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TITLE **IMPLEMENTATION OF A DISTRIBUTED COMPUTER CONTROL SYSTEM AT THE LOS ALAMOS PROTON STORAGE RING**

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Implementation of a Distributed Computer Control System at the Los Alamos Proton Storage Ring

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Abstract. A distributed computer control system is being implemented at the Los Alamos Proton Storage Ring using DEC MicroVAX computers with a distributed database. The first prototype system is now in place and has been running during the last storage ring running period. This paper describes the implementation, initial tests, and future plans for the system.

Keywords: distributed database, distributed control system, real-time, accelerator control systems.

The Proton Storage Ring (PSR) at the Meson Physics Facility of Los Alamos National Laboratory is used for basic research in both solid state physics and nuclear physics. Here neutrons are produced by 800 MeV protons from the Los Alamos proton linac.

The Proton Storage Ring control system was designed and implemented by Accelerator Technology Division of Los Alamos National Laboratory during the period from 1980 to 1985.[1,2]. This system is shown schematically in Fig. 1.

As originally configured, the system consisted of a VAX 11/750 connected to a CAMAC serial highway through a Kinetics Systems 2060 controller. Presently this VAX 11/750 has been replaced by a MicroVAX 3600. On this serial highway are five PDP 11/73 subsystems connected to the serial highway with auxiliary crate controllers. Each of the PDP 11/73 subsystems also has a CAMAC serial highway which is driven with a serial highway driver manufactured by BiRa Systems. The vast majority of the devices in the PSR are controlled from the PDP 11/73 subsystems. The PDP 11/73 computers run the diskless RSX 11S operating system.

In total, there are approximately 40 CAMAC crates in the system and about 700 devices. Since there are several parameters associated with each device, the database consists of approximately 5200 entries. The database in the system is a centralized one, residing in the memory of the VAX in a global section. Each PDP-11 database is a copy of part of the VAX database. The database in the VAX and the PDP-11 subsystems is refreshed approximately every 0.5 seconds by direct memory access to and from the VAX. In each PDP-11 there is a reader program which reads analog and binary devices about twice every second and places their values in the PDP-11 database. This type of database, where values

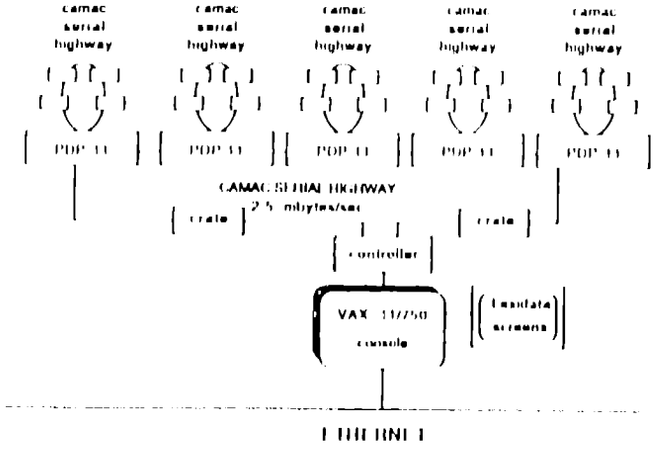

Fig 1 Block diagram of the original PSR control system

are at most about a half second old, is referred to as a "live" database. Fig. 2 shows the communication between the central VAX and one PDP-11 subsystem schematically. Here the migrator program performs the reading and writing of the database between the PDP-11 subsystems and the VAX. Graphics output from the system is on seven 19 inch color Lexidata screens which are updated from the VAX using DMA through the Unibus. Control of the equipment is done with touch screens mounted on the Lexidata screens and knobs which are mounted below the screens.

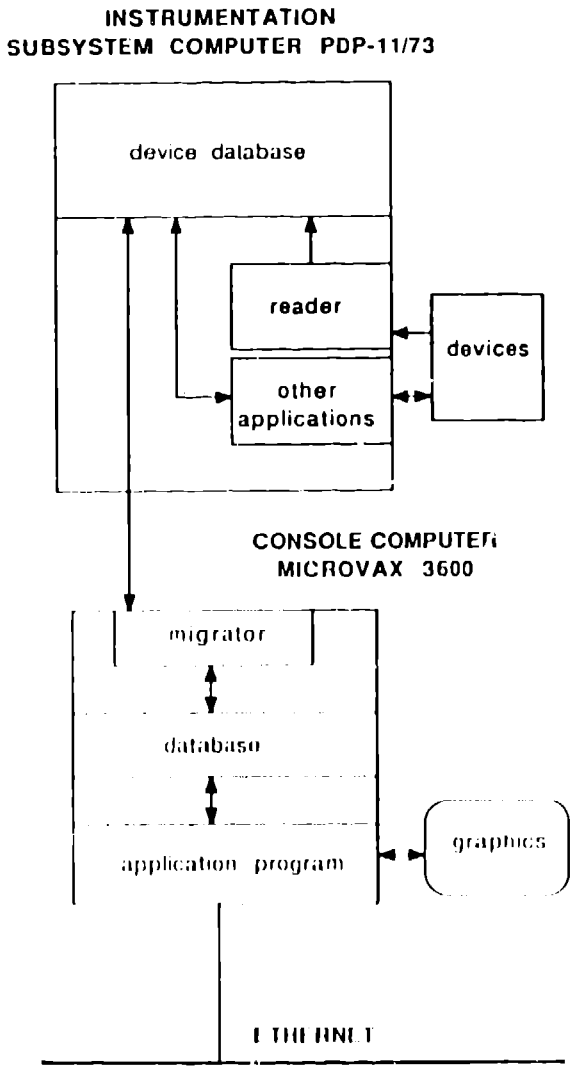

Fig. 2 Data flow in the current PSR control system

Reasons for Changing the System

Aside from the fact that the PDP-11/73 machines are now becoming obsolete, the address space of the PDP-11 has become the major factor in our decision to replace them with other hardware. Fig. 3 shows the arrangement of the address space in the PDP-11. Here 4K words are used by the I/O page, 12K words are used for the database and 16K words are left for the program. In this system these boundaries are adjustable only in 4K increments. Since very few programs can run in less than 16K words and the I/O page size is fixed, this amounts to having a fixed database space of 12K words. Thus, even though the computer may be capable of managing more devices with the available CPU time, the fixed database space forces one to add additional PDP-11 subsystems to handle additional devices.

As we replace the PDP-11 subsystems, we wish to make the system more modular and more maintainable. The fact that all the PDP-11 subsystems are on the same serial highway and that the operating system and all the application codes are downline loaded over this highway makes failure diagnosis difficult. It is not possible, for example, to take a PDP-11 off-line to run diagnostic programs. In addition the architecture of having a central VAX forces a centralized database which limits the expansion of the control system by the processing power of the central computer. Since the system was designed the Lexidata screens have become obsolete, making procurement of spare parts difficult, and expansion expensive.

Future PSR Control system

We envision the future PSR control system as in Fig. 4. The PDP-11 computers have been replaced by MicroVAX systems running VMS and the CAMAC serial highway previously used for downline loading and database transfers replaced by Ethernet. The individual CAMAC serial highways remain for device access. The Lexidata console will be replaced by color work stations. We have installed the database and database access routines developed by the Los Alamos Accelerator Technology Division [3]. In order to meet performance demands and additional functionality required by the PSR control system, we have expanded the original system to include many more database access routines and additional features.

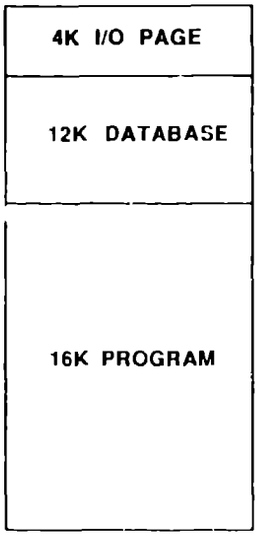

Fig. 3. PDP-11/73 address space.

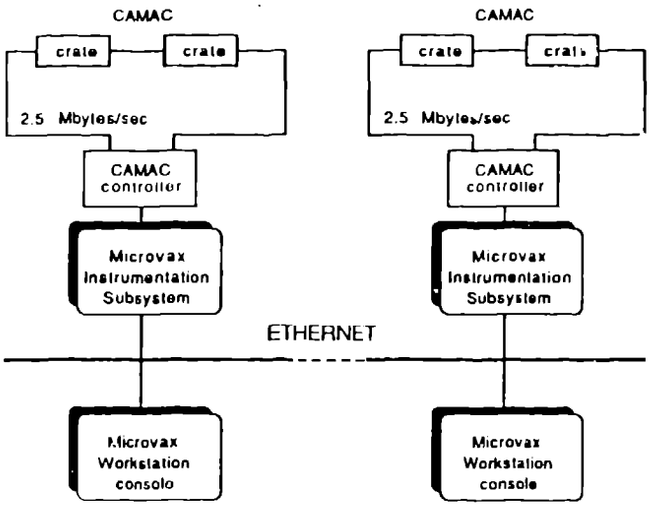

Fig. 4. Future PSR control system.

We feel this new system will give us several desirable features:

1) The database will be distributed among the MicroVAX subsystem computers. Each subsystem will maintain that portion of the database which is associated with the devices on the CAMAC serial highway of that machine. This allows a modular approach to expansion of the system, since as new devices are added one need not alter existing device configurations on other subsystems.

2) The system will be modular which will allow expansion to more workstations and additional subsystems should the need arise.

3) We anticipate that replacing the Lexidata screens with workstations will provide a graphics interface which we believe will be more efficient and effective in presenting controls information to the operator. The workstations will have the added advantages of greater portability and modularity.

4) All programming will be in the same operating system.

Schematically, the new system is shown in Fig. 5 for one workstation console and one MicroVAX subsystem. Data requests and commands will be sent using the Ethernet link between console workstations and the instrumentation subsystem computers. The binary and analog reader programs in the subsystem computer will update a live database in memory. The server program provides remote access to the device database for workstation consoles or for other subsystem computers.

Access to the database on the subsystem computer is via three different modes of remote procedure calls:

1) In *synchronous* mode the application program in the console computer requests one database value and waits for the value to be returned.

2) In *asynchronous* mode the application program buffers data requests or commands and does not wait for the transfer to complete.

3) *AST* mode uses the VAX/VMS Asynchronous System Trap facility to provide the requesting application program with a software "interrupt" and the requested data when the desired device parameter has changed by more than a specified amount.

Present State of the Conversion

At the present time, we have installed one of the MicroVAX subsystems with one CAMAC crate in order to prototype the system and test the speed of database transfers and CPU overhead in both the subsystem computer and the console. This crate was removed from one of the PDP-11 systems and is used to read target temperatures and radiation levels from neutron detectors. This configuration is shown in Fig. 6. At the present time we have devices on the system which can only be read. Consequently, control, or the capability to write to devices, has not been completely implemented yet.

Test Results on the Prototype System

Initially, a MicroVAX II was installed as the subsystem computer. Excessive CPU loading led us to replace it with a MicroVAX 3200. The database on the MicroVAX subsystem is approximately one quarter of that presently on one of the PDP-11 systems. We find that the reader programs consume about 3% of the CPU time on the 3200 when the database is updated about once per second and that the overhead of network server processes is currently about 6-10%. On a MicroVAX II this would have been approximately 13% for the readers and 20-80% for network server processes. The variation in the CPU usage by the server processes depends on the number of application programs in the console computer and their method of access. In practice, we feel that the reader load on the CPU of the subsystem should not be above about 30% of the total CPU time in order to allow for periods of peak loading. Also, we feel that the server process CPU usage should be limited to about 40%.

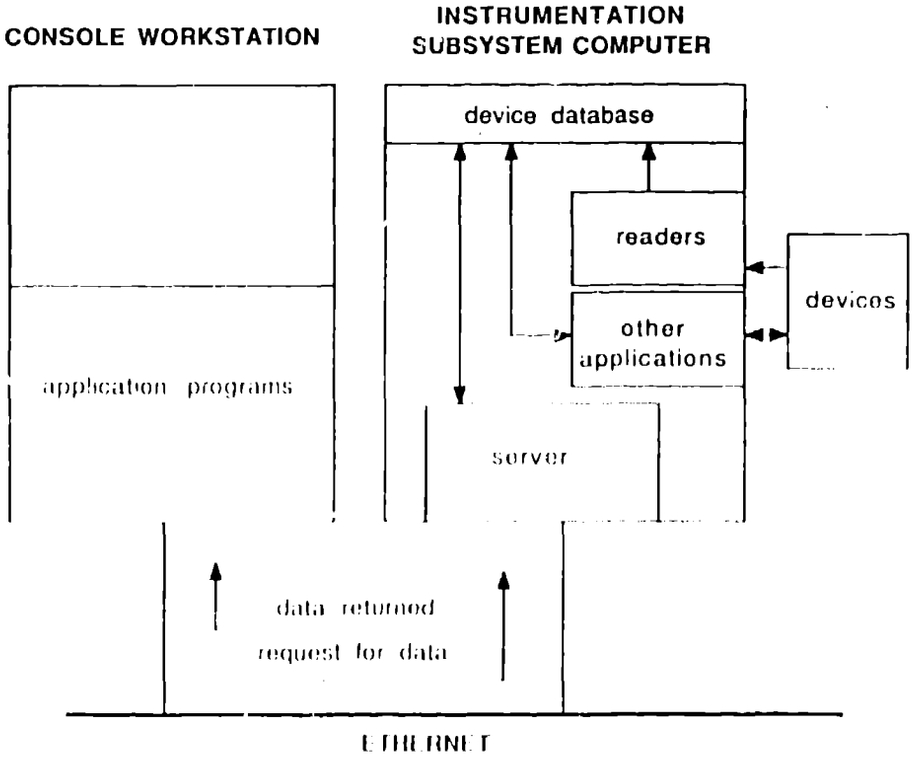

Fig 5 Dataflow in the future PSR control system

The important features which have been determined are:

1) Network server processes are the largest consumers of CPU time in both the console computer and in the MicroVAX subsystem. This demands careful console application program design in order to reduce unnecessary accesses.

2) The MicroVAX II is a little slower than the PDP-11 computers for CAMAC access and about the same speed otherwise. Except for special applications, the MicroVAX II is probably too slow for our intended application.

3) In order to reduce the CPU overhead of network server processes in the MicroVAX subsystem, it has been necessary to reprogram application codes in the console MicroVAX 3600 to reduce the use of synchronous database access. The use of synchronous access is a carry-over from the use of the centralized database. Since only a few of the hundred or so of the console computer application codes lend themselves to efficient use of asynchronous database access, we have made extensive use of the AST mode to get data from the database. This has proven to be the technique which loads the computers the least.

Conclusions

From our experience so far, it appears that this system will work on the PSR control system. The next phase will be the installation of control functions and additional devices. Following that, the PDP-11 computers will be replaced gradually over the next two years during periods of accelerator downtime.

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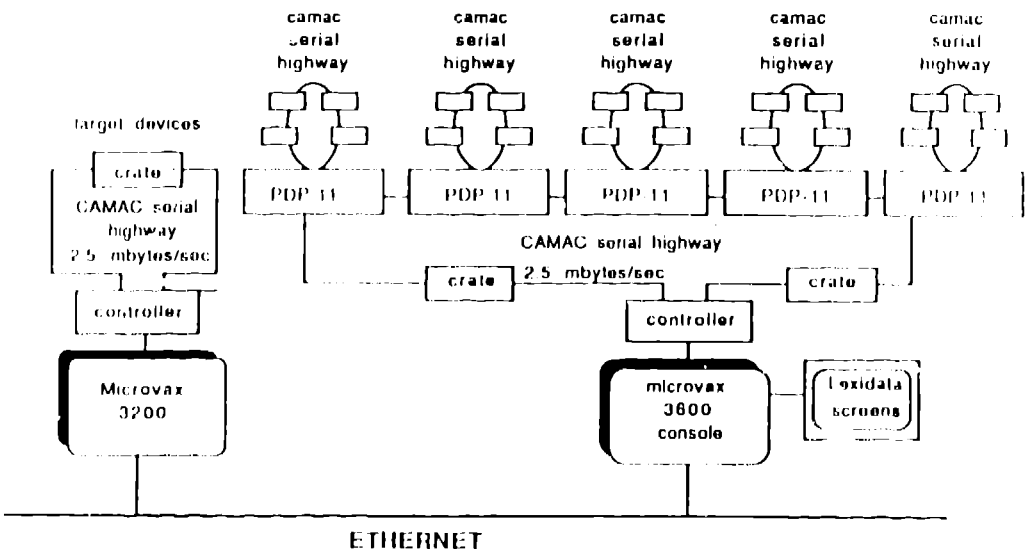

Fig 6 Current configuration of the PSR control system