NOV 08 1985

TITLE FINAL REPORT ON THE FMIT CONTROL SYSTEM

LA-UR--85-3581

DE86 002398

AUTHOR(S) James A. Johnson

MASTER

SUBMITTED TO 2nd International Workshop on Accelerator Control Systems
Los Alamos, New Mexico, October 7-10, 1985

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

By acceptance of this article the publisher recognizes that the U S Government retains a nonexclusive royalty-free license to publish or reproduce the published form of this contribution or to allow others to do so for U S Government purposes

The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U S Department of Energy

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FINAL REPORT ON THE FMIT CONTROL SYSTEM*

James A. JOHNSON, AT-4, MS H821
Los Alamos National Laboratory, Los Alamos, NM 87545

The computer control system for the Fusion Materials Irradiation Test Facility (FMIT) prototype accelerator was designed using distributed intelligence driven by a distributed database. The system consists of two minicomputers in the central control room and four microcomputers residing in CAMAC crates located near appropriate subsystems of the accelerator. The system uses single vendor hardware as much as practical in an attempt to minimize the maintenance problems. Local control consoles are an integral part of each node computer to provide subsystem check-out. The main console is located in the central control room and permits one-point operation of the complete control system. Automatic surveillance is provided for each data channel by the node computer with out-of-bounds alarms sent to the main console. Report by exception is used for data logging. This control system has been operational for two years. The computers are too heavily loaded and the operator response is slower than desired. A system upgrade to a faster local-area network has been undertaken and is scheduled to be operational by conference time.

1. Introduction

The Fusion Materials Irradiation Test Facility (FMIT) was to be a facility to produce high energy neutrons to aid in the development of suitable materials for the fabrication of controlled thermonuclear reactors. This facility was to be built at the Hanford Engineering Development Laboratory (HEDL) at Richland, Washington. A prototype of the injector, radio-frequency quadrupole (RFQ), and a portion of the drift-tube linac tank was built at Los Alamos. The FMIT project has been cancelled, but the work on the prototype was funded through September 1985. The prototype accelerator was designed to produce a 100-mA continuous wave (cw) deuteron beam at 5 MeV.

*Work supported by the US Dept. of Energy.

The supervisory control system for the prototype accelerator was to be prototypical of the final system to be installed at HEDL. The control-system design needed to be versatile and expandable to support both accelerator development and operation of a "neutron factory" at HEDL. The functional specifications are summarized below.

- Provide control of the facility from central control room
- Support accelerator development
- Provide local control
- Run a "neutron factory"
- High availability

2. Design philosophy

The availability of powerful minicomputers and microcomputers at moderate cost led to the design of a distributed control system to better solve the FMIT control problem. This application was unique in that the accelerator was to be designed at Los Alamos and then built and operated at HEDL by personnel with little previous experience in accelerator operation. The use of single-vendor computer hardware and software where possible was deemed desirable to facilitate maintenance during operation of the facility at HEDL. Therefore, a single vendor who could provide a medium-sized minicomputer for console support and primary control, a microcomputer that could be mounted in the I/O card cage, and a network to handle the data communication was needed. The vendor-supplied operating system for the microcomputer was a memory-resident subset of the disk operating system used in the minicomputer. A central control room was required to concentrate the control of the entire facility. The main console was not to have direct access to the computer's operating system, nor was a keyboard needed to operate the accelerator.

A simple operator's console was available near the accelerator subsystems to assist in subsystem check-out and maintenance. The system, both hardware and software, was modular to provide easy maintenance.

A high-level language was used except where assembly language was required to meet time restraints. Software was designed to minimize the possibility of computer "crashing".

3. Control-system design

The design chosen consists of a database-driven control system with distributed intelligence. The computer configuration (fig. 1) is a star network of DEC computers. The primary control computer (PDP 11/60) is the center of the star and supports the operator console. There are four local-node computers (LSI 11/23) located near the accelerator subsystems, which interact with the CAMAC I/O equipment. Each node sends control signals to an accelerator subsystem, monitors the subsystem data channels, and reports appropriate data and alarm information to the primary computer. The subsystem can be operated from the local-node computer. The injector and rf/dc power nodes operate as described above. The cooling node has the additional function of providing closed-loop control of several temperatures, one of which is the RFQ cooling-water temperature. The beam-diagnostics node consists of the standard-node computer, plus an LSI 11/23 with disk, that is dedicated to the calculations required to produce a three-dimensional reconstruction of the accelerator beam from profiles digitized from television data. A support computer (PDP 11/60) is connected to the network and is used for database maintenance, data reduction, and software development. A test node is connected to the support computer to aid in software development.

An operator's console position consists of a color-graphics terminal with a touch-sensitive screen, a character display panel and four control knobs, a set of fixed buttons, and a color alarm monitor. The color-graphics terminal is used for displaying system diagrams with data updates. The touch-sensitive screen provides software "buttons" that are used for menu selection, binary control, to activate a program, or any of several other options. The character display panel and control knobs give the operator binary control and real-time analog control of the accelerator. The fixed buttons give the operator access to the functions that should be available to him at all times. The alarm monitor is used to display alarm messages to the operators.

The software is structured and database driven to provide flexibility. The database is distributed with the main database residing in the support computer. A run-time database is generated for each node and consists of the information needed to support that node. The run-time databases are downline loaded into the node computers when the node computers are booted up. The primary run-time database resides in the primary computer and contains the information needed to support the alarm display.

The main database resides on the support computer and contains all the information required to define each data point or control point. This database is not used directly in the control of the accelerator. The database is maintained on this computer, and tasks operate against the main database to produce the primary run-time database and the local run-time database for each of the node microcomputers. The primary run-time database contains the title of each channel, the alarm limits, and the conversion information needed to provide a useful alarm message to the operator.

The run-time database for each node contains the hardware address of each data channel, data conversion information, and alarm and report-by-exception limits for the set of data channels serviced by that specific node. The run-time database for each node is task built with the system image for the node and transferred to the primary machine ready to be downline loaded to the node.

The software was designed using structured techniques (fig. 2). Because the network (DECNET) has a complicated connect sequence, the design included a task in the primary computer and in each node computer to handle the DECNET connect sequence. These tasks are named MSG60 in the primary computer and MSG23 in each of the node computers. They receive task-to-task command messages, from other tasks in the same computer, pack them into DECNET messages, and send them to the receiving node. This structure was desirable because, at design time, it was not clear that DECNET could handle the data communications for this control system [1].

The other tasks running in the primary computer are the main interface program (MIP), the operator module (OPM), and the alarm task (ALARM). The MIP provides the interface with the color-graphics terminal, the touch-sensitive panel, and the fixed buttons. The OPM provides the

interface to the character display panel and the control knobs. The data updates on the character display panel are provided at four updates per second while a control knob is being turned to give the operator the required "real-time" response. The ALARM program receives the alarm messages from the node computers, presents an alarm message on the alarm monitor, starts an audible alarm, and stores the message on the disk.

Each node computer has a set of tasks that are the same in each node and one or more tasks that are unique to a given node. Each node computer runs an equipment module dispatch (EMDISP) task, a surveillance (SURV) task, and a local control program (LCP). The EMDISP task receives a command message from the primary computer, interprets it, and routes the command to the proper equipment module. The SURV task reads each data channel serviced by the node, compares the reading with the previous reading, and sends an alarm message to the primary computer if the alarm limits are exceeded or sends a report-by-exception message if those limits are exceeded. The LCP provides the interface to the local terminal, which has a set of displays that are periodically updated. It also receives commands from the keyboard, forms command messages, and sends them to the appropriate task for execution. Each node has one or more tasks that are unique to that node.

This control system has been operational for over two years and has been used to support the development of the injector and RFQ for the FMIT prototype accelerator. The combination of the PDP 11/60 computer's limited memory, the DECNET data-communications software, the operating system, and the control-system software results in memory saturation on the primary computer resulting in slow response to the operator under some conditions. This situation became obvious over two years ago, and a decision was made to operate the prototype accelerator with one console position to ease the load on the primary computer. A parallel effort was initiated to upgrade the network. The ETHERNET had been accepted as an industry-wide standard, and several vendors were delivering hardware to this standard. The software support for the available hardware was general purpose and just becoming available. We decided to commit the effort to write drivers for the DEC Q-bus machines to talk to ETHERNET. The availability of the micro PDP11 with extended address space, soon to be upgraded to the 11/73,

prompted us to move a console position to a micro PDP11. The Q-bus drivers for the RSX11M and RSX11S would satisfy the needs of the upgraded console positions, and a second console position has been added. This complete system upgrade has been completed, and the system has been used to operate the prototype accelerator. The performance is much better than the previous system using DECNET.

4. Conclusions

The control-system design using a star configuration of computers interconnected with DECNET provided marginally acceptable control-system performance. As additional features were added and application programs were written, the PDP 11/60 primary-computer memory became saturated and, as programs rolled in and out to the disk, the memory became fragmented and programs were unable to get into memory. The time to transmit task-to-task messages between MSG60 and other tasks in the primary computer became excessive as the computer became busy. These problems led to the upgrade, which has provided good performance.

Acknowledgments

The author would like to acknowledge the joint Hanford Engineering Development Laboratory/Los Alamos National Laboratory staff for their efforts in the design and development of the FMIT control system.

Reference

- [1] R.M. Suyama, D.R. Machen, and J.A. Johnson, "The FMIT Facility Control System," IEEE Trans. Nucl. Sci. 28 (3), 2252 (1981).

Figure Captions

Fig. 1. The FMIT computer architecture.

Fig. 2. The FMIT software structure.

2 MeV PROTOTYPE ACCELERATOR COMPUTER CONFIGURATION

FIGURE 1

CONTROL SYSTEM TASKS