DEVELOPMENT OF THE NUCLOTRON LAN

V.A. Andreev, E.A. Frolov, A.D. Kovalenko, I.I. Kulikov, B.V. Vasilishin, V.I. Volkov

Veksler and Baldin Laboratory of High Energies, JINR, Dubna, Russia

ABSTRACT

This report is dedicated to the Local Area Network of the Nuclotron - superconducting synchrotron, which is intended to accelerate nuclei and multicharged ions including the heaviest ones up to the energy of 6 GeV/u for the charge to mass ratio $Z/A = 1/2$.

The Nuclotron Control System (NCS) provided an efficient support for the machine operations during all runs. The NCS accomplishes geographically distributed tasks. Its component parts are situated in four buildings of the Laboratory and separated from each other up to 500 m.

The basis of NCS is local area Fast Ethernet network of the Nuclotron. The purpose of the Nuclotron LAN is to provide data communication between the NCS components of high rate and fault tolerance.

Overview of the NCS, the current topology and configuration of the LAN, chosen technical solutions, the characteristics of the NCS data flows, the principles of data communication between NCS components and interaction with JINR LAN are reported.

NUCLOTRON FACILITY

The superconducting synchrotron, named the Nuclotron [1] is based on miniature iron-shaped field SC-magnets. It was put into operation in March 1993 at the Veksler and Baldin Laboratory of High Energies of the Joint Institute for Nuclear Research in Dubna. 32 runs of the accelerator have been performed by the present time. There are 96 dipole, 64 quadrupole, 32 correcting multipole SC-magnets in the Nuclotron magnetic ring with a circumference of 251.5 m. The maximum value of the magnetic field is about 2 T. The accelerator cycle has the next characteristics:

- main field ramping rate   - 0.7 T/s

- repetition rate   - 0.1…0.2 Hz

- flat-top duration   - from hundreds of ms to 10 s

NUCLOTRON CONTROL SYSTEM

The Nuclotron Control System [2] in its present form comprises the following subsystems: cryogenics, thermometry, magnet diagnostics, an injection beam line, beam injection, beam diagnostics on the first turns, magnetic field correction, vacuum, circulating beam diagnostics, beam losses monitor, radio frequency, main power supplies, beam slow extraction, external beam diagnostics and radiation safety.

The NCS consists of two physical levels: an Operator Control Level and a Front End Level. The former supplies all appropriate man-machine tools for operators to run the accelerator. High performance workstations and server computers are used at this level. The workstations act as operator consoles, while the servers provide a communication process, data storage, printing utilities, a common database, alarm service, a program library, and data exchange between the Nuclotron and the users. The Front End Level comprises both industrial personal computers (IPC) with peripheral specialized data acquisition modules and intelligent CAMAC crate-controllers with embedded micro-PCs.

The NCS software complex [3] supports such functions as data acquisition, processing, storage and browsing of on-line and archive data. Now it is presented by the wide and various set of program tools and applications. Interconnection between consoles and front end computers is carried out by two ways: direct data exchange (for control and some data viewing operations) and data exchange with intermediate storing of information on the file-server (for data viewing and browsing).

THE NUCLOTRON LAN REQUIREMENTS

The NCS is a distributed system. Its component parts are situated in some buildings of the Laboratory and can be subdivided into four local groups. These groups are geographically separated by as much as 500 m.

The Nuclotron LAN is one of the most important parts of the NCS. There is a list of the main LAN requirements made conditional upon the NCS tasks and specificity:

- the LAN must communicate all the equipment groups mentioned above

- high reliability of the network

- enough carrying capacity for data exchange processes between the NCS components

- possibility of external users to access information about the accelerator cycle and beam

Average summary traffic produced by regular data exchange between the NCS components highly depends on the accelerator cycle repetition rate mentioned above in the facility description section. This value is in the interval from 200 kB/s to 400kB/s. The periodical peak load of the LAN is several times more than average traffic value on account of a concurrent exchange processes of some the NCS subsystems.

GENERAL DESCRIPTION OF THE NETWORK

The Fast Ethernet technology was chosen to construct the Nuclotron LAN. It gives a simple way to communicate local parts of the NCS in different buildings. Its capacity is quite enough to satisfy the control system demands. Also it was not so hard to make a gradual upgrade of the old Nuclotron LAN (Ethernet) to the new one.

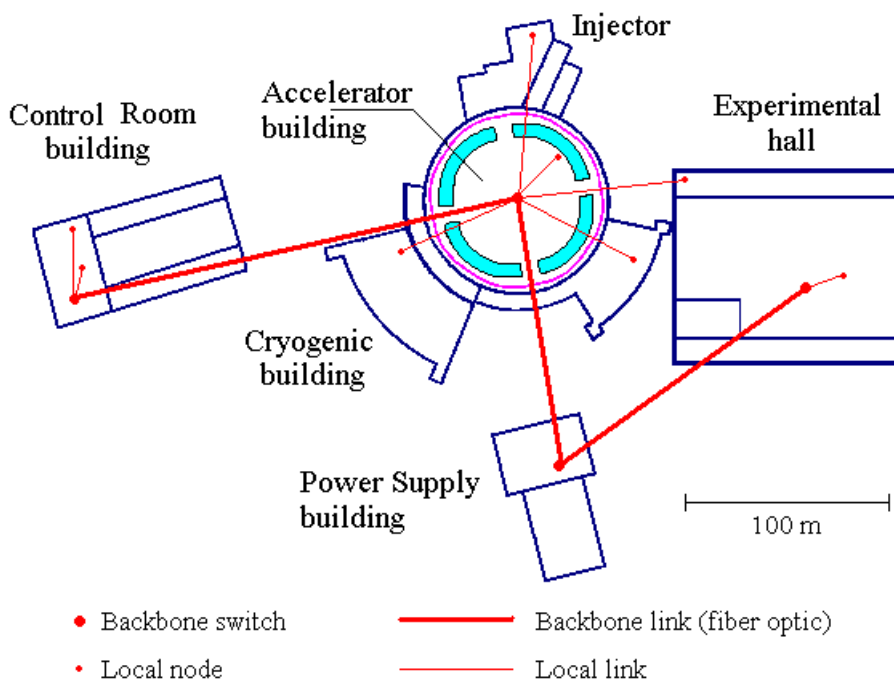Topology of the Nuclotron Fast Ethernet LAN presented in Figure 1.

Figure 1: Topology scheme of the Nuclotron LAN

As one can see, the LAN has a structure with a distributed backbone. The central nodes of the network are the 24-ports switches placed in corresponding buildings. These nodes are connected to each other in series on physical layer 100Base-FX (fiber optic cable). The cables were installed through special underground and overhead tunnels between the buildings. Local nodes such as

servers, workstations, front-end computers and mini-switches are connected to these backbone nodes forming a star topology.

The Nuclotron LAN is the subnet of the LHE/JINR Network. The gateway computer provides connection of the LAN to the JINR Network backbone as well as to the Internet. So an external user can access public data of the NCS.

THE NETWORK TECHNICALS

We chose HP ProCurve Switch 2524 model for the backbone nodes. This switch model allows to install two additional modules including optical transceivers. So the switches are connected to each other by the Gel Filled Loose Tube Distribution Rodent Protected Multimode Optic Cable (62.5 μm) in full-duplex mode. We use the HP ProCurve 100-FX SC transceivers to connect the switches by optic cable. The local nodes are linked to the backbone ones via category 5 UTP-cables (some old coaxial cable segments still exists and to be replaced by UTP ones as soon as possible).

HP NetServers are used as gateway and file servers. Novell NetWare was chosen as the most proper network operating system for the NCS principle of operation.
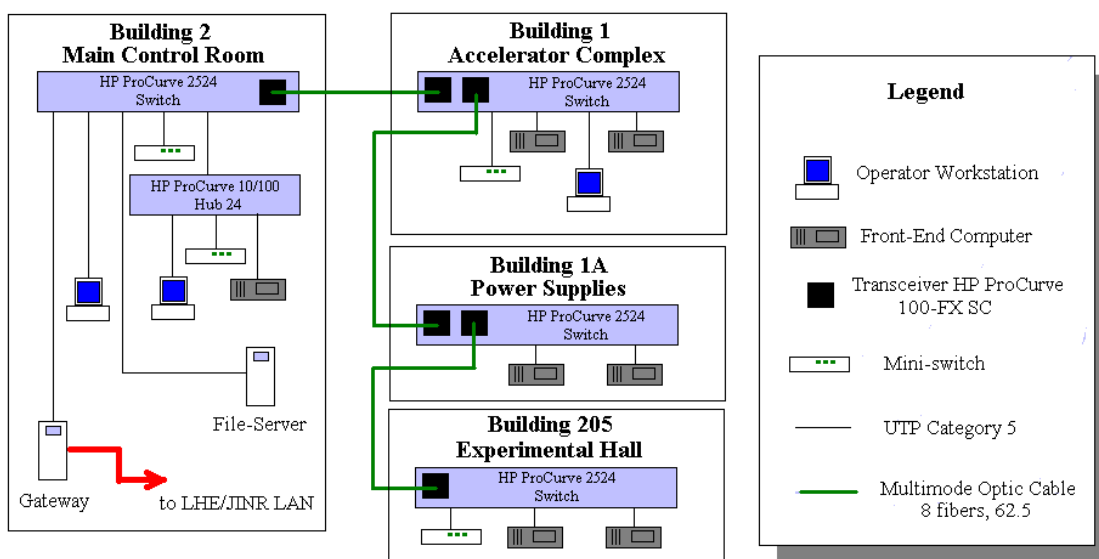

Figure 2: Structure of the Nuclotron LAN

THE NUCLOTRON LAN EXPANSION

Today the LAN communicates more than 50 computers: about 20 front-end computers and over 30 workstations. There is a tendency towards a permanent growth of the Nuclotron network caused by two factors.

The first is an expansion of the Control System. New subsystems of the NCS are developed and installed. That means increasing the number of the front-end computers as well as workstations connected to the Nuclotron LAN.

The second factor is a requirements of experimentalists. The NCS provides remote access for external users to data of the four subsystems such as thermometry, magnetic field cycle, slow extraction system and beam intensity through the Nuclotron web server. However some experimentalists prefer to be connected to the Nuclotron LAN directly. That gives a faster access to the NCS data (that is very important for some their real-time application) and an ability to use the NCS software complex. The simple way is to install additional local node of the LAN (mini-switch) in handy place to connect one or more experimentalists' computers. So some experimentalist groups were linked to the LAN in that way and have been getting proper access to the NCS subsystems data during several the accelerator runs.

We are planning to organize temporary wireless links to the Nuclotron LAN from any appropriate place in the Accelerator building and Experimental hall. It may be suitable for the NCS staff during some tuning and checkout work as well as for the experimentalists to make quick additional connection to the LAN. Now this project is being developed and equipment selection is being carried out.

CONCLUSION

The Nuclotron LAN in its present form has been working effectively for several runs of the accelerator and satisfies all the demands of the NCS. Further upgrade and expansion of the network are being worked out.

REFERENCES

[1] A.D. Kovalenko, "Nuclotron: status & future", EPAC'2000, Vienna, June 2000, v.1, p.554.
[2] V. Andreev et al, "Nuclotron Control System", PAC'97, Vancouver, May 1997, v.2, p.2452.
[3] V. Andreev et al, "Nuclotron Control System. Prospects of the program complex development", RUPAC XIX, Dubna, 2004.