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**LNF-94/022 (NT)  
28 Aprile 1994**

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**THE HEWLETT PACKARD CLUSTER CONFIGURATION**

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## **THE HEWLETT PACKARD CLUSTER CONFIGURATION**

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### **1 Introduction**

The increasing request of computing power coming from High Energy Physics has determined the interest of the Scientific Community toward the RISC technology, that in the last years is substituting the CISC technology.

Hewlett Packard Company offers the workstation family HP 9000/7xx, with architecture RISC, operating under HP-UX, based on Unix.

In this note the hardware and software configuration of the L.N.F. HP 9000/7xx cluster is shown together with the system adopted implementation, the Cluster Operating System and the Software Configuration.

### **2 Hardware Configuration**

The Hewlett Packard cluster available at LNF includes 7 HP 9000/7xx, with hardware configuration shown in Tab.1.

The workstation HP 9000/7xx are in the *Edificio Alte Energie*, and are located in different places inside the building; for this reason the Network connection to the LAN (Local Area Network) uses two different **Thin Wire Ethernet** that are connected to the **LNF Ethernet**

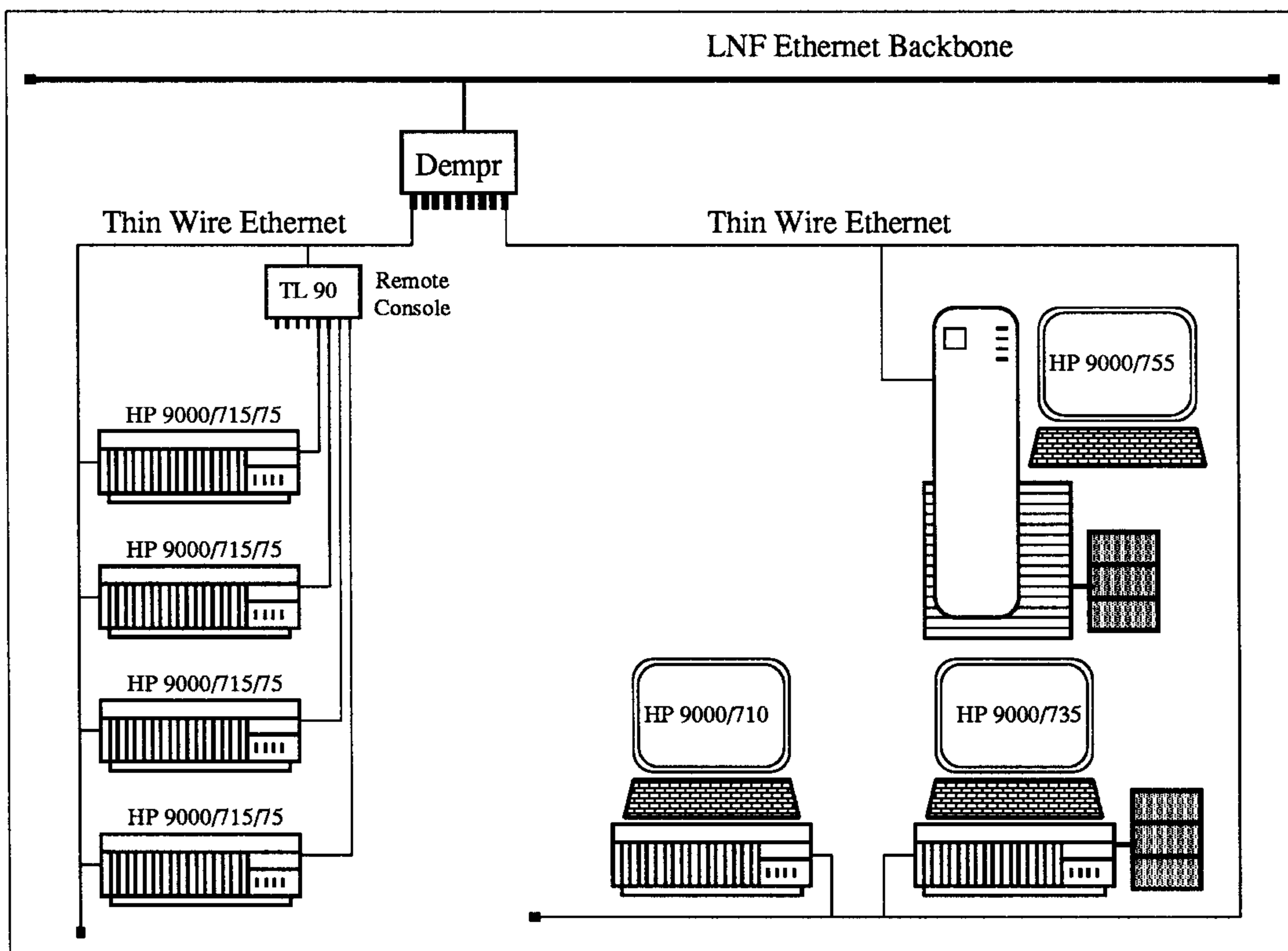


Figure 1: Hardware Configuration

It is possible for cluster clients to have their own disks drives. These can hold file systems (but not root file system, which must be on the cluster server) or swap space, or both.

### Context-Depend Files

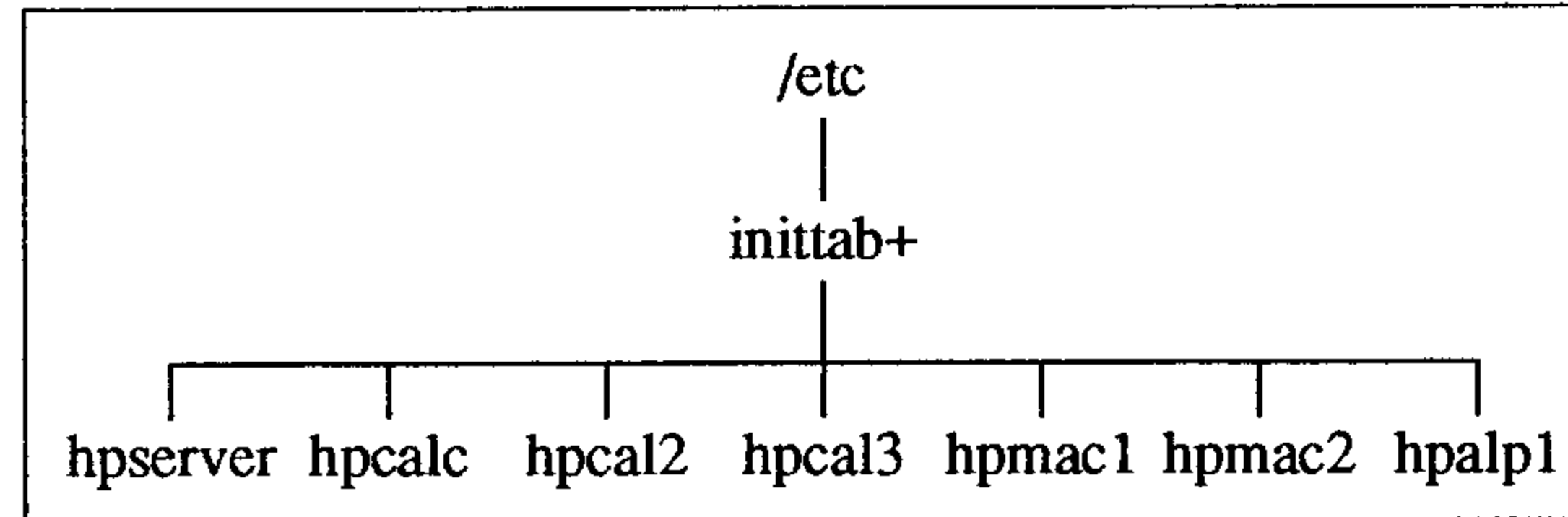
The basic idea of the HP-UX cluster, is that even though all cluster nodes in a cluster share the same file system, there are some files that must be not shared. Some examples of files whose contents should not or cannot be shared are device files and files that contain system setup script, such as `/etc/inittab`.

To allow file specific to a cluster node or a class of a cluster nodes, Hewlett Packard has developed **context-depend files**. A context depend file (or CDF) is a mechanism for allowing to different cluster nodes to see different contents for a file that has the same name on all cluster nodes. It is really a directory that looks like a file<sup>1</sup>.

For example, all the elements of the CDF `/etc/inittab` correspond to the name of each node in the cluster, so that each element matches a cluster node name, as shown in Fig.2.

The + appended to the file name `inittab` in Fig.2 is not really part of the file name. It is an

<sup>1</sup>A directory can itself be a CDF, and in that case it's a nest of directories that looks like a single directory.



**Figure 2: /etc/inittab in a Cluster**

escape mechanism that allow to access explicitly an element of the CDF.

### **Cluster Server Processes (CSPs)**

Cluster Server Processes (CSPs) are kernel processes that handle requests from remote cluster nodes (or by certain local activities).

CSP functions include:

- All file system requests (e.g., opens, reads, writes, mount table updates).
- Swap space allocation requests.
- Sync requests.
- PID (Process ID) allocation.

There are three different types of Cluster Server Processes: Limited CSPs (LCSP), General CSPs (GCSP), and User CSPs (UCSP).

The limited and general CSPs are kernel processes. Even though these are processes that run in the kernel, they are shown by the Print Status command (ps).

A User CSP is a special program that runs in user address space to perform some operation on behalf of the kernel.

### **Process IDs (PIDS)**

Processes executing on different cluster nodes in a cluster must have unique Process IDs because many HP-UX programs use the PID in temporary file names.

In a cluster, the cluster root server allocates PIDs for the cluster clients. To save the network traffic that would be caused if a cluster client had to go to the root server for each PID, PIDs are allocated in “chunks” of 50 at a time.

Each cluster node keeps tracks of the PID chunks allocated to it and maintains a table of available PIDs. PIDs in this table are not recycled, but once a whole PID “chunks” is free, all 50 PIDs are returned to the server and may then be reallocated to another cluster node.

Certain PID numbers are reserved for the kernel processes, and in this cases the same process will have the same PID number on every node in the cluster. For example, /etc/init always has a PID of 1.

#### **4 Software Configuration**

A large part of the software installed on the HP-Cluster comes from the Internet Community as Free Software. The software configuration has been implemented following the users needs; this task has requested the tailoring of the available software in form of *Machine Independent Code*, to the characteristics of the HP-Cluster.

The main package available on the HP-Cluster are listed below with a short description.

##### **HP Software**

**HP Fortran 9000** HP FORTRAN 9000 is Hewlett Packard’s implementation of the ANSI 77 standard FORTRAN language, running on HP 9000 HP-UX system. In addition to being ANSI 77 standard, HP FORTRAN/9000 conforms to the following standards:

- MIL-STD-1753
- FIPS PUB 69-1
- ISO 1539-1980(E) standards

**HP C/ANSI C** HP C originates from the C language designed in 1972 by Dennis Riechie at Bell Laboratories. The ANSI mode is a conforming implementation of ANSI C, as specified by American National Standard X3.129-1989.

##### **CERN Software**

The CERN program library is a large collection of general-purpose programs maintained and offered in both source and object by the CERN computer center. Most of the software is developed at CERN and is therefore oriented towards the needs of a physics research laboratory. Documentation is available on /cern/ps.dir in compressed format.

##### **Network Queueing System**

The Network Queueing System (NQS) batch system has been installed on LNF - HP Cluster and is used for batch job submission. A NQS job is a series of Unix commands combined in a

Shell script. The NQS on HP Cluster distinguishes between two types of queues:

**Batch queue:** Batch queues are defined on each system in NQS domain. Each queue has different resources limits, in particular the CPU time.

**Pipe queue:** Pipe queues are a mechanism to distribute jobs and balance the workload evenly over the destination servers. Users submit to the pipe queue, and the load balancing software in NQS finds an empty server in which the job has to be run. If all servers are full, then the job is put on wait. If more than one job is on wait, then the next job to be started is determined by an intelligent script which is aware of the current state of running and queued jobs.

### **T<sub>E</sub>X and L<sub>A</sub>T<sub>E</sub>X text processing**

T<sub>E</sub>X[1, 2] is a text processing system developed by Donald E. Knuth of Stanford University to compose by computer high quality documents, especially those containing many mathematical formulae.

T<sub>E</sub>X is generally considered the most sophisticated computer typesetting system, as well as (for an experienced user) one of the easiest to use. L<sub>A</sub>T<sub>E</sub>X is a macro package built on top of T<sub>E</sub>X.

Fundamental to L<sub>A</sub>T<sub>E</sub>X is the idea of a **document style** which determines exactly how a document will be formatted. L<sub>A</sub>T<sub>E</sub>X provides standard document styles that describe how standard logical elements should be printed. One may have to supplement these styles by specifying the formatting of logical structures peculiar to a given document such as mathematical formulae.

### **GNU Software**

GNU stands for **Gnu's is Not Unix** and is the name for a complete Unix-compatible software system developed by the Free Software Foundation. Some large part of this system is already available. Interesting GNU programs installed on the HP Cluster are on /usr/local/gnu/bin :

**emacs** GNU Emacs is a powerful editor in the Unix environment. Emacs is available on nearly all Unix platforms, like AIX (IBM), HP-UX (Hewlett Packard) and Ultrix (Digital). We have only hp-ux running.

Unlike most of the other editors, emacs is a complete working environment. One can start emacs in the morning, work all day and night, and never leave it. It can be used to edit, rename, delete and copy files; to compile programs; to work interactively with the Unix shell, and so on. Before windowing system like x became popular, emacs often served as a complete windowing environment.

**gcc - g++** GNU project C and C++ Compiler

**gdb** GNU C and C++ Debugger

**GNU C Lib** The Posix.1 C library

**libg++** C++ class library

**Ghostscript (gs)** A PostScript interpreter

**ghostview** X11 user interface for Ghostscript

**gnuplot** An interactive plotting program

**less** A better pager

### **Other Software**

**tcsh** C shell with file name completion and command line editing

**XtoPS** Allow to dump an image of a X window as encapsulated PostScript

**a2ps** Formats a ascii file for printing on a PostScript printer

**pstops** Shuffle pages in a PostScript file

**ps2a5** Allows to print 2 pages per sheet

**psbook** Rearranges pages in PostScript file into signatures

**psbb** Extracts bounding box from PostScript document

**psnup** Uses pstops to merge multiple pages per sheet

**psselect** Select pages from a PostScript file

**www** WorldWideWeb wide area hypertext browser for dumb terminals

**xmosaic** WorldWideWeb wide area hypertext browser under X11

**tgif** Xlib based interactive 2-D drawing facility under X11. Supports hierarchical construction of drawings and easy navigation between sets of drawings. It can also be used to launch applications.

**3270** IBM 3277/3278 terminal emulator

**x3270** IBM remote host access tool

## References

- [1] D.E.Knuth, the *T<sub>E</sub>Xbook*, Addison-Wesley, Reading, (1990)
- [2] D.E.Knuth, *Computers and typesettings*, Vol. A-E, Addison-Wesley, Reading, (1986)

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