*R*TIME/WIN Client/Server in the Control Room and on the Desktop at Northeast Utilities Millstone Unit 2*

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Northeast Utilities System

R*TIME/WIN Client/Server in the Control Room & on the Desktop

ABSTRACT:

R*TIME/WIN client/server software is being implemented in the control room at Millstone Unit 2 (a 900 MWe Combustion Engineering PWR Nuclear Plant). A redundant pair of DEC VAX process computers serves Unit 2 data to Windows NT client workstations in the control room. Corporate wide desktop access to Unit 2 and Unit 3 process computer data is being provided through separate Windows NT server systems that isolate direct access to the process computers. Data is also available from the Unit 2 simulator.

Existing Unit 2 application software was not modified for the Windows NT display workstations. An emulation interface shell was implemented to allow existing software developed for Industrial Data Terminals (IDT) to continue to function. IDT display definitions were converted automatically, then touched up to provide an appearance that is nearly identical to the old displays.

A primary objective of the conversion was to provide a common look and feel across client workstation platforms. System engineers, I&C technicians, management and others that have an interest in current and historical plant data can now access information without assistance from either the computer group or the control room operators.

Configuration management / distribution for the new system is non-trivial. Applications can now reside locally on the workstation or on the server. Over 1000 display files have been implemented for Unit 2 alone. Configuration management would be extremely difficult, were it not for the capability to embed considerable intelligence in display layouts and menus.

INTRODUCTION:

At Millstone Unit 2, the man-machine interface (MMI) hardware was at the end of its useful life. Installed in January, 1987, Industrial Data Terminal Model 2250 display generators performed flawlessly, but were aging. All display monitors had already been replaced. A recently failed video display generator was repaired at a cost exceeding $20,000. IDT 2250 display generators are no longer manufactured. Given the likelihood of further failures and the age of the equipment, replacement was deemed necessary.

A number of different MMI systems were examined for replacement feasibility. In addition to R*TIME/WIN, Foxboro's IA system, Intellution, Wonderware, SAIC and others were examined. R*TIME/WIN was selected for the replacement project.

An illustration of the new process computer configuration is contained in Figure 1. Asynchronous interfaces have been retained for printers and a few other special data acquisition interfaces. Otherwise, the process computer system's interfaces are now strictly network based using DECNET and TCP/IP protocols.

Northeast Utilities - Millstone Unit 2

Process Computer Network Overview

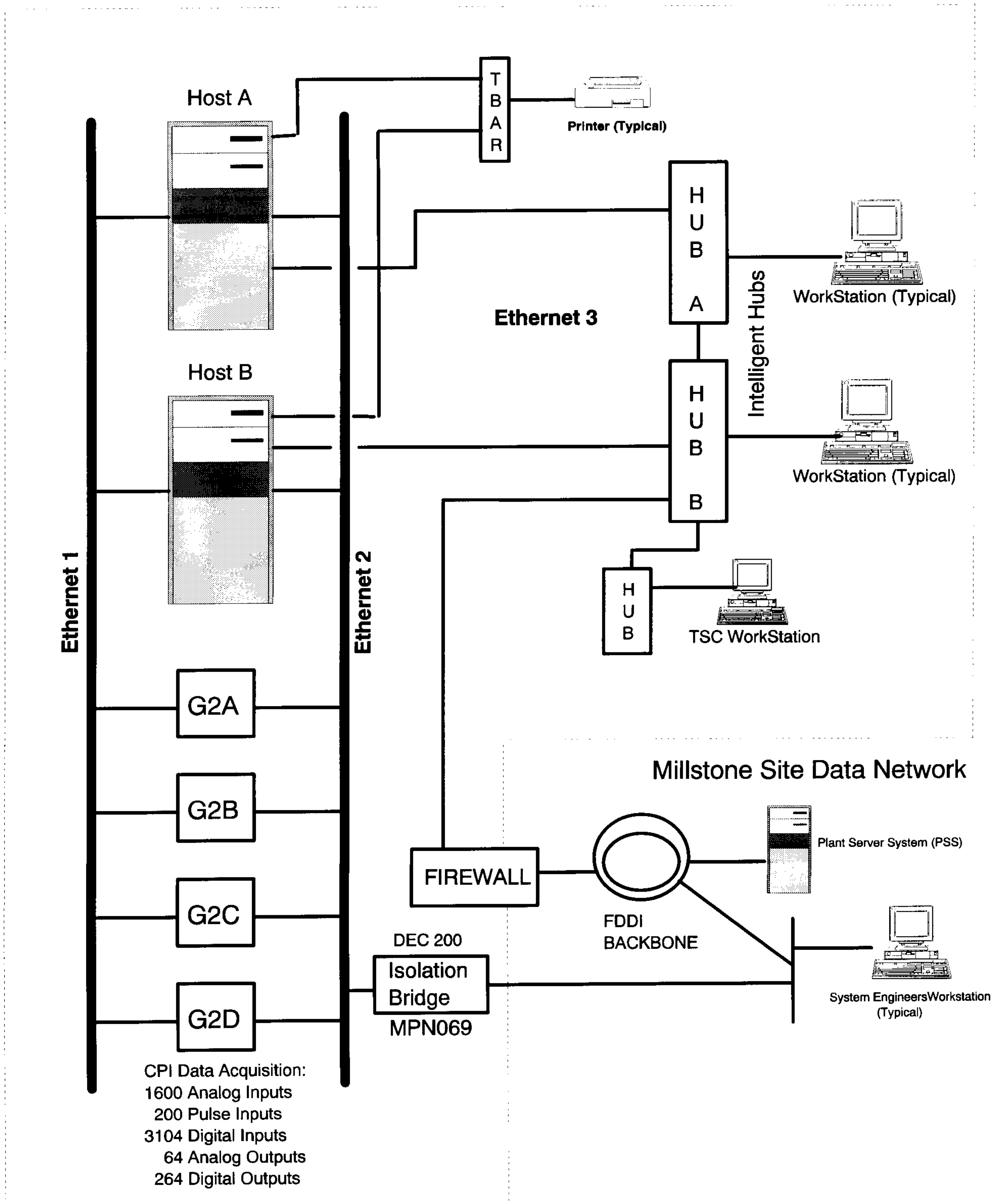

Figure 1 - Network Diagram

PROJECT OBJECTIVES

A number of important project objectives were identified:

1. The new MMI was to be based on a hardware platform that could be easily replaced such as an IBM PC clone.
2. Existing application software was to be retained with NO or minimal modification
3. Existing display layouts were to be retained with little or NO modification.
4. The interface to the MMI was to be network based, preferably using the same (MS Windows) desktop interface that is used by plant operators for other applications used in the control room.
5. Non-control room access to Process Computer data was to be provided.
6. New (display related) features were to be added to the system.
7. Convert (retain) historical data for the unit.

HARDWARE UPGRADES (disk, tape, cpu)

A new layer of Operating System software (POSIX) was required for the R*TIME/WIN server software. POSIX is Digital Equipment's implementation of UNIX for the Open-VMS operating system. Real-time data collected through the existing current value tables had to be mapped to the R*TIME/WIN virtual database. Also, current values are mapped to buffers for archive recording. The combination of new operating system software with R*TIME/WIN mapping left us short on CPU horsepower.

The additional server processing requirements were addressed by upgrading the process computer CPU from a VAX 6410 series to a 6610. At the same time, disk and tape drive devices were upgraded to a SCSI interface subsystem (RZ29 4.3Gbyte disks, 10+ Gbyte cartridge tapes). An unexpected benefit of the SCSI subsystem interface was its much higher I/O throughput (I/O rates in excess of 160/sec versus 60/sec maximums for the old RA92 disk drives).

There are user expectations that historical data will be available for an entire fuel cycle (18 months). The flexibility of the R*TIME/WIN archive server will help address these needs. Not only will we keep data on-line for an entire fuel cycle, but we have made plant operating data available on a continuous basis beginning January, 1994. System engineers can use this data to make performance and operating condition comparisons across fuel cycles.

PROJECT COST

In 1987, the Unit 2 process computer was replaced at a cost in excess of $12 million. An in-house attempt to replace the process computer was abandoned when there was a pressing need to redirect resources to the completion of the Unit 3 process computer.

By contrast, replacement of the man-machine interface and archive systems via R*TIME/WIN server has been accomplished for an inclusive cost of less than $1.75 million. It is important to note that this cost does not reflect one-for-one replacement. Larger capacity disk and tape drives were added to the system as was a separate server system, a firewall interface, and corporate wide licensing of the R*TIME/WIN client..

RETENTION OF EXISTING APPLICATION LOGIC THROUGH EMULATION

Conversion of existing applications would have made this project costly and added significant risk. Existing application logic as well as look and feel were retained through emulation and by converting existing display definitions.

The IDT 2250 display system used a separate membrane keypad to provide fast operator access to menus and the plant's safety parameter display system. The membrane keypad interface was emulated by a top level function button display that has the same look as the membrane keypad (see Figure 2).

Interactive application software used a set of standard interface routines for communication with the IDT 2250 display terminals. These applications took two forms: interactive applications that remain active between user inputs and conversational applications that served multiple CRT's. Conversational applications were (re)activated when a user pressed a function button. Communication for both types of applications took place through numbered fields such that display placement did not affect program logic. Program events were processed by passing either an integer variable or function key string mnemonic to the application.

Scientech built a shell around existing applications by making them subroutines to a generic MAIN application program. Replacement interface routines were provided to emulate the existing IDT field number oriented routines. Function key and/or mouse click requests continue to be passed to the applications such that program logic did not need to be changed.

DISPLAY CONVERSION

Approximately 500 displays were automatically converted from IDT 2250 form to the new R*TIME/WIN environment. ASCII text IDT 2250 display definitions were translated to a de-compiled version of R*TIME/WIN displays. These were then compiled and touched up to provide an appearance that closely resembles the IDT 2250 displays.

Since the aspect ration changed from 512x512 pixels to 1024x768, font choice was crucial to providing R*TIME/WIN displays that closely resembled their IDT counterpart.

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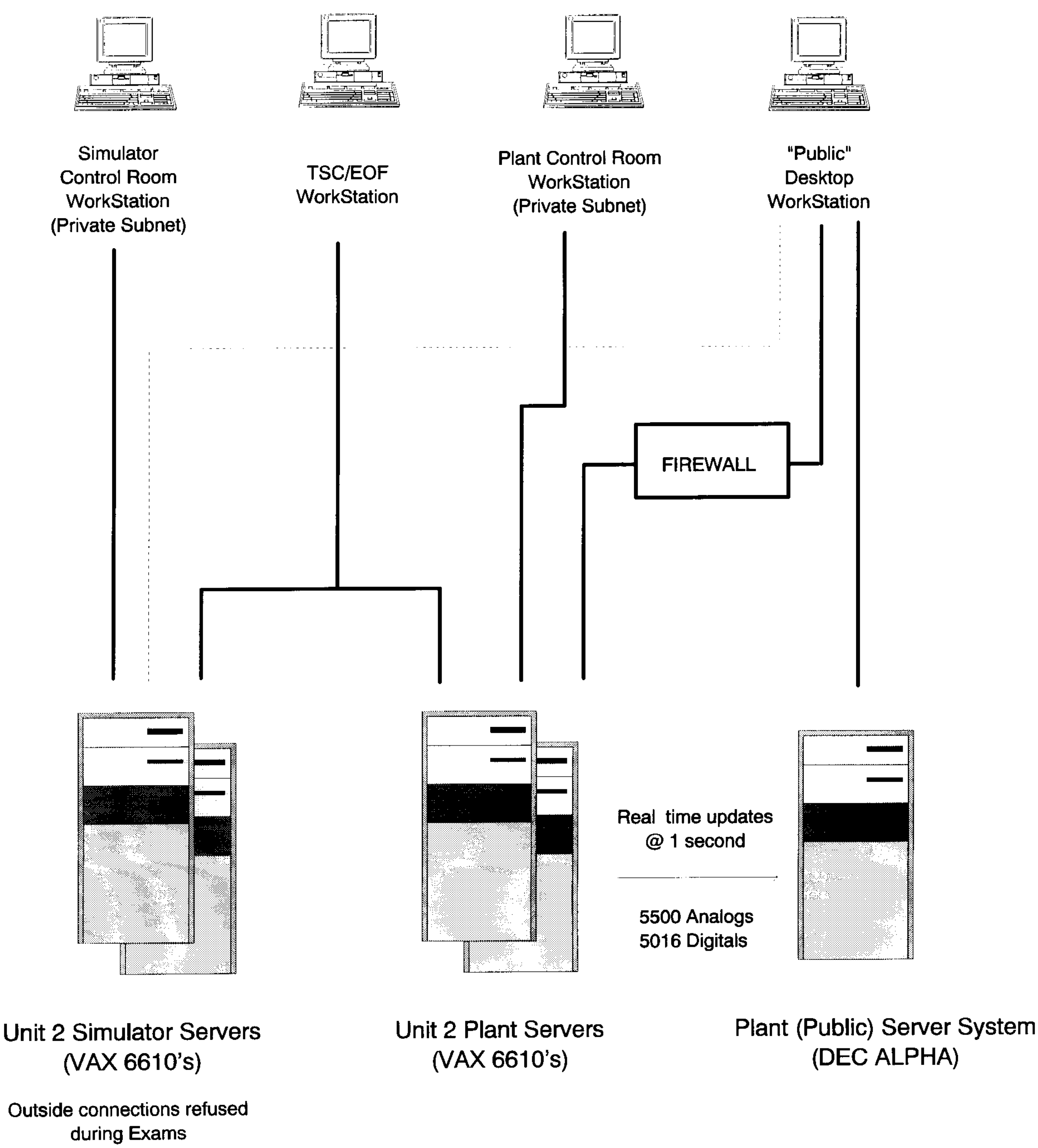
Connectivity Options for Workstations



Server controls client Host Connections for all but "public" worksations

Simulator & Plant Server IP addresses are not known to public (domain name servers)

Figure 2 - Connectivity

Several special fonts were tried before settling on ARIAL and ARIAL NARROW for predominant use. Because most Window Font sets use proportional spacing, text alignment was a problem on at least two displays where descriptive data was presented through a single field. In these cases FIXEDSYS font was used. Unlike most R*TIME/WIN displays, when a FIXEDSYS based display is resized smaller, text data may be omitted from the display. The application could have been modified to use multiple resizable fields, but the conversion to FIXEDSYS was considered adequate.

ARCHIVE CONVERSION

All historical archive save sets were converted. Magnetic tape save sets dating from January 1987 contained special plant event (e.g., plant trip) data. These were converted to separate disk files. Beginning January, 1994 plant data was captured at 30 minute intervals and saved in a 2 ½ year circular file. Four month sets of the 30 minute data were saved on 2400' reel-to-reel magnetic tapes.

When new 4.3 Gbyte disks and a 10Gbyte tape cartridge system were installed, two year sets of the 30 minute data were reloaded from reel-to-reel magnetic tapes onto disk. This data was then dumped to a cartridge tape data set and subsequently converted to the new R*TIME/WIN archive format on disk.

Disk based archive structures have been retained on the new system: 50 hours of plant data at 2 second resolution and long term archives at 30 minute resolution. A number of event files have also been added such as a pre/post plant trip event file, diesel generator load test event files, and others.

APPLICATION & DISPLAY EXTENSIONS

In a few cases, existing application logic has been changed to provide tighter integration with the new MMI. Two applications were modified to access the $LOCAL variable that contains the latest selected analog point. This gave the appearance that the existing applications "remember" the last selected point in much the same manner as other MMI interfaces.

The sequence of events reporting function was also modified. The old application contained many utility features that were used only by the system manager. The old interface used a multi-display interface whereby the user would select a range of data for reporting, then view the data on a separate display. If the user wanted to select a new range of data for reporting, he had to go through the entire selection sequence again.

The old sequence of events interface used prompts for user input with top to bottom application flow processing controlled by the process computer (see Figure 3). The new interface provides an interface that is driven by user selections (see Figure 4). The replacement function was streamlined by removing approximately 3000 lines of code from a 5000 line module such that only those functions needed for reporting were left. The old program has been retained for utility functions.

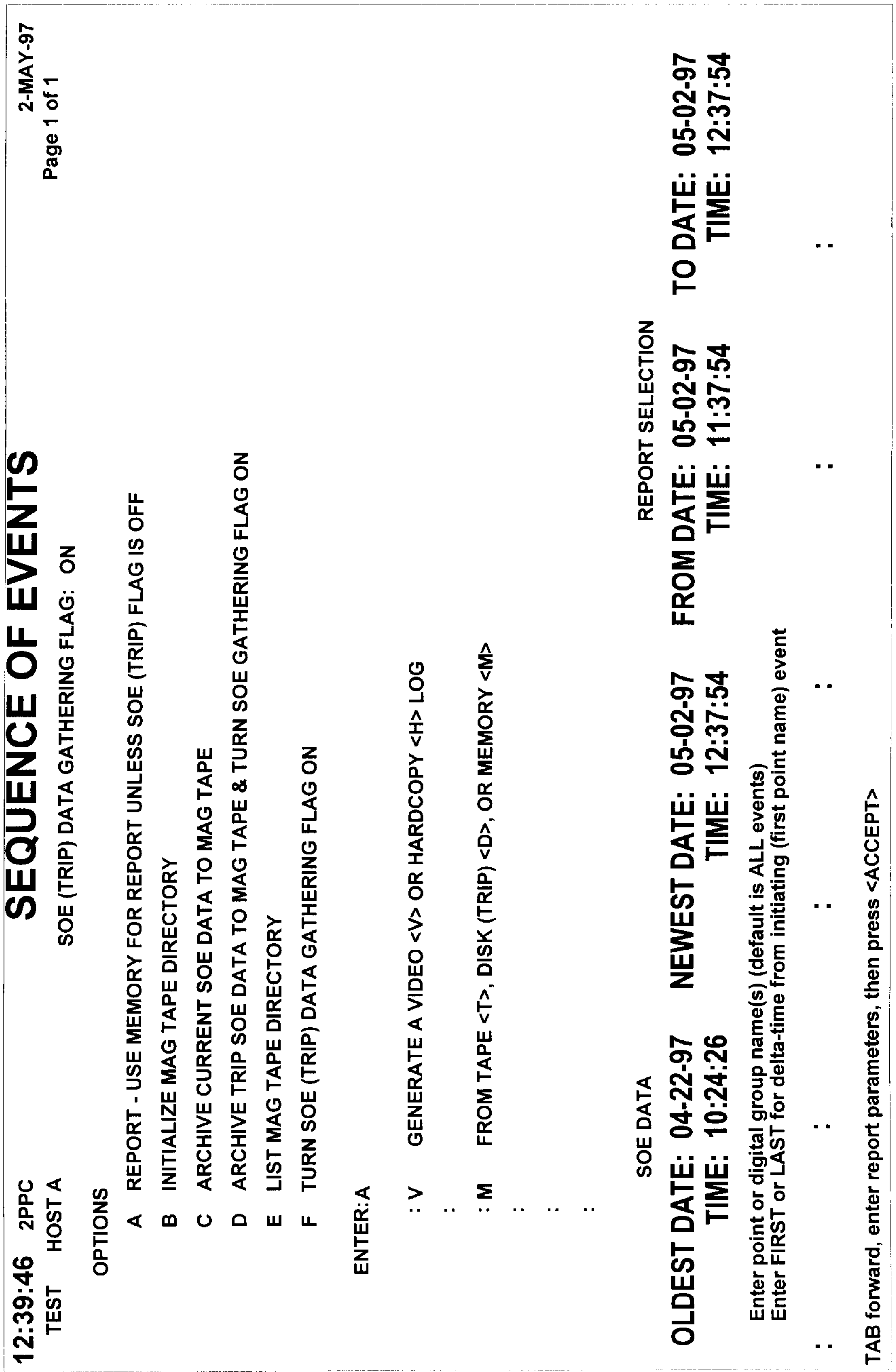


Figure 3 - Old Sequence of Events Interface

12:42:11 2PPC
TEST HOST A

Sequence of Events Report

2-MAY-97
Page 1 of 1

AVAILABLE SOE DATA | Printer for Data Request:LP4

FROM: 04-22-97 10:24:41 | TO: 05-02-97 12:39:17 | FROM: 05-02-97 11:39:17 | TO:05-02-97 12:39:17

Display Report | Print Report

FIRST or LAST = delta time report for entered point name(s), otherwise enter point(s) or group(s) to be reported

:FIRST :DGA*TRB : : : :

highlighted point if FIRST, LAST, or ALL selected

Page: 1

Delta Time or Date	Time	Sensor	Description		O/1	State
0 00:03:48.4087	11:38:17.2505	ZE377	WEST VITAL SWGR ROOM FAN F51		0	STOP
- 0 00:02:44.7510	11:39:20.9082	ZE936	DIESEL FUEL OIL XFER PP A P47A		1	START
- 0 00:00:00.0312	11:42:05.6280	L7002*9	DSL*OIL*SPLY*TK*A*LVL	8B32	1	NORM
02-MAY-97	11:42:05.6592	DGA*TRB	DG*A*TROUBLE	8A36	0	TRBLE
0 00:00:03.6711	11:42:09.3303	DGA*TRB	DG*A*TROUBLE	8A36	1	NORM
0 00:00:23.1160	11:42:28.7752	ZE978	LOWER 4160 ROOM FAN F134		1	START
0 00:01:05.1303	11:43:10.7895	CUB*1	COND*DEMIN*SYS*TROUBLE	5A16	1	TROUBL
0 00:01:45.7574	11:43:51.4166	ZE936	DIESEL FUEL OIL XFER PP A P47A		0	STOP
0 00:04:13.5543	11:46:19.2135	ZE978	LOWER 4160 ROOM FAN F134		0	STOP
0 00:07:48.5536	11:49:54.2128	CUB*1	COND*DEMIN*SYS*TROUBLE	5A16	0	NORM
0 00:10:16.8986	11:52:22.5578	ZE978	LOWER 4160 ROOM FAN F134		1	START
0 00:10:34.8805	11:52:40.5397	U8624	AUX*STM*REBLR*SYSTEM	6B19A	1	ABNORM
0 00:10:36.4809	11:52:42.1401	U8624	AUX*STM*REBLR*SYSTEM	6B19A	0	NORM
0 00:10:38.6718	11:52:44.3310	U8624	AUX*STM*REBLR*SYSTEM	6B19A	1	ABNORM
0 00:10:39.9461	11:52:45.6053	U8624	AUX*STM*REBLR*SYSTEM	6B19A	0	NORM
0 00:11:33.3913	11:53:39.0505	ZE688	NONRAD WSTE SPLY FAN F17		0	STOP
0 00:12:59.2894	11:55:04.9486	ZE377	WEST VITAL SWGR ROOM FAN F51		1	START
0 00:13:40.4747	11:55:46.1339	ZE978	LOWER 4160 ROOM FAN F134		0	STOP
0 00:14:59.7648	11:57:05.4240	ZE377	WEST VITAL SWGR ROOM FAN F51		0	STOP
0 00:19:28.4063	12:01:34.0655	ZE978	LOWER 4160 ROOM FAN F134		1	START
0 00:21:26.4228	12:03:32.0820	L7002*9	DSL*OIL*SPLY*TK*A*LVL	8B32	0	HI-LO
0 00:21:26.4759	12:03:32.1351	DGA*TRB	DG*A*TROUBLE	8A36	0	TRBLE
0 00:21:51.0999	12:03:56.7591	DGA*TRB	DG*A*TROUBLE	8A36	1	NORM
0 00:22:40.4635	12:04:46.1227	ZE978	LOWER 4160 ROOM FAN F134		0	STOP
0 00:25:44.1680	12:07:49.8272	ZE688	NONRAD WSTE SPLY FAN F17		1	START

Total SOE events in time span = 58

Figure 4 - New Sequence of Events Interface

The base R*TIME/WIN analog/digital point displays were extended to include alarm and sequence of events information from the existing system. The R*TIME/WIN server's own alarm package has been deliberately disabled in favor of the existing process computer alarm package due to interfaces with existing applications.

CONNECTIVITY & SECURITY ISSUES

Deterministic communication schemes can be achieved on an Ethernet network only through careful planning. The Figure 1 illustration shows three separate Ethernet connections to each process computer. Ethernet 1 is the primary path for data acquisition traffic. Ethernet 2 acts as a hot standby for data acquisition and as an interface to other systems using DECNET protocol. Man-machine TCP/IP traffic moves along the third Ethernet connection. Ethernet 3 also has a SUN solaris firewall interface.

The Millstone 2 process computer scans most of its data at 1 second rates. Raw analog values are acquired at ¼ second frequency. Control rod movement pulse inputs and associated digital outputs are scanned every 100 milliseconds. Each host computer receives analog data while acting as a slave to the individual G2 Motorola based scan processors. Failure to accept data in a timely fashion will result in dropped links on either the process computer or G2 side. G2 Ethernet traffic utilization runs at a nominal 5% of the network bandwidth. Since MMI traffic could be unpredictable, we chose to isolate MMI traffic from normal data acquisition activity.

Security requirements for the process computer are largely dictated by corporate policy at Northeast Utilities. Even though the corporate WAN is already isolated from external INTERNET access by a firewall, an additional INTRANET firewall was deemed necessary for the process computer. The simulator version of the process computer does not have firewall protection. It does, however, have a special server protection feature. When NRC exams are underway, ALL external MMI connections are refused/terminated.

In addition to the special Ethernet security precautions, R*TIME/WIN security password protection is provided. The method we have used to set up connection and security privileges is illustrated in Figure 5. Connect status is visible in the title area of display template (overlay) files where appropriate.

PUBLIC vs. PRIVATE SERVERS

There was additional concern expressed over the possible impact of users outside of the control room accessing process computer data. Early in the project, it was decided that a separate data server system would be set up on the "public" WAN to provide process computer data. This system "acquires" data every second from the master host computer (about 50 Kbytes/second). The data is converted to Intel floating point and stored as if the data were acquired locally.

Database and application updates must take place in a coordinated manner due to the distributed nature of the data. Database updates are still performed through legacy applications on the process computer master host. The master host is the primary

Geographic Connect Characteristics

MP2 & Simulator Control Room -
- Autologin with OPS privileges -
  - STA & SCO workstations will have SPDS control security privileges
- No Password Timeouts, always connected to MASTER HOST
- Connect status visible

TSC, EOF
- Autologin with remote OPS privileges
- No Password Timeouts, always connected to MASTER HOST
- Connect status visible

Computer Room CRT's
- Autologin with remote OPS privileges
- Password timeout after 1 hour
- Client controlled connections via SWTPER display
- Connect status visible

Non-computer room CRTs connected to PPC & Simulator
- No password autologin (security level = 0)
- Password timeout after 5 minutes
- Client controlled connections Host A/B enabled via mmi FAILOVER display
- Connect status visible

Plant Server System (public) connections (PSS has a subset of PPC functionality)
- Autologin with remote OPS level privileges
- No password timeout
- Connect status visible

Security privilege scheme

31 = Max security - can view/update passwords
24 = OnCall - system level - can configure archive files
15 = Reactor Engineer - can perform RX engr functions
12 = Can control SPDS (EOP change, reset dgrd ctmt, post-sras, rad limits, isolated/affected steam generator, abnormal rise)
10 = OPS privileges - can remove from scan, disable alarming, change value
9 = I&C - calibration privileges - remove from scan
8 = Remote OPS privileges (OK to look but no changes are allowed)
0 = Default & password timeout security

NOTE: On an exception basis, some database points & functions will have security requirements that are higher than OPS (level 10). These points and functions can affect quality software (core calorimetric, rcs leakage, etc) or cause changes to the system configuration.

$Local900 connect status scheme	**Text**	**Color**
01 - 10 = PPC control room terminals	"2PPC"	cyan on dark blue
11 - 20 = Simulator control room	"2SIM"	black (not visible)
21 - 30 = PPC not in control room	"2PPC"	cyan on dark blue
31 - 40 = Simulator not control room	"2SIM"	cyan on dark blue
51 and up = Plant (public) server	"2LAN"	cyan on dark blue

Figure 5 - Connection & Security Privilege Scheme

configuration control point for arming the system(s) with point names, descriptions, scan information and alarm limits. Master host database updates are transferred automatically to the process computer test (standby) host. When an update is complete, an R*TIME/WIN database update is performed on the test host. The R*TIME/WIN database is then redistributed to the master host, the public data server and to the simulator server systems. The above references to database updates do not apply to real-time dynamic data passed through one or more current value tables.

FAILOVER

Redundant host pairs serve data for the plant process computer. Control room MMI device connections are controlled exclusively by the process computer in a manner similar to the RS232 T-bar device used for IDT 2250 terminals. A separate digital input is assigned to control connect status for each control room MMI device. The setting of this digital controls whether an MMI connect request is accepted or refused on the respective process computer or simulator server system.

Other (non control room) MMI connection requests are ALWAYS accepted except when the exam-in-progress digital is set. The non control room client (if enabled) controls his host connection.

DISPLAY DISTRIBUTION and CONFIGURATION MANAGEMENT

R*TIME/WIN comes with a number of features that can be used to manage display definition distribution to client workstations. Whenever a client restart is initiated, display updates can be requested from a mapped server disk directory. Control room terminals are used on a 24 hour by 7 day basis, so shutdowns are undesirable. R*TIME/WIN capability has been supplemented by using scripts that copy selected display updates to control room MMI devices.

Public users access binaries and displays from a common Novell file server. This constrains display names to the FAT 8.3 convention. We have chosen to use a single display directory that is identical for ALL servers. Intelligence is built into menus and some displays so that server specific implementation is possible through a single display set. If a user opens a display that is not appropriate to his connection (e.g., a process computer application), R*TIME/WIN will automatically present error message pop ups for missing server applications.

Display files and R*TIME/WIN *.ini files act in concert to deliver appropriate resources to the user's desktop based on his server connection. MMI.INI client specific settings include:

1. Analog and digital point default display definitions,
2. Password login and security time-out presets, and
3. $LOCAL900 settings for poke button intelligence based on server connection(s).

DATASERV.INI contains the node names for the server(s). Most workstations have single versions of these files that emanate from one of the following:

data_ppc.ini.......Plant process computer
data_pss.ini........Public plant server system
data_sim.ini.......Simulator

mmi_ppcr.ini.....Plant control room
mmi_ppct.ini.....Plant computer room
mmi_ppot.ini.....Plant outside the control/computer room
mmi_ppss.ini.....Plant shift technical advisor/supervising control operator
mmi_pss.ini.......Public plant server system
mmi_smcr.ini....Simulator control room
mmi_smot.ini....Simulator outside the control room

RESULTS AND DISCUSSION

Has the installation of R*TIME/WIN been a smooth and easy transition? We are still in the early phase of rollout of the system. We did not initially anticipate or plan for adequate CPU processing resources. Most of our "public" network users are running Windows 3.1 on 16 Mbyte 486 desktop processors. Again, the processing resources have been found to be inadequate. The current state of technology is such that both client and server hardware upgrades are likely to be required for any system that has been in service for more than 5 years.

R*TIME/WIN installation was/is more than 6 months behind our originally planned schedule. The factory test was run three times. Why? Because we did not provide sufficient information and direction to the vendor for current value table information, color conventions, and special processing requirements. Other initiatives also interfered with the installation schedule. New plant emergency operating procedures were not ready on time. The plant has reverted to a "revised" current emergency operating procedure approach for startup.

One unintended benefit has been the capability to run both the IDT 2250 MMI and the R*TIME/WIN MMI in parallel. Our original plans called for a clean cutover to R*TIME/WIN. When we added CPU resources, we found that we could support both operating environments. We have a full complement of display hardware operating for both MMI interfaces. The plant operators have asked for a phased approach to installation such that half of the IDT 2250 display devices will be retained for a few months during transition.

Even though display layouts were unchanged, human factors reviews caught many flaws in the existing layouts. We have taken additional time to improve display layouts where possible.

CONCLUSIONS

R*TIME/WIN installation in the Unit 2 control room has greatly improved the plant operator's ability to access and interpret process computer information. It also holds great potential for future improvements and expansion.

SUMMARY

"Information at your fingertips" has become a familiar motto. We, as information providers, must endorse this philosophy and do our best to deliver information to users. We need to do it in a way that enhances the productivity of the users of the data.

Many data processing systems just make life more difficult for users. When a system is inherently complex, its complexity can be carried through to the user interface. That is no excuse. For example, is your budgeting, time reporting, materials management or other administrative system user-friendly? Many of these systems require the dedicated expertise of an individual in each department. The challenge for us is to embed ease of use features into complex process computer systems.

By deploying R*TIME/WIN in the control room and on the desktop, Northeast Utilities has simplified access to plant information for the plant operators. We have done it in a way that provides a consistent look and feel for all users. There is no need to mount a tape, or run a special application to transfer information. Users have access to information through common, familiar desktop tools such as Excel to analyze information they have collected.

By combining graphic bitmap pictorials with real-time information the relevance of data is less abstract. System engineers, managers and plant equipment operators all finally have process computer information that is available at their fingertips!