Rejuvenation of the CPS Control System; the First Slice

G. Benincasa, G. Daems, B. Frammery
P. Heymans, F. Perriollat, Ch. Serre, C.-H. Sicard
CERN 1211 Geneva 23 CH

Abstract

The consolidation of the CERN Accelerator Control Systems is, as a common official project of the CERN PS and SL Accelerator Divisions, expected to be completed in 1995. As a first slice for the CPS complex, the LEP Pre Injector (LPI) was chosen for its coherent wholeness as a particle source and as a system with a reasonable number of equipment to control. This machine is large enough to be a good validation testbed for the new control architecture, and modern enough to reduce the software porting problem. (Fig. 1)

The implementation of the new architecture, hardware as well as software, will be performed during the normal running time of the machines and step by step transferred into operation at the end of the annual long shut down of each set of accelerators. The report presents a general overview of this rejuvenation plan, and a detailed analysis of the first slice, including the estimation of the manpower, together with the selected options.

I. PROJECT OVERVIEW

The rejuvenation project is the result of a collaboration between the Accelerator Divisions which elaborate a common design performed by working groups, composed of people from the controls, operation and instrumentation groups. The first working group designed the common control system architecture and the front end processing. The second working group defined a common approach to the application software and the future layout of the work place in the control rooms. A third working group, mainly composed of users, elaborated a control protocol to connect, in a uniform way, equipment to the control system. The conclusions of these working groups were presented to the control system users, discussed and accepted by the different groups concerned. [1].

II. SOFTWARE AND HARDWARE ARCHITECTURES

The main aim of this project is to replace the obsolete 16 bit mini computers and microprocessors (ND100 family, PDP11, and TMS9900). They will be replaced by a distributed system including workstations, servers and equipment front end processors split in a clear two layer architecture linked by Ethernet network. (Fig. 2) Economical constraints enforce the reuse as far as possible of the hardware, mainly CAMAC, used to connect equipment to the control system, because of the enormous investment previously made.

- The Operation Layer in the control rooms which provides the operators with a reliable and user friendly set of tools to adjust the accelerator parameters, uses modern UNIX workstation platforms running commercial software packages (X-Windows and OSF Motif standards; DVDraw/DVTools based interface for synoptic representation). This layer includes also a number of Central Services executed in servers (more powerful machines of the same workstation family) using standard NFS service : coordination of various control tasks, central data and file storage, model computing and equipment alarm collection, RT relational Data Base (ORACLE and SQL interface).

- The Front End Computing Layer based on Device Stub controllers (DSC) made of VME crates with MC 68030-based controllers running a diskless version of the RT-UNIX (Posix 1003.4 compliant) multitasking system LynxOS. Equipment access through Field Buses (serial CAMAC, 1553 MIL and

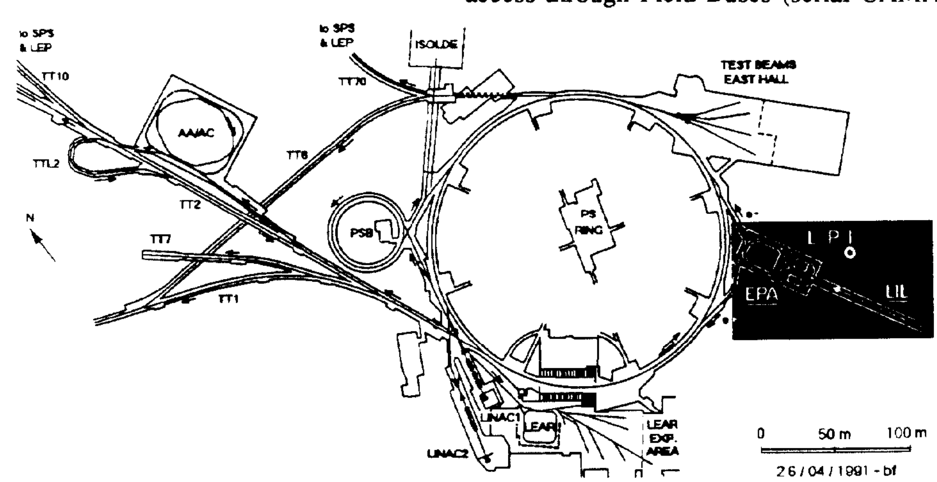

Figure 1. The CERN Proton Synchrotron (CPS) layout, with LPI accelerators highlighted

0-7803-0135-8/91$01.00 ©IEEE

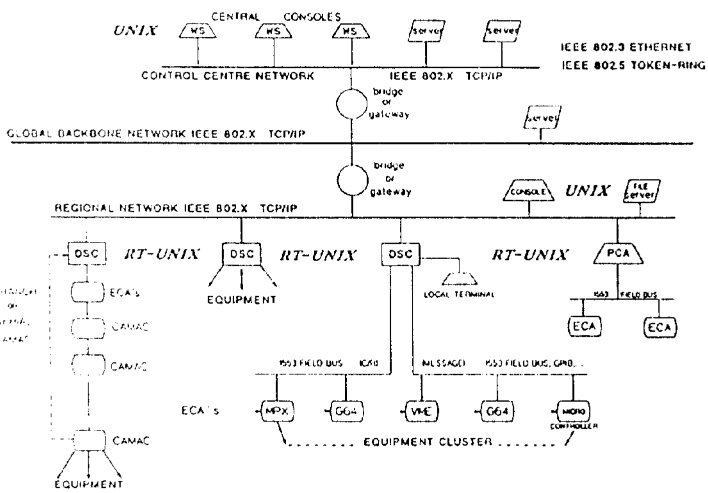

Figure 2. Control System Architecture

GPIB) is completed with local facilities where needed (display, touch-panel and Nodal interaction). The Operational Control Protocol will provide standard software interface with different types of equipment independent of the type of connection. [2].

The communications within and between the Control Room and Front End layers are based on modern networking standards using TCP/IP protocol suite. A remote Procedure Call with asynchronous call function, developed at CERN, completes the basic TCP/IP facility for easy implementation of distributed processing.

The Front End Layer will handle all the real time process constraints. At the level of workstations and servers no real time constraints must be treated. The only constraint is to react to the operator's requests in the shortest delay.

III. THE IMPLEMENTATION SCHEDULE

For the PS complex, the LEP Pre Injector has been chosen to be the first slice of the consolidation project. The main emphasis is on the level of Front End processing in order to remove completely two ND120 and the associated auxiliary CAMAC crate processor (SMACC) and to replace it with the new DSC architecture. In order to upgrade the man-machine interaction, DEC workstations were added to the slice; in order to reuse as much as possible the interactive application software, the Nodal functions of the old consoles will be emulated on the workstations. (Fig. 3)

The LEP Pre Injector [3] is continuously in use until mid-November 1991 and then turned off until March 1992. The upgrading should not disturb at all the operation and all the on-line tests have to be performed during the shut-down. A strict schedule of events is defined.

The first step to reach this goal will be the setup of the DSC basic system facilities. This environment will include remote boot (DSC are diskless machines for reliability), Nodal interpreter, Remote Procedure Call (RPC), device drivers for serial CAMAC and GPIB, external interrupts handler, and operation sequencer access routines. When needed a local video graphic facility will be added. DSC survey programs and the error reporting and logging package complete the basic software.

The second step is the transfer of the control application software to the new architecture from the ND120/SMACC processors. This action will partially starts in parallel with the previous one (basic system) at least for the initial phases. About 20% of the software, written in P+ (Pascal like language) and in NPL (Intermediate language proper to Norsk Data computers) in the ND120 will be rewritten; but the remaining 80%, written in C, will need only to be ported. As soon as the DSC basic implementation is setup for the Application programs, the new versions of the application programs on the DSCs will be generated and integrated, ready for the off-line tests.

The third step is the initial test period in November. When the LPI complex will be stopped, CAMAC crates will be connected to the newly installed DSC and on-line tests of the equipment control software modules in the DSC will be performed. Some interactive Nodal application programs will be integrated in the workstations and LPI will be run with beam as final test.

After these tests, the rest of the shut down between December and February will be spent to complete the transfer of the interactive programs in the workstations, prepare the modeling programs for the use with the workstations and with the network servers, and also to correct the bugs found during the preliminary tests. The last tests, and the complete system implementation, will be done at the end of the annual shutdown during the operational start-up period of the LPI machines (beginning of March 1992).

IV. DETAILED ANALYSIS OF THE LPI SLICE

Equipment control : The CAMAC embedded microcontrollers (SMACC) are removed. The 2 ND120 FEC mini-computers (LIL, EPA) are disconnected from the CAMAC serial loops. The serial loops are reconfigurated to be driven by DSC. The number of Camac crates driven by one DSC depends on the Real Time constraints of the equipment controlled, and on the geographical distribution of the crates in the different buildings. This is the case for power supplies (dc, pulsed, kickers), timing, motors, RF cavity, modulators and klystrons. For the complex instrumentation and when the necessary VME modules exist, a CAMAC crate is replaced by a DSC crate which controls directly the equipment.

On the software side, the equipment access package [4] is ported from the FEC+SMACC layout to the DSC. All the process equipment control modules from FEC+SMACC are ported to the VME microcontroller. These modules (Equipment Modules and Real Time tasks) are exclusively written in C.

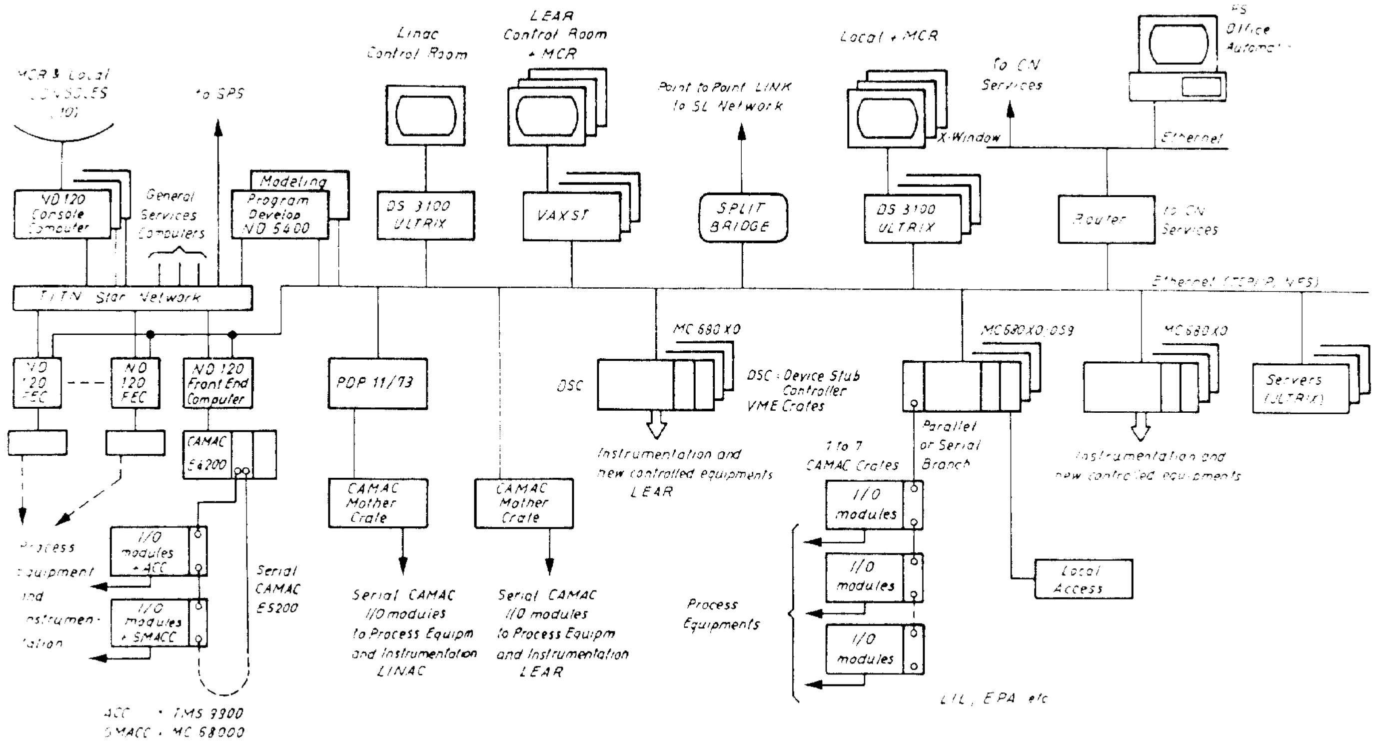

Figure 3. PS Control System during Transition Phase

The exploitation and test programs for the equipment interface remain in Nodal in the DSC.

Operation consoles : The equipment control part of the two consoles mainly used for LPI are replaced by two workplaces made of 3 DEC3100 workstations. The analog and video signal selection and observation systems will remain unchanged. Their future replacement will be done later during the control consolidation project. It will be based on developments underway using VME equipment and VXI bus capability.

The main part of the Nodal interactive application programs of the actual consoles are emulated on the workstations with a minimum of program editing. The generic programs developed in C for the workstations interaction prototype will be integrated; they include knobs parameter control, table and synoptic presentation and operation sequencer interaction. The LPI modeling programs (FORTRAN) will be ported in the workstations/servers network.

Manpower : the total effort requested to perform this first slice is estimated to 12.5 men-year which can be split into:

Hardware implementation of the DSCs -	
Console modification :	~ 1.5 my
Basic software running in the DSCs :	~ 2.- my
35 equipment modules+Real Time tasks :	~ 3.- my
General application software :	~ 4.5 my
Nodal emulation+program transfers generic C programs integration from the prototype, transfer of more specific programs :	~ 1.5 my

V. CONCLUSIONS

Rejuvenating the control system of a running installation is not a trivial work, and it must be executed in coherent slices in order to preserve the integrity of the accelerator complex operation. The choice of the first slice to be renewed is one of the critical decisions to be taken in the management of such a project. This slice must be large enough, and well representative of the other parts of the complex to be a good validation testbed for the new architecture adopted and for the methodology used. Strange to say, the better choice is to take the newest part of the actual control system, the LPI complex in our case, to concentrate the effort only on the new architecture and technology and not to spend too much work on reengineering obsolete software modules.

With a unique annual shutdown to implement the major modifications, the planning of such a project is very constraining and any major event can result in a complete rescheduling. A good decoupling between interaction presentation and equipment access is very favorable because it gives the capability to validate step by step the control software architecture.

VI. REFERENCES

[1] The PS and SL Controls Groups, PS/SL Controls Consolidation Project, Technical Report, CERN PS/91-09 (CO), CERN SL/91-12 (CO), April 1991.

[2] Reported by G. Benincasa, Generalities on the operational Control Protocol, PS/CO/Note 91-01, April 1991.

[3] The LPI Beam Commissioning Team, J.H.B. Madsen et al., First experience with the LEP Pre-Injector (LPI) Proc. of the 1987 Particle Accelerator Conference, Washington, p.298.

[4] L. Casalegno et al., Distributed Application Software Architecture applied to the LPI Controls, IFAC Workshop, Bad Neuenahr, FRG, October 1986.