ARGONNE'S ATLAS CONTROL SYSTEM UPGRADE

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Abstract

The ATLAS facility (Argonne Tandem-Linac Accelerator System) is located at the Argonne National Laboratory. The facility is a tool used in nuclear and atomic physics research, which focuses primarily on heavy-ion physics. The accelerator as well as its control system are evolutionary in nature, and consequently, continue to advance. In 1998 the most recent project to upgrade the ATLAS control system was completed. This paper briefly reviews the upgrade, and summarizes the configuration and features of the resulting control system.

1 THE ATLAS ACCELERATOR

ATLAS is a heavy ion accelerator located at the Argonne National Laboratory. It is used primarily by physicists in the research of nuclear and atomic physics with an emphasis on heavy-ion physics. In the early 1960's the facility consisted of a single electrostatic Tandem accelerator. The current configuration is the result of the addition of two booster LINACs (Linear Accelerator), an injector LINAC, and two ion sources.

While ATLAS has been designated a National User Facility, the accelerator attracts researchers from all over the world. The accelerator operates 24 hours a day, seven days a week.

2 THE CONTROL SYSTEM TO BE UPGRADED

While particle accelerators differ in many respects, most use the same basic components. These include an ion source, the accelerating structure itself, and a beam transport system. When the first booster LINAC was added, those responsible for the control system realized that the complexity of the new accelerator called for a computer assisted control system. Consequently, due to evolutionary and operational constraints, the resulting accelerator system was controlled by a hybrid control system. The more traditional control system of potentiometers, meters, dials, switches, and indicator lamps was retained for the Tandem, while a computerized control system was implemented for the new LINAC.

This hybrid system eventually grew to include three DEC PDP-11 computer systems [1]. Control and monitoring of the newly constructed PII (Positive Ion Injector) was accomplished using one of the PDP-11s. Control and monitoring of the primary accelerator section was controlled by a second PDP-11, while all beam transport was controlled by the third PDP-11. All three systems contained separate and isolated databases.

A CAMAC (Computer Automated Measurement And Control) subsystem served as the primary interface between the computer systems and the various accelerator components. This CAMAC subsystem evolved into two separate and isolated serial highways.

While the control system was adequate, by the early 1990's it was in many respects already two generations behind in control system technology. It was at this time that work began on upgrading the ATLAS control system to provide a more cohesive system based on a singular control and monitor design.

3 UPGRADE STRATEGY

Two committees were formed to evaluate the plans for the upgrade. It was the general consensus that the upgrade needed to provide a system that was modular, expandable with a minimum of effort, and conformant to current and emerging software and hardware standards to ensure long term viability. The facility was entering a period where a record number of operational hours were planned (in FY1996, 5828 "beam on target" hours out of a scheduled 6060), so it was crucial that the upgrade be implemented without interfering with normal accelerator operations.

3.1 Existing CAMAC Subsystem and Software

Since there was a large investment in CAMAC components, the CAMAC I/O subsystem was retained, and configured into a single serial highway. All of the PDP-11 computers were replaced. Special in-house written process software existed on the old system. These processes were the result of years of programming effort. Consequently, it was decided that the new system had to be capable of accepting as much of the existing process code as possible.

3.2 Staffing Considerations

Day to day operation and maintenance of the control system, as well as achieving the upgrade goals, typically consisted of one full-time system manager/programmer, one full-time operator/programmer, and one part-time

* Undergraduate Research Participant, supported by the ANL Division of Educational Programs.

undergraduate student/programmer. The size of this staff, given its responsibilities, provided a strong preference for acquiring an established control system software package.

3.3 Software Candidates

Both commercial and non-commercial candidates were researched. Since the software package known as EPICS (Experimental Physics and Industrial Control System) was just being developed through a collaborative effort of participating national laboratories, there was a convincing motivation for adopting this control system software. However, at the time when the upgrade started it was not possible for the limited sized ATLAS staff to achieve the upgrade goals in a timely fashion while contributing to the EPICS development effort. In addition EPICS did not provide support for the CAMAC Serial Highway subsystem. One package did provide the needed CAMAC support as well as technical support. Therefore, based on the size of the staff, and other considerations, the software package marketed under the name “Vsystem” by Vista Control Systems was acquired [2].

4 UPGRADE IMPLEMENTATION

The strategy for implementing the upgrade called for four overlapping phases. Since the initial goal of the upgrade was to centralize control of the entire accelerator in the main control room, the first step in phase one was to integrate control and monitoring of the positive ion injector into the main control system.

4.1 Upgrade Phase One

The PII development computer system and the main computer system maintained two separate and isolated databases and two CAMAC subsystems. The two databases were combined to create one database, and the two CAMAC Serial Highways were combined to form one. Therefore, the first of the three PDP-11 computer systems was retired.

4.2 Upgrade Phase Two

The second phase called for porting all of the beam transport processes to the new control system. To help accomplish this a second I/O subsystem was installed. This was an Ethernet based LAN (Local Area Network), which is used to interconnect the various control system computers.

A MicroVAX was installed and connected to this newly installed LAN. Two new database structures were installed on this new machine. The first database was the more dynamic "Vsystem" real-time database. This database provides the software or logical link to the CAMAC hardware. Changes made to this database causes CAMAC I/O to occur. The second database is a relational database, which uses the data management software product "Oracle Rdb" [3]. This database contains static information about accelerator devices that would be inappropriate to store in the Vsystem real-time database. Information such as a device's name, the associated channel/record name in the real-time database, chassis rack location, and any other constant-like parameters associated with a device are stored in this database.

Cooperating communication processes were written for both the MicroVAX and the PDP-11. Since at this time the PDP-11 was still physically interfaced to the CAMAC subsystem, these two processes provided a means for the PDP-11 to issue CAMAC I/O requests on behalf of the newly configured computer system. This scheme provided the means for developing processes on the new system without affecting the configuration or operation of the old system.

Two additional cooperating processes were written for the MicroVAX and the PDP-11 that were responsible for maintaining database consistency between the two systems. This allowed an operator the flexibility of controlling a device from either the old system or the new system. If a device parameter was changed on the old system, the database of the new system would be updated. Likewise, if a device parameter was changed on the new system, the database of the old system was updated.

At the end of the second phase of the upgrade all processes used for control and monitoring of all beam transport devices were moved. They were moved from the PDP-11 that was responsible for this task to the newly installed MicroVAX. This second of the three PDP-11 computers was retired.

4.3 Upgrade Phase Three

During phase three, as more processes were moved to the new control system, the PDP-11 was issuing an increasing number of CAMAC I/O requests on behalf of the MicroVAX. This consequence lead to a degradation of overall system performance. It was at this time that the physical connection of the CAMAC Serial Highway was moved from the PDP-11 to the MicroVAX.

Also in phase three a method of storing complete accelerator tune configurations was put in place. The Oracle Rdb relational database plays a key role in the archiving of complete accelerator tune configurations. Using this archived information, a tune configuration for a given experiment can be stored for future experiments. A Corel product called Paradox was installed to provide the operator with a graphical interface to the archived tune data [4]. This was done to eliminate the need for an operator to learn, and use commands in SQL (Structured Query Language) to manipulate data in the relational database. The implementation of this interface provides the operator with a "point and click" windowing environment for retrieving data from the archive database.

When the final process that was executing on the remaining PDP-11 was moved from the PDP-11 to the MicroVAX, this remaining PDP-11 was retired.

4.4 Fourth and Final Phase

Since from the beginning of the project it was planned that the interim MicroVAX computer system would be replaced when the DEC/Compaq Alpha technology became available, an inexpensive machine was purchased with a maximum memory limit of 64 MB [5]. Due to the memory limitation, system performance became less than desirable once all control processes had been moved to the new system. Since the Alpha technology was now available, a new AlphaServer was purchased to replace the MicroVAX.

A new CAMAC Serial Highway interface and software driver was purchased from Kinetic Systems Inc., and both were tested offline [6]. All control processes, databases, and operator display files were moved to the new AlphaServer. When all was ready the last step was to physically move the two CAMAC Serial Highway cables from the MicroVAX to the AlphaServer completing the fourth and final phase.

5 THE NEW CONTROL SYSTEM

The new control system provides the operator with all the features of the old control system as well as new features. The current hardware configuration of the new control system is depicted in Figure 1.

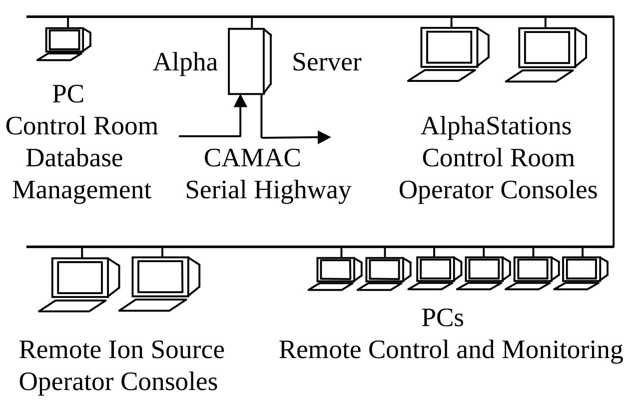

Figure 1: Atlas Control System

The new system consists of one AlphaServer, four AlphaStations, and seven PC workstations. The AlphaServer is at the core of the system, and provides the single link to the CAMAC Serial Highway. Two of the AlphaStations are physically located in the main control room, and provide the primary operator interface to the control system. The remaining AlphaStations are remotely located at the facility's two ECR (Electron Cyclotron Resonance) ion source control consoles, and provide local interfacing to these devices. Six of the PCs are distributed throughout the facility and provide remote control and monitoring functions. The seventh PC is located in the main control room, and is used to provide a graphical interface to the archiving relational database system.

Two I/O subsystems are utilized by the new control system. The first is a CAMAC Serial Highway, which currently links 18 crates and operates at a clock speed of 2.5 MHz. The second subsystem is a mix of 10 MB/s and 100 MB/s Ethernet LAN segments. This LAN is used to link all of the computers, and is the means by which data is exchanged.

Oracle Rdb and Paradox provide the database structures for archiving purposes. Vsystem provides the foundation for the real-time aspects of the control system. This system was chosen, as previously discussed, largely due to the relatively small size of the staff. Vsystem is a network distributed control system software that provides distributed database access and CAMAC I/O processing. While the ATLAS control system does not currently make use of the distributed CAMAC I/O processing feature, it does take advantage of the distributed operator interfacing capabilities. Through the use of the "X Windowing System", operator interface processing is distributed among the various workstations [7].

6 CONCLUSION

Demands on the system will no doubt grow in the future. It has been demonstrated that one of the better ways to deal with increased demand is distributed I/O processing. To ensure that the system will be prepared for future demands, plans to implement distributed I/O are underway.

The control system resulting from the upgrade has met all of the design goals of the upgrade project. The development effort took place on line, and simultaneously with the operating schedule of the accelerator. Except for negligible periods of time, the accelerator's operating schedule was never delayed due to upgrade activities. This was accomplished during a period when the accelerator's operating schedule was designed to achieve a record number of operational hours.

REFERENCES

[1] Former Digital Equipment Corporation, Maryland, MA, USA.
[2] Vista Control Systems, Inc., Los Alamos, NM, USA.
[3] Oracle Corporation, Redwood Shores, CA, USA.
[4] Corel Corporation, Jericho, NY, USA.
[5] Compaq Computer Corporation, Houston, TX, USA.
[6] Kinetic Systems Corporation, Lockport, IL, USA.
[7] "X Windowing System", A system resulting from a collaborative effort of a consortium of vendors and the Massachusetts Institute of Technology.

Work supported by the U. S. Dept. of Energy, Nuclear Physics Div., under contract W-31-109-ENG-38.