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UPGRADING THE ATLAS CONTROL SYSTEM

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ABSTRACT

Heavy-ion accelerators are tools used in the research of nuclear and atomic physics. The ATLAS facility at the Argonne National Laboratory is one such tool. The ATLAS control system serves as the primary operator interface to the accelerator.

A project to upgrade the control system is presently in progress. Since this is an upgrade project and not a new installation, it was imperative that the development work proceed without interference to normal operations. An additional criteria for the development work was that the writing of additional "in-house" software should be kept to a minimum.

This paper briefly describes the control system being upgraded, and explains some of the reasons for the decision to upgrade the control system. Design considerations and goals for the new system are described, and the present status of the upgrade is discussed.

INTRODUCTION

The ATLAS control system has reached its present state due to an evolutionary process much like that of the ion accelerator it is associated with.

The older portion of the control system consists of a minimum of six CPUs. Four of the CPUs are part of complete computer systems that include disk drives and operator interfaces. Two of these computer systems are DEC PDP-11s running the RSX-11M operating system, while the other two are PCs running a version of PC-DOS.

Two I/O subsystems are currently responsible for interfacing the computer systems to a variety of accelerator components.

The first subsystem is a CAMAC serial highway which services nearly the entire accelerator facility, and includes a fiber optic link to an ion-source high-voltage platform which typically operates at a voltage between 100 and 150 kV above ground potential.

The second subsystem is a combination serial RS-232 and IEEE-488 communication structure, which also includes a fiber optic link to a second and different type of ion-source high-voltage platform, and it typically operates between 250 and 300 kV above ground potential.

Operator interface for control and monitoring of the accelerator, its injectors, and ion sources is achieved through the use of two separate control consoles that are serviced by one or more of the above mentioned computer systems.

UPGRADE MOTIVATION

A variety of reasons had motivated the ATLAS operational staff to consider upgrading the control system. Below are listed some general observations:

- The older portion of the system was based primarily on technology that was two generations behind present-day technology.
- There is very little commercially available software for the RSX-11M operating system. Software such as database management systems, spread sheets, graphical user interfaces, and plotting packages are in short supply. Consequently, nearly all software needs to be written "in house".[1]
- Operator interfaces, primarily older technology touch screens, had become cumbersome to use, and inflexible to design changes.[1]
- The control system consisted of several computer systems that were virtually isolated from each other, and they did not share information in any meaningful way.
- Finally, making additions and modifications is becoming exceedingly more difficult and time consuming.

DESIGN CONSIDERATIONS AND GOALS

It was decided that any upgrade to the present ATLAS control system should provide a system that was modular, fast, secure, capable of expansion and modification with minimum effort, "operator friendly", and conformant to certain standards to ensure long-term viability.

It was recognized early on that the following factors needed to be considered when developing the overall upgrade concept:

- It is crucial that the new system be integrated into the overall control system without interfering with accelerator operations.
- The ATLAS facility exists in a DEC environment, and local expertise is primarily with DEC systems.[1]
- The facility has a heavy investment in the CAMAC subsystem.[1]
- Nearly all of the software presently being used was written in house. Consequently every effort had to be made to provide the portability required to allow the continued use of this software.
- Much of the commercially available control system software was either too slow or did not support the CAMAC subsystem.[1]
- The size of the ATLAS staff was such that commercially available software had to be acquired when appropriate.

These requirements lead to the development of a new system that utilizes a DEC platform, with PC support, and provides for CAMAC interfacing.

NEW SYSTEM DESCRIPTION.

The overall concept of the new control system in its simplest form is depicted in Fig. 1. The control system makes use of two subsystems.

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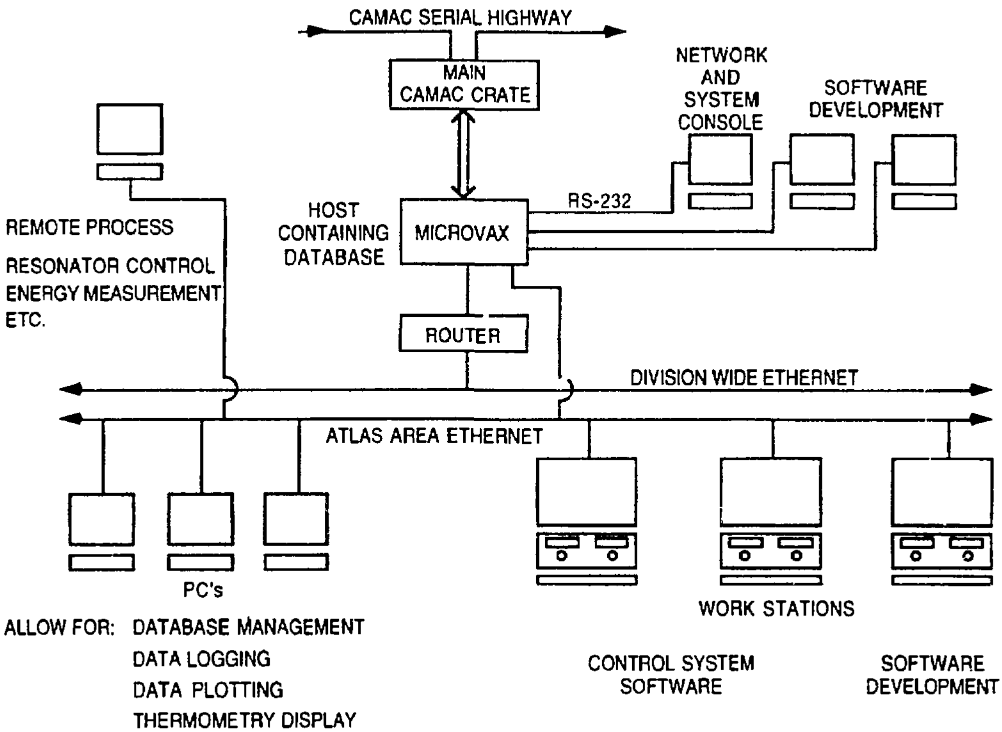

Fig. 1 Control System Concept

The first of these subsystems is a local area network (LAN), which incorporates use of an Ethernet backbone to connect the various computer systems that make up the control system. Through the use of a router the control system LAN is linked to the Division-wide LAN. The use of the router ensures that Division-wide network traffic does not interfere with the control system, while at the same time the router maintains a link with the Division network.

The control system LAN is configured for "cluster" operation using DECnet software. The cluster has been configured for a mode of operation that employs a single disk storage system that is used as the system disk for all central processing units (CPUs) that are part of the cluster, and one single CPU acts as the cluster server.

The second subsystem is a CAMAC serial highway. The highway is operated in a "byte-serial" mode. That is, eight bits are transmitted simultaneously upon every transmission cycle typically at a rate of 2.5 MHz. Except for the addition of CAMAC crates (there are currently 15 on line), and a new "serial highway driver", the CAMAC system is being retained in its present configuration for the new control system.

Given the power of today's PCs an attempt was made to locate a process control software package that would run on a PC, provide a CAMAC driver, and fulfill a variety of special needs of the ATLAS accelerator. None were found. Some were too slow. Most did not support CAMAC. After some investigation into a variety of software packages that were designed to be process control applications, it was decided to purchase the Vsystem product.

The new portion of the control system currently consists of a MicroVAX, two VAX stations, and three PCs.

One of the VAX stations is used as the operator's console, the other is used primarily for software development. Two PCs are used for remote display of cryogenic parameters, while the other is used primarily for software development and database maintenance.

Since there seems to be little operator acceptance of a workstation mouse as the primary control device, a "knob unit" is currently being tested, and touch screens will be ordered in the very near future.

A touch screen will be used in addition to a mouse on both PCs and VAXstations, especially in those remote locations where use of a mouse is inconvenient.

The knob unit would be used in place of the mouse as the primary operator's control device. A scheme has been devised and put into place that allows the "knob unit" to have the functionality similar to that of a "slider bank" control tool that contains two sliders. The operator simply selects a device on the display with the mouse or touch screen, and the device becomes logically connected to the two knobs of the "knob unit".

The heart of the system is the MicroVAX. This machine contains the necessary "run-time" databases, and ultimately will provide the only direct link to the CAMAC subsystem through the use of a "serial highway driver" that will be connected directly to the bus of the MicroVAX. With this configuration values from the run-time databases are sent directly to the CAMAC driver and do not travel over the network. In addition the MicroVAX acts as the network/cluster server described earlier.

The computer systems are interfaced to a variety of accelerator components, which include quadrupole, steerer, and magnet power supplies which are used as beam guidance tools. These devices are used to focus, steer, and bend the beam of ions in a manner consistent for delivering the beam of ions to an experimentalist's target.

These devices use CAMAC DACs and ADCs (typically 0 to 10V) to achieve control and monitoring, and thus lend themselves well to the basic control strategy of the Vista package without the need for external code.

Other devices called Faraday cups, beam-defining slits, beam-defining apertures, and beam-profile monitors are generally inserted in the beam path. These devices are used to stop the beam, define the beam's size and shape, monitor the beam's size and shape, and measure the beam's intensity.

These devices typically require only single-bit manipulation of an output or input register for selection, monitoring, and control. Since mask values are required to isolate single bits, these devices do not fit into the basic Vista package strategy. Consequently, it was necessary to write additional code, which have been called 'control programs", to handle these devices.

In other cases the need to write additional code stems from the specialized nature of the control process. This would be the case of resonator control, which are devices that actually impart energy to the ion beam.

Since the accelerator is a "super-conducting" device, and makes use of liquid helium and liquid nitrogen to achieve superconductivity, the monitoring of these cryogenic parameters is important.

Monitored data points include liquid nitrogen and liquid helium temperatures and pressures, and high vacuums. Most monitored data points require "conversion routines". In part this is due to the fact that curve-fitting algorithms are required, or the fact that much of this data is provided by controllers in BCD format.

To date approximately eight of the previously described "control programs" have been written, approximately four "conversion routines" have been written, and approximately 1750 channels have been configured in ten separate ".VDB" database files. The smallest of these files has approximately 50 channels, and the largest has approximately 500 channels.

DATABASE MANAGEMENT

The new system is currently being serviced by two database management systems (see Fig. 2). The first is a DEC product called RDB. The present implementation of RDB consists of the "development" option running on a VAXstation and the "run-time" option running on the MicroVAX. The second is a Borland product called Paradox that runs on a PC that is attached to the network. The RDB database is "device" oriented and contains device related information. The PARADOX database is "Vsystem channel" oriented and it contains only that information required by the Vsystem run-time database. Both database management systems are based on the relational database concept. This allows data associated with particular device types to be organized and stored in separate tables.

The RDB database contains device information such as the device's name, facility location, chassis rack location, associated channel name in the Vsystem run-time database, etc. Provisions have been made to allow for the merging of the two databases into one RDB database.

The Paradox database, as mentioned earlier, is currently used to store all Vsystem channel information needed to generate a run-time database. A report in the form of an ASCII file is created from the database that meets the Vsystem formatting requirements. This file is then copied to the VAX for the purpose of generating the Vsystem run-time database.

In addition a Paradox product called SQL LINK provides a low cost front end to the RDB database located on the VAX. This gives the user the ability to manipulate data stored in the RDB database using a PC that is connected to the network without the need for learning the structured query language (SQL). Although this approach seems promising, further testing needs to be performed.

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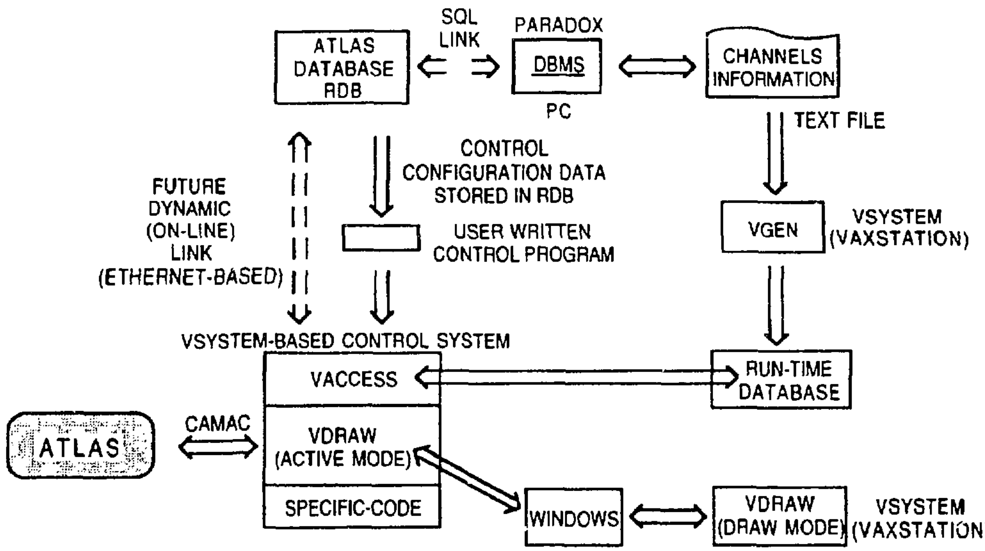

Fig. 2 Database Management

UPGRADE TRANSITION PROCEDURE

At least two schemes were devised to ensure that the development of the new system did not interfere with accelerator operations, and to allow the existing system to run simultaneously with the new system during the upgrade transition period. Both procedures use fundamental approaches.

The first scheme enables the new system to be phased in without making physical changes to the CAMAC interfacing. It involves communication between one of the existing PDP-11s and the MicroVAX. Since the MicroVAX is not presently interfaced directly to the CAMAC subsystem, and the PDP-11 is, the Vsystem running on the MicroVAX issues CAMAC requests to the PDP-11. The PDP-11 then executes the CAMAC request. If, for example, an operator uses a Vsystem control tool to request a change in the value of some CAMAC device, that request is passed on to a communication process using the VMS "mailbox" feature. This communication process then transmits the CAMAC request over Ethernet to a receiving process running on the PDP-11. The CAMAC request is then issued to the PDP-11's CAMAC driver, and then on to the device (see Fig. 3).

While this approach places a lot of traffic on the Ethernet, initial tests seem to indicate that performance times are acceptable for the immediate future. Once development has reached a point where the existing system can be phased out, the MicroVAX will then be interfaced directly to the CAMAC subsystem. Since the Vsystem run-time database resides on the MicroVAX, all CAMAC request traffic will be removed from the network.

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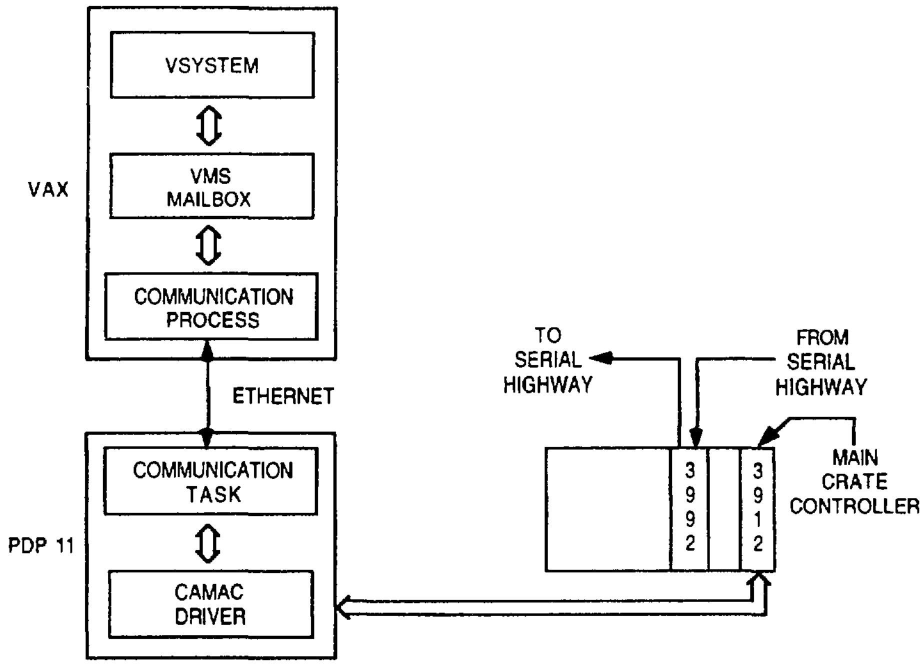

Fig. 3 Upgrade Transition Process for CAMAC Interface

The second scheme provides the operator with the option of using the existing or new control system during the upgrade development period. To make this possible it is necessary to ensure that both old and new database information is consistent.

The old system database is updated in the following fashion:

A process running on the MicroVAX is constantly scanning the Vsystem run-time database. If a change in data is detected, that change is transmitted over Ethernet in much the same way as described above to a receiving process on the PDP-11 where the old database resides. The receiving process then passes the new data to another process that is responsible for writing the new data to the old database (see Fig. 4).

Updating the new Vsystem run-time database with changes in the old database is handled somewhat differently. In this case a copy of the old database is copied over Ethernet using the DECnet copy server facility to the MicroVAX periodically (nominally once every minute) whether a change in the old database has occurred or not. In the MicroVAX a process copies the entire contents of the old database into the new Vsystem run-time database (see Fig. 4).

This mode of operation does have its limitations. A device could conceivably be called up on both the old and new systems (there is no lockout implemented) which could lead to obvious problems. In addition there are brief periods of time (one to two minutes) when the databases are not consistent. This implies that a device should not be called up on one of the control systems in less than approximately one minute of having been detached from the

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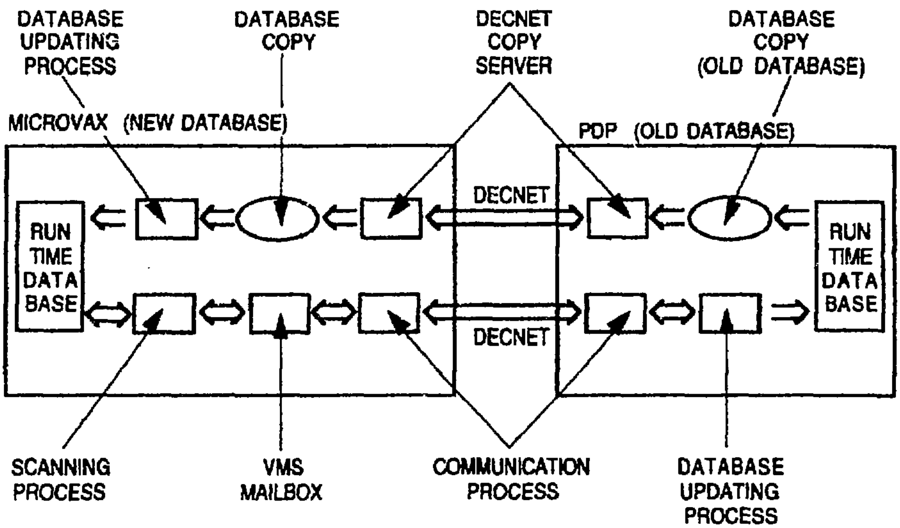

Fig. 4 Temporary Database Updating Procedure

other system. This operation policy does not seem to hinder operational efficiency in any way, especially when one is reminded that this is intended to be a temporary mode of operation.

PRESENT STATUS

Effort directed at upgrading the existing control system has provided the following accomplishments:

- A local area network "VAX cluster" has been configured which currently consists of a MicroVAX, two VAXstations, and three PCs.

- A scheme has been devised and put into operation that has allowed for a smooth transition from the existing system to the new system with virtually no accelerator down time to date.

  This includes the use of the CAMAC subsystem by both the old and new systems without the need for hardware changes, and the updating of databases in both systems to allow for devices to be controlled by either system.

- Two relational databases have been configured for use by the new system. One database is configured under the VAX-based RDB, and the other is configured under the PC-based PARADOX. Provisions have been made to merge these two databases into one in the future if so desired.

- The existing control system is divided into two main parts. These are the "accelerator" control system and the "beam-line" control system. In principle the "beam-line" control system has been replaced, and work has begun on the "accelerator" part of the control system.

- An Ethernet cable has been run throughout the facility, and remote PC nodes are providing displays of cryogenic parameters.

While much of the work has been completed toward the goal of replacing the previously existing control system, it is estimated that at least one more year will be needed to replace it in its entirety. Meanwhile the foundation has been laid to allow the new control system to achieve tasks that would have been nearly impossible in the past.

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