The BEPC Control System Upgraded

J. Zhao, X. Geng, Y. Yu, B. Wang
C. Wang, J. Xu, W.Liu, H. Luo, Y. Wang, M. Zhan
Institute of High Energy Physics, Chinese Academy of Sciences
P.O.Box 918-10, Beijing 100039, China
E-mail: zhaojj@bepc3.ihep.ac.cn

ABSTRACT

The upgrade of the BEPC control system has been finished one year ahead of the schedule and new system was put into use in October, 1994. The upgraded system adopts a distribution architecture based on DECnet. The workstations are used as console to replace the old hardware console, the new VAX computers carry out control jobs. Some dedicated adapters have been eliminated. Up to now, the new BEPC control system has been running safely and reliably for five months. The system upgrading is crowned success. What we have been finished is presented in this paper.

1. INTRODUCTION

The BEPC control system is a significant part of BEPC (Beijing Electron Positron Collider) which was built by the end of 1987. It adopted a centralized architecture copied from the new SPEAR control system because of the tight construction schedule, the system showed some obvious weak points during the long run.

The first weakness is the poor CPU power and the limited memory resource of the unique control computer VAX750. Another problem arises from the fact that some hardware adapters, such as VCC and the Grinnell controller, are old dedicated products from SLAC, which are no longer produced. This threatens the reliability of the control system.

As early as in 1990, we were planning to transform this system into a distributed one to make it faster in response and more reliable in performance. The upgrading work started in an all-round way in 1993, which carried out without interrupting the normal operation of BEPC. Therefore the low level CAMAC system was not changed. The main effort in upgrading the control system lies on software side. The upgrade of the BEPC control system has been finished and the new system was put into use in October, 1994, one year ahead of the schedule.

2. SYSTEM OVERVIEW

New console consists of two VAX4090 workstation and two X-terminals. Console manager based on X-window, which has a friendly man-machine interface and provides 12 graphic windows to display status of accelerator devices. We remain former style of the control panel to reduce training time of operatorThe dedicated adapter Grinnell and VCC was eliminated, so that it is easy to maintain. Both VAX4500 and VAXII can independently control all BEPC equipment, or control the different devices separately. IEEE802.3 ethernet that connects all computers serves data communication. (see Figure 1)

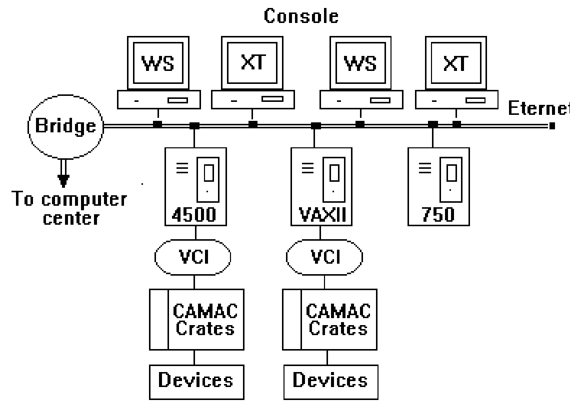

Fig. 1 The hardware structure of BEPC control system

The software is divided into three parts: console manager, network communication manager and real-time control jobs running on the control computers, such as local database, data acquisition programs, multi-task scheduler and about 23 accelerator application processes. (see Figure 2)

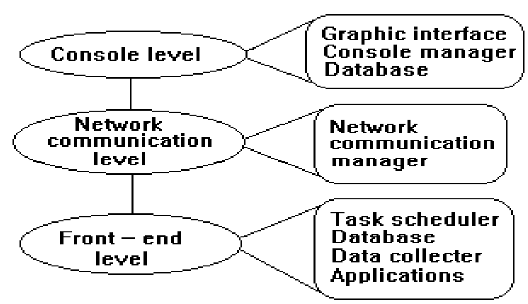

Fig. 2 Software structure

3. CONSOLE MANAGER

For the hardware console was substituted by software console under X-window environment, which carries out controlling and displaying. For that purpose, Console manager programs based on window were transplanted from SLAC. The principle of program is as follows: Create a window on VAX4090 and designate four areas (tile) simulating touchpanels and display devices. Though this programming ingeniously avoids great amount of work to improve the lower level program of the former control system, it still has some drawbacks:

(a) The weakness of XUI: it can not make perfect interface, and it is only able to quit and choose left or right touchpanel. (b) Serious shortcomings in operation: the size of "tile" can not be changed; because some "tile"s are too small and the text is overlapped, the operator can not observe the contents of both "tile"s simultaneously. So it is not convenient for operator (c) inconsistency with developmental project of BEPC control system.

Because of the above-mentioned reasons, the program cannot be used in BEPC practical control. So we did a lot of work to analyze and regenerate it. Now we use Motif widget set. User Interface Language (UIL) is adopted in interface design to reduce the program crash caused by the mistake of interface design. Instead of former four areas (tile) divided in one window, six independent windows represent former 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 windows at the same time. The windows adopt Application Shell as their toplevel window, so that they can be turned into icon and stored in icon box when it was not used. All of the windows can be chosen to show on workstation or X-terminal. Thus the inconvenience of overlapping windows is avoided. In addition, the operator can acquire functions by using menus. The acknowledge windows can show operator some information. We have also developed knob control program by ourselves, which adopts client-server mode to control individual device.

The improved program maintains the advantage of the original program. And the program provides operators a friendly user's interface and convenient circumstance to operate. The program can completely replace the former console. Operator can operate as before. The only difference is the usage of Mouse instead of touch panel.

4. NETWORK COMMUNICATION

DECnet for task to task non-transparent communication is adopted to develop network manager programs because it can realize data exchanging between programs running on different operating system and it provides more network functions, such as rejection of the network link request, synchronous or asynchronous termination of the netlink, management of net link multi-requests, etc.

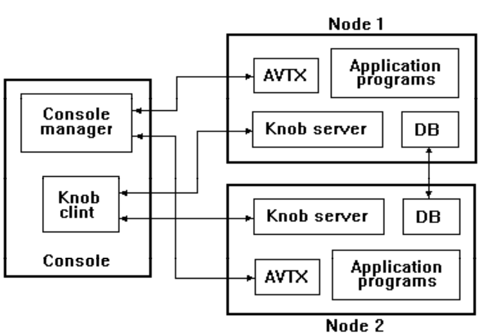

Fig. 3 The network links

The major procedure to make the network communi-cation is ¢Ù Requesting a logical link which creates a net control block, mail box or declares itself as a network object. ¢Ú Accepting or rejecting a logical link request. ¢Û Sending and receiving data. ¢Ü Terminating the link.

The structure of network communication in our control system shows in Figure 3. When the control system startup, three kinds of network links are created by network manager. One is network link between console manager and multi-task scheduler on front-end computer, which sends commands and data from console to FEC and passes FEC's messages to console manager. The second is between local databases on FEC's nodes, to carry out data exchange of the databases. There is a third network link between knob client program on console and knob server program on FEC. During the running time of BEPC, all of above network links keep opening. A library for network users has been established to let low level network operations be transparent for application programmers and to realize RPC (remote procedure call).

5. SCHEDULER PROGRAM

There are sixteen processes in original control system. They are divided into two levels. The low level contains data input/output, devices on/off, ramp of magnet power supply and the monitoring of vacuum, radio frequency, beam position , etc. The high level software contains current monitor, orbit correction, lattice calculation and generation, Comfort and so on. Program AVTX is responsible for scheduling these processes . In addition, it is also a server program of touchpanels. The mail box is used to exchange information between AVTX and the application processes.

The upgrade system of BEPC is based on the DECnet. Program NEWAVTX is transplanted from SLAC. Because the associated graphic and touch panel will appear on X-window through the network, the NEWAVTX declares itself as a "network object" so that it can receive console commands and send out Grinnell commands through the network. The NEWAVTX gets the command and activates the proper application process. On the other hand , the related figure and touch panel files will be displayed on X-Window.

The upgraded structure of BEPC is different from that of SLAC in that our console node communicate with two nodes , so two network links are created among those nodes. Thus the NEWAVTX has been improved . But when debugging , we found the touch panel "flashes ", Since the panel files from the two different computers simultaneously appear on the X-Window. In order to solve the problem, we corrected program NEWAVTX in VAXII, by setting a switch and putting it into database. As a result, the panel files in VAX-II are forbidden. Now, those programs work well and reach the expected goal.

6. UPGRADING DATABASE

In original control system, there is a hierarchical database and its management system which located in physical memory. It consists of a static area and a dynamic area. In the static area, there are device messages and theory parameters of BEPC machine. Raw data from devices is stored in the dynamic area, which refreshes 2 times per second.

For the distribution architecture of the new system, the original database has to be modified. First of all, we installed the database in each FEC computer with same data structure and records in the static area. To keep uniformity of the data records in those databases, the structure of the dynamic area has been changed, a new global index is created in each database when control system starts up. So that high level application programs can read the raw data with the global index and their source codes needn't any change. In addition, a shareable data pool was installed in the physical memory to exchange changed data by DBMS and manager of network communication. So the DBMS programs were modified to manage the records in database and the shareable data pool. And a special network link serves transfer of the database records.

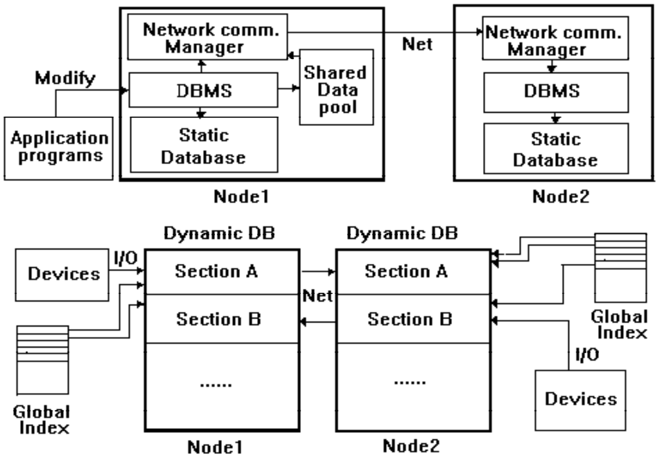

Fig. 4 The upgraded database

As figure 4 shown, when an application program or any one modifies a data record in node 1, the local DBMS sends the change to local database and the shareable data pool. And it notifies the network communication manager by event flag to fetch the data and send it to the node 2. The network communication manager in the node 2 receives the data and lets local DBMS put it in the local database. The raw data from devices in the dynamic area are refreshed each other once a second through network, so that the data in each database keep uniform.

7. DATA ACQUISITION

Data acquisition process XCAMAC refreshes the database at a rate of 2 times per second, and acquires about 4000 signals every time. What is more, the process also carries out the ramp operation of magnet power supply during particle acceleration of BEPC.

VAX-II/750 takes VCC as its Unibus-CAMAC interface, but in the improved system, VAX computers uses Qbus and their interface KSC2922/3922. KSC 2922 Computer Bus Adapter provides an interface between the DEC Q-Bus and up to eight 3922 dedicates crate controllers through a byte wide parallel bus. The 2922/3922 combination provides four DMA modes and a programmed transfer mode. DMA data rates up to 0.77 Mbytes per second can be achieved.

The format of data and command packet differs from that for VCC, therefore, the main work is changing the packet chains from VCC format to 3922 format. The other difference is data bit format. VCC require 16 high bits to be valid , but 2922 need 16 low bits.

Programs needing change include: packet creation program RPBZ, data I/O program XCAMAC, device on/off program DCOUT and beam position monitor program BPM. New packet organization program QPBZ acquires the CAMAC I/O address of every signal from the database, assembles them to CAMAC control words by calling 3922 software package subroutine and stores them in the database for CAMAC and other process to use. Since block transfer operation is need for acquiring analog signal by SAM module, so we wrote a new program for the organization of SAM packets. We find that the I/O speed of KSC2922/3922 is lower than that of VCC, so we don’t acquire device status information during the ramping of main PS to enhance the speed of it. In accordance with 3922 packet rules, the output data are placed in the packet chains and readback is mapped onto old VCC data area, so that the high level application programs reading raw data need no alteration.

8. CONCLUSION

The upgraded BEPC control system has been running safely and reliably for five months. The system upgrading is crowned with success. In the near future, some beam diagnostic, injection and Linac devices will be controlled by several PC/486 computers and connected to DECnet. With those done, the data needed by operator can be sent to the central console.

ACKNOWLEDGMENT

The author wishes to take this opportunity to thank Prof. Shi-yao Liu, who gave us a lot of advice. Our thanks also go to Prof. Shu-Ming Tang for her contribution to the upgrading plan. We would like to thank all the members of our control group.

REFERENCES

[1] J. Zhao et al., Nucl. Instr. and Method in Phys. Res., (1994)A352.
[2] X. Geng, Y. Yan, Nation Conf.
[3] Y. Yu, J. Xu, Nation Conf.
[4] J. Zhao, B. Wang, Int. Conf. on Elec.and Infor. Tech. (1994) 337
[5] C. Wang et al., Int. Conf. on Elec. and Infor. Tech. (1994)112
[6] J. Xu, Internal Report.