panels and applications, new requirements did not result in the substitution of the old panels for basic equipment access. Instead, the user interface has been enhanced with new applications located at ancestor nodes, giving to the interface a unique coherence and backward consistency. Besides operating a quadrupole individually, for example, we may operate all quadrupoles of the same type, seen as a whole, with a panel at higher level, and, further up, operate all quadrupoles in the ring. A similar approach is used to locate applications that group different equipment together, or relate to global settings of the machine.

Despite the distribution and the diversity of the resources, an homogeneous file system has been implemented through all the control system levels by merging the services of NFS on Ethernet and of OS-9/NET [6] on VME and MIL-1553B. A file stored on the RAM disk created inside the memory of an EIU CPU board can be accessed from the control room workstations by the usual UNIX-like path definition syntax.

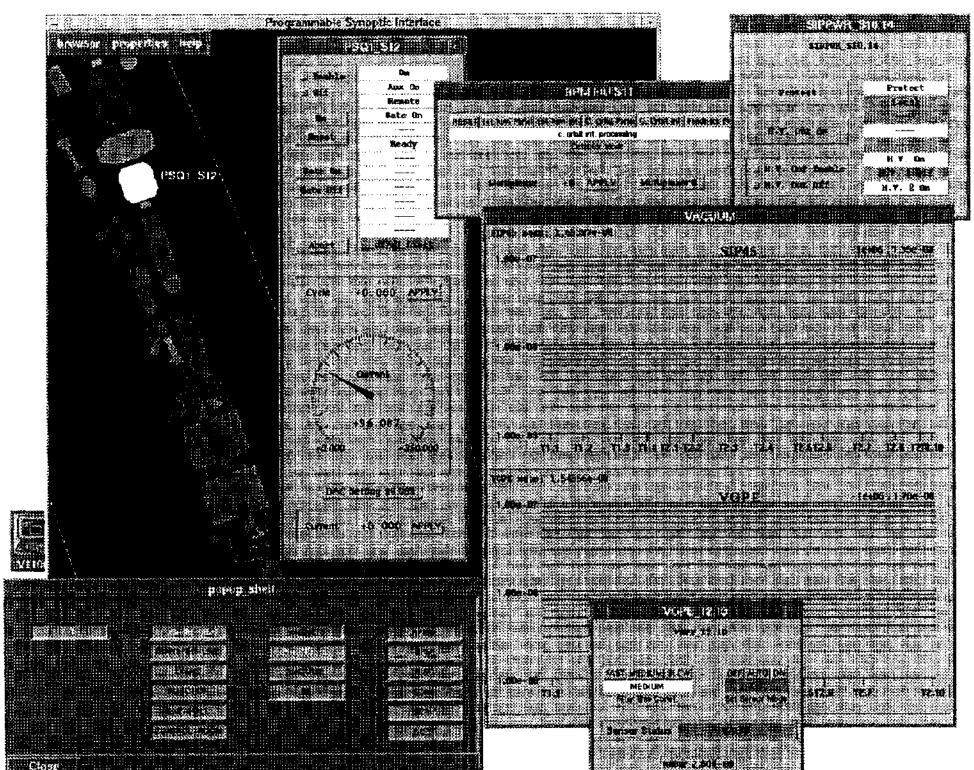

Figure 1. Man–Machine Interface Session

3.2. System Balancing

The three-level architecture has allowed a very good balancing of the loading among the different computer types.

At the process level, the LPC computing power can be adapted to the specific needs just by adding more CPU boards [7].

Ethernet loading has been optimised by bridges [8]; a mean load between 5 and 8% has been measured during the commissioning shifts.

3.3. Fault Isolation and Debugging

The described LPC/EIU configuration makes fault isolation straightforward. The distribution of the equipment interface over many dedicated EIUs reduces the effect of control system hardware failures.

The combination of the TCP/IP Telnet and OS-9/NET utilities allows to remotely login from the control room on both the LPCs and EIUs for debugging purposes.

The possibility of accessing the equipment avoiding typing, compiling and runtime errors and equipment naming inconsistency, greatly simplified the detection of more serious bugs, like incorrect cabling, communication and hardware problems. Of course particular attention was payed in updating the controls database, where equipment naming, graphic representation, alarms thresholds, communication and hardware details had to be correct.

4. SYSTEM OPERATION AND PERFORMANCE

The installation of the control system progressed together with the machine commissioning phases. The pre-commissioning of the linac and transfer line gave us the possibility of testing our system "on the field" and gaining in advance a useful experience.

Operational performances have been remarkable. No hardware faults have been found on the control room computers, on the fibre-optic Ethernet and on the MIL-1553B highway, whose very good noise immunity has been confirmed. About 4% of the VME CPU boards and 2% of the VME input/output boards have been replaced for repair; most of them during the first 3 months of commissioning.

Apart from the automatic detection of a few faulty relays, the interlock system hardware has worked reliably. The PLCs have allowed a relatively easy reconfiguration of some interlock triggering conditions and the implementation of new ones. At the beginning of the storage ring commissioning, vacuum interlock logic has been modified to take into account the pressure increase induced by the first electron beams. An interlock has been added in order to disable injection in case all the insertion devices carriages are not completely opened.

Since the beginning of the commissioning, applications have been available for the control of the magnet power supplies, vacuum system, injection system, beam position monitors and other diagnostic instrumentation like fluorescent screens, scrapers, DCCT.

The open and scalable architecture has already allowed the development of complex designs on top of the basic configuration. A completely integrated energy ramping system [9] has been installed since January '94 and electron beams up to 2.3 GeV, which are requested by some of the user experiments, can be provided.

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6. REFERENCES

[1] A. Wrulich, "Status of ELETTRA", these proceedings.
[2] D. Bulfone, "Status and Prospects of the ELETTRA Conrol System", Proc. Int. Conf. on Accelerator and Large Experimental Physics Control Systems, Berlin, Germany, 1993, to be published on Nucl. Instr. and Meth. for Phys. Res, Section A.
[3] D. Bulfone et al., "The ELETTRA Field Highway System", Proc. Int. Conf. on Accelerator and Large Experimental Physics Control Systems, Tsukuba, Japan, 1991.
[4] F. Potepan, "An Artificial Reality Approach to Accelerator Controls", Proc. Int. Conf. on Current Trends in Data Acq. and Control of Accelerators, Calcutta, India, 1991.
[5] G. Surace, "Control Panel Editor Release 2.4.2", Internal Report ST/M-TN-91/27.
[6] OS-9/NET Version 3.0, Microware Systems Corporation.
[7] L. Barbina and D. Bulfone, "The MIL-1553B Bus Controller Board for the ELETTRA VMEbus Multimaster Local Process Computer", Internal Report ST /M-TN-91/3.
[8] C. Scafuri and F. Radovcic, "Installing and Managing the High Level Network of the ELETTRA Control System", these proceedings.
[9] D. Bulfone, M. Lonza, P. Michelini and L. Pasquali, "The Design of the Energy Ramping System for ELETTRA", this proceedings.