New Man-machine Interface at the BEPC

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The BEPC (Beijing Electron Positron Collider) control system was upgraded in October 1994. Except for low level CAMAC hardware equipment, all high level control computers and their adapters have been updated. The old console with touch panels, color monitors and knobs has been replaced by workstations. This paper describes the methods of developing the man-machine interface under X-windows in a network environment without having to change existing programs greatly.

1. INTRODUCTION

The BEPC control system was built by the end of 1987 and has been upgraded in October 1994.

The old control system used a VAX-11/750 computer and the VAX-CAMAC-Channel to connect to the low level CAMAC data acquisition system. The old console has color and B/W monitors for displaying the status of the controlled equipment. A touch panel and knobs were used as the man-machine interface to operate the BEPC machine. A Grinnell controller interfaced the color and B/W monitors to the VAX computer. This controller is no longer manufactured and the lack of spare parts made the central console unreliable. So workstations are now employed as the new man-machine interfaces of the control system.

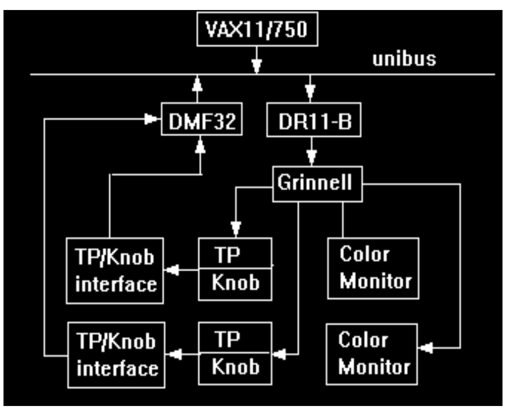

Figure 1 Former BEPC console structure

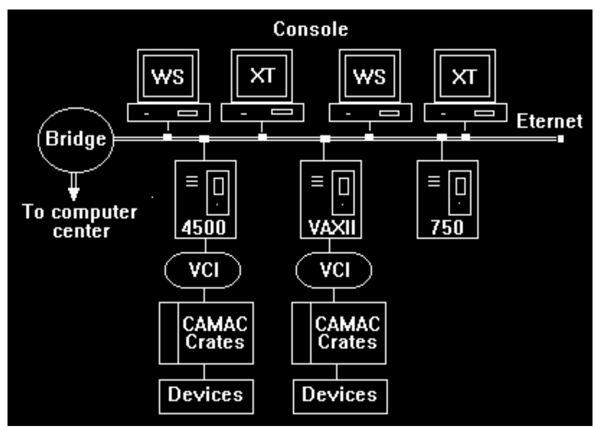

Figure 2 Upgraded BEPC control system

The upgraded control system, as shown in figure 2, adopts a distributed architecture based on Ethernet [1]. Both the VAX4500 and Micro VAXII can independently control all BEPC equipment or control the different devices separately. Two VAX workstations are used as the new console to replace the old one. A mouse is utilized as the operating tool. Ethernet connects all the computers serves for data communication. Our strategy was to avoid having to change low level programs greatly in the development of the new console.

2. CONSOLE MANAGER.

The new console consists of two VAX4090 workstations and two X-terminals. The console manager developed under X-Windows and OSF/Motif has a friendly man-machine interface which retains the former style of the control panel to reduce the training time for operators [2]. The dedicated Grinnell adapter was eliminated; thus the new system is easy to maintain. A new knob control program has been developed, using the client-sever mode to control individual devices.

2.1. Environment of the console development.

Jointly developed by MIT and DEC, X-Windows is being widely adopted as a standard by nearly every workstation manufacturer for its extremely convenient user interface, powerful programming ability, high quality code and distributed processing ability, and it has been used in many large-scale control systems.

X-Toolkit is a software package established on the basis of X-windows for the convenience of users to develop interfaces. It contains a large widget set including Motif, which provides many artistic widgets for interface design and makes it possible for the user to do further development as required, and OPENLOOK, which adopts the concept of OOP.

2.2. Console database.

A hierarchical database was installed on the console computer with a DBMS system, DBA, which can read write, print, and backup the data record on a terminal; console manager programs can access the database by a set of subroutine calls. At console startup whole data records, the information on the accelerator devices and console messages, are brought into physical memory from the disk. The console manager fetches the useful information from the database.

2.3. Program Realization.

The hardware console was replaced by a software console, which provides both controls and displays. SLAC has developed a console manager program, the principle of which is as follows: Create a window on workstation and designate four areas (tile) simulating the original left and right touch panels, two color displays and one black and white monitor. When the information with Grinnell codes is sent to the workstation from server program Newavtx running on the VAX4500, it will be encoded into X-Window format and displayed on the workstation by the console manager. The control information from an operator at the workstation is sent to through Ethernet Newavtx , where it can be interpreted and switched to the corresponding application process.

Though this programming ingeniously avoids a great amount of work on improving the lower lever programs of the former control system, it still has some drawbacks: (a) The weakness of XUI: it can not make a perfect interface. (b) Serious shortcomings in operation: the size of "tile" cannot be changed and thus some tiless are too small, the text is overlapped and the operator can not observe the contents of both tiles simultaneously. (c) Inconsistency with developmental projects for the BEPC control system.

For these reasons,the program cannot be used unmodified for practical control of BEPC. Thus we did considerable work to analyze and regenerate it and now we use the Motif widget set. User Interface Language (UIL) is adopted to reduce program crashes caused by mistakes in interface design. Instead of one window divided into four areas, six independent windows represent console devices and the windows can be reduced or enlarged independently to make full use of the limited screen and to make it possible for the operator to get information on several devices at the same time. The windows adopt the Application Shell as their top level window so that they can be turned into icons and stored in the icon box when not in use. Each of the windows can be independently chosen to be shown on a workstation or X-terminal. Thus the inconvenience of overlapping windows is avoided. The improved program retains the advantages of the original and provides the operator with a friendly user interface and convenience of operation.

In addition, the operator can acquire functions by using menus. For example, using the FILE menu an operator can print and quit, the CONTROL menu can control the window state, the OPTION menu can change the foreground or background color, the HELP menu supplies details of operation to the operator.

2.4. Knob manager.

There are four knobs on the old console to trim the currents of magnets individually; these are connected to the VAX-11/750 by an RS-232 port. In the upgraded system, the hardware knobs have been eliminated and a new knob manager program developed, consisting of a knob client program running on the workstation and a knob server program on the VAX4500 computer. A network link is created at start-up between the knob client and the server program in order to exchange data and commands.

The knob client program developed with Motif widgets allows the operator to tune one to four power supplies and to select the up or down speed and size of the steps. The relative values of the current can be shown in the knob windows. The accuracy of the trim is a single bit. If the current setpoint value overflows, an alarm message will be shown in an information window and the operation will be stopped. The knob server program in the VAX4500 computer sets current values for specified devices. It waits for an event flag sent by an operator through the network. Once the event is set up, the server program packs the I/O commands and data into CAMAC control words, resulting in the setting values being exported to the devices.

3. NETWORK COMMUNICATION

DECnet for task-to-task non-transparent communication has been adopted to develop the network manager programs because it can provide data exchange between programs running on different operating systems and provides many network functions. Among such functions are rejection of the network link request, synchronous or asynchronous termination of the net link, management of net link multi-requests, etc. [3]

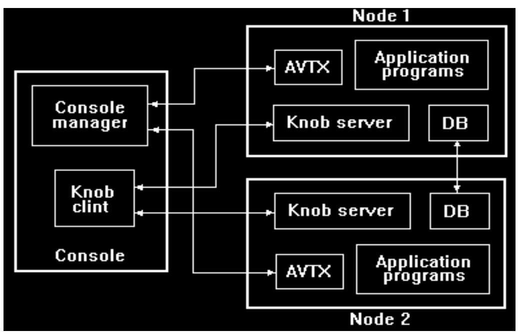

Figure 3 The network links

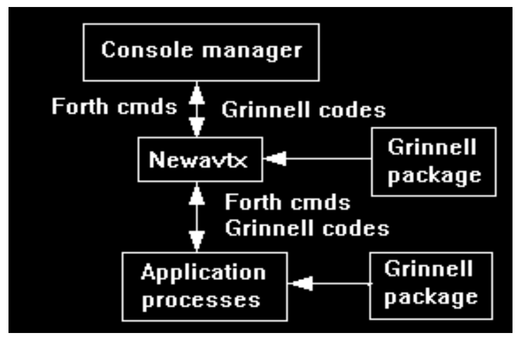

Figure 4 Relationship between the console and the application processes

The network link in our control system is shown in Figure 3. When the control system starts up, three kinds of network links are created by the network manager. One is a network link between the console manager and the multi-ask scheduler on the front end computer, which sends commands and data from the console to the FEC and passes the FEC messages to the console manager. The second is between local databases on FEC nodes, to carry out data exchange among these databases. There is a third network link between the knob client program on the console and the knob server program on the FEC. All of above network links are kept open when BEPC is operating.

4. CONSOLE SEVER AND SCHEDULER.

There is a program Newavtx, a set of panel files written in FORTH and twenty application processes in the VAX4500 computer. Newavtx is used for scheduling and managing those processes. It may activate or stop any application process on operator request [4] and supervises many processes running simultaneously. Under the control of the program any equipment of the collider may be monitored and adjusted to ensure that the collider operates optimally.

The application programs are divided into two levels. The zero level contains programs for data input/output, on/off and ramping of the magnet power supply and monitoring of vacuum, radio frequency, beam position etc. The first level software contains the programs Orbit, Current Monitor, Lattice and so on. The program Newavtx is responsible for scheduling those processes. Because Newavtx provides the network communication by making a logical link with the console manager netlink, it may receive the data from the console through the network. Thus it is also a sever program for the console. Its other duties are: (1) receiving network commands, (2) interpreting and executing FORTH commands, (3) scheduling application programs, (4) diagnostics.

Here, for simplicity we only discuss some key problems.

4.1. Data communication between the console and application processes.

By creating a logical link with the console manager using task-to-task nontransparent communication, the program Newavtx may receive or reject the netlink request from the console manager, or synchronously or asynchronously terminate the netlink. The maximum number of remote nodes is six. In addition, by declaring itself to be a "network object", Newavtx not only receives the data with FORTH command format from the console, but also sends the data, mostly Grinnell codes, to the console. Thus it connects the console with the application processes. A mailbox created by Newavtx is used for the exchanger of data between the console and the application processes .

4..2. Interpreting commands and scheduling

Newavtx interprets the FORTH command from the console to active appropriate application processes and sends back the result to the console. So it connects the console with the application processes. Two kinds of data are distinguished by an event flag. One kind is for FORTH commands and the other is for Grinnell codes. The FORTH commands interpreted by Newavtx come from the two sources: the console panels and some application programs. The Grinnell codes were previously encoded by the Grinnell hardware adapter. To avoid great changes in the application programs, they still use the Grinnell codes and send these codes to Newavtx. The console manager converts the Grinnell codes to the X-window graphic ones.

Newavtx waits for an event flag. Once the event flag N-efn is set up by a network transmission, Newavtx fetches the console commands and sends them to the interpreter subroutine. The appropriate process is activated after these commands have been translated and executed. When an application process wants to send some graphic information to the console, it assembles Grinnell codes by using the Grinnell graphic library and sends them to the Newavtx mailbox with the event flag set up. As soon as Newavtx receives the event flag , it fetches the data and sends them to the console manager. The related graphic will be displayed in the console window after the codes are translated into X-Windows graphic codes by the console manager. If some application processes need to send text messages about the current operation status or error to the console panel, they must assemble the data in FORTH command format and send them to the Newavtx mailbox with the event flag set up. When Newavtx receives the event flag, it fetches the data and sends them to the interpreter subroutine. After these FORTH commands are translated and executed, they are changed into Grinnell codes. Finally the Grinnell codes are sent to the console manager by the network. The text messages which will be shown in the console panel for these codes are converted by the console manager.(figure 4)

4.3. Display console panel.

There are six windows on the console. One is used to display panel files, the other five are used to display the status and messages from the controlled equipment. There are two kinds of buttons on the console panel, the panel selecting button and the control buttons. With the control buttons, the commands and data can be issued for controlling the collider. There are about two hundred panel files written in FORTH which are resident in the VAX4500 computer. At control system startup, Newavtx sends an index panel to the console. When the panel selecting button is pushed, the console manager sends the Forth commands to Newavtx through the network. Newavtx receives the commands and sends the selected panel to the console manager for display.

In the upgraded system, one VAX4090 workstation communicates with two nodes, VAX4500 and VAX-II. So network links are created between these nodes. A console manager program is located on the VAX4090 and two Newavtx of same version are running on the VAX4500 and and VAX-II. When debugging, we found the console panel "flashed" since the panel files from the two different computers appeared simultaneously on the screen. In order to solve the problem, we modified the program Newavtx in the VAX-II by setting a switch to prevent the VAX-II from producing panel files.

5. CONCLUSION

The upgraded BEPC control system runs safely and reliably. The system has been successful. The new workstation console with a friendly man-machine interface has replaced the former console. The operators can operate the machine in the same manner as before, the only difference being the use of a workstation and mouse instead of a touch panel.

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