NSLS Control System Upgrade Status *

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Abstract

The NSLS control system initially installed in 1978 has undergone several modifications but the basic system architecture remained relatively unchanged. The need for faster response, increased reliability and better diagnostics made the control system upgrade a priority. Since the NSLS runs continuously, major changes to the control system are difficult. The upgrade plan had to allow continuous incremental changes to the control system without having any detrimental effect on operations. The plan had to provide for immediate improvement in a few key areas, such as data access rates, and be complete in a short time. At present, most accelerator operations utilize the upgraded control system.

1 Introduction

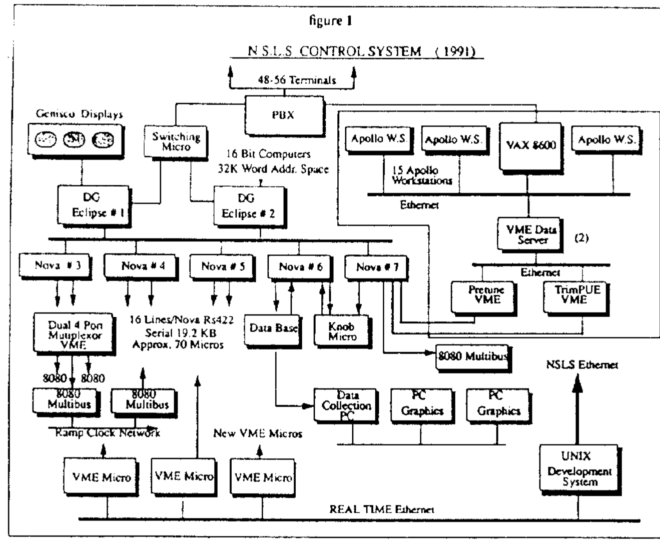
The NSLS initial control system design included a pair of Data General computers and multibus micros. A VAX, Apollos and VME micros were added later. The result was a system with a mixture of equipment that was unreliable, slow and difficult to maintain. The NSLS realized that a major improvement to the control system was necessary. It had to be complete in a very short time utilizing existing manpower.

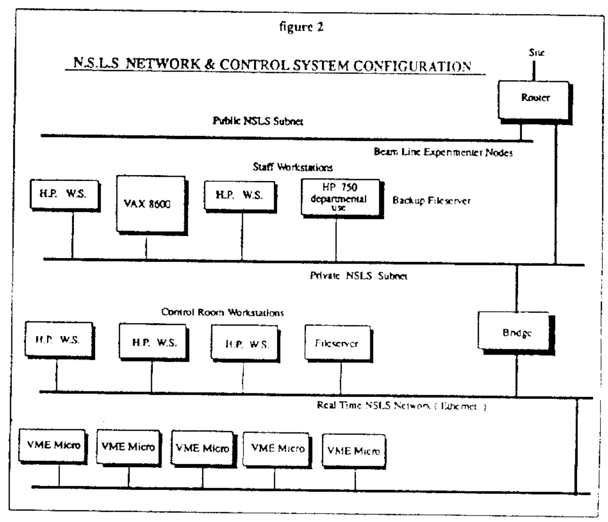
The first step focused on converting from serial communications to Ethernet communications, replacing the multibus hardware and adding high speed workstations. The goal was to convert from the old system(fig. 1) to the new system(fig. 2). Although many new functions were envisioned for the control system, the focus was on making the basic architecture change and other improvements were postponed until this was accomplished.

Key to the smooth transition is a module in the monitor which allows simultaneous computation with old serial lines and new Ethernet.

The immediate goals were to:

- convert all Multibus micros to VME.
- remove Data General and Nova computers.
- remove VAX computer from the control system.
- provide a graphical interface to programs.
- add Ethernet to existing VME micros.
- upgrade several existing micros.
- add several new micro systems.
- Remove the Apollo Domain workstations.





2 Original Control System

The control system (figure 1) in late 1991 consisted of two Data General 16-bit computers that communicate with five Nova computers over a high speed(100k to 300k words) DG proprietary parallel bus. Each Nova computer is connected to sixteen micros using 19k baud serial lines. The Nova computers act as store and forward processors and buffer the data to accommodate the differences in speed between the serial and parallel lines. All messages contain source and destination addresses. The Novas determine the destination ports from the message headers. This gives a micro to micro communications capability which is used

*Work performed under the auspices of the U.S. Dept. of Energy under contract no. DE-AC02-76CH00016.

0-7803-1203-1/93$03.00 © 1993 IEEE

for fast update of micro displays, knob control of devices and provides for device access from the VAX and Apollo computers.

When the Xray ring was upgraded the simulation and modeling programs could not run on the DG computers. To quickly integrate the department VAX computer into the control system, a Unix VME server was installed to provide a communications path from Ethernet to the serial links. Later Apollo workstations were added in the same manner. Graphic programs for orbit plotting and diagnostics were provided on the Apollo computer. The VAX and Apollo programs were slow because dual serial lines are used to access micro data.

Since 1988 all new control micros added have been VME system. In early 1992 there were about fifty five multibus and twenty VME systems. It was important to convert all multibus micros since many parts are no longer available. When including the test and development micros the total number of micros exceeded the number of Nova lines so the NSLS used multiplexors to increase the number of serial lines.

Each computer system used a different operating system. The DG's used AOS, the VAX used Ultrix and the Apollos used the Domain operating system. VME micro software development is done on a Motorola Unix system. All the multibus micros were written in assembly language and use an NSLS developed operating system. New VME micros were written in C and utilize a commercial operating system (RTUX).

The NSLS does not use a standard field bus. Each system uses the most appropriate interface method. Systems may use a parallel bus, serial bus, GPIB, Camac or other interface system. Conversion of the micros required modifications to the interface hardware to be compatible with VME systems.

3 New Control System Design

The new computer control system is shown.(figure 2). All the VME micros are connected via Ethernet to all the control room workstations. The Apollo workstations are shown upgraded to HP/700 series workstations. The operator terminal is a high performance workstation with sufficient memory and a local disk to give fast response. Several operator workstations are shown in addition to a file server and backup file server. Uninterruptible power supplies are provided for key systems. The low power consumption of workstations make UPS backup economical.

The file server will run programs that periodically take a snapshot of the data and provide a history capability. It also stores all the system files needed for day to day operations. Files are automatically copied to the backup file system periodically.

The performance of workstations has increased dramatically over the last few years. The new HP workstations are rated at over 10 times the performance of the Apollo workstations which substantially decreases the response time to operator requests.

In some cases several multibus micros were combined into one VME micro. The increased power of the VME system allows more functions to be programmed into one system. In the upgrade fifty five multibus micros were reduced to about thirty VME systems. In one case eight multibus micros were combined into one VME system. This eliminated a clock system needed to synchronize the multibus systems. Micros were combined so that related data could be collected in one micro. This minimizes Ethernet traffic and more functions can be done locally in micros. Some systems have several VME crates connected with Bus Repeaters and some have multiple CPUs.

Each new micro has a multipage TV compatible display some of which go to the CATV system. Presently there are over twelve TV displays continuously being updated. Since the displays are generated by micros very little of the network bandwidth is used. The memory mapped displays are a great diagnostic aid for realtime programmers.

4 Micro Changes[1]

The key to a smooth upgrade was a design modification made to the Micro monitor. All VME application software is designed around the NSLS monitor. The monitor does the functions common to all systems. The application program will deal with hardware and software requirements unique to a particular system.

The monitor handles all the messages from the serial lines. It interprets the messages and calls the application programs as needed. For example, all read requests are handled by the monitor. A new system module was added to the monitor that handles Ethernet communications. This module operates in parallel with the serial communications module. Messages can be received simultaneously from different computers over the serial and Ethernet links. The micro applications programmer does not need to know the source of the message. The goal is to allow all existing micro application code to continue running while new applications were written using the Ethernet communications.

By relinking existing micro application code with the new monitor, all twenty existing VME systems obtained Ethernet communication while each maintained a compatible serial interface.

Fast communications was a requirement in the new system. New additions to the monitor allow reading a group of devices with one message whereas with serial communications only one message per device was allowed. Depending upon the data format twenty or thirty devices can be read from a micro with one message.

In analyzing the old system, we found that the average data rate was up to 450 messages per second. Much of the traffic was needed to update displays or for micro to micro communications. In the new system, more functions are done in the micros which minimizes Ethernet traffic.

Two multibus micros would have required significant engineering effort to convert to VME. Special NSLS hardware was incorporated into the multibus micros and there was not sufficient manpower available to upgrade the system. To prevent these micros from holding up the conversion process a VME interface micro was built that controls the multibus systems. In such a case the multibus systems act as peripherals to the VME system. These two systems will be converted to VME systems soon.

The micros can send unsolicited error messages when an error is detected. These messages are sent over the serial link to an error process. The monitor was modified so that the setting of a switch in the VME crate will route the message to an error process on Ethernet. When the last micro is converted to VME, the Ethernet Error Processor will be enabled.

5 Workstation Software[2]

All the programs written for the DG, VAX and Apollo had to be ported to the HP workstations. This consists of over 100 programs and several hundred interpreter programs.

All programs written for the VAX, Apollo and DG utilized a user interface library (Ucode) to isolate the communications hardware from the application programmer.

To minimize the time needed to convert programs to Ethernet a Ucode library was written which is compatible with the Ucode library for serial interface. This simplified the porting of old programs from the DG, VAX and Apollo.

Many changes were made in the interface library. Options were made to allow reading a group of devices with one message. The device name size was increased from eight to fifteen characters. Programs were combined to give a more efficient user interface and there was an increased use of graphics. Realtime orbit displays and realtime orbit history programs were added. The orbit history normally runs at five Hz but can run at up to twenty Hz. The system will support fifty Hz or higher, depending upon the cpu used, but the micros presently have an arbitrary limit of 20 hz. Only critical programs were modified to collect data at fast rates. For the comint digital feedback system, a 200 Hz data rate is planned[3].

There are many terminals scattered around the building near the equipment. Some programs had to be accessible via ASCII terminals so that technicians had remote access from equipment locations scattered around the building. For some programs the interface had to be

6 Present Status

All programs are now running on the HP workstations and all but two micros have been converted to VME. The last two micros are ready for testing. Essentially all accelerator operations are run with the new system.

7 Conclusion

The conversion from old to new system was completed faster than expected. One reasons for this has been management involvement in the plan. Clear goals were defined and remained relatively unchanged throughout the project. During the upgrade many requests for improvements were made but there was strong support for limiting change requests and maintaining an appropriate level of effort on the conversion process.

The modular design of the Micro and host system software facilitated the upgrade. Interface libraries were used for communications and graphics software. Much of the conversion could be done by making changes to system libraries. In early program development attention was paid to evolving standards and portability. With the NSLS monitor, modifying or building new micros is relatively easy.

Now that the conversion is nearing completion the next phase of the upgrade can be started. The operator interface will be improved, a commercial database will be used, commercial GUI software will be tried, an upgraded monitor with provision for automatic code generation will be installed, hardware and software to time-synchronize all micros and workstations will be added, a real time name-server for micros will be added, FDDI links for the file server and control room workstations are planned and more logical device types will be added.

8 Acknowledgements

The authors would like to acknowledge the support given by many staff members including: S. Kramer, N. Fewell, H. Langenbach, R. Rose, A. Friedman, J. Dabrowski, P. Pearson, the Computer Support Group, R. Church and the NSLS control room operators.

I. References

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