Control System for the Holifield Radioactive Ion Beam Facility

B.A. TATUM, R.C. JURAS, M.J. MEIGS

Oak Ridge National Laboratory [1], P. O. Box 2008, Oak Ridge, TN 37831-6368 USA

A new accelerator control system is being implemented as part of the development of the Holifield Radioactive Ion Beam Facility (HRIBF), a first generation radioactive ion beam (RIB) facility. The pre-existing accelerator control systems are based on 1970's technology and addition or alteration of controls is cumbersome and costly. A new, unified control system for the cyclotron and tandem accelerators, the RIB injector, ion sources, and accelerator beam lines is based on a commercial product from Vista Control Systems, Inc. Several other accelerator facilities, as well as numerous industrial sites, are now using this system. The control system is distributed over a number of computers which communicate over Ethernet and is easily extensible. Presently, implementation at the HRIBF is based on VAX/VMS, VAX/ELN, VME, and Allen-Bradley PLC5 programmable logic controller architectures. Expansion to include UNIX platforms and CAMAC hardware support is planned. Operator interface is via X-terminals. The system has proven to be quite powerful, yet it has been easy to implement with a small staff. A Vista users group has resulted in shared software to implement specific controls. This paper details present system features and future implementations at the HRIBF.

I. INTRODUCTION

Conversion of the Holifield Heavy Ion Research Facility (HHIRF) to the Holifield Radioactive Ion Beam Facility (HRIBF) [2] began in 1992. The HHIRF control system was a mixture of control technologies based on 1970's-vintage interface hardware and computing technology. The Oak Ridge Isochronous Cyclotron (ORIC) [3] and its associated beam lines were controlled through a combination of hardwired controls, an Allen-Bradley programmable logic controller (PLC) system, and a Modcomp real-time computer with CAMAC and "homemade" interface hardware. The tandem electrostatic accelerator control system was based on an Interdata computer system with a CAMAC hardware interface. These systems were not interconnected, were quite difficult to reconfigure, had non-graphical interfaces, and spare parts were either expensive or non-existent.

Both of the existing accelerators required considerable modifications in the facility reconfiguration. Additionally, existing beam lines had to be redesigned and reconfigured and new beam lines constructed. The major new addition to the facility was a 300 kV high-voltage platform system, referred to as the RIB injector [4], which houses a Target-Ion Source [5] and mass analysis system. The advent of these changes and additions mandated a unified, modern, and easily extensible control system for the facility. The decision of which system to implement was not an easy one, but based on budgetary, scheduling, and manpower constraints, as well as flexibility and ease of operation, the control system manufactured by Vista Control Systems, Inc. was selected. The remainder of this paper details the implementation of this system at the HRIBF.

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II. HARDWARE COMPONENTS

The Vista control system was, in 1993 when the HRIBF control system selection was made, purely based on the VAX/VMS/ELN architecture. The drawing utility VDRAW, the database generator VGEN, and the hardware interface code VACCESS all operate at the VMS level. Yet an advantage to Vista is an ability to expand the system by adding ELN nodes running just the VACCESS component. The conclusion for the HRIBF implementation was to distribute control with rt300 VAX processors in VME running the ELN operating system. Standard VME modules are used to provide an interface to existing Allen-Bradley programmable logic controllers (PLCs), serial interfaces, GPIB, ADCs, and DACs.

It was apparent that the hardware necessary to interface accelerator devices to Vista had to be as inexpensive and as flexible as possible. Most control functions were simple binary controls or analog control requiring at most 16 bits of resolution. Previously, ORIC beam line vacuum controls were implemented via an Allen-Bradley (A-B) PLC5 system which proved to be reliable and cost-effective. Devices are easily interfaced to the modules because of their terminal strip connectors. Additionally, Allen-Bradley manufactures a full line of ground-isolated ADC modules with resolutions of up to 16 bits and ground-isolated DAC modules with resolutions to 14 bits. Thus the majority of new devices in the HRIBF system are controlled via A-B PLCs. Scanner modules in VME link Vista to the A-B remote I/O link which can transfer data at a maximum rate of 115 kB. Analog and digital controls may be implemented in this manner directly through a remote I/O adapter residing in the PLC chassis. Thus the controls appear as "dumb I/O" to Vista. No PLC processor programming is required. A-B PLC5/20E ethernet processors were added to the system with chassis containing these processors tied directly to the 10-MB Ethernet rather than an A-B VME scanner module. Only discrete I/O are implemented in these chassis. (Analog I/O could be implemented, but block transfers would have to be programmed in the PLC ladder logic) Discrete I/O data tables can be read from and written to directly with Vista. An advantage to this scheme is that interlock functions for vacuum equipment, powers supplies, etc… can be programmed in ladder logic, thus minimizing wiring and installation costs. Additionally, reliability is increased since the PLC processors continue to operate when the Vista system is not running and changes to interlock strings can be made quickly.

In addition to the A-B PLC hardware, a serial interface has been implemented through VME to provide both RS-232 and RS-485 interface to power supplies, teslameters, vacuum gauge and turbomolecular pump controllers. The VME Microsystems VMIC VME-6015 quad-serial interface card is presently being used. Each of the four ports may be individually configured.

Currently, four rt300 processors and corresponding VME chassis exist in the HRIBF system. Two of these chassis contain serial interface modules. All four chassis contain A-B scanner modules which have up to four PLC chassis attached to the remote I/O link. The total number of PLC chassis in the system presently connected in this manner is ten. Six A-B chassis containing PLC5/20E ethernet-connected processors are utilized. A schematic layout of the HRIBF control system is shown in Fig. 1.

III. SOFTWARE COMPONENTS

ASCII databases are developed which contain channels that specify parameters for device initialization and individual I/O points. Databases are thus easily created and changed. The Vista database generator, VGEN, is then used to compile the database. Once the databases are generated, they are mapped to various ELN nodes distributed on the ethernet. Quantity and organization of databases is at the user's discretion. In the HRIBF implementation, separate databases are used for each beamline and/or specific subsystem such as the target/ion source. Generally, each I/O point on a PLC module has a channel associated with it that contains, for example, address, initialization, priority, and scaling information.

Software has been written to integrate the Allen-Bradley PLC5 series hardware with Vista. Two Vsystem I/O scanner utilities provide updates of outputs based on "interest," which is a change in value of the database channel. Additionally, the utilities provide a time-based scanning of inputs with timing based on user specified clock ticks, a scan period, and a priority setting. The first of these utilities is an extension of Vaccess to ELN and runs on the rt300 VAXELN processors in VME. Its purpose is to provide interface via the A-B remote I/O scannner module in VME. The second utility is quite similar in operation to the first, but it runs under VMS and works in conjunction with A-B Interchange software to provide a means of accessing the PLC5/20E processors across the ethernet.

The serial interface program previously mentioned also runs on each rt300 VAXELN node, with a separate process for each of the four serial ports on each VME-6015 module.

IV. SYSTEM PERFORMANCE

Operational experience to date has been good. As with any newly implemented system, there is a learning process. This includes both familiarization with the system code and software specific to I/O. Timing with all A-B hardware has proven to be adequate thus far. If performance decreases with the addition of other components to the system, there are numerous ways to redistribute the hardware to improve throughput. For example, more A-B VME scanners can be added to an ELN node or more ELN nodes can be added.

Some basic problems exist. Timing and noise problems must be solved in conjunction with some serial devices. ELN nodes must be made independent of one another such that crashes or power loss in one node does not result in inadvertant crashes of other portions of the system. Support of additional hardware such as CAMAC will be necessary.

The operator interface is always an aspect which generates considerable debate. Vista is no exception to this because of the flexibility of screen creation with VDRAW. In subsequent months as routine facility operation resumes, operator training in the usage of Vista will take place and many improvements on screen design will evolve. The major request at this juncture is for knobs for beam tuning, and it is apparent that knobs will receive a high priority in future enhancements.

V. FUTURE IMPLEMENTATION

Presently, all aspects of the RIB injector and target/ion source are controlled through the new system, as are all aspects of the beam transport lines from ORIC to the RIB injector. The beam transport line from the RIB injector to the tandem and a transport line from the tandem to a new recoil mass spectrometer will be completed in late summer. All aspects of these beamlines will be controlled via Vista. Vista is also currently utilized to control the ORIC internal ion source and monitor the ORIC extraction system.

Many additions to the new control system must be accomplished in the coming months. The ORIC controls conversion will proceed as the next phase followed by the conversion of other existing beam transport lines, the tandem accelerator controls, and the stable beam injector controls. Knobs and additional handlers will be added to aid in beam tuning.

VI. SUMMARY

The Vista control system has been implemented for accelerator system control as part of the creation of the Holifield Radioactive Ion Beam Facility. This system has proven to be extremely flexible and reliable. Implementation of both hardware and software with a small controls group of three people has been been straightforward and without great difficulty. Vista Control System personnel have provided outstanding support. To date, ORIC beam lines, some aspects of ORIC, the RIB injector, and the tandem injection beam line are being controlled with Vista. Additional beam lines to be completed in FY95 will also be controlled through Vista as will additional ORIC components converted as time permits. A subsequent phase will be to convert the tandem controls to Vista, and add UNIX and CAMAC support. The culmination will be a versatile, distributed, and unified control system for the HRIBF.

VII. REFERENCES

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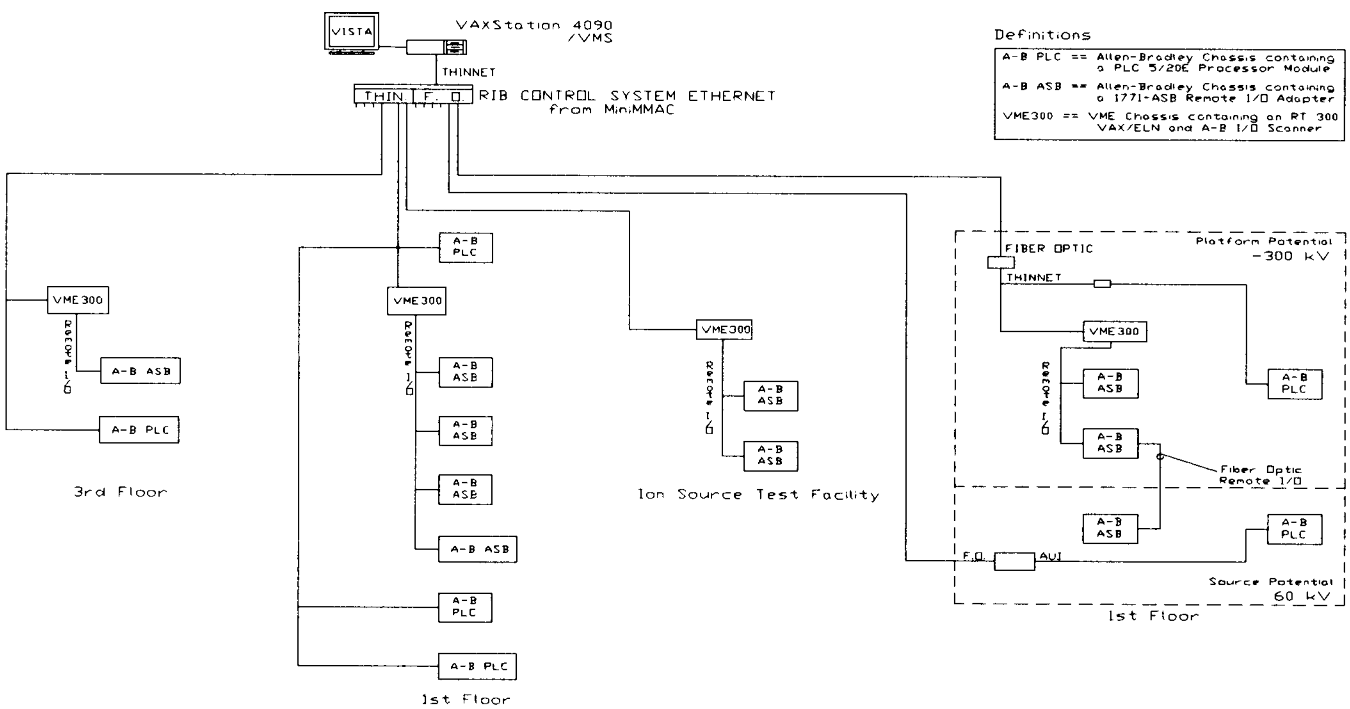

Figure 1: Schematic Layout of the HRIBF Control System