POINT LEPREAU'S LOCAL AREA NETWORK BASED STATION CONTROL COMPUTER AND GENERIC MONITORING SYSTEM LIVE AND HISTORICAL PLANT DATA COLLECTION AND DISTRIBUTION SYSTEM

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ABSTRACT

A system has been developed and installed at Point Lepreau that permits the simultaneous monitoring of live and historical plant data from a number of sources including the Station Control Computers (DCC's), the Safety System, Chemistry System, and D2O Vapour Recovery System Monitoring Computers. This system gives System Engineers and Analysts the ability to monitor present and past real time operations from their desks.

The system consists of a Banyan Vines Local Area Network (LAN) / File Server system, a Gateway Computer System, several Generic Monitoring System Computers, and a dedicated tape archive system. Depending on the system, 100 ms, two or six second resolution of all data points that are monitored by their associated systems will be stored in a LAN file server for instantaneous and historical data retrieval at MS DOS or OS/2 based work stations that exist throughout the plant.

INTRODUCTION

A live and historical plant data collection and distribution system has been developed and installed at the Point Lepreau Generating Station that permits the simultaneous monitoring of live and historical plant data from a number of sources including the Station Control Computers (DCC's); and, the Safety System, Chemistry System, and D2O Vapour Recovery System Monitoring Computers.

Depending on the system, 100 ms, 2 s, or 6 s resolution of all monitored data points are stored in a Local Area Network (LAN) file server for instantaneous and historical data retrieval at MS DOS or OS/2 based work stations that exist throughout the plant. This powerful new tool is a primary input device for Systems Health Monitoring. It gives System Engineers and Analysts the ability to monitor present and past real time operations data from their desks.

The system consists of a Banyan Vines LAN / File Server system, several Gateway Computer Systems, several Generic Monitoring System Computers, and a dedicated tape archive system.

The following hardware systems are used:

- The Gateway Computers associated with DCCX, DCCY, and DCCS.
- The Generic Monitoring System Computers.
- An Ethernet active hub that has both fibre-optic and thin wire coax capabilities.
- File Servers, each with over a gigabyte of hard disk storage capacity.
- Ethernet connections to the numerous work stations already existing throughout the station including those in the administration buildings.
- A helical scan tape storage and retrieval system with 50 gigabytes of on-line data storage capacity.

Background

Shortly after Point Lepreau was declared in service in 1983, station management requested that the Station Control Computer Group make provision to permit the monitoring of Station Control Computer data from the various plant processes from the Administration Building. It turned out that such a request was quite a formidable task since it was virtually impossible to add a regular Main Control Room keyboard/CRT pair to the Station Control Computers. It was possible, however, to install a system that dumped live plant data from the Station Control Computers to a remote computer that in turn would transfer this data to remote terminals in the station.

It was originally envisaged that this information would be transferred into the station's VAX computer system where it would be made available to other users. Due to other station priorities, time delays were introduced in the implementation of the system. As time passed, and as computer technology improved it became apparent that the amount of data that was required to be stored was sufficient to merit a dedicated LAN based file server system.

Originally, it was envisaged that only selected data requests would be provided by the system. Again, as technology progressed, it became possible to save virtually all of the data that is processed by the Station Control Computers. Further to this, with the addition of the Generic Monitoring System (GMS) computers, it became possible to also save the data that was collected from areas of the plant that were not monitored by the Station Control Computers.

A large base of installed PC's already existed throughout the station. It was decided to utilize these systems, rather than special, and consequently more expensive, dedicated work stations to access the data available in the file server. Common MS-DOS or OS/2 file formats are used throughout the system, permitting the use of inexpensive powerful software packages such as spreadsheet programs.

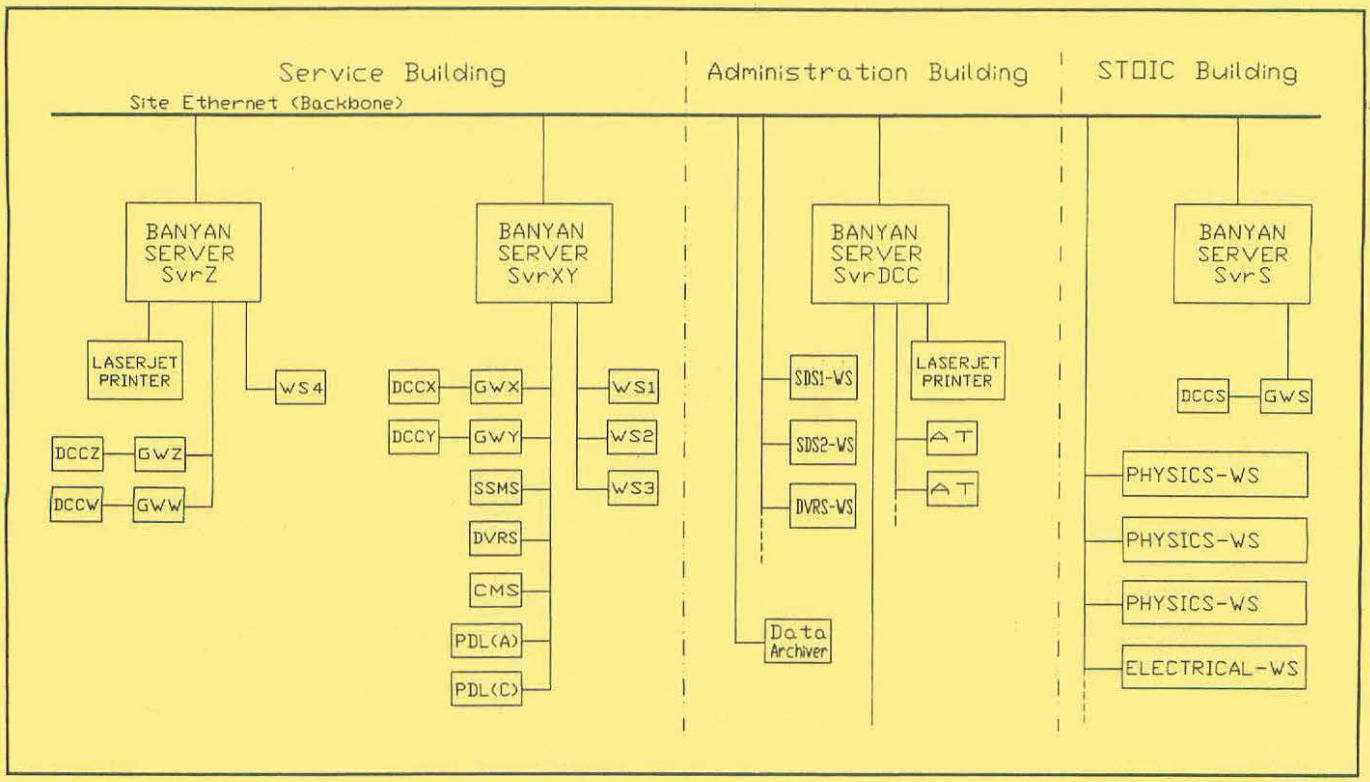

Figure 1. Gateway Computer System

The Station's Banyan Vines Local Area Network

The Gateway Computer system, shown in Figure 1, interfaces each of the Station Control Computers to the Station Ethernet network.

The Gateway Computers GWX, GWY, GWW, GWZ and GWS are interfaced directly with Station Control Computers DCCX, DCCY, DCCW, DCCZ and DCCS respectfully via Parallel Data Link Controller cards (PDLC's). A backup serial interface is also provided. DCCX and DCCY are the Station Control Computers, DCCW and DCCZ are maintenance and development computers, and DCCS is the full scope simulator DCC.

The File Servers designated as SvrDCC, SvrXY, SvrZ, and SvrS are connected to the Gateway Computers using a Banyan Vines LAN. All of the File Server computers communicate with each other via the plant Ethernet backbone.

Computers

The Gateway Computers and File Servers are 16 MHz 80386 Transduction Rack-Mount Industrial Grade IBM AT-compatible computers. All machines have 8 megabytes of RAM, and each File Server has a 1.2 gigabyte, and a 130 megabyte hard drive. The Gateway Computers run under OS/2 and are programmed in Modula-2.

Network Topology

Point Lepreau's Ethernet backbone system is used to connect the Station VAX computers, and their various peripherals together. It extends from the Main Control Room in the plant to the Administration buildings. The Banyan Vines File Servers, SvrDCC, SvrXY, SvrZ, and SvrS are connected to the backbone. Each server runs a local segment. In many cases the data packets on these local segments are not transmitted to the backbone. This helps to minimize backbone loading.

SvrDCC and its users are located in the Administration Building. Its two hard drives contain the DCC, Gateway, and other master software files, and SvrDCC's files. There are several PC's connected to this server which are used for software development and maintenance, hardware maintenance, and documentation purposes. SvrDCC has a 20 page per minute HP LaserJet 2000 printer connected to it.

SvrXY is located in the DCCX/DCCY Room (adjacent to the Main Control Room) in the station. This machine is connected by fibre-optic cables to GWX and GWY. SvrXY is a production machine, used for on-line data collection from the Station Control Computers, and the various monitoring systems such as the Safety System Monitoring System, and Chemistry System Monitoring System. SvrXY is also used as bridge to SvrDCC for software maintenance purposes.

SvrZ is located in the DCCZ Room (adjacent to the Main Control Room). It has the same functionality as SvrXY, but is used for maintenance and development purposes.

SvrS is located in the DCCS room in the STOIC (Simulator, Training, and On-site Information Center) building. This machine is connected to GWS, and is setup similar to SvrXY.

Network

All network nodes are standard Ethernet which communicate at 10 megabits per second through the LAN. Thin wire Ethernet cards are used throughout the system with the following exceptions:

- Communications with DCCX, DCCY, and SSMS are over fibre-optic cables - this is for electrical isolation.
- Communications with SvrS are over 10BaseT (twisted pair).

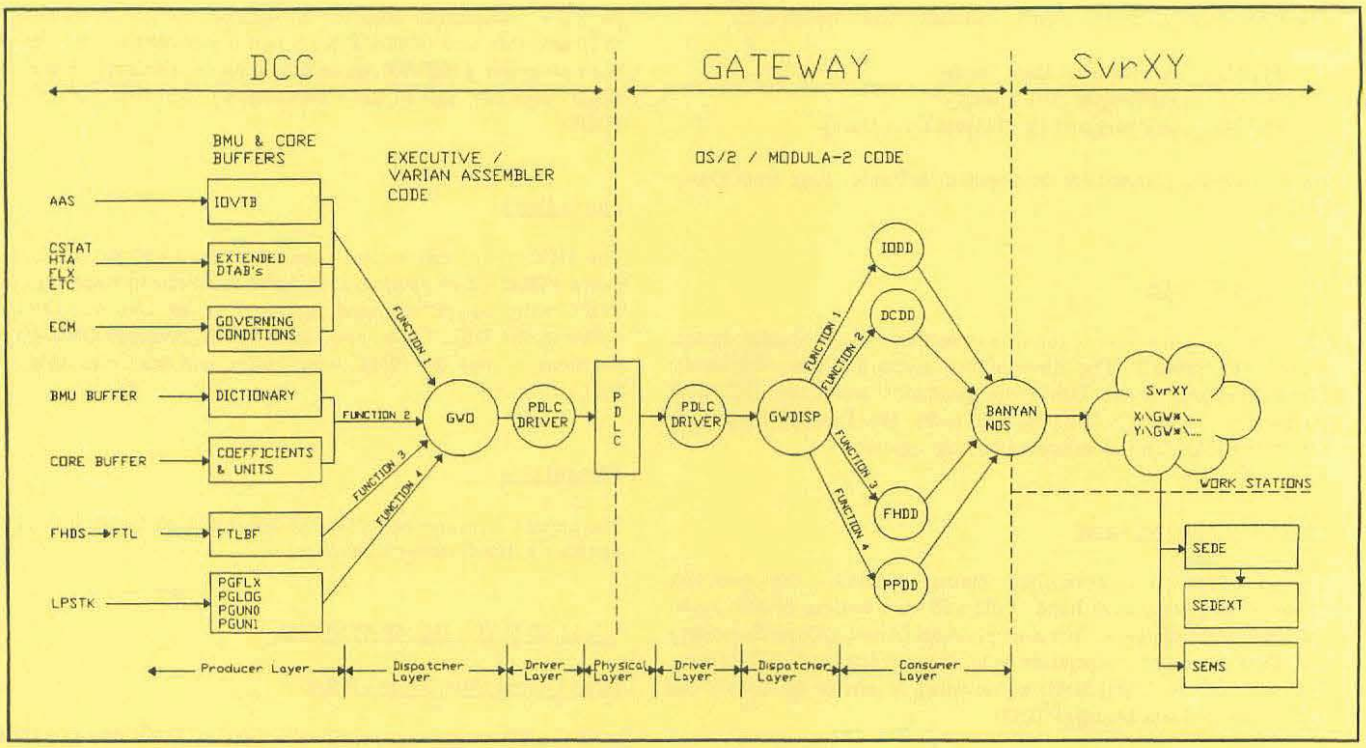

Figure 2. Gateway Data Flow Block Diagram

Parallel Data Link Controller (PDLC)

The Parallel Data Link Controller is a bidirectional buffered card developed for Point Lepreau by AECL. It contains one in-bound and one out-bound buffer, each 64 kilobytes (0100000 word). A PDLC card is installed in each Gateway Computer to interface to its DCC via a BIOC (Buffered I/O Controller) connected to a BIC (Buffered Interface Card) for DMA transfers. Data transfer is done in the DMA mode at a rate of approximately 128 kilobytes/s.

Data Archiver and Tape Stacker

The on-line data collection systems and GMS systems collect data at a rate of approximately 200 megabytes per day. This data is maintained in SvrXY for 4 days, and is then archived in 5 gigabyte magnetic tapes. This system provides a continuous electronic record of high resolution live plant data which will be available for the rest of the life of the station.

Archiving of the data is done by an Exabyte helical scan tape system. A tape stacker system will be installed on-site soon, which will have the facility to retrieve data from up to ten such tapes. Software will provide facilities for automated retrieval of data from any tape that is installed in the stacker. This will provide approximately eight month's worth of on-line plant data. Computer operators will load older tapes than the ones that exist in the tape stacker upon request.

THE GENERIC MONITORING SYSTEM

The Generic Monitoring System (GMS) computer systems are rack-mount 80x86 based machines, which are programmed in Pascal to operate in a similar manner to the Station Control Computers. The GMS computers are interfaced with an IEEE 488 bus to Motorola 680x0 based Hewlett Packard 3852A Data Acquisition / Control Units. Field data can be trended, bargraphed, numerically, or pictorially displayed. The field data is also logged to SvrXY for further monitoring and analysis at work stations that are situated throughout the station.

GMS systems are in place to monitor the Safety Systems (SSMS), the Chemistry System (CMS), and the D2O Vapour Recovery System (DVRS). As well, two general purpose GMS systems named Plant Data Logger A (PDL(A)) and Plant Data Logger C (PDL(C)) are used to collect and process data from a variety of tests, such as Reactor Building and Airlock pressure tests.

Currently under development are systems to monitor: Electrical Billing and Metering; Water Treatment Plant; and, Standby Diesel Generator parameters.

Extensive discussion of the Generic Monitoring System is beyond the scope of this paper.

STATION CONTROL COMPUTER DATA COLLECTION

Station Control Computer live and historical data collection and distribution has been implemented using the station's Gateway Computer system and the SvrXY File Server. Various software systems have been developed or modified to output data from the DCC's to the Gateway Computers.

The programs in the DCC's that process the data of interest have been modified to collect the data and then output it to the Gateway Computers by scheduling a program named **GWO** (Gateway Output). The data is received in the Gateway Computers by software that processes, and stores the data in SvrXY. This data can then be extracted and displayed using work station programs such as **SEDE** (System Engineers Data Extractor) and **SEMS** (System Engineer's Monitoring System).

The three data collection programs currently implemented are:

FHDD - Fast Historical Data Dump
IODD - Input Output Data Dump
DCDD - Dictionary and Coefficients Data Dump

Another system planned for development is Printer Page Data Dump (**PPDD**).

ARCHITECTURE

The layered architecture of the data collection and distribution system is shown in Figure 2. The three software layers: Producer/Consumer; Dispatcher; and Device Driver are symmetric across the DCC and Gateway Computers. The physical layer, the Parallel Data Link Controller (PDLC), is common to both computers.

Producer/Consumer Layer

The DCC Producer/Consumer layer consists of periodic, composer, and demand programs which build BMU and core buffers of data to be dumped to the Gateway. For example **AAS** (Analog Alarm Summary) and **TPM** (Channel Temperature Monitor) generate the IOVTB (Input Output Variable Table) BMU buffer which is part of the data in the Input/Output Data Dump (**IODD**).

The Gateway Producer/Consumer layer consists of the programs which build the data files in file server SvrXY via the Banyan Network Operating System (NOS). For example **IODD** builds 10 minute data files containing the instantaneous status of all the DCC input and output points with a resolution of 6 seconds. **SEDE** and other work station programs have been developed to allow the System Engineers to analyze the data in SvrXY.

Dispatcher Layer

All communication between the DCC producers and the Gateway consumers is through the dispatcher layer, using an interrupt driven message passing protocol. A packet header is used to define the packet's contents, and destination in the Gateway Computer. The DCC dispatcher is implemented by **GWO** (Gateway Output), while in the Gateway it is implemented by **GWDISP**. OS/2's multitasking, virtual memory, and priority level features have been utilized to maximize throughput in the Gateway Computer.

GWO processes data transfer requests from each of the DCC producer programs in order of priority. Each request can specify up to four BMU or core buffers to transfer. Currently 4 of the 16 priority levels are in use.
To keep it from excessively loading the DCC, **GWO** has been programmed to transfer a maximum of 020000 words (16 kilobytes) per composer pass - each 020000 word transfer takes less than 80 ms. If more than 020000 words are requested to be transferred, **GWO** reschedules itself to complete the request on a subsequent DCC pass through the background executive loop. **GWO** will place up to 4 packets or a maximum of 040000 words (32 kilobytes) in the PDLC write buffer prior to sending a data ready message to **GWDISP**. This is done through calls to the DCC Executive PDLC Driver.

GWDISP reads the data in the PDLC buffer, and dispatches it to the appropriate consumer layer program. It reads the PDLC buffer through calls to the OS/2 PDLC driver. It then validates the data and sends an acknowledge/no acknowledge message back to **GWO**. **GWDISP** uses data selectors and named pipes to send the validated data to the appropriate consumer layer program. Named pipes are an OS/2 inter-process communication mechanism. Since each named pipe can hold up to 50 selectors, and **GWDISP** has a higher priority then the consumer layer programs, **GWDISP** can backlog data. For example 5 minutes of **IODD** data can exist in the Gateway prior to it being consumed by **IODD**.

Driver Layer

The DCC device driver layer consists of the DCC Executive driver, called **PDLC**, which provides **GWO** with functions to write data to the PDLC write buffer, and send messages to the Gateway Computer. Likewise, the OS/2 driver, also called **PDLC**, provides **GWDISP** with functions to read the PDLC write buffer, and send messages to the DCC.

Physical Layer

The physical layer consists of the Parallel Data Link Controller (PDLC), installed in the Gateway Computer.

ON-LINE DATA DUMP SYSTEMS

Input Output Data Dump - IODD

AAS and **TPM** have been modified to write all of the AI's and DTAB's (data tables, ie. computed variables) which they process to a BMU buffer called IOVTB. In addition, **AAS** writes all the DI's, CI's (contact scanner inputs), DO's, AO's, and the executive's program execution time and performance monitor tables to IOVTB.

AAS schedules **GWO** to transfer the IOVTB buffer, the extended DTAB's, and the Governing Conditions table to the Gateway Computer every 6 s. The extended DTAB's are generated by programs such as **CSTAT** (Calculation Status Monitor), **HTA** (Heat Transport Auxiliaries), and **FLX** (Flux Mapping). The Governing Conditions are generated by **ECM** (Emergency Conditions Monitor).

On the Gateway Computer the Input Output Data Dump is collected by **IODD**. It builds instantaneous and 10 minute data files in SvrXY. Both sets of data have 6 s resolution.

AAS's period was changed from 5 s to 6 s to permit its update frequency to correspond with one of the standard GMS update frequencies. Coincidentally there was no net change in DCC loading due to adding the new logic. This is because **GWO**'s execution time is almost exactly compensated for by slowing **AAS** down.

Fast Historical Data Dump - FHDD

FHDS, a DCCX only switched periodic program, was modified to sample up to 37 points (AI's, DI's, or Core locations) every 100 ms. It saves its data in a rotating core buffer. **FTL** (Fast Trend Log), another switched periodic program, copies the core buffer to FTLBF, a BMU buffer. From there it is sent via **GWO** to the Gateway Computer every 8 s. **FHDD** is the Gateway consumer program which builds the **FHDD** data files in SvrXY. The system has the capacity to continuously record this data, however, when in use, it does consume quite a bit of server disk space.

FTL, and the fast trend display program, **FTRND**, are not permitted to run simultaneously.

Among other applications, **FHDD** has replaced the need to take a DCC off-line for data collection during the annual SOR rod drop test.

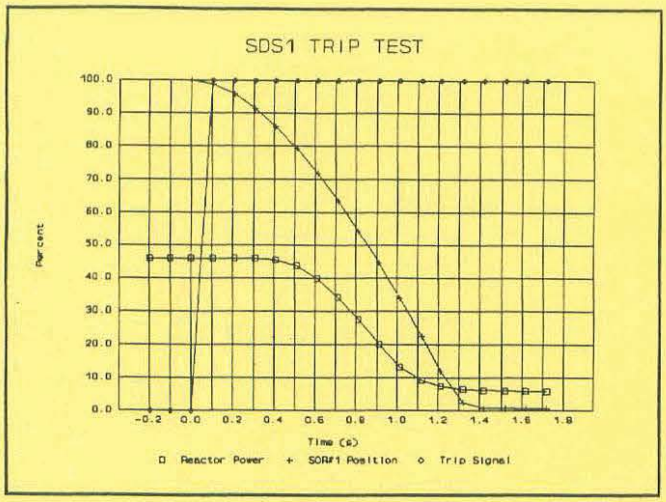

Figure 3. Sample Plot of Data Extracted by **SEDE**

CONCLUSION

The layered architecture of the on-line DCC data dump system, OS/2's multitasking, and virtual memory features; and the modular programming techniques used in its implementation allow the live and historical data collection and distribution system to be easily expanded.

This powerful new tool provides a continuous electronic record of high resolution live plant data which will be available for the rest of the life of the station.

The plant data collected by this system is a primary input device for Systems Health Monitoring. It gives System Engineers and Analysts the ability to monitor both live and historical plant data from a number of sources including the DCC's, and GMS systems from their desks. The data synchronization provided by **SCLK** allows the users to line up plant data collected by different systems.

This continuous on-line data collection system provides station staff with plant data that was previously not available. Any plant transient is a defacto plant test since 6 s data surrounding any plant transient is collected, and is immediately accessible for analysis.

In addition to providing historical plant data, this system is also used to collect data during reactor run-up, and various station tests.

Based upon the first two months of use, it has proven itself to be a valuable tool for various members of the station's Technical Unit staff.

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