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The SPS and LEP Control Network Architecture

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Abstract

This paper describes the Local Area Network for the control of SPS and LEP. It presents the network architecture, its topology and shows the criteria that contributed to the selection of the transmission medium and its implementation. It also describes different aspect of network management, the software utilities for the detection of faults and the reconfiguration process.

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1. INTRODUCTION

The data communication network is an essential element of the controls system for the LEP/SPS accelerators. The key design criteria for this network are:

- The network covers a very large site (more than 150 km²).
- The network must allow a large number of hosts (over 300 hosts).
- Some of the areas where network connections are required are not accessible during operation of the machines.
- Most of the areas have a high noise environment.

These criteria lead to the following requirements:

- Galvanic isolation between hosts.
- Flexible and powerful network management facilities.
- Capability of remotely reconfiguring the network.
- Very high reliability.

Taking into account all these desirable features, the token ring ISO 802.5 was chosen to provide the physical and MAC (Medium Access Control) layers of the data communication network. The upper software layer follows the DARPA TCP/IP specifications. Although the ISO 802.5 token ring standard provides the basic facilities, it was necessary to carry out a number of additional developments, mostly in the area of long distance transmission.

This work was done as a joint project with the IBM Research laboratories, who carried out a pioneer study on this protocol.

2. INFRASTRUCTURE

2.1 Topology

The requirements for the LEP communication network have been subdivided into three main classes according to geographical distribution of the host connections:

- Surface buildings located on eight sites situated at the top of the machine access pits. These buildings house the control equipment for

the power converters, the vacuum equipment and the cooling and ventilation plant.

- Underground areas (tunnel alcoves, 3 per octant) which contain all the controls for the beam observation and separators.
- The main control room from which both LEP and SPS are operated.

This leads to the definition of three main token ring networks for LEP controls (Fig. 1):

- The LEP Service ring which interconnects the surface buildings.
- The LEP Machine ring which interconnects the 34 underground alcoves, which can not be accessed during operation.
- The PCR ring which interconnects the consoles for operation in the main control room.

In addition to these main rings, a connection to the Ethernet segment of each of the four LEP experiments is provided by means of IP routers. The LEP Service ring and the LEP machine ring are also interconnected to the PCR ring with IP routers which will soon be replaced by more efficient token ring bridges.

2.2 Transmission

A large number of signals have to be transported round the 27 km of circumference of LEP. These include timing, TV, telephone, experimental data and the token ring.

In order to keep the number of cables and thus the cabling cost to a minimum it was decided to transport signals by means of a standard CCITT Time Division Multiplexer System (TDM). According to this, standard signals are multiplexed at various channel levels, those of main interest for this purpose being at 8.448 and 34.36 Mbit/s and can be carried over long distances.

For the transmission of the token ring signals on a TDM system two problems arose:

- **Code conversion.** The 802.5 token ring uses NRZ Manchester code while the TDM G703 uses HDB3. The code conversion has been done by a code converter called ACCI ¹⁾.

- **Frequency adaptation.** The 802.5 token ring transfers the data 4 Mbit/s, which with the Manchester code requires a clock frequency of 8 MHz compared with the channel frequency of 8.4448 MHz for the TDM G703. After a collaboration with IBM and with their approval, we have changed the token ring frequency to 4.224 Mbit/s which fits the TDM requirements.

The connection of a token ring to a TDM trunk is shown on Fig. 2.

In order to increase the transmission reliability and provide better fault isolation, the LEP Service token ring consists of a backbone token ring, with separate local rings at each of the eight concentrations of equipment, connected to the backbone by means of bridges.

This topology gives two main advantages: there is no side effect on other sites in case of a fault on a local site, and the bridge can change the bit rate to allow the use of the standard IBM 4 Mbit/s in a local ring.

The bridges use industrial PC/AT compatible machines without disks and with their programs burned in EPROM ²⁾.

To fulfill the needs for fault recovery or site isolation, a reconfiguration system has been installed using Intelligent Wiring Center (IWC) ³⁾. This IWC allows the exclusion of hosts or locking of attachment ports (Fig. 3).

The monitoring of IWC's and of the TDM is done from a dedicated computer in the control room by means of a separate and independent channel using the MIL-STD-1553B protocol. This monitoring channel can be accessed from anywhere ⁴⁾.

3. NETWORK MANAGEMENT

A satisfactory network management system should provide the following facilities, in the aim to minimise downtime:

- The recording of all events and the time they occurred.
- To test and quantify the traffic.
- To configure and manage devices such as bridges and IP routers.
- To control the access on the network.

- To provide preventive maintenance.
- To allow for extensions.
- To provide documentation.

The network management strategy is based on a relational database which is the source of all information and all actions to be taken on the network. The standard database for the LEP machine uses the ORACLE system, and this is also used for the network database.

3.1 The Database

The database has been divided into two parts: a static part, which describes all elements of the network architecture, and a dynamic part, which contains all recorded events from the network.

The static part of the database is based on the IP (Internet Protocol) addressing scheme, using five levels of hierarchy to reflect the topology.

- **Network level.** This is the description of the network, the addressing class, the medium used and the main use.
- **Subnetwork level.** If the network allows subnetting, it describes the subnet architecture.
- **Ring level.** Up to 16 rings can be declared in a subnetwork.
- **Medium attachment level.** This is the description and the location of the medium attachment unit (IWC, ACCI) on a specified ring.
- **Host level,** which describes the name, the IP address, the type of host, the port attachment on the IWC, the location and the remote monitoring parameters.

Two other levels are declared:

- **IP router level** which interconnects two networks or two subnetworks. The IP router or gateway is the result of the association of two hosts.
- **The bridge level,** which interconnects two rings from the same network or two bridges from the same subnetwork.

All events from the network are kept in the dynamic part of the database. Events are of two kinds:

- **Network events.** Transmission problems, loss of gateways or bridges, network integrity.
- **Hosts events.** Hosts leaving the ring or joining the ring, user login or out; host rebooting.

3.2 Network Management System

The network management system has been designed to comply with the following criteria:

- Network information is available everywhere without restriction.
- Acting on a host is allowed only in one specific place such as the control room.
- Network intervention or remote reconfiguration is only allowed from the network management computer.
- The PCR control room network is the central network for all intervention.
- The Oracle database is the unique reference for information concerning the topology of the network.

Hierarchical management is carried out by splitting functions between bridges, local network managers and the global network manager. (Fig. 4).

The IBM bridge software ⁵⁾ provides network management facilities based on the Medium Access Control (MAC) layer; this can be configured to be the ring configuration server, the ring parameter server and the ring error monitor.

The IBM bridge software can communicate with other products, such the IBM Netview PC, by a connection oriented protocol built above ISO 802.5 Logical Link Control (LCC).

The Local network Manager (LMGR) is connected to the bridge via this LLC channel and can manage up to 16 rings. The local network manager reports or refers to the Global Network Manager (GNETMGR). On request from the GNETMGR,

the LMGR will build the ring configuration by interrogating the bridge(s) and using the reference ring configuration table from Oracle.

All ring configurations are kept and updated by the GNETMGR so that it knows all ring states. All events that occur at the MAC level on a ring are detected by the bridges and reported to the local network manager, which will complete the information and transmit it to the global network manager. The global network manager will then update the database and generate an alarm to the operator.

All events, such as login, logout and reboot, issued from hosts are transmitted directly to the global network manager. The global network manager tests continuously all local network managers and generates alarms if local network managers are inactive.

4. MANAGEMENT TOOLS

Two programs are presently available to interrogate the state of the network:

1. A program called NETVW ⁶⁾ allows the checking of the network status and the reading of all events that occur on the network. It also allows the execution of the following commands in hosts:
 - RWHO: who is working?
 - RPS: gives the list of the active programs
 - RKILL: allows the killing of a task, if the user of netvw is the owner of that task
 - RSTART: allows the remote launching of a task

The operator is able to reboot hosts, using a dedicated console in the control room.

2. A more user friendly version, using a graphic interface, is now available on the Apollos in the control room.

5. RECONFIGURATION

To achieve high reliability for the machine operation, it was most important to implement a remote reconfiguration mechanism ⁷⁾. For this purpose, a number of MIL-STD-1553 multidrop independent channels have been installed to allow the remote control of the IWC's and the monitoring of the TDM where required.

A remote monitoring computer located in the PCR, in relationship with the global network manager, can carry out the following actions:

- The reboot of a remote host.
- Host isolation by acting on the appropriate port of the IWC.
- Site isolation.
- To bypass the token ring trunk for fault domain isolation and rapid recovery.

The TDM reconfiguration is presently under study. Its implementation would provide further facilities for reducing down-time.

The above actions can be requested from the GNETMGR, which knows all reconfiguration parameters from the ORACLE database.

6. NETWORK PROTECTION

The general concept of protection is described in Reference 8. This protection scheme is not yet installed but has a high priority. The aim is to protect the operation of the machine and avoid all uncontrolled intervention to machine parameters.

The protection scheme will be designed to have three domains (Fig. 5):

- A machine operation domain, where there are no restrictions for accessing the equipment.
- A peripheral domain, including laboratories and offices, where data taking is allowed but where control of equipment is only possible if granted by the machine operators, for a specified equipment and a determined time.

- The external domain, such as the CERN Computer Centre and outside CERN, where some channels may be privileged but where a systematic filtering of users and protocols has to be carried out.

7. CONCLUSIONS

The selection of the ISO 802.5 network standard was a challenge at the time when the decision to use it was taken. Experience has shown that it was a good choice. There are today more than 300 operational hosts on the LEP/SPS networks and 30 token ring networks around the LEP/SPS complex. The flexible implementation and the rapid start-up of the machine have both shown that the ISO 802.5 token ring network was the appropriate transmission medium for the LEP/SPS machines.

By a careful choice of industrial products and in depth exploitation of the salient features of the ISO 802.5, it was possible to build and put into operation a network management system which fulfill the requirements.

The present reliability of the transmission system, including the TDM, the Token Rings, the ACCIs and the IWCs, is shown by the integrated up time which is close to 96% after 5 months of operation. It will be further increased when the new tools under development will be available.

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REFERENCES

- 1) D. Swoboda, CERN LEP Controls Note 84 (unpublished).
- 2) Kontron Elektronik AG, Munich, West Germany PC/KAT 386.
- 3) Proton Ing. Pronet-4 Series P2700 Multistation Wire Center.
- 4) R. Rausch, CERN LEP Controls Note 88 REvised (unpublished).
- 5) The IBM Token Ring Network Bridge Program Version 1.2
- 6) J. Navratil, CERN/SPS/ACC/Note 89-13 (unpublished).
- 7) L. Guerrero, CERN LEP Controls Note 108 (unpublished).
- 8) J. Altaber, Access Protection in the LEP/SPS Control System (private communication).
- 9) C.R.C.B. Parker,

Fig. 1

LEP - SPS TOKEN RING NETWORK

TOKEN-RING LAYOUT
IN A SURFACE BUILDING

Fig. 2

RELAYS :

- b,c : Ring In , loopback
- d,e : Ring Out , loopback
- f : Port Insert,Remove
- g : Isolate Port

NETWORK MANAGEMENT HIERARCHY

Fig. 4

NETWORK PROTECTION SCHEME

Fig. 5