EVOLUTION OF THE DARLINGTON NGS FUEL HANDLING COMPUTER SYSTEMS

by

CA9700718

V. Leung and B. Crouse
Ontario Hydro
Darlington Nuclear Generating Station
P.O. Box 4000, Bowmanville
Ontario, Canada
L1C 3Z8

ABSTRACT

The ability to improve the capabilities and reliability of digital control systems in nuclear power stations to meet changing plant and personnel requirements is a formidable challenge. Many of these systems have high quality assurance standards that must be met to ensure adequate nuclear safety. Also many of these systems contain obsolete hardware along with software that is not easily transported to newer technology computer equipment. Combining modern technology upgrades into a system of obsolete hardware components is not an easy task. Lastly, as users become more accustomed to using modern technology computer systems in other areas of the station (eg: information systems), their expectations of the capabilities of the plant systems increase.
This paper will present three areas of the Darlington NGS Fuel Handling computer system that have been or are in the process of being upgraded to current technology components within the framework of an existing Fuel Handling control system.

1. INTRODUCTION

The Darlington Nuclear Generating Station is a four unit station with a fuel handling system consisting of the following primary components:

- Three independent transport trolleys. Each trolley contains two fuelling machines for reactor fuelling and maintenance operations. Each trolley is capable of fuelling any of the four reactors.
- Four Fuelling Facilities Auxiliary Areas (FFAAs) each containing new fuel and irradiated fuel mechanisms to load and unload the fuelling machines.

The F/H control system that controls this equipment consists of three independent control systems connected together in a network to allow electronic communication among the three systems (Figure 1).

Each control system in-turn consists of three computers which work together to provide all the required functionally for fuelling. The south control system contains an additional computer to control a second set of new fuel and irradiated fuel mechanisms.

When the initial control system software design was completed and placed into service, the computers were overloaded causing excessively display update times and false stops to the fuelling programs. This problem was successfully resolved by a combination of software efficiency changes and the installation of faster processors that were capable of running the existing software.

Subsequently, station requirements mandated that the Fuel Handling system be able to handle both standard length and long fuel bundles to control pressure tube fretting. This additional requirement has forced the implementation of a disk drive upgrade to accommodate the larger software.

Lastly, the additional reporting requirements of the long fuel bundle management program has necessitated the installation of an electronic communication link between the Fuel Handling control systems and the Fuel and Physics LAN to provide improved fuel tracking capabilities by the Fuel and Physics department.

2. Processor Upgrade

The justification for the replacement of PDP 11/70 processor started on June 8, 1992. The project was approved on December 31,1992. Evaluation tests started on February, 1993 were conducted in GE Lab System and in DNGS site.

QED95D processor, made by Quickware Engineering & Design Inc. was chosen. Review & specify QA, documentation & hardware tests requirements for QED95D started in June,1993. Review quotation & finalize hardware, cost & performance evaluation was done in July,1993. An order of 21 sets of QED95D processor was placed in February,1994. Unit testing for all 21 sets of QED95D processors in the GE Lab system was done in October, 1994. The installation of the QED95D processors in the F/H systems started in November 2, 1994 and was completed installations in April 5, 1995.

QED95D processor is a DEC Unibus compatible processor that is fully compatible with all PDP-11 Unibus hardware and software. It addresses four megabytes of memory and implements the complete PDP-11 architecture, excluding the Commercial Instruction Set.

The QED95D consists of two processor boards, a memory board, a massbus adapter board and a battery backup & Unibus connector board. These five processor boards replaced 22 boards in the PDP-11/70 CPU chassis, eliminated the PDP-11/70 memory chassis, and three PDP-11/70 battery backup units. Power consumption of the CPU system dropped from 40A to 13.7A. QED95D processor has built-in self-check diagnostics, which are initiated when the CPU is powered up and started.

QED95D is a high-speed CMOS processor with a 32 KB cache memory, it has a major cycle time of 110 nanoseconds (ns), allowing the execution of up to 9 MIPS. By comparison, the PDP-11/70 only runs at 1.36 MIPS.

The new upgraded processors in each trolley system scan and operate 4700 - 5000 I/O points, receive input from operator work stations, drive Ramtek Display Generators. They execute various application programs which operate the process equipment and perform the man-machine interface.

The PDP-11/70's took up to 8 seconds to update CRT displays. With the QED95D which is 4 to 5 times faster, the update time for the CRT displays now is less than 1 second.

The installation of the QED95D was straight forward and took about 2 hours for each computer. The total project cost is $910,000.00.

3. Disk Drive Upgrade

A replacement disk drive is required for the existing DEC PDP-11 RL11/RL02 disk sub-system to provide a modern high capacity sub-system. This will increase the executable and data storage size and give a more reliable and more easily maintained sub-system. This replacement sub-system must be fully compatible with the DEC PDP-11 UNIBUS hardware.

A review of the hardware options for RL02 disk sub-system replacement indicates that a standard UNIBUS / SCSI interface would be the preferred choice so that any standard SCSI storage device could be used now or in the future and give device independence.

Three replacement disk drives are required. Two of the units must be identical fixed and each to be divided into two 300M bytes or more partitions. The third unit must be a removable media unit.

The storage must be non-volatile. The read / write time must be less than or equal to the RL02 disk drive time (55m sec, transfer rate 512K bytes / sec)

The chosen SCSI interface is the CMD 720/M card , made by CMD Technologies due to :
- Low cost.
- Good reliability statistics & warranty.
- Excellent support from CMD Technologies.
- Good operating experience with the CMD SCSI cards over the past couple years.

The final selection of the disk drive replacement is as follows:

- Two Seagate 1.0 Gb winchester type units to be the on-line units in each F/H computer system.

- One Syquest 540Mb removal harddisk cartridge style unit to be the off-line unit in each F/H computer system.

These disk drive selections were made base on:
- High reliability statistics.
- Long warranty periods.
- Competitive pricing.
- Good trade publication reviews.

The total quantities of the disk drive replacement for the F/H computer systems as follows:

- 23 CMD 720/M SCSI host adapters.
- 45 Seagate 1.0 Gb winchester units.
- 23 Syquest 540Mb removal harddisk units.

The preliminary cost estimates are:

- Hardware: 300 K$
- Software: 350 K$

The Darlington Fuel Handling computer hardware configuration is shown in Figure 2.

4. Fuel Handling LAN

A number of user requirements have been identified that require the interconnection of the Fuel Handling control computers to the Darlington Information System LAN and to the Fuel and Physics LAN. The requirements include the ability to:

- automatically transfer long fuel bundle transaction logs from the Fuel Handling control computers to the Fuel and Physics fuel accounting system.
- automatically transfer the fueling activity computer logs from the Fuel Handling computers to electronic storage media for long term archive purposes.
- automatically transfer the fueling activity computer logs from the Fuel Handling computers to the Information System LAN for use in technical surveillance and support activities.
- automatically transfer the job, sequence, and operation data from the Fuel Handling computers to the Information System LAN for use in configuration management and technical support activities.

The current control system interconnects the various Fuel Handling control computers through the use of 2400 baud serial data links. These links are currently running near capacity transferring control data among the various control computers. These links do not have the capacity or speed necessary to meet these new requirements.

An alternative solution was identified by General Electric Canada after searching the Internet for potential solutions. It was identified that a mature product with a large customer base was using the TCP/IP communication protocol. This protocol is commonly used to interconnect various computer types using high speed ethernet data links and to interconnect various computer networks.

The product that has been chosen is called TCPware or RSX by Process Software Corporation. It is designed to run on Digital Equipment Corporation (DEC) PDP-11 computers running the DEC RSX11-M V4.0 operating system software. This product provides FTP file transfer tools, TELNET terminal sessions, and provides facilities to allow PDP-11 application programs to interface to the ethernet.

While the Fuel Handling computers are running a modified version of the DEC RSX11-M V3.2 operating system, the TCPware product has been successfully implemented on that platform at GE Canada in preparation for installation at Darlington in mid-1997. However, RSX11-M V3.2 cannot support the TELNET server software of TCPware.

Each Fuel Handling computer will be equipped with a DEC DELUA ethernet card though which TCPware will interface to the ethernet. The various Fuel Handling computers will then be interconnected via hubs and fiber optics cables to a single Sun Microsystem SPARC20 workstation. The workstation will act as the gateway between the Fuel Handling control system and the outside world (Fuel and Physics LAN and the Information System LAN is shown in Figure 3).

This configuration of the ethernet cabling does not allow for complete independence of the three Fuel Handling control systems. As such, a single failure may impact on more than one control system. This is considered acceptable as the information that will be carried on these data links is not required to operate the Fuel Handling equipment. In addition, this configuration does not connect to the FFAA computers. However, if this network proves highly reliable, then control data may be carried on these links once the FFAA computers have been interconnected and the cabling arrangement has been adjusted to provide functional independence of the three control systems.

The workstation will be equipped with a router between the workstation and each of the Fuel and Physics LAN and the Information Systems LAN. These routers, in combination with the workstation, will provide security for the Fuel Handling system from computer users outside the Fuel Handling system. Initially, the system will be configured to block all requests from computers outside of Fuel Handling. All communication will be one way; from Fuel Handling to the outside world.

The workstation will be set up to automatically transfer various files from the Fuel Handling control computers each day and send them to the Fuel and Physics LAN and the DNGD Information Systems LAN.

To meet the stated requirements the system will function as follows:

- Once each day the workstation will transfer the long bundle fueling log file from each of the control computers and send it to the Fuel and Physics LAN.
- Once each day the workstation will transfer the fueling activity log data file from each control computer. It will store it on large volume media for long term storage and also send a copy to the Information System LAN for user access.
- Periodically transfer the jobs, sequences, and operation data files from the control computers and send them to the Information System LAN for user access.

Once satisfactory performance of this system has been obtained, other potential uses of this link between the Fuel Handling control computers and the other site LANs include:

- Electronically sending the Fuel Change Orders from the Fuel and Physics department to the Fuel Handling control computers for execution.
- Modification of the jobs, sequences, and operations on the Information System LAN and uploading these changes into the Fuel Handling control computers. At present all changes must be entered using the control computer software.
- Transferring plant I/O status data from the Fuel Handling control computers to the Information System LAN for use in technical support and surveillance activities.

FIGURE 1

DARLINGTON FUEL HANDLING CONTROL SYSTEM

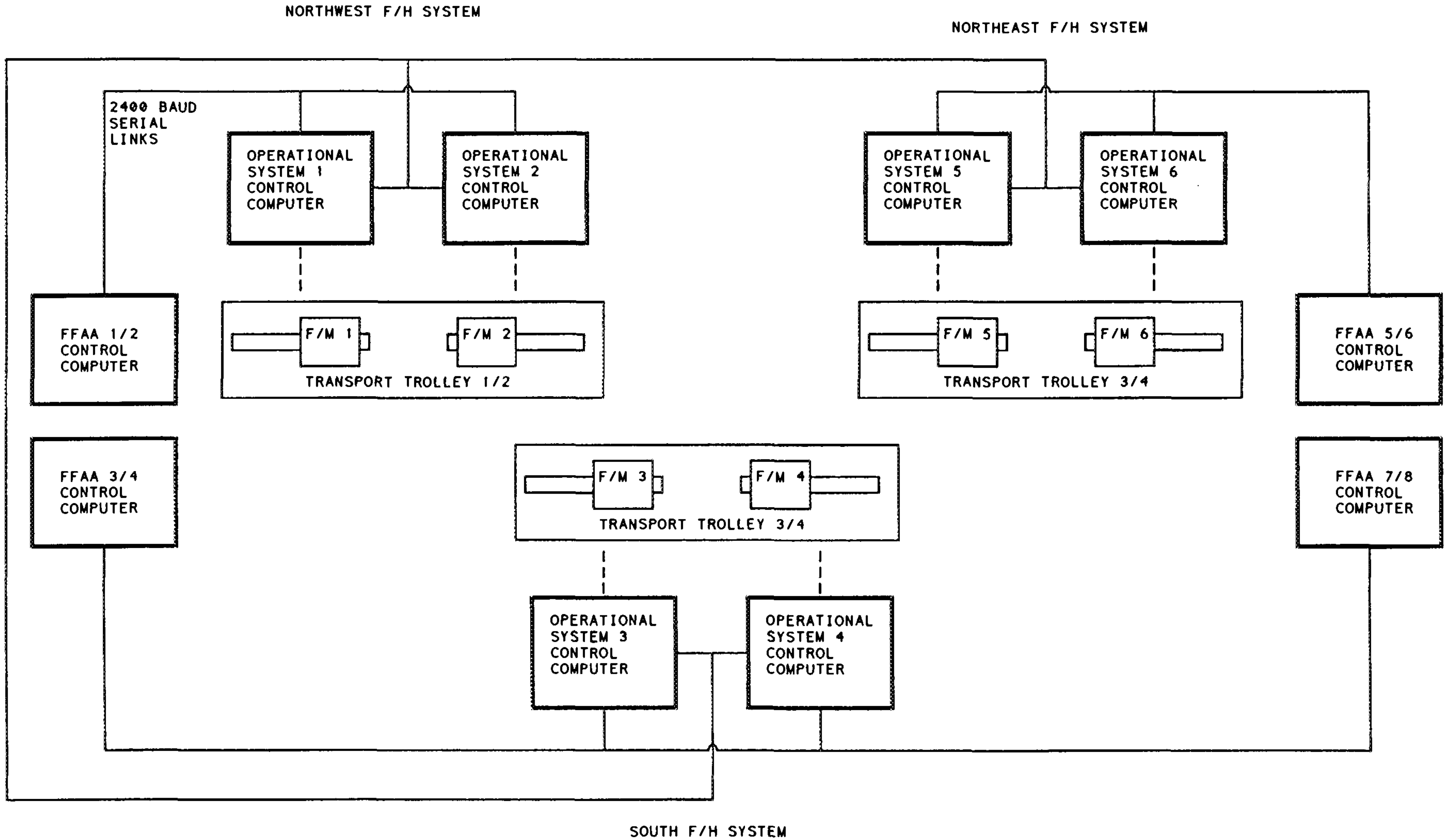

FIGURE 2

DARLINGTON FUEL HANDLING COMPUTER HARDWARE CONFIGURATION

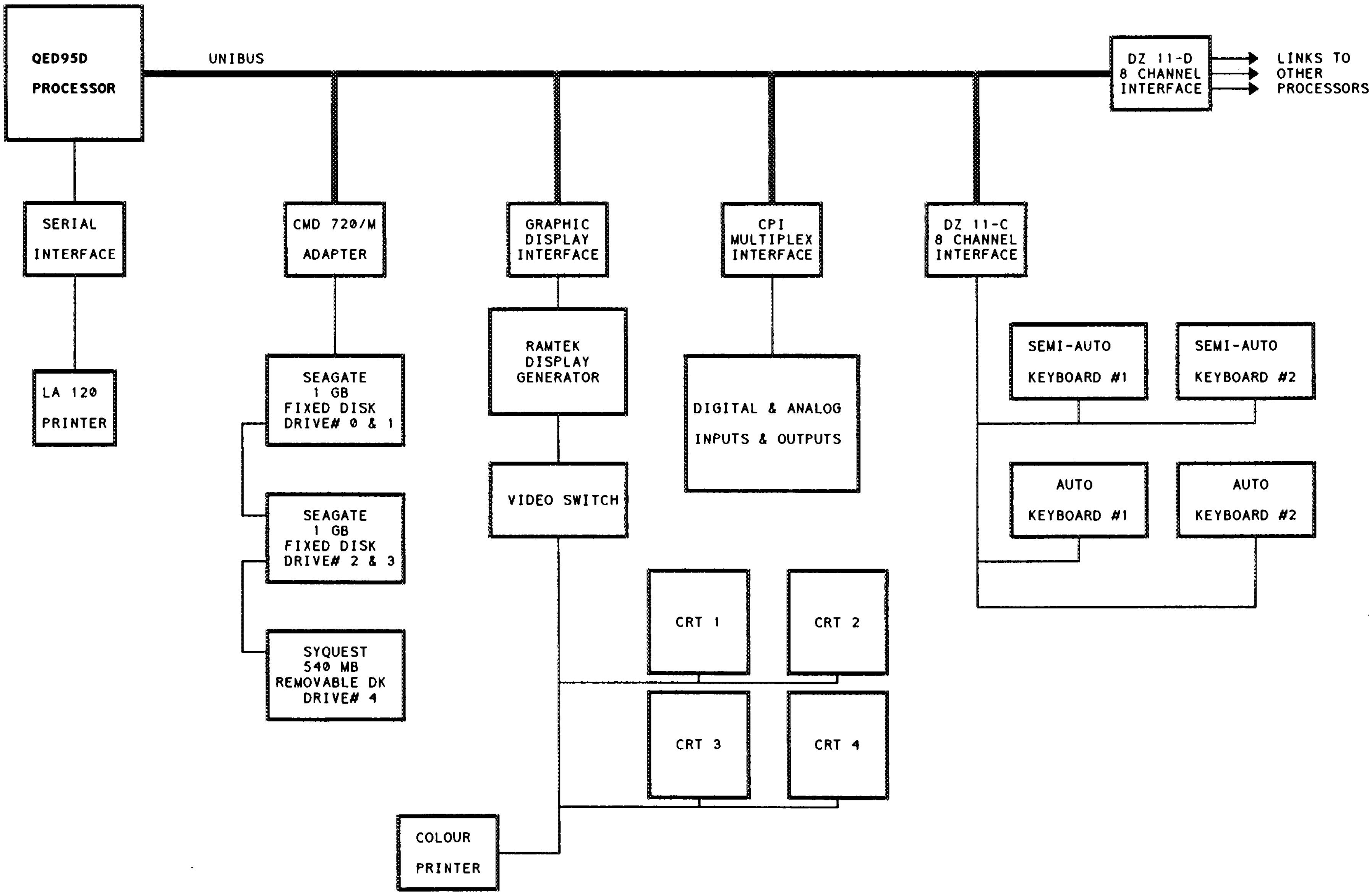

FIGURE 3

DARLINGTON FUEL HANDLING LAN