EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN/PS/91-50 (CO)
November 1991

Replacing PS Controls Front End Minicomputers by VME Based 32-bit Processors

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Paper presented at the International Conference on Accelerators and Large Experimental Physics Control Systems

Tsukuba, Japan, 11-15 November 1991

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Abstract

The PS controls have started the first phase of system rejuvenation, targeted towards the LEP Preinjector Controls.

The main impact of this phase is in the architectural change, as both the front-end minicomputers and the CAMAC embedded microprocessors are replaced by microprocessor based VME crates called Device Stub Controllers (DSC).

This paper discusses the different steps planned for this first phase, i.e:

- implementing the basic set of CERN Accelerator common facilities for DSCs (error handling, system surveillance, remote boot and network access);
- porting the equipment access software layer;
- applying the Real-time tasks to the LynxOS operating system and I/O architecture, conforming to the real-time constraints for control and acquisition;
- defining the number and contents of the different DSC needed, according to geographical and cpu-load constraints;
- providing the general services outside the DSC crates (file servers, data-base services);
- emulating the current Console programs onto the new workstations.

I. INTRODUCTION

The CERN accelerators are composed of two sets: the PS Complex of ten small and fast cycling machines (PS Division), the SL Complex of two big and slow cycling machines (SPS and LEP, SL Division). The rejuvenation of the CERN Proton Synchrotron control system is done on a basis of a common CERN project, aiming at a real convergence between all accelerator control systems. [1] [2]

The first phase of PS control system rejuvenation has started in 1991 for the subset of LPI machines (LEP Pre-Injector). [3] The main impact of the architectural change is the replacement of both front-end minicomputers and distributed CAMAC embedded microprocessors by a set of distributed microcomputers linked on an Ethernet segment with a local file server.

These microcomputers called DSC (Device Stub Controller) are based on both standards PC and VME crate with 32-bit embedded microprocessors. For the PS control system, the VME crates are mainly used. The DSC provides a uniform interface to the equipment and acts as a master and data concentrator for distributed equipment, interfaced via field buses. Due to the large investment in the associated interface equipment, the serial CAMAC loops are kept and their control are done via a serial driver module in the VME crates. [4]

II. BASIC FACILITIES FOR DSC

A. Control System Architecture

The common accelerator control system architecture consists of three layers:

- control room layer with workstations and central servers,
- front-end computing layer distributed around accelerators and based on the DSC,
- equipment control layer with ECA (Equipment Control Assembly) control crates which form part of the equipment.

For the PS Control System the communication between the two first layers, as well as the communication within these layers, is based on a TCP/IP network. The processor of the VME crate has an on-board Ethernet controller as a standard link to the network, and is a diskless machine for reliability [disks proved to be the weak point of the actual LEP PCA (Process Control Assembly)] and because the back-up procedures and management of files and data are supposed to be easier when storage is less distributed. The different programs of the different DSC are centralized on a single server.

B. Choice of a Real-Time UNIX Operating System

The constraints choosing an operating system for the front-end processors were the following:

- the system has to be real-time in order to warranty a predictable response time to external events,
- the same operating system must be available for both VME based MC68030 and PC processors,
- for networking, TCP/IP (with BSD socket interface library) and NFS client are required,
- system must be able to run diskless without swapping,
- shared libraries and data segments are required, as well as source level debugger.

In order to minimize the formation required to develop applications, we had to minimize the heterogeneity between various systems. We had to re-use common facilities developed for the LEP accelerator control (based on Xenix system). This resulted in the choice of the LynxOS real-time

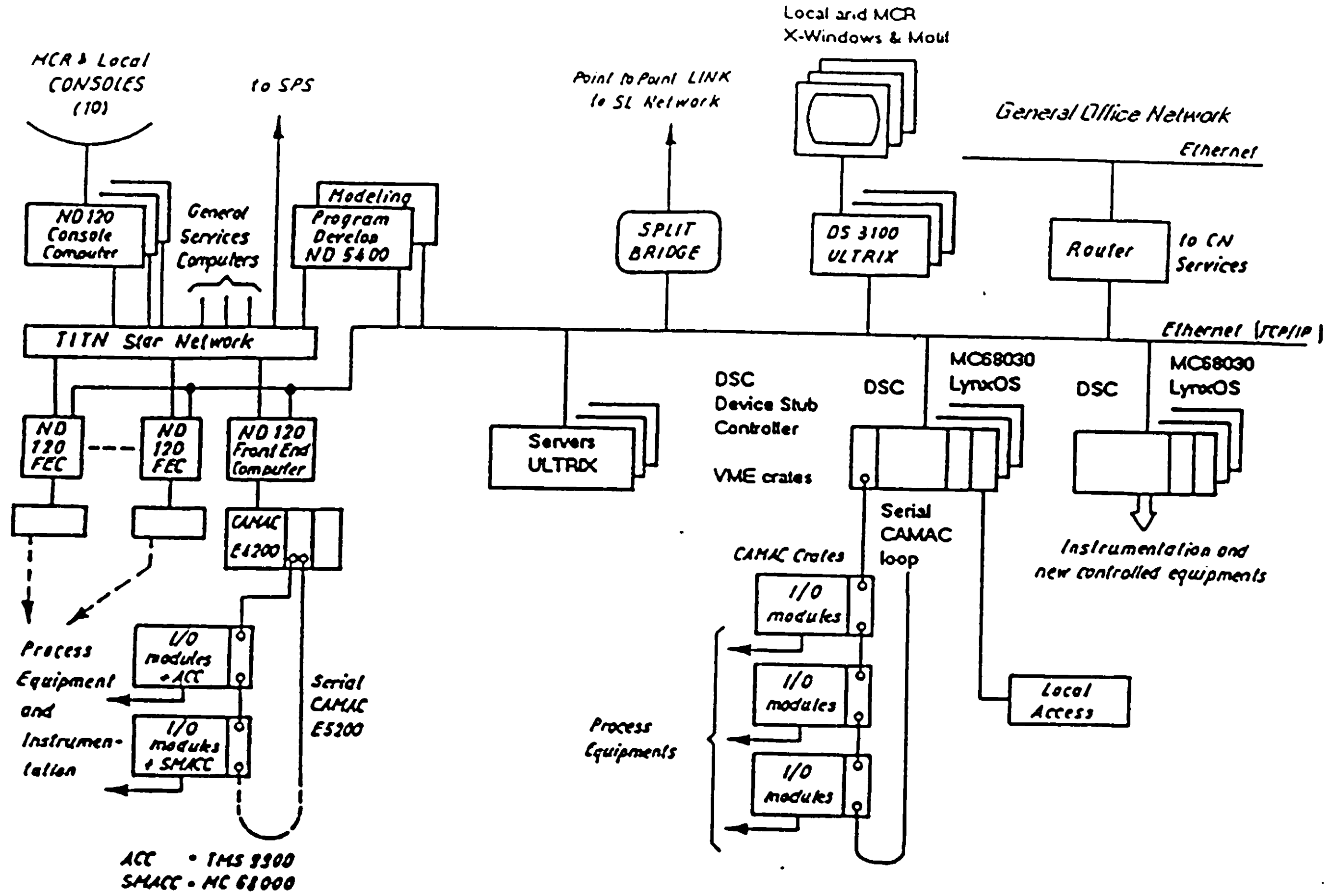

Figure 1. PS Control System during Transition Phase

system, which offers the most recent POSIX standard definitions, especially for the real - time (draft 1003.4 and 1003.4a). The biggest advantage of this choice is that the whole system documentation is intended for a C programmer and even a device driver can be written in C.

C. Common CERN Facilities

One of the main goals of the CERN accelerator control systems convergence is the non-duplication of effort inside the accelerator community. For the front-end processors software the work was shared between both PS and SL Divisions for the following facilities:

- RPC (Remote Procedure Call) and network compiler,
- Common ORACLE on-line Data Base management,
- Error reporting and system survey,
- Nodal interpreter (written in C) running on the different platforms of the network, with network extensions based on the TCP/IP protocol suite, and integrated with X-Windows and Motif environment [5]

III. PORTING THE PS CONTROL APPLICATIONS TO THE DSC

A. Equipment Access Software

The present application structure layout providing the equipment access from the workstations remains unchanged. This software, actually located in the front end minicomputers and in the CAMAC embedded microprocessors, is ported in the DSC processor. The former code (mainly in C) of the CAMAC embedded processors running RMS68K operating system is, for a major part of it, directly re-used under LynxOS operating system.

In the VME context, simple VME interface boards are accessed using the memory mapped I/O. Connections to field buses, such as serial CAMAC, GPIB or 1553, are handled by standard device drivers. Interface compatibility libraries hide the structure changes from the former implementation. The control data of these equipment access routines use the UNIX "shared memory segment" and the code of all the application programs call a shared library where all the equipment access routines are stored. This point will increase the reliability as the programs use a single copy of the library.

B. Real-Time Tasks

Whenever possible, the same interface library used for equipment access is re-used by real time tasks. The application programs are not integrated at the level of interrupt routines, but are working at the level of the user task. In case of response time problems, the system thread facility will be used. Our main real time constraints are today repetitive acquisition at the rate of 3 msec. The actual measured response time for such a processing (including the wake up of a task waiting for an external event, the time for this task to access the CAMAC interfaced equipment through a standard device driver) is compatible with these constraints.

C. General control applications

Detection of equipment alarms has been incorporated into the equipment access software layer, through a unique function, which can return an alarm indication, for all classes of equipment.

Application libraries and tasks may log informative or fault messages to a central service, which will record them in the ORACLE data base and, if they occur in a remote call, display them on a window of the originating workstation.

A general data collection mechanism, synchronized with the accelerator cycle, allows the workstations to subscribe to specific sets of control parameters, and thus receive regularly complete updated data messages.

IV. FIRST ACTUAL IMPLEMENTATION IN THE PS COMPLEX

First actual implementation of the rejuvenated common ontrol system in the PS Accelerator Complex concerns the LPI machines (Linac e^-, Linac e^+ and electron/positron accumulator). A present console will be replaced by a work place of three DEC workstations running ULTRIX, associated with selection and observation of analog and video signals. The present control of the LPI equipment is done through front end minicomputers (NORD 120) and CAMAC embedded microprocessors: they will be replaced by a file server and a set of DSC, each of them driving a serial CAMAC loop, linked on a regional Ethernet segment of the control network. (Fig.1)

For the man machine interaction, at the level of the workstations, in order to re-use as much as possible the interactive application software, the Nodal functions of the present consoles are emulated on the workstations in order to minimize changes to existing Nodal programs. The generic programs developed in C for the workstation interaction prototype will be integrated (knob control, synoptic presentation, console manager). [6] [7] No accelerator real-time nstraints must be treated at the level of the workstations, the DSC will take care of them. The number of DSC is function of:

- the geographical distribution of the CAMAC crates and the topology of the equipment interfaces,
- the real-time load of each DSC processor, depending on the real-time constraints of the application programs controlling the equipment (instrumentation, pulse-to-pulse modulation).

As often as possible, one single DSC is used to control one given beam instrumentation device; this point facilitates the device diagnostic, and allows more development capability to the equipment specialist.

As one of central service given by the network server, one powerfull server is used to house the ORACLE on-line data base management service; this data base is also used for the off-line data preparation to allow an adequate continuous running of the application whatever happens to the data base server.

V. CONCLUSION

The main points introduced by the common rejuvenated control system for the CERN accelerators could be listed as follows:

- UNIX is the single operating system for all the control levels of the architecture,
- the network is based on commercial well established standards as TCP/IP protocol suite and NFS facilities,
- to increase the reliability and to ease the maintenance, the workstations and the DSC are used as diskless devices,
- the access to equipment is done through a single homogeneous level, the DSC,
- the present important hardware investment (serial CAMAC crates for the PS Complex) is kept; the equipment interface does not need to be modified immediately,
- we hope that the proposed architecture, based on open and well accepted standards (hardware as well as software) will permit continuous upgrading as the technology evolves.

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