INTEGRATION OF PCs INTO THE VEPP-4 CONTROL SYSTEM

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Abstract

The VEPP-4 Control System is based on using of the home developed intellectual CAMAC controller named Odrenok. Now there are 10 Odrenoks in the control system. Almost all the electronics is based on CAMAC. Almost all of the control and monitoring programs are running in Odrenoks. Odrenok has very poor capabilities for data storage and graphical interfaces. The first idea was to use PCs for data archiving and as graphical stations for the control system. Later some monitoring electronics were connected to the PCs. This paper describes hardware and software aspects of PCs using for the VEPP-4 control and announces about the next steps of the VEPP-4 control system upgrading.

INTRODUCTION

The VEPP-4 accelerator complex consists of 1.5 – 6 GeV electron-positron collider, 2 GeV booster storage ring, and pulsed 350 MeV injector [1]. The accelerator complex started its operations after upgrade under present control system in 1986. Since then before the appearance of PCs the control system has no any sufficient changes. Most of control and measuring electronics are based on CAMAC. The total amount of CAMAC modules is about 600. All modules are distributed between 60 CAMAC crates. Some part of electronics us not CAMAC and use home developed serial interfaces.

The main control machine in the VEPP-4 control system is home developed intellectual CAMAC controller Odrenok which was designed in 1982. Odrenok's architecture is based on ICL-1900 series 24 bits machine. Such types of computers have been used to control the VEPP-4 complex from 1970-th to the upgrade in 1986. The special operation system and programming language like FORTRAN were designed in latest 70th. All the system programming components were modified for Odrenok. Now the control system includes 10 Odrenoks, which connected via Ethernet.

Since operations have started more than one hundred applications were designed to control the VEPP-4. Many of the applications have connections between each other via special protocol.

A lot of data shall be stored during operations. But there is no possibility to collect such amount of data in Odrenok's own data medium. Integration of PCs provides non-limited data archiving.

Another need for PC integration into the control system is the increasing of requirements for graphical interfaces. PC allows us to use many graphical and scientific packets for the development of the new applications.

Also we have possibility to integrate new purchased or home developed electronics into the control system via PC.

BASE SUPPORT

To present day the base computer of the VEPP-4 control system is Odrenok. The principle "one computer controls one system" is used for the distribution of computers in the control system. Each Odrenok is used to control of one part of the VEPP-4 complex.

Odrenok has no his own hard disk. Before the appearance of PCs this problem was solved via using the central node (also Odrenok) which had hard disk and provided an access to the disk for the other Odrenoks via special serial link [1]. This link included the special home developed protocol for the Odrenok boot procedure.

The first task of the non-stop upgrade of the control system was the realization of PC as a storage machine. A specific adapter CAMAC-Ethernet was designed at that time to connect all Odrenoks to the storage PC. First version of the file server was realised in PC running under DOS. But then Linux was taken as base operation system. Now eight PCs operating under Linux are included in the VEPP-4 control system. The scheme of the VEPP-4 control system computers is shown in Figure 1.
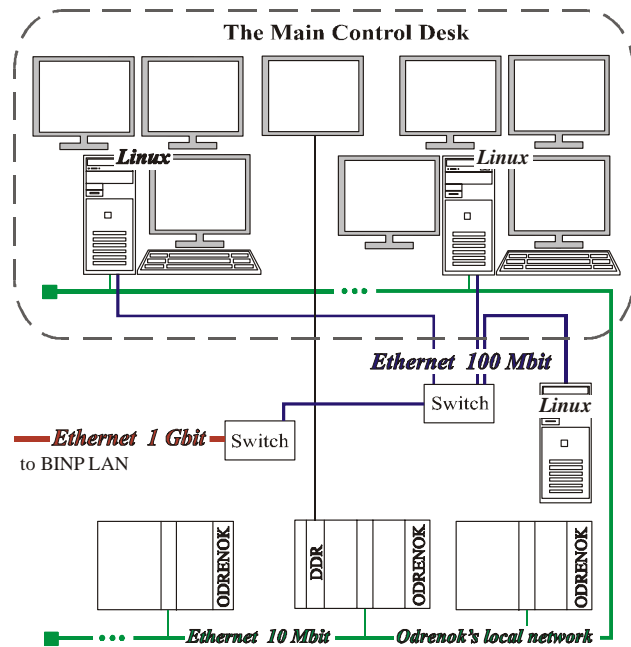

Figure 1: The scheme of the VEPP-4 control system computers.

The file server which runs in one of the PCs provides storing and loading of files and codes, and supports

Odrenoks boot protocol. There are special Odrenoks folders in the hard disk. Each Odrenok can write to his own folders, but can read from any folder. At the same time these folders are opened for new applications that run in PC. This is one of the methods to communicate between Odrenok and PC applications. Odrenok's folders are mounted to all of the PCs in the control system.

Another work of the file server is to collect most important data from the all Odrenoks. Applications running in Odrenok computers send the data via Ethernet to the file server. The file server receives these Ethernet packets and collects the data to a single packet. Once per second the sever sends broadcast packet with the collected data to Odrenok's local network. In each Odrenok the special program receives this packet. Another Odrenok's applications get the information from the data buffer in this special program. So, the main information about all systems is presented in all Odrenok computers of the control system simultaneously.

The usual method of data input/output in Odrenoks is realised via alphanumeric terminals. The next task of the file server is supporting of terminal sessions in Odrenoks from PCs. The terminal program in PC asks the file server for Odrenok's MAC address. Then the terminal program tries to open a session via Ethernet directly in correspondent Odrenok. Odrenok's operation system provides three terminal sessions via Ethernet only. But each PC of the control system can open terminal sessions with any of Odrenoks. The typical set of windows with terminal sessions in one of the PCs in the main control room is shown in Figure 2. Also Linux allows us remote control in Odrenoks via terminal session in the control room PCs.
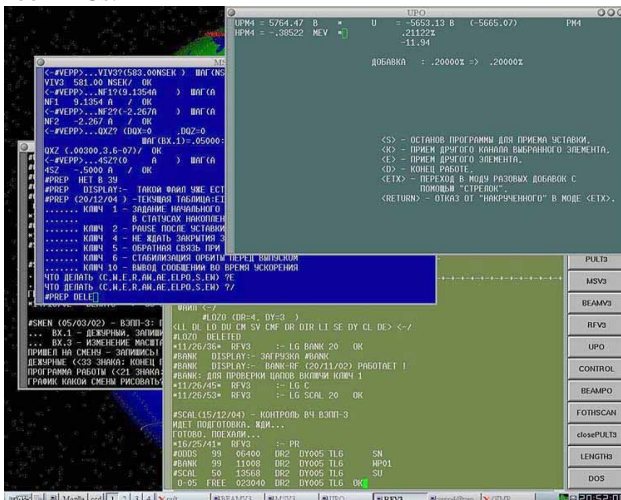

Figure 2: Odrenok's terminal sessions.

GRAPHICAL SUPPORT

Most of Odrenok's applications have graphical output. Before appearance of PCs home developed CAMAC adapters DDR (Digital Display Raster) were used for the graphical output.

As usual DDR places in CAMAC crate with Odrenok (see Figure 1). The resolution of the adapter is 256 x 256 points, 3 bit colour (7 colours) only. In spite of so poor possibilities these adapters were used effectively for visualisation of the main data and the state of the systems. Totally about 20 DDR modules were used in the VEPP-4 control system.

At present many of DDR modules are deteriorated. It is not possible to convert most of applications working with electronics from Odrenok to PC at present time, but many of the applications use graphical output. So, a method based on data transmission via Ethernet was developed to support graphical output from Odrenok applications.

The special application – graphical display server - running in PC receives packets from Odrenok's applications and draws graphical information in windows on PC's displays. Up to four displays can be connected to each PC. Also any number of display servers can be run in each PC. The display server runs with the next parameters:

dispserv -b -d :0.2 -f 20x40 -s 2 -l 2 -n NAMEDISP, where *-b* – background mode,

- d :0.2 – number of display, *- f 20x40* – font size,

-s 2 – scale factor, *- l 2* – thickness of lines,

-n NAMEDISP – name of display server for identification when packets send.

Each Odrenok's application can open any number of graphical windows in any PCs of the control system. Schematically the principle of graphical windows distribution is shown in Figure 3.
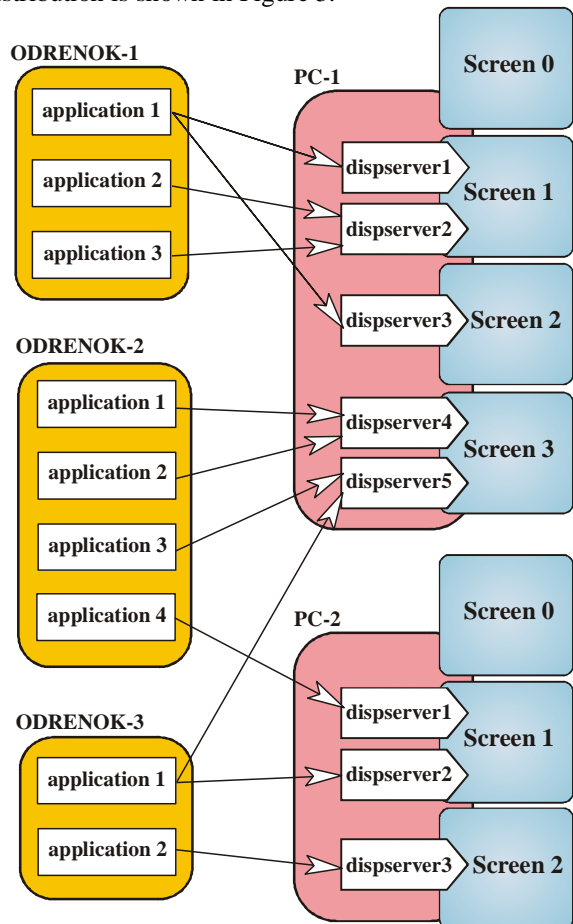

Figure 3: Graphical windows distribution.

There is a special procedure to open the graphical window in which name of PC, name of display server, number of PC's display, and size of the window are determined. Graphical packet in Odrenok provides drawing of text, numbers, points, linens, circles, rectangles in the window. Odrenok's application prepares a correspondent set of commands for the display server and sends the packet via Ethernet. As usual each Odrenok's application sends about one packet per second.

ODRENOK – PC DATA EXCHANGE

As the most of electronics is under Odrenok's control the most of the control system data is produced in Odrenok's applications.

Using of PCs and Ethernet for the connection allows us to store most of Odrenok's on-line data in the special folder in PC as text data [2]. This folder is mounted on the all PCs of the control system. Odrenok's applications renew or add their data periodically in the text files in this folder. PC's applications can read and store these data.

There are several new graphical applications for visualization of different Odrenok's data. These applications are not operate with control and measuring electronics directly, but use only the data from different text files in the special folder. For example, there is the application for visualization of the beam orbit. This application asks Odrenok's application to read measuring electronics connected to pick-up electrodes. After reading Odrenok's application writes the data to the special text file in the folder. The application in PC reads the data, calculates and stores the bean orbit. This application provides the operator with convenient interface to show, to compare and to store the beam orbits. The screens of this application are shown in Figure 4.
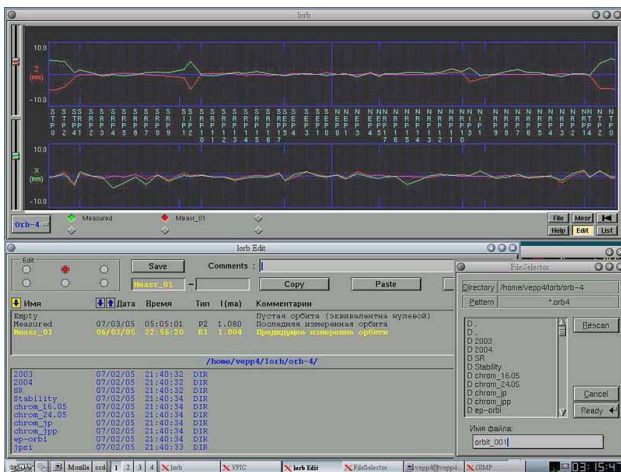

Figure 4: Visualization of VEPP-4 beam orbit.

Some measuring applications working with electronics were redeveloped for PC. This kind of applications has not many electronics, and there are no intercommunications between these applications and different applications in Odrenoks. These applications also write their measured data to the text files for exchange with different applications from Odrenoks.

Once per second the special server receives the broadcast packed with the main Odrenok's data from Odrenok's local network and stores this data in *stap.dat* text file. Many applications in PCs use this file for long storage and graphical visualisation. For example, the application forming the status screen and current diagrams in the VEPP-4 home page (v4.inp.nsk.su/~vepp4/status/Vepp4Status1.html) reads data from *stap.dat* file.

NEW ELECTRONICS INTEGRATION

Using of PCs gives a possibility for integration of modern devices to the control system.

One of the first newly integrated systems was beam image monitor [3]. This device includes CCD matrix and controller for processing of the image and data transmission. CCD matrix fix the image of the optical component of synchrotron radiation of the beam. The use of the CCD matrix allows to observe a beam spot and to obtain both transverse dimensions σ_z, σ_r, and transverse beam particles density.

The use of the PC under Linux allows us easy connection of matrix controllers to the PC via Ethernet interface card. The controller can send the image to the PC several times per second via 100 Mbit Ethernet. The packets are based on a simple home developed protocol. There are three CCD systems on the VEPP-4: for monitoring of the beams in the storage ring VEPP-3 and for monitoring of electron and positron beams in the VEPP-4 collider.

Image processing is performed with ROOT framework. ROOT has a developed library for data processing and visualisation. The picture showing screen of the VEPP-4 monitoring system is shown in Figure 5.
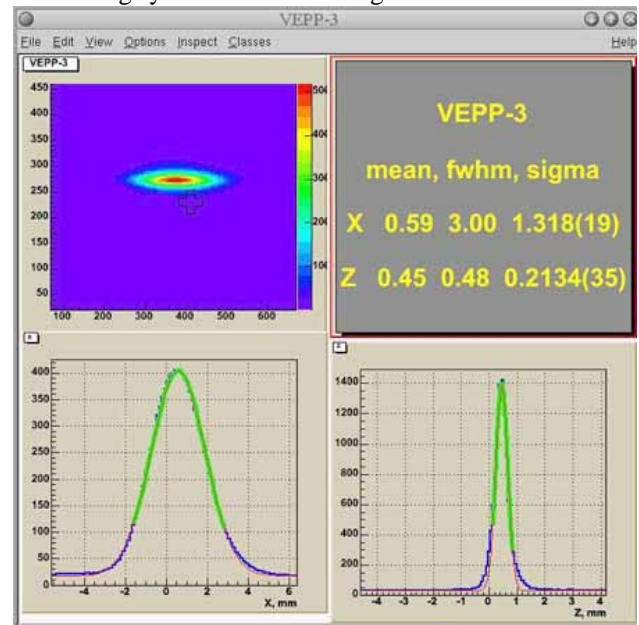

Figure 5: Visualization of beam spot.

Another new system is the temperature monitoring system. The main goal of installation of this system is

increasing of the accuracy of temperature measurements and more wide arrangement of the temperature sensors. The task of precision measurement of the beam energy and then energy approximation on the VEPP-4 collider requires total temperature measurements with accuracy more than 0.1 grad [4]. The old system provides accuracy about 1 grad only.

New temperature measurement system includes a set of controllers connected to the PC via serial link. up to 32 temperature sensors can be connected to each controller. More detail description of the temperature measurement system is presented on this conference in paper "The precision control of temperature VEPP-4M accelerator facility".

Using of PCs allows us to integrate new electronics and use high developed graphical packets for visualization. But concerning of the old electronics we have next plans to connect CAMAC crates to PC. For this purpose the special CAMAC controller is developed. The connection will be via Ethernet. This step will give us a possibility to change some of Odrenoks for PCs.

REFERENCES

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