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X-Window for Process Control in a Mixed Hardware Environment

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Abstract

X-Window is a common standard for display purposes on the current workstations. The possibility to create more than one window on a single screen enables the operators to gain more information about the process. Multiple windows from different control systems using mixed hardware is one of the problems this paper will describe. The experience shows that X-Window is a standard per definition, but not in any case. But it is an excellent tool to separate data-acquisition and display from each other over long distances using different types of hardware and software for communications and display. Our experience with X-Window displays for the cryogenic control system and the vacuum control system at HERA on DEC and SUN hardware will be described.

I. Cryogenic Controls

A. Components

The cryogenic control system for the HERA collider -which has a circumference of 6.3 km- is based on a commercial, distributed control system called D/3. The backbone of the system is a redundant communication link using HDLC protocol and a token passing algorithm(Fig. 1). Display and control functionality a separated from each other in the individual display-(DCM) and process control computers (PCM). The cryogenic processes, as there are: compressors, coldboxes, helium distribution in the HERA tunnel to the 422 superconducting dipole- and 224 quadrupole magnets, low temperature measurement, superconducting cavity control, supervisory control for the ZEUS solenoid, controls for the magnet test hall etc. are controlled by means of the PCMs. More than 3000 analog and 3100 digital signals are scanned,archived and calculated in control loops and logic devices. The scantime for the individual points is defined to be between 0.25 [sec] for fast control loops and 3 [sec] for temperature read-out of the HERA magnets. All points are checked for over and underrange, and high and low limits. Alarms are send to various printers throughout the system according to the alarm destination index (ADI). The printers can be host based or connected to terminal servers.

B. Access

All process points can be accessed from any PCM and DCM in the whole system. This way no 'special' consoles exist in the system for process control. There are some consoles that have additional/other functionalities like annunciator panels with function keys and X-Window displays with or without the full access to the process. This (X-)extension to the existing system is very useful since the architecture of the D/3 system does only foresee consoles directly connected to one of the DCMs. X-Displays of the cryogenic control system are now running in various places at DESY: In the main control room where the D/3 link is not jet installed, and where ever it is useful for the

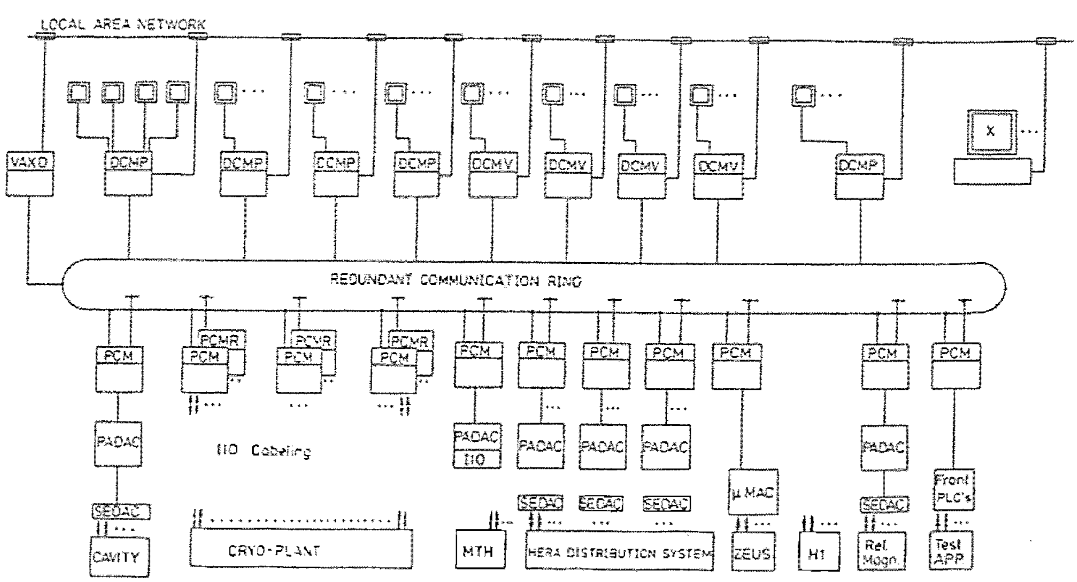

Figure 1. The Cryogenic Control System

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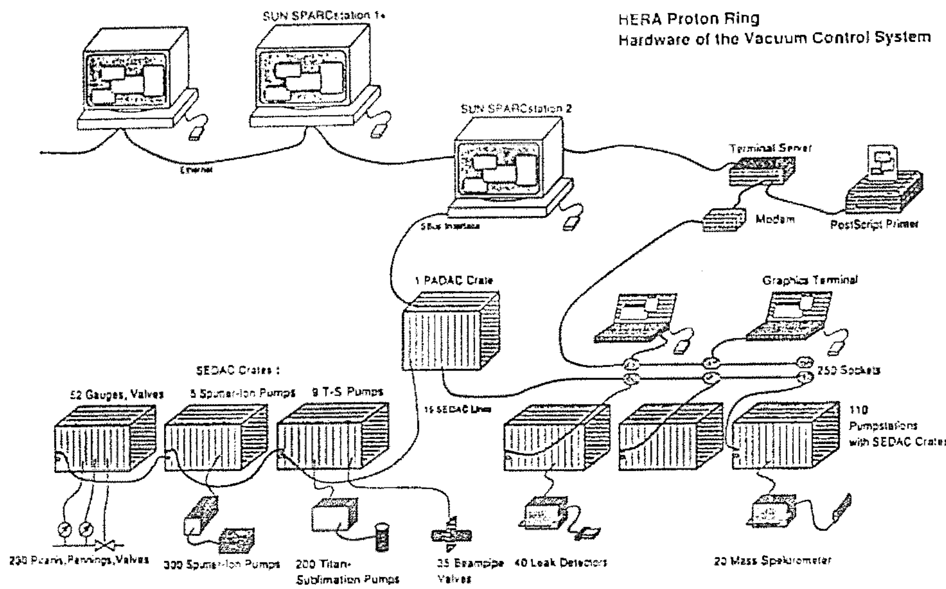

Figure 2. The Vacuum Control System

vacuum operators and in smaller control rooms like the magnet testhall and at the ZEUS experiment. The X-Clients for these displays run on one of the VAX-based DCM's (DCMV) in the cryogenic controls cluster.

II. The Vacuum Control System

A. Components

The insulating vacuum of the superconducting magnets, the beam pipe of the ring and the insulating vacuum of the helium distribution line are part of the vacuum control system. We have installed 700 pumps of different type, 1200 gauges and 360 valves. These devices are controlled by several Sun SPARCstations and graphic terminals. The workstations are linked by an Ethernet network running the TCP/IP protocol. One workstation has a hardware connection to all vacuum devices and runs the server program.

B. Communication

The device server program reads out the equipment every four seconds, checks the status and acts on special situations, writes out error messages, stores measurement and status readings in a database and writes changes of the values to a history file on disk. All other programs can access the device server by remote procedure calls (RPC) to allow calls from different

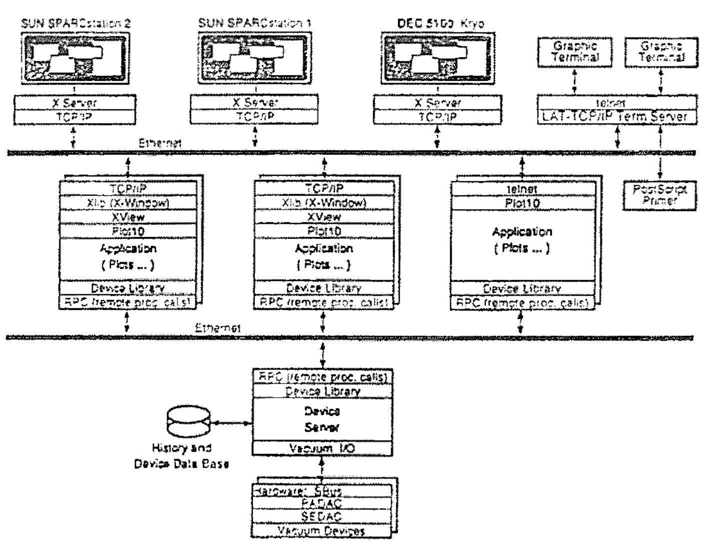

Figure 3. Vacuum Communication

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workstations on the network. The data transfer of the RPCs is done in a machine independent manner by using external data representation (XDR) protocol. This gives all sorts of computers of different manufactures access to the vacuum database by means of converting the data to a standard format on the network.

All application programs are requesting device related information by the specification of a device type, a device position, the type of function to perform and the property to transfer. The server responds with an error code and a single data structure or a data block with actual measurements of several similar devices or the history of one device.

C. Data Presentation

The data are presented in a graphical way to the user, either in forms of diagrams or in plots with time or position dependence. Presentation devices are: workstations running Open Look; Tektronix compatible terminals for use in situations where hand held terminals -designed by DESY- have to be used and matrix color printer or postscript printers.

The transport protocol for the workstations is X11 (X-Window) to allow displays on different types of machines. The next layer on top of the Xlib routines of X-Window is the XView library, an interface to Open Look graphics, which provides a simple access to X11. A further layer is the Plot10 graphic standard. This additional interface gives the ability to display graphics on Tektronix type terminals as well as X11 windows from one source.

All user interaction is done by mouse input. The operator can scale plots and diagrams, switch vacuum devices or display windows with history plots or faceplates by a simple mouse click. A window displaying the timedependence of the pressure is for example generated by a click on the gauge reading in a diagram. Additional services, like printing or refresh rates etc., are provided by pull down menus.

III. Reliability

A. Long term operation

Compared with a host based display, the X-display has to rely on the availability of many components like cpu's networks and software. Fortunately the development of soft- and hardware has made a great progress during the last years. We are running X-displays from different machines to one X-Server over the Ethernet without major problems.

B. Display Activation

Calling up a host based application is as easy as for any other application. But calling an X-Display and redirecting it to another machine is not easy to perform. Specially operators on a control room should not have to deal with this task. Tools are needed to make life easier. Under DECnet you can call DECnet objects installed on the application server. Starting up the image and redirecting the output to the calling machine is done automatically.

Display call-up:
DEC: $ set display/create /node=HOST /transport=
[(DECnet), TCPIP, LAT, LOCAL]
$ run application
SUN: : application -display IP-HOST:0

C. Redundancy

Even if the operator does not have to deal with the proper X-setup, he will be in trouble if the application server with the X-client goes down. If possible there is a chance to solve even this problem. If the application can be run on a DEC LAVC(local area VAX cluster) the X-Client can be started as a Batch job. Defining the queue as generic with queues on other LAVC members the task will be automatically passed to another machine in the cluster and send the same output to the X-Server. The operator just observes a short blackout before he can continue work. This is a big advantage compared with host based applications.

D. Long Distance

End of 1990 a demonstration system was installed on an exhibition at CERN. The X-Window communication had to pass a well saturated 64 kbit line between DESY and CERN. The demo was running over a long time period with reasonable results. The most important experience was, that the X-System does not suffer from long answering times. The display was slow but stable.

IV. Fonts

A. Standards

Even though the X-System is a standard, this does not really mean that you will be able to run any application on any X-Window terminal. The X-Window system disposes several standard fonts. If you keep using these fonts you will normally

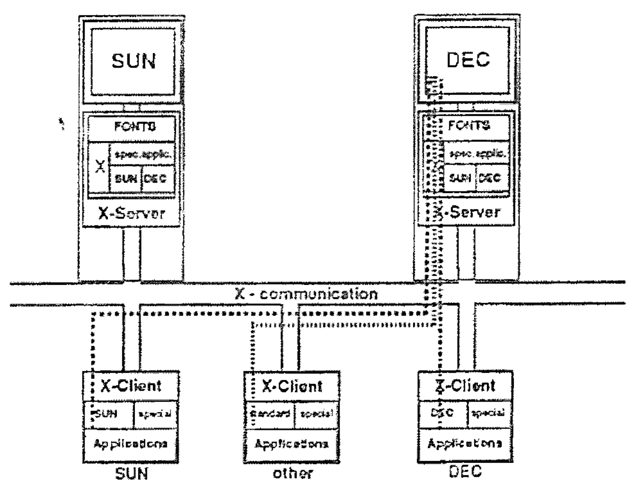

Figure 4. Standard X-Window Fonts

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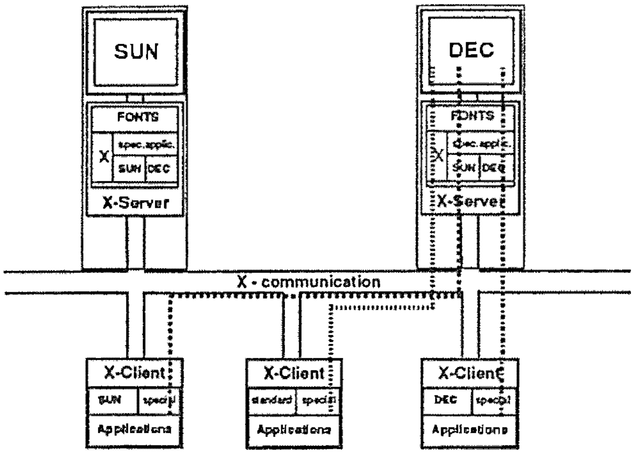

Figure 5. Special Application X-Window Fonts

be able to run this application on any X-Server. Standard fonts which are not known will be displayed in another font -the one that fits best-. There are ways to write non standard applications if your program explicitly needs a special set of fonts. In this case the font will not be replaced by other fonts, but you will have to load the fonts to your server. Not enough, you will also have to put them into the right directories and make them known to the system.

B. Different Systems

If you have to include fonts from other systems you will find out that there is no standard for the file format of the fonts. Fortunately there is a way to exchange the font information. This is done in the Binary Distributed Format (BDF). The files are ASCII files readable by any system. These files have to be compiled with a font compiler which is special for every system.

Font compiler:
DEC: $ DECW$FONTCOMPILER
SUN: : convertfont

Afterwards the fonts must be included in the standard font directories or the actual directory must be included in the font path.

Font path:
DEC: $ sys$manager:DECW$PRIVATE_SERVER_SETUP
SUN: : bldfamily

IV. Networking

A. Communication Protocols

The X-System is designed to be network and vendor independent. The most common protocols on top of which the X-protocol runs are: TCPIP,DECnet,LAT local. TCP/IP is the common protocol for UNIX systems. Also for DEC machines several implementations of this protocol exist. DECnet is a proprietary protocol of Digital Equipment. There are several implementations on other systems i.e. SUN-OS. LAT is a protocol from DEC designed for LAN transport only.

B. Network Load

Several measurements between different systems using different protocols have shown that the applications we use for the cryogenic and the vacuum controls need very rare band width of the Ethernet. A graphic with about one hundred bargraphs updated each second takes less than 0.4% bandwidth. In this case it was X-Window over DECnet. Using 'pure' DECnet to transfer the graphic information took about 0.2%. There is an overhead for the X-display but the real numbers can not be drawn from this measurement since the numbers are at the low end of the resolution of the network monitor we used. All the relevant informations for the display update must be packed into less than 8 DECnet packets. The same results were measured for the X-display using TCPIP as the transport protocol between a SUN and a DEC machine. If client and server are both connected to the same LAN it seems to be reasonable to use LAT as a transport protocol since LAT uses smaller packages. Since the measurements with LAT were made with a DEC-X-Terminal which obviously was equipped with a to small CPU, measurements with other X-Terminals should be made. The only measurable network load occurs during the initialization of the display on the X-Server. But also this takes only some percent of the bandwidth.

V. Conclusions

Almost one year of operating experience showed a reliable operation of the vacuum control system. The provision of two network layers between the vacuum equipment and the user display gives much of freedom in transferring data and graphics to different sorts of computers. It makes good software development capabilities available by allowing application programs to be tested with real data without interrupting the vacuum process. In general the overhead in speed of the network is negligible. Only some data bound applications are performing better by sending graphics data instead of fetching data from the history memory across the network. The integration of vacuum displays on the cryogenic workstation -and vice versa have proved to be very useful for the operators and will be expanded in the future.

VI. References

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