# Integration and usage of an Industrial Network Management System in an Accelerator Controls environment

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Abstract
In the last years the CERN accelerator networks infrastructure has been upgraded to contemporary industrial standards. A commercially available network management tool has been selected to monitor and optimise the usage of the infrastructure. HPOpenview Network Node Manager (NNM) provides concise and in-depth views of network and devices connected with their operational status. It provides instant failure detection, can supply alarm information and gathers statistics to allow proactive maintenance thus reducing network congestion and downtime. The heterogeneous community of equipment as installed around CERN's PS, SPS and LEP accelerator complex can be monitored in a uniform manner from a single entry point. The integration of a network specialist tool into the accelerator operations environment required additional developments in information reduction and presentation to create intuitive graphical displays related to the accelerators geographical and functional situation. This report describes the integration of the most recent version of the HPOpenview NNM in the CERN Accelerator's Controls System and details the accelerator controls specific developments.

## 1 THE CONTROLS NETWORK

The actual CERN controls network infrastructure is based on FDDI and Ethernet (10Mb/s and 100 Mb/s). The main protocol used is TCP/IP. A heterogeneous collection of Routers, Switches and Hubs is used to interconnect the networks, subnets and segments. The current infrastructure covers the main CERN accelerators PS[1], SPS[2], LEP[3] and the Technical Services. Future networks extensions for LHC[4] can be included in the existing network management system. The network infrastructure is an integral part of the accelerator control system. Its continuous monitoring requires a dedicated management system. A database is used to maintain the network configuration parameters.

## 2 HPOPENVIEW NNM

HPOpenview Network Node Manager (NNM) has been selected in the past to guarantee optimal performance and rapid problem detection. The NNM package is available on HP-UX and Windows NT.

The Package as delivered can be used to monitor the network and contains the basic network diagnostics tools. A development environment is available to attach specific developments in C and JAVA.

## 3 MONITORING REQUIREMENTS

### *3.1 Target audience*

Two distinct types of monitoring requirements can be defined for the control network.

- "Standard" network management facilities to be used by the network specialists.
- Accelerator specific functionality to allow integration of network management in the controls environment to be used for first line diagnostics by accelerator operators.

### *3.2 Requirement specification*

The developments described in this report were initiated by the requests from the accelerator and technical services operators as the standard NNM functionality did not fulfil all their needs. A working-group, with members from the different CERN control-rooms, has formulated the specific requirements within the scope of the existing management system.
The requests can be summarised as:

- Simplified user interface
- Simple and intuitive network views
- Alarm handling
- Single button access to diagnostics and repair tools.

### *3.3 Initial constraints*

As the CERN controls network is a multi-vendor environment the monitoring tools should be based on a standard protocol, SNMP[5]. This guarantees standard functionality in management of TCP/IP networks. The Management station is an HP-UX system. The available development environment contains MOTIF and the C programming language.

### *3.4 Selected Solution*

We build our solution around a commercially available network management system. While reusing the existing system we adapted it to the CERN specific requirements and created the software for the missing functionality.
Additions and improvements were made to:

- Graphical user interface .
- Topology discovery & display

[1] Proton Synchrotron
[2] Super Proton Synchrotron
[3] Large Electron Proton collider
[4] Large Hadron Collider

[5] Simple Network Management Protocol

- Alarm handling and Reboot

# 4 CONTROL'S FUNCTIONALITY

## 4.1 *Topology views*

The NNM supplied graphical user interface consists of network maps and tools for specialists' usage.

The CERN developed simplified topology views (Fig 1) always contain the "chain" of network elements to pass to the centre of the network (backbone), the network elements on the same level and the nodes connected to the same network element. The symbol colours allow immediate visual problems detection.

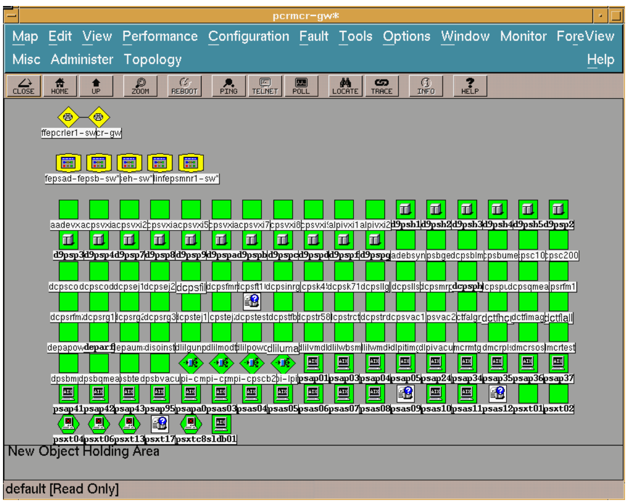


**Figure 1: Topology View**

The CERN network view (Fig 2) shows all network elements with their physical links. It is used to verify the status of all active network elements in a single view.

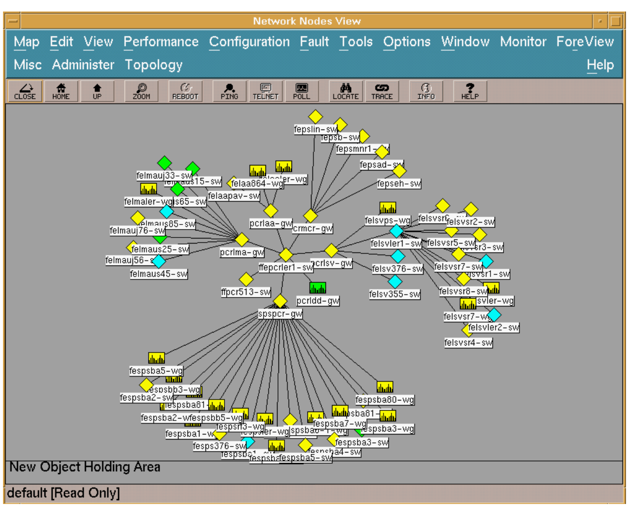


**Figure 2: Network View**

## 4.2 *Topology tools*

To build the detailed topology views, more topology information than available in NNM is required. This is the main purpose of the CERN developed tools described in this section.

### 4.2.1 *General functioning*

The topology building process includes 3 phases:

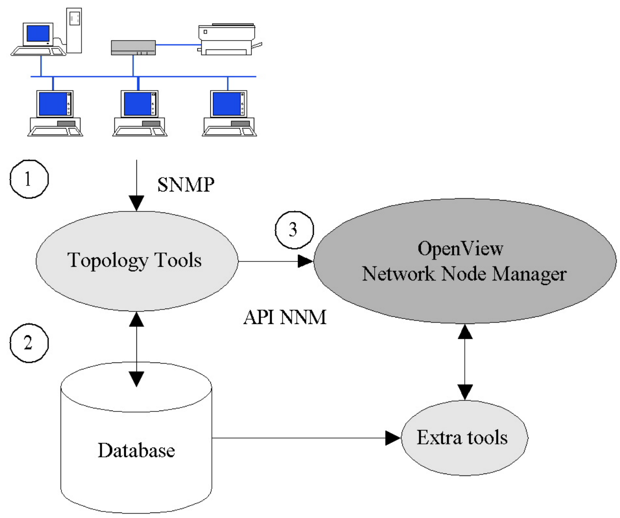


**Figure 3: Topology Tools**

1. ARP-Tables[6] and bridge-tables are collected from the network nodes using SNMP (MIB2[7]). These tables identify, for each node, the port to be used to reach a given node on the network.
2. A CERN-developed algorithm extracts and stores the tree structure in a database for future use (see 4.2.2)
3. Finally, topology views are updated using an NNM provided library[i].

### 4.2.2 *Tree extraction algorithm*

The ARP and Bridge table information fills a collection table in the database. Each row (A, B) of this table means "node A sees node B".

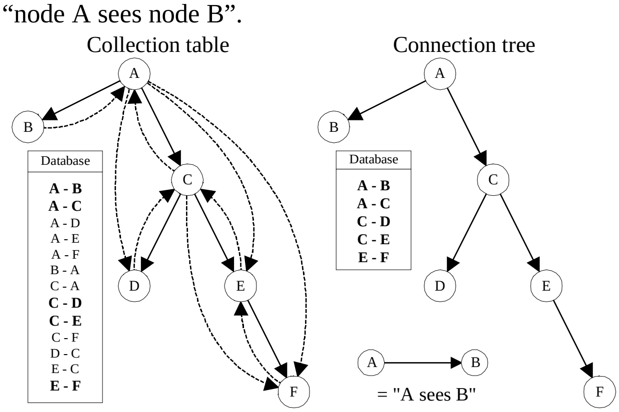


**Figure 4: Example of tree extraction**

Assuming the following hypothesis, the algorithm extracts the top-down connection tree from the table.

- Network-equipments "see" at least their directly connected nodes.

[6] Address Resolution Protocol Table
[7] Management Information Base, extension 2

- Network-equipments do not “see” higher level nodes than their direct parent.
- The root node (A) must be known.

#### 4.2.3 Additional tools

Additional tools accessible from the NNM menu bar use the topology information stored in the database:

- Locate: finds a node and loads the appropriate Detailed Topology View.
- Trace: loads the Network View and highlights the network path between two nodes.

## 5 ADDITIONAL FUNCTIONALITY

### 5.1 Alarm handling

Alarm Handling tools have been developed to link the NNM alarms and events facilities to the CERN Central Alarms System (CAS)[ii].

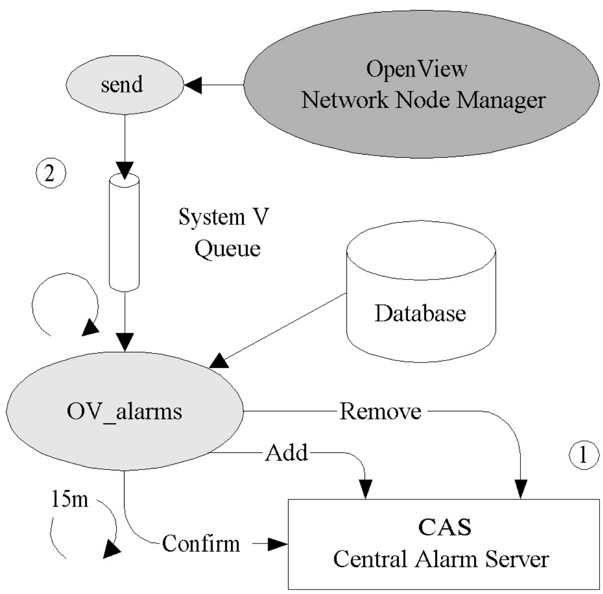


**Figure 5: Alarms Handling**

1. The main process, OV_ALARMS is a cyclic program that uses a CAS library[iii] to add, remove and confirm alarms in the control rooms. OV_ALARMS also uses data stored in the database to filter and dispatch useful alarms to the appropriate alarm screen.
2. NNM event and alarm facilities trigger execution of a command shell when an event is raised. In our case, “Node Up” and “Node Down” events trigger the SEND process, this writes an appropriate message in a Unix System V Queue. OV_ ALARMS reads the queue and updates its failing nodes list.

### 5.2 Database

The controls network database contains the description of networks, subnets and nodes. NNM and topology specific data-structures have been included to federate both information sources into a single network information base.

- Database information on a specific node can be viewed from NNM using the More Info function.

### 5.3 Reboot

Reboot uses a network independent long distance fieldbus system to send a hardwired signal to equipment to be reset.

## 6 OPERATIONAL RESULTS

The accelerator operators have participated in the specification and testing of an adapted version of the NNM. While improving the functionality it also improved the relations between the operations and networking teams through an increased mutual understanding. The simplified system allows operators to improve their ability to diagnose and solve networking problems.

## 7 CONCLUSIONS

- Commercially available products can not fulfill all the needs of an accelerator environment.
- We have integrated an industrial standard product into CERN’s controls environment by (re)using its basic qualities while improving and adding functionality. It has been successfully introduced in the SPS/LEP and TCR[8] controlrooms.
- The actual “reactive” management tools allow detection of and intervention on network errors. To prevent failures (downtime), a “proactive” management layer is required, using traffic measurements and the statistics available in the network nodes. Measurement probes, remote monitoring software (RMON[9]) and manpower are required to implement this and thus increase the quality of service offered to the networks users.

## 8 ACKNOWLEDGEMENTS

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## 9 REFERENCES

[i] HpOpenview Windows Developers Guide Hewlett Packard j1261-90002 Nov. 1998
[ii]M.Tyrrell, The LEP Alarm System, in Proc. ICALEPCS'91,pp254-259.
[iii]User Interaction with the CERN Alarm System SL-Note 93-48 (CO): C.A. Cameron

[8] Technical Control Room
[9] Remote MONitoring