DATA BASE AND DATA FLOW ON THE VEPP-4 CONTROL SYSTEM

S. Karnaev, A. Aleshaev, R. Basalaev, I. Belousov, B. Levichev, I. Protopopov, E. Simonov, S. Tararyshkin, BINP, Novosibirsk, Russia

Abstract

The upgraded VEPP-4 Control System is an example of the “standard model” control system with an additional node to connect a new operator console level with old executive computers. The high level of the control system will include PC based Operator Consoles (OC) (under WinNT, Win95,98) and a database server running Linux OS. Low level control is implemented with a home made CAMAC-embedded microcomputer ODRENOK [1]. This paper describes the database arrangement and a data flow between the same level computers and between the high and low levels.

1 INTRODUCTION

The Budker Institute of Nuclear Physics (BINP) of the Siberian Division of the Russian Academy of Sciences uses a VEPP-4 electron-positron collider [2] for high energy physics experiments in a wide energy range from 1 GeV to 6 GeV. Construction of the main detector is almost completed, and in the autumn-winter of 1999 VEPP-4 will start operation with this new detector. The primary goal of the physics research is to carry out experiments in the energy range from 900 MeV to 1500 MeV (the range of the charm quark and τ lepton).

The architecture of the VEPP-4 control system is shown in Fig.1.

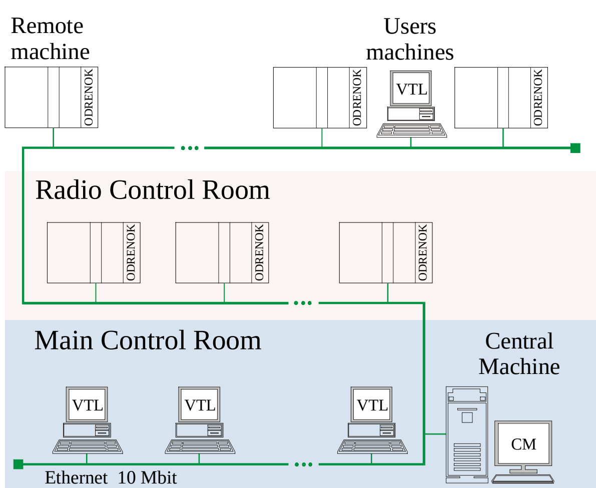

Figure 1: VEPP-4 control system lay-out.

The VEPP-4 control system currently being upgraded [1,2] by modernizing the the control system's architecture with the addition of several PC-based operator machines and has two stages [1]. A first stage is aimed at replacing the existing Central Machine (CM) which is based on the CAMAC-embedded ODRENOK computer [2] with a CM based on a PC. The second goal of the first stage is to unify intercomputer communications with Ethernet. This stage is now completed.

The upgrade is complicated because there are frequent experiments (synchrotron radiation and nuclear physics) with beam using the injection storage ring VEPP-3 [2]. Consequently we need to make the upgrade incrementally with small steps.

There is a central PC (loading and logging machine, file server), fourteen local executive ODRENOK computers and eight PC-based terminals in the main control room. All the machines are connected with Ethernet.

2 THE DATABASE

2.1 Database structure

All data needed for VEPP-4 control operations are stored in the database. The VEPP-4 facility includes 5 different accelerators and has 425 DC power supplies, 81 pulsed power supplies and 5 RF generators controlled by 14 CAMAC-embedded ODRENOK computers connected through an Ethernet network. Peripheral electronics are distributed around the facility.

The VEPP-4 database consists of three parts: the static database, the dynamic database, a STAtus Page (STAP). The database organization is shown in Fig.2.

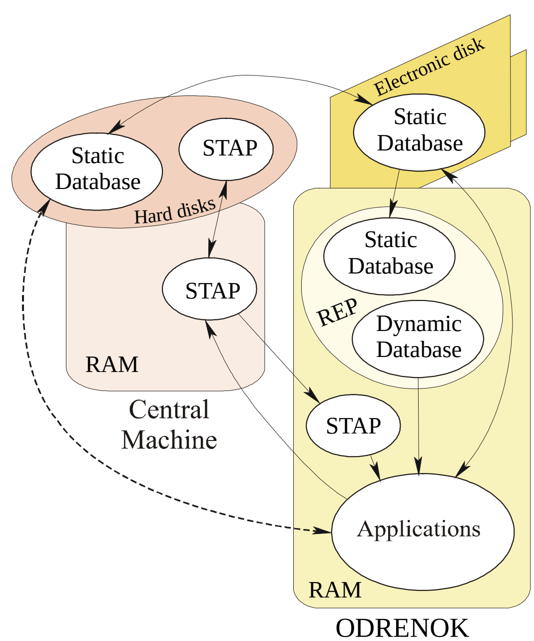

Figure 2: The VEPP-4 database arrangement.

The static database includes all control and monitor channels, all electronic boards as well as stored operations data. This data is initially located on the disk of the CM. A detailed description of the VEPP-4 database structure was presented in [2]. A corresponding part of the database that describes the control and monitor channels served by each ODRENOK is stored on electronic disk and in RAM. The database for each computer consists of several relational tables. This database organization reduces the data flow between computers.

The dynamic database includes values of all control and measurement channels and is stored in the ODRENOK computer's RAM.

We have a STAP in RAM on the central node with status information from all the control computers about different parts of the facility.

All control and monitoring applications run in corresponding computers and have simple and fast access to data on the electronic disk with an average access time of about 1 ms.

2.2 Static data

The static database structure in each ODRENOK is the same. The static database includes three parts.

One part describes the CAMAC crates with the electronic boards. This data is used by testing applications and for building the second part of database.

The second part includes control and monitoring channels. The basic element of this part of the database is the "channel", it consists of various data types: integer, real, binary, strings and arrays. At present we have more than 30 tables of channels description. There are more than 3100 channels in total. The largest database table is for the VEPP-4 collider magnet system. It consists of about 1100 channels. We have special tables with descriptions of virtual channels. These channels describe frequently or common used parameters of the accelerator or beam that require synchronous input/output of several actual control channels. Examples of virtual channels include betatron tune changes ($\Delta\nu_x$, $\Delta\nu_z$), natural chromaticity adjustment ($\Delta\xi_x$, $\Delta\xi_z$), and local orbit bumps produced by several elements of the magnetic structure or steering magnets.

A third part of the static database includes files which describe the operating modes for corresponding parts of the VEPP-4 facility. Those files contain the data sampled from the dynamic database and add data for a long time for restoring and for off-line analysis. All static database tables and files reside on the CM disk.

2.3 Dynamic data

The data collected from the equipment and the data sent to front-end control boards are logged in the dynamic database which keeps the current data for monitoring the status of the facility and equipment. Any request to set a new value for a control channel or to get a value from a monitor channel is performed by a special application named the Resident Executive Program (REP) [2] (see Fig.2) which assures we have valid values for the channels in the dynamic database. The average time to execute a CAMAC single read/write action in the ODRENOK through the REP [2] is about 0.5 ± 0.2 ms.

Data acquisition programs collect signals every 1 or 2 seconds. This period is tied to the 1 Hz injection rate of the beam into the VEPP-3 booster storage ring.

A correspondent part of the dynamic database resides in the executive programs REP in each ODRENOK.

2.4 Status data

Values of certain control and monitoring channels should be available to different computers (for instance, beam current, beam energy, and operation mode). For this purpose we use a special STAP (Status Page) box in the memory of the CM. Applications in the ODRENOK computers send fresh data directly to the corresponding cells in the STAP box on the CM. Each ODRENOK in the control system has a copy of the central STAP and applications in those computers can easily access this information. If the data in the central STAP is changed, the central computer sends a broadcast with the new data within about 1 second. Thus all of the ODRENOK computers have new information in their STAP boxes synchronously.

The length of the STAP is set to the largest size limit of an Ethernet packet, about 1500 bytes.

3 DATA FLOW

We have easy intercomputer data exchange through Ethernet. The average exchange time between two applications in different computers is about 5 ms.

There are about ten virtual terminals in the VEPP-4 control system based on PCs in the main control room. We can use those machines as virtual terminals or as graphical displays.

From the viewpoint of a data flow, there are the following kinds of data exchange in the VEPP-4 control system:

- initial loading (and reloading if necessary) of executive codes, applications and database information into the executive computers from the CM,
- data archiving (storing of a dynamic data base),
- exchange between applications and executive programs in ODRENOK computers,
- data exchange through the STAP box,
- exchange between the ODRENOK computers and virtual terminals.

Most of the data flow is inside ODRENOK computers. An optimal sharing between computers allows us significantly reduce the number of data exchanges through Ethernet.

Most applications in the ODRENOKs use static data from the electronic disks. The data flow through Ethernet between applications (in ODRENOKs) and the static database on the CM is low. In the case of the initial loading and reloading of executive codes and applications, the largest length is about 500 kbytes. The peak utilization in this case is limited by the ODRENOK's performance. In the worst-case, utilization does not exceed 60 kbyte/s.

Data archiving is not fully automated. Only in the case of temperature or vacuum failure are corresponding data, stored on the CM for further analysis. The operating modes of different parts of VEPP-4 facility are periodically stored through operator intervention.

All the above listed kinds of data flow are not regular and do not contribute to an estimation of the average rate of data flow in our Ethernet (dashed lines in Fig.2, Fig.3).

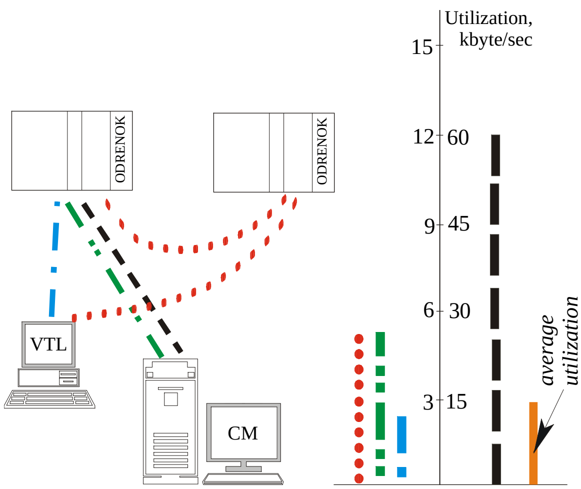

Figure 3: VEPP-4 control system intercomputer data flow and Ethernet capacity.

The next kind of data flow is between applications and executive programs in different computers. The total number of exchanges is about 10 per second. Usually in this case, the exchange length is short, so that the total data flow is not more than about 5 kbyte/s (dotted line in Fig.3).

Data flow between applications in ODRENOK computers and virtual terminals is necessary only for periodic visual data outputs. There are not many simultaneous applications using such outputs, so in this case the measured average data flow doesn't exceed 2 kbyte/s in 10 packets (dot-and-dashed line in Fig.3).

Data exchange through the STAP box is optimized with broadcasts (see subsection 2.4). In this case data flow includes one broadcast packet and about 30 short exchange packets per second between applications and the CM STAP box (double dot-and-dashed line in Fig.3).

The average data flow in the Ethernet is less than 15 kbytes/s in 50 to 60 packets. In the worst-case situation of initial data loading we have a reserve capacity factor of 20 in Ethernet utilization in packets/s and a factor of 10 in Ethernet utilization in kbytes/s [3]. Ethernet utilization is presented in Fig.3.

Our experience with data exchange through Ethernet has shown it is possible to allow high level computers on the low level Ethernet (see Fig. 4). High level applications can exchanges data directly with applications on ODRENOK computers and send requests to executive programs through the CM.

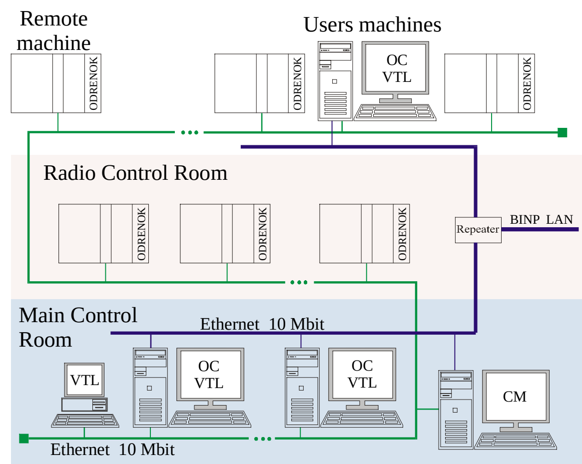

Figure 4: The second step of the VEPP-4 control system upgrade.

4 CONCLUSION

The next step in the VEPP-4 control system upgrade is a migration of the CM (database and file server the for ODRENOKs) to Linux. We plan to use SQL for designing the central database server. SQL techniques will provide data access from the programs, as well as quick access to the data and archives for our users. This step has been hastening our software development.

Future improvements will include an expansion of the high-level PCs as Operator Consoles (OC) and a transfer of applications from the executive ODRENOK computers to PCs. We also plan to construct a dedicated database of information about the VEPP-4 facility operations.

5 REFERENCES

[1] A.Aleshaev, S.Karnaev, B.Levichev, I.Protopopov, S.Tararyshkin, "VEPP-4 Control System Upgrade", ICALEPCS'97, Beijing, China

[2] A.Aleshaev, et al, "VEPP-4 Control System", ICALEPCS'95, Chicago, USA

[3] David R.Boggs, et al, "Measured Capacity of an Ethernet: Myths and Reality", WRL Research Report 88/4, Palo Alto, California, USA