SuSE

SuSE Linux

ADMINISTRATION GUIDE

2nd edition 2004

Please direct suggestions and comments to documentation@suse.de

Authors:	Frank Bodammer, Stefan Dirsch, Olaf Donjak, Torsten Duwe, Roman Drahtmüller, Thorsten Dubiel, Karl Eichwalder, Thomas Fehr, Stefan Fent, Werner Fink, Kurt Garloff, Carsten Groß, Andreas Grünbacher, Franz Hassels, Andreas Jaeger, Klaus Kämpf, Hubert Mantel, Anas Nashif, Johannes Meixner, Lars Müller, Matthias Nagorni, Peter Pöml, Siegfried Olschner, Heiko Rommel, Marcus Schaefer, Nikolaus Schüler, Klaus Singvogel, Hendrik Vogelsang, Klaus G. Wagner, Christian Zoz
Translators:	Daniel Pisano, Tino Tanner, Olaf Niepolt
Editors:	Jörg Arndt, Antje Faber, Berthold Gunreben Roland Haidl, Jana Jaeger, Edith Parzefall, Peter Reinhart, Thomas Rölz Marc Rührschneck, Thomas Schraitle, Rebecca Walter
Layout:	Manuela Piotrowski, Thomas Schraitle
Setting:	LaTeX

This book has been printed on 100 % chlorine-free bleached paper.

Contents

Preface 1

New Features in the Administration Guide 2

Typographical Conventions 3

A Word of Thanks 3

I Installation **5**

1 The Installation **7**

Text-Based Installation with YaST 8

The Start Screen 8

The Basis: linuxrc 9

Starting SuSE Linux 15

The Graphical SuSE Screen 15

Special Installation Procedures 17

Installation Without CD-ROM Support 17

Installation from a Network Source 17

Tips and Tricks 19

Creating a Boot Disk in DOS 19

Creating a Boot Disk in a UNIX-Type System 20

Booting from Disk (SYSLINUX) 21

Using CD 2 for Booting 22

Supported CD-ROM Drives 22

ATAPI CD-ROM Hangs While Reading 22
Partitioning for Experts 23
Size of Swap Partition 24
Utilization of the Computer 24
Optimizations 26
LVM Configuration with YaST 28
Logical Volume Manager (LVM) 29
LVM Configuration with YaST 30
LVM — Partitioning 30
Logical Volumes 34
Soft RAID 35
Common RAID Levels 36
Soft RAID Configuration with YaST 37

2 Updating the System and Package Management 39
Updating SuSE Linux 40
Preparations 40
Updating with YaST 42
Manual Update 42
Updating Individual Packages 44
Software Changes from Version to Version 45
From 7.3 to 8.0 45
From 8.0 to 8.1 46
From 8.1 to 8.2 48
From 8.2 to 9.0 49
RPM — the Package Manager 49
Verifying Package Authenticity 50
Managing Packages: Install, Update, and Uninstall 51
RPM and Patches 52
RPM Queries 54
Installing and Compiling Source Packages 56
Compiling RPM Packages with build 58
Tools for RPM Archives and the RPM Database 59

II Configuration 61

3 YaST in Text Mode (ncurses) 63
- Usage . . . 64
- Using the Modules . . . 65
- Starting the Individual Modules . . . 66
- YaST Online Update . . . 67

4 Booting and Boot Managers 69
- Booting a PC . . . 70
- Boot Concepts . . . 71
- Map Files, GRUB, and LILO . . . 72
- Booting with GRUB . . . 73
  - The GRUB Boot Menu . . . 74
  - The File device.map . . . 78
  - The File /etc/grub.conf . . . 79
  - Setting a Boot Password . . . 80
  - Troubleshooting and Further Reading . . . 81
- Booting with LILO . . . 82
  - Basics . . . 82
  - Configuring LILO . . . 83
  - Structure of lilo.conf . . . 84
  - Installing and Uninstalling LILO . . . 87
- Uninstalling the Linux Boot Loader . . . 88
  - Restoring the MBR (DOS/Win9x/ME . . . 89
  - Restoring the MBR of Windows XP . . . 89
  - Restoring the MBR of Windows 2000 . . . 89
  - Booting Linux after Restoring the MBR . . . 90
- Creating Boot CDs . . . 90
  - Boot CD with ISOLINUX . . . 91

5 The X Window System **93**

Historical Background 94

Version 4.x of XFree86 94

Advantages 95

Configuration Using xf86config 96

Mouse 96

Keyboard 97

Monitor 98

Graphics Cards and X Server 99

Saving Your Configuration 104

Optimizing the Installation of the X Window System 105

Screen Section 107

Device Section 108

Monitor Section 109

Integrating Additional (True Type) Fonts 110

OpenGL — 3D Configuration 113

Hardware Support 113

OpenGL Driver 114

The Diagnosis Tool 3Ddiag 114

OpenGL Test Applications 114

Troubleshooting 114

Installation Support 115

Additional Online Documentation 115

6 Printer Operation **117**

Printing Basics 118

Important Standard Printer Languages 118

Processing Print Jobs 118

Various Printing Systems 121

Preconditions for Printing 122

General Requirements 122

Finding the Right Printer Driver 122

- The Issue with GDI Printers . . . 124
Configuring a Printer with YaST . . . 126
- Print Queues and Configurations . . . 126
- Printer Configuration with YaST: The Basics . . . 126
- Automatic Configuration . . . 128
- Manual Configuration . . . 129
Configuring Applications . . . 131
Manual Configuration of Local Printer Ports . . . 132
- Parallel Ports . . . 132
- USB Ports . . . 134
- The IrDA Printer Interface . . . 136
- Serial Ports . . . 136
Manual Configuration of LPRng and lpdfilter . . . 137
The LPRng Print Spooler . . . 137
- Printing from Applications . . . 138
Command-Line Tools for LPRng . . . 138
- Managing Local Queues . . . 139
- Managing Remote Queues . . . 141
- Using Command-Line Tools for LPRng Troubleshooting . . . 142
The Print Filter of the LPRng and lpdfilter Printing System . . . 142
- Configuration of lpdfilter . . . 144
- Customization of lpdfilter . . . 144
- Troubleshooting Hints for lpdfilter . . . 151
The CUPS Printing System . . . 152
- Naming Conventions . . . 152
- IPP and Server . . . 152
- Configuration of a CUPS Server . . . 153
- Network Printers . . . 154
- Internal CUPS Print Job Processing . . . 155
- Tips and Tricks . . . 157
Printing from Applications . . . 158
Command-Line Tools for the CUPS Printing System . . . 159

Managing Local Queues 159
Managing Remote Queues 161
Using Command-Line Tools for CUPS Troubleshooting 162
Working with Ghostscript 163
Sample Operations with Ghostscript 164
Working with a2ps 166
Using a2ps to Prepare a Text File for Printing 167
Reformatting PostScript with psutils 167
psnup 168
pstops 168
psselect 170
Using Ghostscript to View the Output 171
ASCII Text Encoding 171
A Sample Text 171
Printing in a TCP/IP Network 173
Terminology 173
Quick Configuration of a Client Machine 174
Protocols for Printing in TCP/IP Networks 175
Filtering for Network Printers 181
Remote Printer Troubleshooting 188
Print Servers Supporting Both LPD and IPP 191

7 Hotplugging Services **193**
Hotplugging in Linux 194
Hotplugging and Coldplugging 194
USB 195
PCI and PCMCIA 196
Network 197
Other Devices and Further Development 198

8 Configuring and Using Laptop Computers 199

PCMCIA 200

The Hardware 200

The Software 200

Configuration 202

Switching Configurations — SCPM 204

Troubleshooting 204

Installation via PCMCIA 208

Other Utilities 209

Updating the Kernel or PCMCIA Package 209

For More Information 210

SCPM – System Configuration Profile Management 210

Basic Terminology and Concepts 211

SCPM YaST Module and Additional Documentation 211

Configuring SCPM 212

Creating and Managing Profiles 212

Switching Configuration Profiles 213

Advanced Profile Settings 214

Profile Selection during Boot 215

Common Problems and Solutions 216

APM and ACPI — Power Management 217

Power Saving Functions 217

APM 219

ACPI 221

Rest for the Hard Disk 229

IrDA — Infrared Data Association 230

Software 231

Configuration 231

Usage 231

Troubleshooting 232

III System 235

9 SuSE Linux on AMD64 Systems 237

64-bit SuSE Linux for AMD64 . . . 237

Hardware . . . 237

Software . . . 238

Installation of 32-bit Software . . . 238

Software Development in a 64-bit Environment . . . 238

Additional Information . . . 239

10 The Linux Kernel 241

Kernel Update . . . 242

Kernel Sources . . . 243

Kernel Configuration . . . 243

Kernel Modules . . . 244

Settings in the Kernel Configuration . . . 247

Compiling the Kernel . . . 247

Installing the Kernel . . . 248

Cleaning Your Hard Disk After Compilation . . . 249

11 Special Features of SuSE Linux 251

Linux Standards . . . 252

File System Hierarchy Standard (FHS) . . . 252

Linux Standard Base (LSB) . . . 252

teTeX — TEX in SuSE Linux . . . 252

Example Environments for FTP and HTTP . . . 252

Hints on Special Software Packages . . . 253

Package bash and /etc/profile . . . 253

cron Package . . . 253

Log Files — the Package logrotate . . . 254

Man Pages . . . 256

The Command ulimit . . . 256

The free Command . . . 257

The File /etc/resolv.conf 257
Settings for GNU Emacs 258
Booting with the Initial Ramdisk 259
Concept of the Initial Ramdisk 259
The Order of the Booting Process with initrd 259
Boot Loaders 260
Using initrd in SuSE 261
Possible Difficulties — Self-Compiled Kernels 262
Prospects 263
linuxrc 263
The SuSE Rescue System 267
Preparations 268
Starting the Rescue System 270
Working with the Rescue System 271
Virtual Consoles 274
Keyboard Mapping 274
Local Adjustments — I18N/L10N 275

12 The SuSE Linux Boot Concept **279**
The init Program 280
Runlevels 280
Changing Runlevels 282
Init Scripts 283
Adding init Scripts 285
The YaST Runlevel Editor 286
SuSEconfig and /etc/sysconfig 288
The YaST sysconfig Editor 289

IV Network 291

13 Linux in the Network 293

TCP/IP — The Protocol Used by Linux . . . 294
Layer Model . . . 295
IP Addresses and Routing . . . 297
Domain Name System . . . 300
IPv6 — The Next Generation's Internet . . . 302
A New Internet Protocol . . . 302
Advantages of IPv6 . . . 302
The IPv6 Address System . . . 304
IPv4 versus IPv6 — Moving between the Two Worlds . . . 308
Further Reading and Links . . . 310
Network Integration . . . 311
Preparing . . . 311
Configuration Assisted by YaST . . . 311
Hotplug and PCMCIA . . . 313
Configuring IPv6 . . . 313
Manual Network Configuration . . . 314
Configuration Files . . . 315
Start-Up Scripts . . . 321
Routing in SuSE Linux . . . 321
DNS — Domain Name System . . . 323
Starting the Name Server BIND . . . 323
The Configuration File /etc/named.conf . . . 324
Secure Transactions . . . 331
Dynamic Update of Zone Data . . . 333
DNSSEC . . . 333
Further Reading . . . 333
LDAP — A Directory Service . . . 334
LDAP versus NIS . . . 335
Structure of an LDAP Directory Tree . . . 336

Server Configuration with slapd.conf 339
Data Handling in the LDAP Directory 344
LDAP Configuration with YaST 348
For More Information 355
NIS — Network Information Service 358
NIS Master and Slave Server 358
The NIS Client Module of YaST 361
NFS — Shared File Systems 363
Importing File Systems with YaST 363
Importing File Systems Manually 363
Exporting File Systems with YaST 364
Exporting File Systems Manually 364
DHCP 367
The DHCP Protocol 367
DHCP Software Packages 367
The DHCP Server dhcpd 368
Hosts with Fixed IP Addresses 370
For More Information 370
Time Synchronization with xntp 372
Configuration in a Network 372
Establishing a Local Time Normal 373

14 The Apache Web Server **375**
Basics 375
Web Server 375
HTTP 375
URLs 375
Automatic Output of a Default Page 376
What Is Apache? 376
The Most Popular Web Server 376
Expandability 377
Customizability 377

Stability 377

Features 377

Basics 378

Differences between Apache 1.3 and Apache 2 378

Overview 378

What is a Thread? 379

Threads and Processes 380

Conclusion 380

Installation 380

Package Selection in YaST 380

Activating Apache 381

Modules for Active Contents 381

Other Recommended Packages 381

Installation of Modules with apxs 382

Configuration 382

Configuration with SuSEconfig 383

Manual Configuration 384

Using Apache 388

Where Can I Place My Pages and Scripts? 388

Apache Operating Status 388

Active Contents 388

Overview 388

Script Interpreter as Module versus CGI 389

SSI 389

CGI 390

What Is CGI? 390

Advantages of CGI 390

GET and POST 390

Languages for CGI 391

Where Are the Scripts Placed? 391

Generating Active Contents with Modules 391

Modules for Scripting Languages 391

mod_perl . . . 392
mod_php4 . . . 394
mod_python . . . 394
mod_ruby . . . 395
Virtual Hosts . . . 395
Overview: Virtual Hosts . . . 395
Name-Based Virtual Hosts . . . 395
IP-Based Virtual Hosts . . . 397
Multiple Instances of Apache . . . 398
Security . . . 398
Minimizing the Risk . . . 398
Access Permissions . . . 399
Stay Updated . . . 399
Troubleshooting . . . 399
Further Documentation . . . 400
Apache . . . 400
CGI . . . 400
Security . . . 401
Additional Sources . . . 401

15 File Synchronization 403
Data Synchronization Software . . . 404
InterMezzo . . . 404
Unison . . . 405
CVS . . . 405
mailsync . . . 405
Determining Factors for Selecting a Program . . . 405
Client-Server vs. Peer-to-Peer . . . 405
Portability . . . 406
Interactive vs. Automatic . . . 406
Speed . . . 406
Conflicts: Incidence and Solution . . . 406

Selecting and Adding Files 407
History 407
Data Volume and Hard Disk Requirements 407
GUI 407
User Friendliness 408
Security Against Attacks 408
Protection Against Data Loss 408
Introduction to InterMezzo 409
Architecture 409
Configuring an InterMezzo Server 410
Configuring InterMezzo Clients 411
Troubleshooting 411
Introduction to Unison 412
Uses 412
Requirements 412
Using Unison 412
More Information 413
Introduction to CVS 414
Uses 414
Configuring a CVS Server 414
Using CVS 415
More Information 416
Introduction to mailsync 416
Uses 416
Configuration and Use 416
Possible Problems 419
More Information 419

16 Heterogenous Networks **421**

Samba . . . 422

Installing and Configuring the Server . . . 423

Samba as Login Server . . . 427

Installing Clients . . . 428

Optimization . . . 429

Netatalk . . . 430

Configuring the File Server . . . 431

Configuring the Print Server . . . 434

Starting the Server . . . 435

Netware Emulation with MARSNWE . . . 437

Starting the Netware Emulator MARSNWE . . . 437

The Configuration File /etc/nwserv.conf . . . 437

Access to Netware Servers and Their Administration . . . 440

IPX Router with ipxrip . . . 440

17 Internet **441**

The smpppd as Dial-up Assistant . . . 442

Program Components for the Internet Dial-Up . . . 442

Configuring the smpppd . . . 442

Configuring kinternet and cinternet for Remote Use . . . 443

Configuring an ADSL or T-DSL Connection . . . 444

Default Configuration . . . 444

DSL Connection by Dial-on-Demand . . . 444

Proxy Server: Squid . . . 445

About Proxy Caches . . . 445

Some Facts About Cache Proxying . . . 446

System Requirements . . . 448

Starting Squid . . . 449

The Configuration File /etc/squid/squid.conf . . . 450

Transparent Proxy Configuration . . . 455

Squid and Other Programs . . . 458

More Information about Squid . . . 462

18 Security in the Network **463**

Masquerading and Firewalls 464

Masquerading Basics 464

Firewalling Basics 466

SuSEfirewall2 466

SSH — Secure Shell, the Safe Alternative 470

The OpenSSH Package 470

The ssh Program 471

scp — Secure Copy 471

sftp — Secure File Transfer 472

The SSH Daemon (sshd) — Server-Side 472

SSH Authentication Mechanisms 473

X, Authentication, and Other Forwarding Mechanisms 474

Network Authentication — Kerberos 475

Kerberos Terminology 476

How Kerberos Works 477

Users' View of Kerberos 480

For More Information 481

Installing and Administering Kerberos 481

Choosing the Kerberos Realms 482

Setting up the KDC Hardware 482

Clock Synchronization 483

Log Configuration 484

Installing the KDC 484

Configuring Kerberos Clients 486

Remote Kerberos Administration 489

Creating Kerberos Host Principals 491

Enabling PAM Support for Kerberos 492

Configuring SSH for Kerberos Authentication 493

Using LDAP and Kerberos 494

Security and Confidentiality 496

Basic Considerations 496

Local Security and Network Security 497

Some General Security Tips and Tricks 505

Using the Central Security Reporting Address 507

V Appendixes 509

A File Systems in Linux 511
Glossary . . . 512
Major File Systems in Linux . . . 512
Ext2 . . . 513
Ext3 . . . 514
ReiserFS . . . 515
JFS . . . 516
XFS . . . 517
Some Other Supported File Systems . . . 518
Large File Support in Linux . . . 519
For More Information . . . 520

B Access Control Lists in Linux 521
Advantages of ACLs . . . 522
Definitions . . . 523
Handling ACLs . . . 523
Structure of ACL Entries . . . 524
ACL Entries and File Mode Permission Bits . . . 524
A Directory with Access ACL . . . 526
A Directory with a Default ACL . . . 529
The ACL Check Algorithm . . . 532
Outlook . . . 532

C Manual Page of e2fsck 535

D Manual Page of reiserfsck 539

E The GNU General Public License 543

Bibliography 551

Preface

The *Administration Guide* offers an introduction to the technology of SuSE Linux, providing details about the installation, system administration, and the configuration of special system components. It also introduces the theoretical basics of certain properties of Linux and especially of SuSE Linux, including background information about the X window system, the boot concept, printing, and the Linux kernel.

Working with and in networks has always been one of the main strengths of Linux. Therefore, a large portion of the book is dedicated to the theory, configuration, and administration of networks and their various services. Learn about various protocols, routing, NFS and NIS, heterogeneous networks with Samba and Netatalk, and proxies. The final chapter extensively covers the issue of security in networks.

We are confident that the Open Source policy, the boot concept, the easy installation, the stable and secure network operation, and the extremely flexible X11 environment will do their part to convince you that your SuSE Linux is the superior operating system! The digital versions of both SuSE Linux manuals can be accessed by way of the SuSE Help System under SuSE Linux.

New Features in the Administration Guide

This section lists the changes to the documentation from the last version to the current one:

- The GRUB Section in the bootloader chapter has been reorganized and includes some additional details (see Section *Booting with GRUB* on page 73).
- There are major additions to the printing chapter (see Section *Printing in a TCP/IP Network* on page 173).
- The sound chapter has been moved to the *User Guide*.
- There are some minor additions to the notebook chapter which are related to SCPM and power management (see Chapter *Configuring and Using Laptop Computers* on page 199).
- The introduction to IPv6 has been completely rewritten (see Section *IPv6 — The Next Generation's Internet* on page 302).
- The chapter on the domain name system includes new sections about the topics of secure transactions, zone updates, and DNSSEC (see Section *DNS — Domain Name System* on page 323).
- The text as a whole has been updated in many places to reflect the changes brought by SuSE Linux 9.0.
- These parts are completely new:
  - ▷ A chapter about running SuSE Linux on the AMD64 platform (see Chapter *SuSE Linux on AMD64 Systems* on page 237).
  - ▷ A comprehensive introduction to LDAP (see Section *LDAP — A Directory Service* on page 334).
  - ▷ A section about the basics of XNTP (see Section *Time Synchronization with xntp* on page 372).
  - ▷ An introduction to the Apache web server (see Chapter *The Apache Web Server* on page 375).

Typographical Conventions

The following typographical conventions are used in this book:

Text layout	Meaning
YaST	programs
`/etc/passwd`	file or directory names
⟨*parameter*⟩	when entering a command, `parameter` should be replaced by the actual value, excluding the angle brackets.
`PATH`	the environment variable `PATH`
`192.168.1.2`	the value of a variable. In this case, 192.168.1.2
`ls`	the command `ls`
`news`	the user `news`
Alt	A key to press. Keys to press sequentially are separated by spaces.
Ctrl + Alt + Del	Keys to press simultaneously are grouped with the `'+'` sign.
"Permission denied"	System messages
'System Update'	Menu items, buttons, labels

A Word of Thanks

The list of all people who contributed to the success of this distribution would exceed the scope of this book. We would like to express our gratitude to all who worked tirelessly to present this quality SuSE Linux release. With their voluntary commitment, the developers of Linux cooperate on a global scale to promote the development of Linux. We thank them for their efforts — this distribution would not exist without them. Furthermore, we want to thank Frank Zappa and Pawar. Last but not least, special thanks to Linus Torvalds.

Have a lot of fun!

Your SuSE Team

Part I

Installation

The Installation

SuSE Linux can installed in a flexible way according to the local circumstances. The various methods range from a graphical "quick installation" to a text-based installation that allows manual intervention. The following sections cover various installation methods, such as the text-based installation with YaST and the use of various installation sources (CD-ROM, NFS). A comprehensive description of the graphical standard installation can be found in the User Guide. This chapter also offers troubleshooting tips for problems with the installation. The concluding section provides detailed information on partitioning.

Text-Based Installation with YaST 8
Starting SuSE Linux 15
Special Installation Procedures 17
Tips and Tricks 19
Partitioning for Experts 23
LVM Configuration with YaST 28
Logical Volume Manager (LVM) 29
Soft RAID 35

Text-Based Installation with YaST

In addition to installing with the assistance of a graphical interface, SuSE Linux can also be installed with the help of the YaST text menus (console mode). All YaST modules are also available in this text mode. The text mode is especially useful if you do not need a graphical interface (e.g., for server systems) or if the graphics card is not supported by the X Window System.

The Start Screen

Insert CD 1 into the drive and restart the computer. If the computer does not boot the CD, reset the boot sequence in the BIOS to `CDROM,C,A`. The start screen will be displayed after a few moments.

Use the (↑) and (↓) keys to select 'Manual Installation' within ten seconds to prevent YaST from being started automatically. In case your hardware requires special parameters (which is usually not the case), these can be entered in the line Boot Options. The parameter `textmode=1` can be used to run YaST in full-screen text mode.

The (F2) key can be used to determine the screen resolution for the installation. Press (F2) and choose `Text Mode` to enter the text-only mode. Then press (↵). Now, a box will appear with the progress display "Loading Linux kernel". The kernel boots and linuxrc is started. Subsequently, proceed with the installation using the menus of linuxrc.

Troubleshooting

- Other boot problems can usually be circumvented with kernel parameters. If DMA causes difficulties, use the start option 'Installation – Safe Settings'.
- If your CD-ROM drive (ATAPI) crashes when booting the system, refer to *ATAPI CD-ROM Hangs While Reading* on page 22.
- CD 1, which features an optimized kernel for Pentium processors, is not recognized as a boot medium. Try the "boot floppy" or CD 2. See *Booting from Disk (SYSLINUX)* on page 21 or *Using CD 2 for Booting* on page 22.
- The following kernel parameters may be used if you experience problems with ACPI (Advanced Configuration and Power Interface).

  bezeichneracpi=off This parameter disables the complete ACPI subsystem on your computer. This may be useful if your computer cannot handle ACPI at all or if you think ACPI in your computer causes trouble.

acpi=oldboot Switch off ACPI for everything but those parts that are necessary to boot.

acpi=force Always enables ACPI, even if your computer has an old BIOS that dates before year 2000. This parameter also enables ACPI if it is set in addition to acpi=off.

pci=noacpi Prevents ACPI from doing the PCI IRQ routing.

See also the SDB article at `http://sdb.suse.de/de/sdb/html/81_acpi.html`.

- The graphical mode cannot be used for graphics cards like FireGL 1, 2, and 3. In this case, the installation must be performed in text mode. In this case, select F2 in the boot menu.

- If unexplainable errors occur when the kernel is loaded or during the installation, select 'Memory Test' in the boot menu to check the memory. Linux requires the hardware to meet high standards, which means the memory and its timing must be set correctly. More information is available at `http://sdb.suse.de/sdb/html/thallma_memtest86.html`. If possible, run the memory test overnight.

The Basis: linuxrc

The linuxrc program can be used to specify settings for the installation and load needed drivers as kernel modules. Finally, linuxrc will launch YaST, starting the actual installation of the system software and other applications.

Use ↑ or ↓ to choose menu items. Use ← or → to select a command such as 'Ok' or 'Cancel'. Execute the command by pressing ↵.

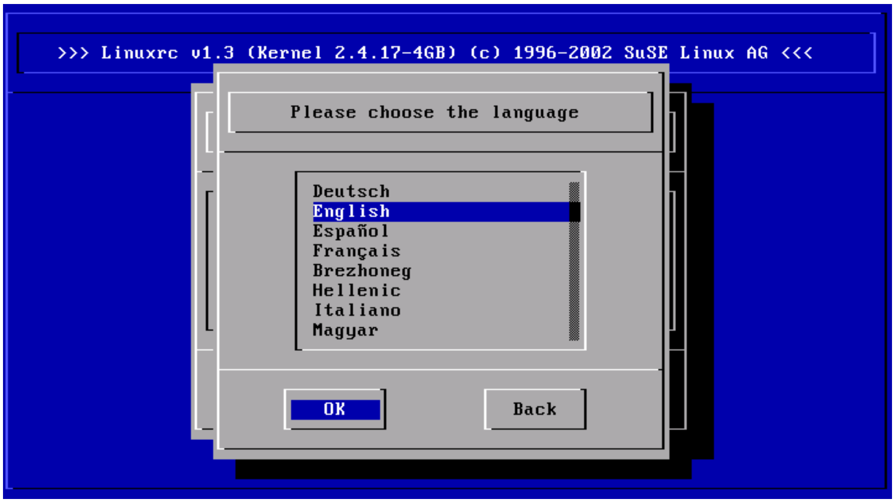
A detailed description of linuxrc is provided in *linuxrc* on page 263.

Settings

The linuxrc application automatically begins with the language and keyboard selection.

- Select the installation language (e.g., 'English') and confirm with ↵.

- Next, select the keyboard layout (e.g., 'English').



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Please choose the language

Deutsch
English
Español
Français
Brezhoneg
Hellenic
Italiano
Magyar

OK          Back
```

Figure 1.1: *Language Selection*

Possible Problems

- If linuxrc does not offer the desired keyboard layout, select an alternative layout. Once the installation is completed, the layout can be changed with YaST.

Main Menu of linuxrc

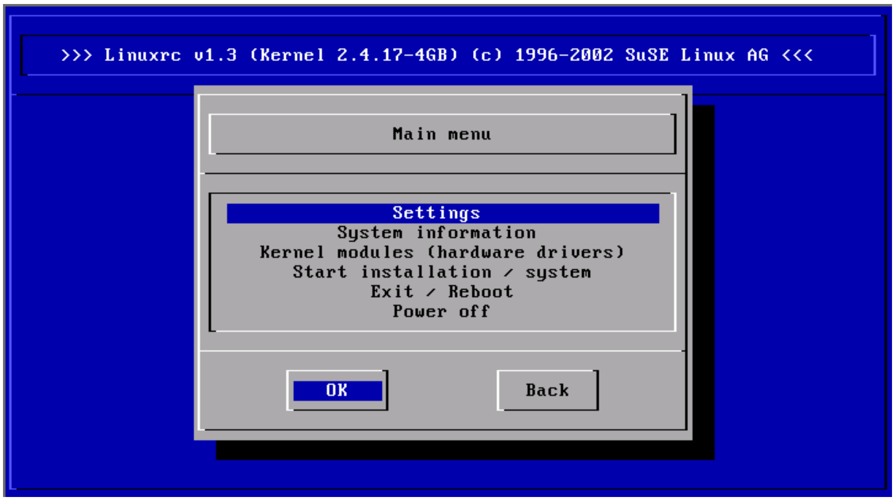
Now, you will find yourself in the main menu in linuxrc (Figure 1.2 on the next page). The following options are offered here:

'Settings' Here, select the language, screen, and keyboard. This subject is covered above.

'System Information' Find information about the hardware as detected by the kernel or activated by loaded modules.

'Kernel modules (hardware drivers)' Here, load any modules needed for your hardware. Also use this to load modules for additional file systems, such as ReiserFS.

Normally, you do *not* need to use this menu item if both your hard disks and the CD drive (ATAPI) are connected to an (E)IDE controller, as (E)IDE support is integrated in the kernel. Details for module selection are presented in the following paragraph.



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<
```

Figure 1.2: The Main Menu of linuxrc

'Start Installation/System' Continues installation.

'Exit/Reboot' Cancels the installation.

'Power off' Halts the system and switches the power off.

Hardware Integration with Modules

Select loading of kernel modules with 'Kernel module' only if you need support for SCSI or for PCMCIA or if you do *not* have an ATAPI drive. At present, other components are also be swapped out as modules (e.g., IDE) or added (e.g., USB, FireWire, or file systems). Read about how modules are loaded in *linuxrc* on page 263. In the following submenu, choose which modules to load. Possible choices are:

A SCSI Module Use this if you have a SCSI hard disk or SCSI CD-ROM drive.

A CD-ROM Module This is required if your CD-ROM drive is *not* connected to the (E)IDE controller or the SCSI controller. This especially applies to older CD-ROM drives connected to the computer by way of a proprietary controller.

A Network Module Use this if you want to install via NFS or FTP. Refer to *Installation from a Network Source* on page 17 for information.

One or More File Systems Required to add file systems, such as ReiserFS or ext3.

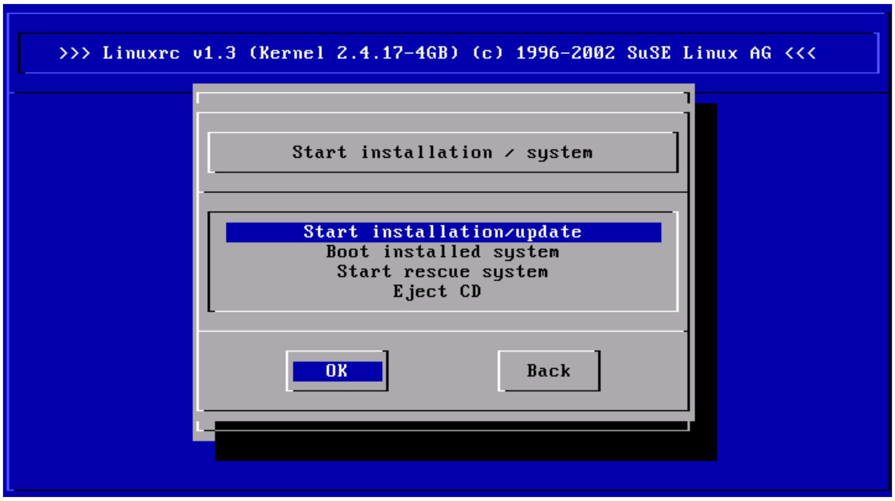
Tip

If you cannot find any support for your installation medium (proprietary CD-ROM drive, parallel port CD-ROM drive, network cards, PCMCIA) among the standard modules, you may find what you need on a module floppy disk, which contains additional drivers. To do this, go to the end of the list and select the item '-- More modules --'. In this case, linuxrc will prompt you to insert the module disk.

Tip

Starting Installation

Because 'Start installation/system' is usually preselected, normally just press ↵ to proceed with the installation.



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Start installation / system

Start installation/update
Boot installed system
Start rescue system
Eject CD

OK        Back
```

Figure 1.3: linuxrc *Installation Menu*

The following items are available:

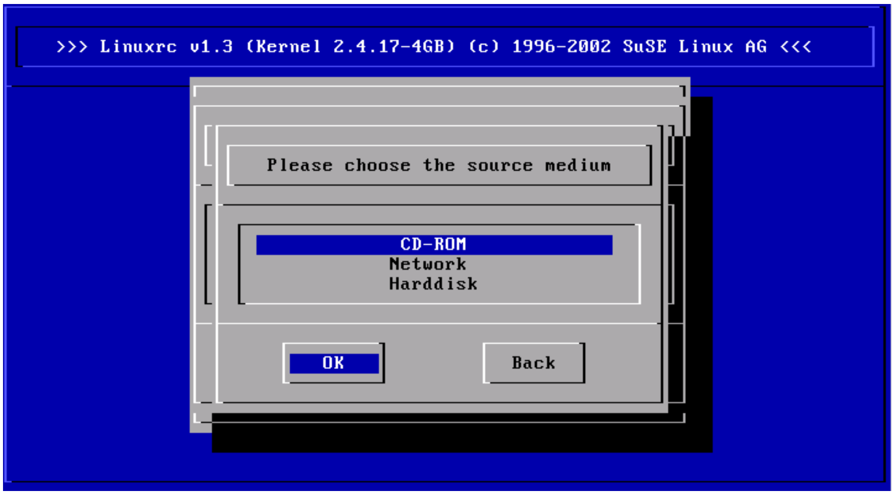
'Start installation/update' Install a new system or update an existing installation.

'Boot installed system' Boot an already installed system.

'Boot rescue system' Start the rescue system, which can be used if an installed system is damaged.

'Eject CD' Eject CD.

To begin the installation, press ↵ to access the menu item 'Start installation/update'. Then select the source medium. Usually, the cursor can be left at the default selection: 'CD-ROM'.


```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Please choose the source medium

CD-ROM
Network
Harddisk

OK          Back
```

***Figure 1.4:** Selecting the Source Medium in linuxrc*

Now press ↵. The installation environment will be loaded directly from CD 1.

As soon as this procedure is completed, YaST starts in the text-based (ncurses) version. The installation will then continue as described in **?**, chapter *Installation*.

Possible Problems

- The SCSI adapter is not detected:
  - ▷ Try loading a module for a compatible driver.
  - ▷ Use a kernel with the appropriate integrated SCSI driver. This kernel would need to be custom-built.

- The ATAPI CD-ROM drive hangs when reading the data. See *ATAPI CD-ROM Hangs While Reading* on page 22.
- For reasons still unknown, sometimes problems occur when loading data to the RAM disk so YaST cannot be started.

  If this situation arises, the following procedure can often lead to efficient results:

  Select 'Settings' → 'Debug (Experts)' in the linuxrc main menu. There, select no in 'Force root image'. Then return to the main menu and restart installation.

Starting SuSE Linux

Following the installation, decide how to boot Linux for daily operations. The following overview introduces various alternatives for booting Linux. The most suitable method depends on the intended purpose.

Boot Disk You can boot Linux from a *boot disk*. This approach will always work and is easy. The boot disk can be created with YaST. See **?**, *YaST—Configuration*: *Creating a Boot, Rescue, or Module Disk*.

The boot disk is a useful interim solution if you have difficulties configuring the other possibilities or if you want to postpone the decision regarding the final boot mechanism. A boot disk may also be a suitable solution in connection with OS/2 or Windows NT.

Linux Boot Loader The most versatile and technically elegant solution for booting your system is the use of a Linux boot manager like GRUB (GRand Unified Bootloader) or LILO (LInux LOader), which both allow selection from different operating systems prior to booting. The boot loader can either be configured during installation or later with the help of YaST.

Caution

There are BIOS variants that check the structure of the boot sector (MBR) and erroneously display a virus warning after the installation of GRUB or LILO. This problem can be easily solved by entering the BIOS and looking for corresponding adjustable settings. For example, you should switch off 'virus protection'. You can switch this option back on again later. It is unnecessary, however, if Linux is the only operating system you use.

Caution

A detailed discussion of various boot methods, especially of GRUB and LILO, can be found in *Booting and Boot Managers* on page 69.

The Graphical SuSE Screen

Starting with SuSE Linux 7.2, the graphical SuSE screen is displayed on the first console, if the option "vga=771" is active as kernel parameter. If you install using YaST, this option is automatically activated in accordance with the selected resolution and the graphics card.

Disabling the SuSE Screen

Basically there are three ways to achieve this:

- Disabling SuSE screen on an as-needed basis:

  Enter the command `echo 0 >/proc/splash` to disable the graphical screen. `echo 0x0f01 >/proc/splash` activates the screen again.

- Disabling the SuSE screen by default:

  Add the kernel parameter `splash=0` to your boot loader configuration. *Booting and Boot Managers* on page 69 offers more information about this. However, if you prefer the old text mode anyway (which was the default with previous versions), set this to `"vga=normal"` .

- Completely disabling the SuSE screen:

  Compile a new kernel after disabling the option `Use splash screen instead of boot logo` in the menu 'framebuffer support'.

Tip

Removing the framebuffer support from the kernel will automatically disable the splash screen as well. SuSE cannot not provide any support for your system if you run it with a custom kernel.

Tip

Special Installation Procedures

Installation Without CD-ROM Support

What if a standard installation via CD-ROM drive is not possible? For example, your CD-ROM may not be supported because it is an older proprietary drive. A secondary machine, like a notebook, might not have any CD-ROM drive at all, only an ethernet adapter. SuSE Linux offers the possibility of performing the installation on machines without a CD-ROM drive over a network connection. Usually this is done by means of NFS or FTP over ethernet. The following section describes the procedure.

Installation from a Network Source

No installation support is available for this approach. Therefore, the following procedure should only be applied by experienced computer users.

To install SuSE Linux from a network source, two steps are necessary:

1. The data required for the installation (CDs, DVD) must be made available on a machine that will serve as the installation source.
2. The system to install must be booted from floppy disk or CD and the network must be configured.

Configuring a Network Installation Source

Prepare the network share by copying the installation CDs to individual directories and make these available on a system with NFS server functionality. For example, on an existing SuSE Linux machine, copy the individual CDs with the following command:

```
earth:/ #  cp -a /mnt/cdrom /suse-share/
```

Then rename the directory, for example, to "CD1":

```
earth:/ #  mv /suse-share/cdrom /suse-share/CD1
```

Repeat this procedure for the other CDs. Then export the `/suse-share` directory via NFS. For information, see *NFS — Shared File Systems* on page 363.

Booting for the Network Installation

Insert the boot medium in the drive. The creation of the boot disk is described in *Creating a Boot Disk in DOS* on the facing page and *Creating a Boot Disk in a UNIX-Type System* on page 20. The boot menu will appear after a short time. Select 'Manual Installation'. You can also specify additional kernel parameters. Confirm the selection with Enter. The kernel will be loaded and you will be prompted to insert the first module disk.

After a short while, linuxrc will appear and ask you to enter a number of parameters:

1. Select the language and the keyboard layout in linuxrc.
2. Select 'Kernel modules (hardware drivers)'.
3. Load the IDE, RAID, or SCSI drivers required for your system.
4. Select 'Load network card modules' and load the needed network card driver (e.g., `eepro100`).
5. Select 'Load file system driver' and load the needed drivers (e.g., `reiserfs`).
6. Select 'Back' then 'Start installation / system'.
7. Select 'Start installation/update'.
8. Select 'Network' then the network protocol (e.g., `NFS`).
9. Select the network card to use.
10. Specify the IP addresses and other network information.
11. Specify the IP address of the NFS server providing the installation data.
12. Enter the path of the NFS share (e.g., `/suse-share/CD1`).

Now linuxrc will load the installation environment from the network source and start YaST. Proceed with the installation as described in **?**, Chapter *Installation*.

Troubleshooting

- The installation is terminated before it actually starts. The installation directory of the "other" machine was not exported with `exec` permissions. Do this now.
- The server does not recognize the host on which to install SuSE Linux. Enter the name and IP address of the host to install in the `/etc/hosts` file of the server.

Tips and Tricks

Creating a Boot Disk in DOS

The requirements for this are a formatted 3.5" floppy disk and a bootable 3.5" floppy drive.

Additional Information

The directory `boot` on CD 1 contains a number of disk images. Such an image can be copied to a disk with the help of a suitable utility. A floppy disk prepared in this way is called boot disk.

These disk images also include the "loader", SYSLINUX, and the program linuxrc. SYSLINUX allows the selection of the desired kernel during the boot process and the specification of parameters for the hardware used, if necessary. The program linuxrc supports the loading of kernel modules for your hardware and subsequently starts the installation.

Procedure

The DOS application rawrite.exe (CD 1, directory `\dosutils\rawrite`) is useful for generating the SuSE boot and module disks. Requirements for this are a machine with a DOS (e.g., FreeDOS) or Windows.

The procedure described in the following is for working with Windows:

1. Insert the SuSE Linux CD 1.
2. Open a DOS window (in the start menu under 'Applications' → 'MS-DOS Prompt').
3. Start the rawrite.exe application by giving the correct path name for the CD drive. The following example takes place on the `C:` drive in the `Windows` directory and your CD drive is `D:`.

   ```
   C:\Windows> d:\dosutils\rawrite\rawrite
   ```

4. After starting the application, it will prompt you for the source and destination of the file to copy. The image of the boot disk is stored on CD 1 under `\boot`. The file is simply named `bootdisk`. Remember to include the path to the CD.

   ```
   C:\Windows> d:\dosutils\rawrite\rawrite
   RaWrite 1.2 -- Write disk file to raw floppy diskette
   ```

```
Enter source file name: d:\boot\bootdisk
Enter destination drive: a:
```

After entering the destination drive `a:`, insert a formatted disk as requested then press ↵. rawrite then shows the copy progress. This process can be terminated with Ctrl + C.

In this manner, you can also create the other floppy images, `modules1`, `modules2`, `modules3`, and `modules4`. These are required if you have USB or SCSI devices or a network or PCMCIA card that you want to address during the installation.

A module disk may also be needed if you want to start using a special file system during the installation.

Creating a Boot Disk in a UNIX-Type System

This requires access to a Unix or Linux system with a CD-ROM drive and a formatted disk.

To create a boot disk:

1. If you need to format the disks first:

   ```
   earth:~ #  fdformat /dev/fd0u1440
   ```

2. Mount CD 1, for example, to `/media/cdrom`:

   ```
   earth:~ #  mount -tiso9660 /dev/cdrom /media/cdrom
   ```

3. Change to the `boot` directory on the CD:

   ```
   earth:~ #  cd /media/cdrom/boot
   ```

4. Create the boot disk with

   ```
   earth:~ #  dd if=/media/cdrom/boot/bootdisk of=/dev/fd0
       bs=8k
   ```

   The README file in the `boot` directory provides details about the floppy disk images. Read the files with `more` or `less`.

In this manner, you can also create the other floppy images, `modules1`, `modules2`, `modules3`, and `modules4` . These are required if you have USB or SCSI devices or a network or PCMCIA card that you want to address during the installation.

A module disk may also be needed if you want to start using a special file system during the installation.

The procedure is little bit more complicated if you want to use a self-compiled kernel during the installation. In this case, first write the default image (`bootdisk`) to the floppy disk then overwrite the actual kernel (`linux`) with your own kernel (see *Compiling the Kernel* on page 247):

```
earth:~ #  dd if=/media/cdrom/boot/bootdisk of=/dev/fd0 bs=8k
earth:~ #  mount -t msdos /dev/fd0 /mnt
earth:~ #  cp /usr/src/linux/arch/i386/boot/vmlinuz /mnt/linux
earth:~ #  umount /mnt
```

Booting from Disk (SYSLINUX)

The “boot disk” can be used if you have to deal with special installation requirements (e.g., CD-ROM drive not available). For more information about creating the boot disk, read *Creating a Boot Disk in DOS* on page 19 or *Creating a Boot Disk in a UNIX-Type System* on the facing page.

The boot process is initiated by the boot loader SYSLINUX (package `syslinux`). SYSLINUX is configured to perform a minimum hardware detection when the system is booted. Basically this includes the following steps:

- The programs checks whether the BIOS provides VESA 2.0 compliant framebuffer support and makes sure the kernel is booted accordingly.
- The monitor information (DDC info) is read.
- The first sector of the first hard disk (“MBR”) is read to be able to map BIOS IDs to Linux device names later during the boot loader configuration. The program attempts to read the block with the lba32 functions of the BIOS to find out if the BIOS supports these functions.

Tip

If you keep ⇑ Shift pressed when SYSLINUX is started, all these steps will be skipped.

For troubleshooting: You can insert the following line In `syslinux.cfg`:

```
verbose 1
```

to prompt the boot loader to tell you which action is currently being performed.

Tip

Possible Problems

- If the machine does not boot from the floppy disk, change the boot sequence in the BIOS to `A,C,CDROM`

Using CD 2 for Booting

As well as CD 1, the second CD is bootable. However, while CD 1 uses a bootable ISO image, CD 2 is booted by means of a 2.88 MB disk image. Use CD 2 if you are sure that you can boot from CD but it does work with CD 1 (fallback solution).

Supported CD-ROM Drives

Generally, most CD-ROM drives are supported.

- ATAPI drives should not cause any problems.
- A key issue for SCSI CD-ROM drives is whether the SCSI controller to which the CD-ROM drive is connected is supported. The supported SCSI controllers are listed under `http://cdb.suse.de/`. If your SCSI controller is not supported and your hard drive is also connected to it, you have a problem.
- Many proprietary CD-ROM drives are supported under Linux. Nevertheless, problems may be encountered with this type of drive. If your drive is not explicitly listed, you can still try to use a similar type from the same manufacturer.
- USB CD-ROM drives are also supported. If the BIOS of your machine does not yet support booting from USB devices, start the installation via the boot disks. For details, refer to *Booting from Disk (SYSLINUX)* on the page before. Before booting from the floppy disk, make sure all required USB devices are connected and powered on.

ATAPI CD-ROM Hangs While Reading

If your ATAPI CD-ROM is not recognized or it hangs while reading, this is most frequently due to incorrectly installed hardware. All devices must be connected to the EIDE controller in the correct order. The first device is master on the first controller. The second device is slave on the first controller. The third device should be master on the second controller, and so forth.

It often occurs that there is only a CD-ROM besides the first device. The CD--ROM drive is sometimes connected as master to the second controller (secondary IDE controller). This is wrong and can cause Linux not to know what to do with this “gap”. Try to fix this by passing the appropriate parameter to the kernel (`hdc=cdrom`).

Sometimes one of the devices is just “misjumpered”. This means it is jumpered as slave, but is connected as master, or vice versa. When in doubt, check your hardware settings and correct them where necessary.

In addition, there is a series of faulty EIDE chipsets, most of which have now been identified. There is a special kernel to handle such cases. See the `README` in `/boot` of the installation CD-ROM.

If booting does not work immediately, try using the following kernel parameters:

hd⟨*x*⟩=cdrom ⟨*x*⟩ stands for `a`, `b`, `c`, `d`, etc., and is interpreted as follows:

- `a` — Master on the first IDE controller
- `b` — Slave on the first IDE controller
- `c` — Master on the second IDE controller
- ...

An example of ⟨*parameter to enter*⟩ is `hdb=cdrom`. With this parameter, specify the CD-ROM drive to the kernel, if it cannot find it itself and you have an ATAPI CD-ROM drive.

ide⟨*x*⟩=noautotune ⟨*x*⟩ stands for `0`, `1`, `2`, `3`, etc., and is interpreted as follows:

- `0` — First IDE controller
- `1` — Second IDE controller
- ...

An example of ⟨*parameter to enter*⟩ is `ide0=noautotune` This parameter is often useful for (E)IDE hard disks.

Partitioning for Experts

This section provides detailed information for tailoring a system to your needs. This section is mainly of interest for those who want a system optimized system for security and performance and are prepared to reinstall the complete system where necessary. It is absolutely essential that you have extensive knowledge of the functions of a UNIX file system. You should be familiar with mount points and physical, extended, and logical partitions.

There is *no* golden rule for everything, but many rules for each situation. However, you will find concrete figures in this section to help you.

First, consider the following:

- What is the purpose of the machine (file server, compute server, stand-alone machine)?
- How many people are going to work with this machine (simultaneous logins)?
- How many hard disks are installed? How big are they and what kind (EIDE, SCSI, or even RAID controllers)?

Size of Swap Partition

Quite often you will read, "Swap should be at least twice as large as the main memory". This is a relic of times when 8 MB was regarded as a lot of RAM. Today, a new computer should not have less than 64 MB RAM. In the past, the aim was to equip the machine with about 30 to 40 MB of virtual memory, meaning RAM plus swap.

Modern memory-consuming applications require even more memory. Usually 128 MB of virtual memory should be sufficient. If you want to compile a kernel in KDE, look at the help pages with Netscape while `emacs` is running somewhere, not much will be left of your 128 MB of virtual memory. As a normal user, 256 MB of virtual memory is currently a reasonable value. Never do without any swap memory. A swap partition should be available even on a machine with 256 MB RAM. However, in this case 64 MB of swap space will be adequate to fill the basic need. The reasons for this are outlined in *Processing Speed and Size of Main Memory* on page 28.

If you want to run extensive simulations with a memory requirement of several gigabytes, you may need a large swap memory. If you are not sure if Linux has sufficient reserves for your application, refer to *As a Compute Server* on page 26.

Utilization of the Computer

As a Stand-Alone Machine

The most common use for a Linux machine is as a stand-alone computer. Table 1.1 on the facing page is an overview of size requirements for different Linux systems.

Installation	Required Disk Space
minimum	180 MB to 400 MB
small	400 MB to 1500 MB
medium	1500 MB to 4 GB
large	more than 4 GB

***Table 1.1:** Estimated Disk Space Requirements for Different Installations*

The recommended partitioning depends on the size used. The following are only examples that should be modified to your needs.

Small Stand-Alone Machine With a 500 MB spare hard disk to hold Linux, use a 64 MB swap partition and the rest for `/` (root partition).

Average Stand-Alone Machine If you have 1.5 GB available for Linux, use a small boot partition `/boot` (5–10 MB or 1 cylinder), 128 MB for swap, 800 MB for `/`, and the rest for a separate `/home` partition.

Deluxe Stand-Alone Machine If you have more than 1.5 GB available, there is no standard way to partition. Read *Optimizations* on the next page.

As a File Server

Here, hard disk performance is crucial. You should use SCSI devices if possible. Keep in mind the performance of the disk and the controller. A file server is used to save data centrally. This data might be home directories, a database, or other archives. The advantage of this is that administration of the data is simple.

If the file server will serve a huge net (twenty users and more), optimizing hard disk access is essential. Suppose you want to provide a file server for 25 users (their home directories). If the average user requires 100–150 MB for personal space, a 4 GB partition mounted under `home` will probably do.

If there are fifty users, you will need an 8 GB partition. In this case, it would be better to split `home` into two 4 GB hard disks, as they would then share the load (and access time).

Tip

The web browser cache should absolutely be stored locally on the user's hard disk.

Tip

As a Compute Server

A compute server is generally a powerful machine that carries out extensive calculations over the net. Normally, such a machine is equipped with extensive main memory (512 RAM or greater). The only point where fast disks are needed is for the swap space. If you have a number of hard disks, you can spread swap partitions across them.

Optimizations

The disks are normally the limiting factor. To avoid this bottleneck, there are two possibilities that should be used together:

- separate the load onto multiple disks
- use an optimized file system (e.g., `reiserfs`).
- equip your file server with enough memory (at least 256 MB)

Parallel Use of Multiple Disks

This needs some further discussion. The total amount of time needed for transferring data can be separated into five parts:

- time elapsed until the request reaches the controller
- time elapsed until this request is send to the disk
- time elapsed until the hard disk positions its head
- time elapsed until the media has turned to the relevant sector
- time elapsed for transferring data

The first item depends on the network connection and must be regulated there. This subject is not covered here. Item two is a relatively insignificant period that depends on the hard disk controller itself. Items three and four are the main parts. The positioning time is measured in ms.Compared to the access times of the main memory, which are measured in ns,this represents a factor of 1 million. Item four depends on the disk rotation speed, which is usually several ms.Item five depends on the rotation speed, the number of heads, and the current position of the head (inside or outside).

To optimize the performance, the third item should be improved. In SCSI devices, the "disconnect" feature comes into play. If this feature is used: The controller sends the command (in this case to the hard disk) "Go to track x, sector y" to the device. Now the disk motor must start. If this is an intelligent disk (if it supports disconnect) and the driver itself is also able to do disconnect, the controller sends a disconnect and the disk separates itself from the SCSI bus. Now other SCSI devices can do work. After a time (depending on the strategy or load on the SCSI bus), a connection to the disk is reestablished. Normally, the device has now reached the requested track.

On a multitasking, multiuser system like Linux, there are lots of optimizations that can be done here. Look at an output of the command `df` (see Output 1).

```
Filesystem            Size  Used Avail Use% Mounted on
/dev/sda5             1.8G  1.6G  201M  89% /
/dev/sda1              23M  3.9M   17M  18% /boot
/dev/sdb1             2.9G  2.1G  677M  76% /usr
/dev/sdc1             1.9G  958M  941M  51% /usr/lib
shmfs                 185M     0  184M   0% /dev/shm
```

Output 1: *Example of df Command Output*

To demonstate the advantages, consider what happens if `root` enters the following in `/usr/src`:

```
root@earth:/usr/src/ >  tar xzf package.tgz -C /usr/lib
```

`package.tgz` will be untarred into `/usr/lib/package`. To do so, the shell launches tar and gzip (located in `/bin`, so on `/dev/sda`) then package.tgz in `/usr/src` is read (on `/dev/sdb`). Last, the extracted data is written to `/usr/lib` (on `/dev/sdc`). With parallel disks, positioning as well as read and write of the disks' internal buffers can be activated at the same time.

This is only one example. There are many more. If this example were a frequent processing requirement and if there are many disks (with the same speed), as a rule of thumb, `/usr` and `/usr/lib` should physically be placed on different disks. Here `/usr/lib` should have approximately seventy percent of the capacity of `/usr`. `/`, due to its access, should be placed on the disk containing `/usr/lib`.

From a certain number of SCSI disks onwards (4–5), consider buying a RAID controller. Thus, operations on the disks are not merely semiparallel but parallel. Fault tolerance is one of its famous by-products.

Processing Speed and Size of Main Memory

The size of main memory is more important in Linux than the processor itself. One reason, if not the main reason, is Linux's ability to dynamically create buffers of hard disk data. Here, Linux uses lots of tricks, such as "read ahead" (getting sectors in advance) and "delayed write" (saving writes until there is a bundle to write). The latter is the reason why you should not switch off your Linux machine. Both factors contribute to the fact that the main memory seems to fill up over time as well as to Linux's high speed. See also *The free Command* on page 257.

LVM Configuration with YaST

This professional partitioning tool enables you to edit and delete existing partitions and create new ones. Access the Soft RAID and LVM configuration from here.

Note

Background information and partitioning tips can be found in *Partitioning for Experts* on page 23.

Note

In normal circumstances, partitions are specified during installation. However, it is possible to integrate a second hard disk in an existing Linux system. First, the new hard disk must be partitioned. Then it must be mounted and entered into the `/etc/fstab` file. It may be necessary to copy some of the data to move an `/opt` partition from the old hard disk to the new one.

Use caution if you want to repartition the hard disk in use — this is essentially possible, but you will have to reboot the system right afterwards. It is a bit safer to boot from CD then repartition it.

'Experts...' opens a pop-up menu containing the following commands:

Reread Partition Table Rereads the partitioning from disk. For example, you will need this for manual partitioning in the text console.

Adopt Mount Points from Existing /etc/fstab This will only be relevant during installation. Reading the old `fstab` is useful for completely reinstalling your system rather than just updating it. In this case, it is not necessary to enter the mount points by hand.

Delete Partition Table and Disk Label This completely overwrites the old partition table. For example, this can be helpful if you have problems with unconventional disk labels. Using this method, all data on the hard disk will be lost.

Logical Volume Manager (LVM)

The Logical Volume Manager (LVM) enables flexible distribution of hard disk space over several file systems. As it is difficult to modify partitions on a running system, LVM was developed. It provides a virtual pool (Volume Group — VG for short) of memory space from which logical volumes (LV) can be generated if needed. The operating system will access these instead of the physical partitions.

Features:

- Several hard disks or partitions can be combined into a large logical partition.
- Provided the configuration is suitable, a LV (e. g., `/usr`) can be enlarged when the free space is exhausted.
- With the LVM, append hard disks or LVs in a running system. However, hot-swappable hardware, designed for these types of interventions, is required for this.

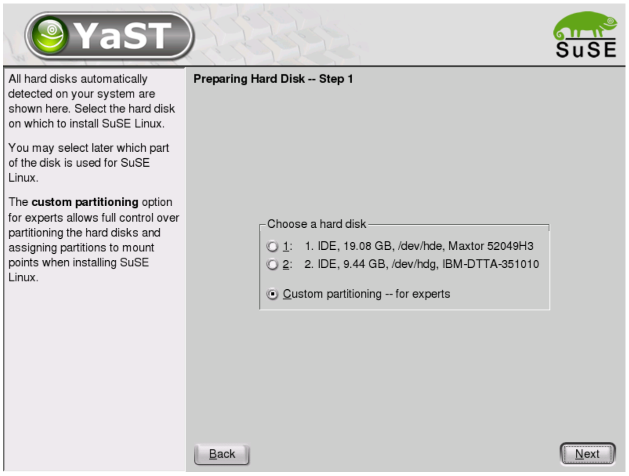
Implementing LVM already makes sense for heavily used home PCs or small servers. If you have a growing data stock, as in the case of databases, MP3 archives, or user directories, the Logical Volume Manager is just the right thing for you. This would allow you file systems that are larger than physical hard disk. Another advantage of the LVM is up to 256 LVs can be added. Keep in mind that working with the LVM is very different than working with conventional partitions.

Instructions and further information about configuring the Logical Volume Manager (LVM) can be found in the official LVM HOWTO and the SuSE documentation:

- `http://www.sistina.com/lvm/Pages/howto.html`
- `http://www.suse.com/us/support/oracle/`

LVM Configuration with YaST

Prepare the LVM configuration in YaST by creating an LVM partition when installing. To do this, click 'Partitioning' in the suggestion window then 'Discard' or 'Change' in the screen that follows. Next, create a partition for LVM by first clicking 'Add' → 'Do not format' in the Partitioner then clicking '0x8e Linux LVM'. Continue partitioning with LVM immediately afterwards or wait until after the system is completely installed. To do this, highlight the LVM partition in the partitioner then click 'LVM...'.



All hard disks automatically detected on your system are shown here. Select the hard disk on which to install SuSE Linux.

You may select later which part of the disk is used for SuSE Linux.

The **custom partitioning** option for experts allows full control over partitioning the hard disks and assigning partitions to mount points when installing SuSE Linux.

Preparing Hard Disk -- Step 1

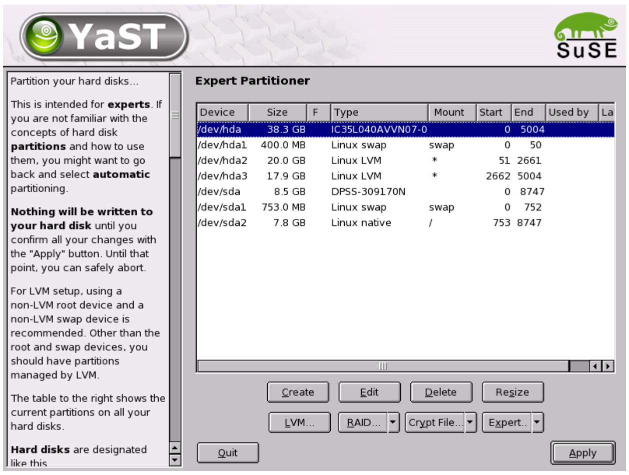
Choose a hard disk

- ○ 1: 1. IDE, 19.08 GB, /dev/hde, Maxtor 52049H3
- ○ 2: 2. IDE, 9.44 GB, /dev/hdg, IBM-DTTA-351010
- ● Custom partitioning -- for experts

Figure 1.5: *Activating LVM During Installation*

LVM — Partitioning

After you select 'LVM...' in the partitioning section, continue automatically to a dialog in which you can repartition your hard disks. Delete or modify existing partitions here or add new ones. A partition to use for LVM must have the partition label 8E. These partitions are indicated by "Linux LVM" in the partition list.



Partition your hard disks...

This is intended for **experts**. If you are not familiar with the concepts of hard disk **partitions** and how to use them, you might want to go back and select **automatic** partitioning.

Nothing will be written to your hard disk until you confirm all your changes with the "Apply" button. Until that point, you can safely abort.

For LVM setup, using a non-LVM root device and a non-LVM swap device is recommended. Other than the root and swap devices, you should have partitions managed by LVM.

The table to the right shows the current partitions on all your hard disks.

Hard disks are designated like this

Expert Partitioner

Device	Size	F	Type	Mount	Start	End	Used by	La
/dev/hda	38.3 GB		IC35L040AVVN07-0		0	5004		
/dev/hda1	400.0 MB		Linux swap	swap	0	50		
/dev/hda2	20.0 GB		Linux LVM	*	51	2661		
/dev/hda3	17.9 GB		Linux LVM	*	2662	5004		
/dev/sda	8.5 GB		DPSS-309170N		0	8747		
/dev/sda1	753.0 MB		Linux swap	swap	0	752		
/dev/sda2	7.8 GB		Linux native	/	753	8747		

Figure 1.6: *YaST: LVM Partitioner*

Tip

Repartitioning Logical Volumes

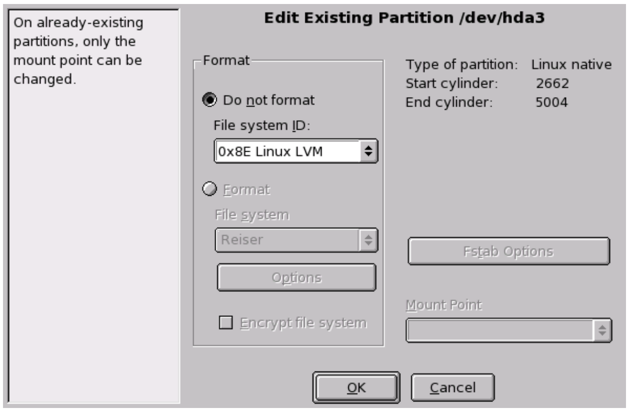
At the beginning of the PVs, information about the volume is written to the partition. In this way, a PV "knows" to which Volume Group it belongs. If you want to repartition, it is advisable to delete the beginning of this volume. In a Volume Group "system" and a Physical Volume "/dev/sda2", this can be done with the command

```
dd if=/dev/zero of=/dev/sda2 bs=512 count=1
```

Tip

You do not need to individually set the 8E label for all partitions designated for LVM. If needed, YaST will automatically set the partition label of a partition assigned to an LVM Volume Group to 8E. For any unpartitioned areas on your disks, create LVM partitions in this dialog. These partitions should then be designated the partition label 8E. They do not have to be formatted and no mount point can be entered.

If a working LVM configuration already exists on your system, it will be automatically activated as soon as you begin configuring the LVM. If this is successfully activated, any disks containing a partition belonging to an activated volume group can no longer be repartitioned. The Linux kernel will refuse to read the modified partitioning of a hard disk as long as only one partition on this disk is used.


On already-existing partitions, only the mount point can be changed.

Edit Existing Partition /dev/hda3

Format

(●) Do not format

File system ID: 0x8E Linux LVM

( ) Format

File system: Reiser

Type of partition: Linux native
Start cylinder: 2662
End cylinder: 5004

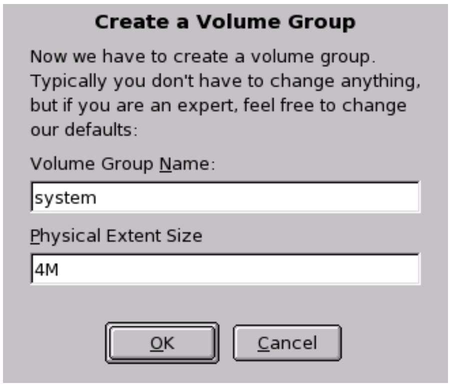
Figure 1.7: *Creating LVM Partitions*

Repartitioning disks not belonging to an LVM volume group is not a problem at all. If you already have a functioning LVM configuration on your system, repartitioning is usually not necessary. In this screen, configure all mount points not located on LVM Logical Volumes. The root file system in YaST must be stored on a normal partition. Select this partition from the list and specify this as root file system using the 'Edit' button. To ensure LVM's optimal flexibility, it is recommended to pool all additional file systems onto LVM logical volumes. After specifying the root partition, exit this dialog.

LVM — Configuring Physical Volumes

In the dialog 'LVM', the LVM volume groups (often indicated by "VG") are managed. If no volume group exists on your system yet, you will be prompted to add one. `system` is suggested as a name for the volume group where the SuSE Linux system files are located. Physical Extent Size (PE Size) defines the maximum size of a physical and logical volume in this volume group. This value is normally set to 4 megabytes. This allows for a maximum size of 256 gigabytes for physical and logical volumes. The physical extent size should only be increased if you need larger logical volumes than 256 gigabytes (e. g., to 8, 16, or 32 megabytes).

The following dialog lists all partitions with either the "Linux LVM" or "Linux native" type. Therefore, no swap and DOS partitions will be shown. If a partition is already assigned to a volume group, the name of the volume group will be shown in the list. Unassigned partitions are indicated by "--".


Create a Volume Group

Now we have to create a volume group. Typically you don't have to change anything, but if you are an expert, feel free to change our defaults:

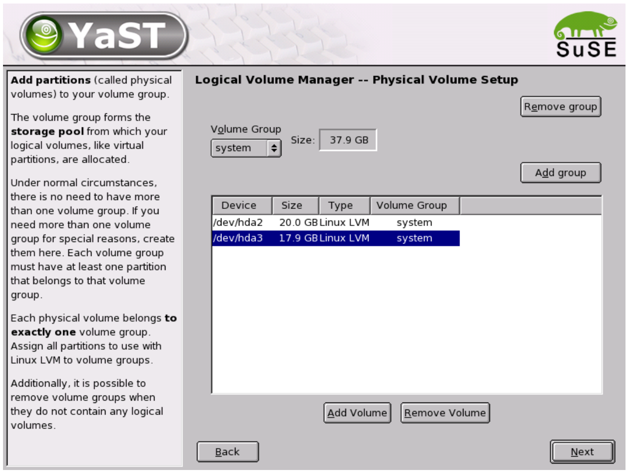
Volume Group Name: system

Physical Extent Size: 4M

Figure 1.8: *Adding a Volume Group*

The volume group currently being edited can be modified in the selection box to the upper left. The buttons in the upper right enable creation of additional volume groups and deletion of existing volume groups. Only volume groups to which no other partitions are assigned can be deleted. No more than one volume group needs to be created for a normally installed SuSE Linux system. A partition assigned to a volume group is also referred to as a physical volume (often indicated by PV).

To add a previously unassigned partition to the selected volume group, first click the partition then the 'Add Volume' button below the selection list. At this point, the name of the volume group is entered next to the selected partition. Assign all partitions reserved for LVM to a volume group. Otherwise, the space on the partition will remain unused. Before exiting the dialog, every volume group must be assigned at least one physical volume.


Add partitions (called physical volumes) to your volume group.

The volume group forms the **storage pool** from which your logical volumes, like virtual partitions, are allocated.

Under normal circumstances, there is no need to have more than one volume group. If you need more than one volume group for special reasons, create them here. Each volume group must have at least one partition that belongs to that volume group.

Each physical volume belongs **to exactly one** volume group. Assign all partitions to use with Linux LVM to volume groups.

Additionally, it is possible to remove volume groups when they do not contain any logical volumes.

Logical Volume Manager -- Physical Volume Setup

Volume Group: system — Size: 37.9 GB

Device	Size	Type	Volume Group
/dev/hda2	20.0 GB	Linux LVM	system
/dev/hda3	17.9 GB	Linux LVM	system

Figure 1.9: *Partition List*

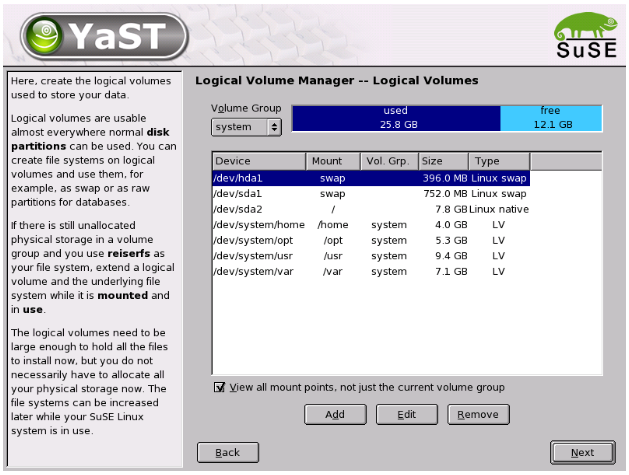
Logical Volumes

This dialog is responsible for managing logical volumes (often indicated by just "LV").

Logical volumes are assigned, one to each volume group, and have a particular given size. To create a striping array when you create the logical volumes, first create the LV with the largest number of stripes. A striping LV with `n` stripes can only be created correctly if the hard disk space required by the LV can still be distributed evenly to `n` Physical Volumes. If only PVs are available, an LV with three stripes is impossible.

Normally, a file system is created on a logical volume (e. g., reiserfs, ext2) and is then designated a mount point. The files stored on this logical volume can be found at this mount point on the installed system. All normal Linux partitions to which a mount point is assigned, all swap partitions, and all already existing logical volumes are listed here.

If you have already configured LVM on your system, the existing logical volumes must be entered now. Before you proceed, assign the appropriate mount point to these logical volumes. If you are configuring LVM on a system for the first time, no logical volumes will be displayed in this screen yet. A logical volume must be generated for each mount point (using the 'Add' button). You will also need to specify the size, the file system type (e. g., reiserfs or ext2), and the mount point (e. g., `/var`, `/usr`, `/home`).



Here, create the logical volumes used to store your data.

Logical volumes are usable almost everywhere normal **disk partitions** can be used. You can create file systems on logical volumes and use them, for example, as swap or as raw partitions for databases.

If there is still unallocated physical storage in a volume group and you use **reiserfs** as your file system, extend a logical volume and the underlying file system while it is **mounted** and in **use**.

The logical volumes need to be large enough to hold all the files to install now, but you do not necessarily have to allocate all your physical storage now. The file systems can be increased later while your SuSE Linux system is in use.

Logical Volume Manager -- Logical Volumes

Volume Group: system — used 25.8 GB — free 12.1 GB

Device	Mount	Vol. Grp.	Size	Type
/dev/hda1	swap		396.0 MB	Linux swap
/dev/sda1	swap		752.0 MB	Linux swap
/dev/sda2	/		7.8 GB	Linux native
/dev/system/home	/home	system	4.0 GB	LV
/dev/system/opt	/opt	system	5.3 GB	LV
/dev/system/usr	/usr	system	9.4 GB	LV
/dev/system/var	/var	system	7.1 GB	LV

☑ View all mount points, not just the current volume group

Figure 1.10: *Logical Volume Management*

If you have created several volume groups, switch between the different volume groups in the selection list to the upper left. The added logical volumes are listed in the volume group displayed there. Once you have created all the logical volumes as required, exit the dialog and go on to software selection if you are still in the installation process.

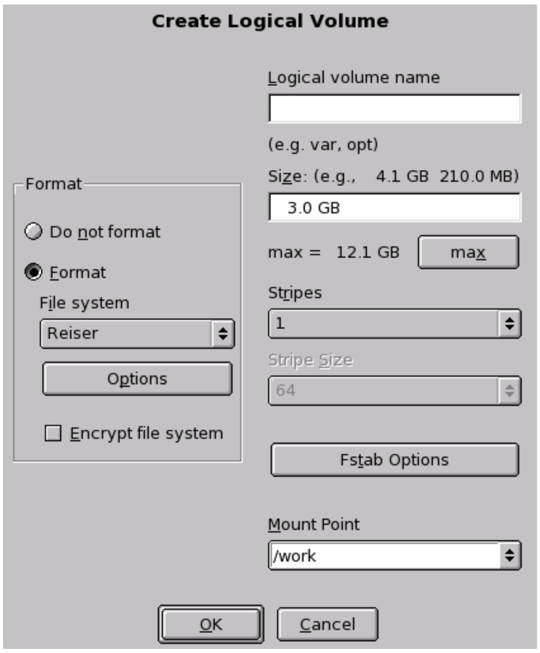
Caution

Using LVM might be associated with increased risk factors, such as data loss. Risks also include application crashes, power outage, and faulty commands. Save your data before implementing LVM or reconfiguring volumes — never work without a backup.

Caution

Soft RAID

The purpose of RAID (Redundant Array of Inexpensive Disks) is to combine several hard disk partitions into one large "virtual" hard disk for the optimization of performance and data security. Using this method, however, one advantage is sacrificed for another. "RAID level" defines the pool and common triggering device of the all hard disks, the RAID controller. A RAID controller mostly uses


Create Logical Volume

Logical volume name:

(e.g. var, opt)

Size: (e.g., 4.1 GB 210.0 MB): 3.0 GB

max = 12.1 GB [max]

Stripes: 1

Stripe Size: 64

Format

( ) Do not format

(●) Format

File system: Reiser

[Options]

☐ Encrypt file system

[Fstab Options]

Mount Point: /work

[OK] [Cancel]

__Figure 1.11:__ Creating Logical Volumes

the SCSI protocol, because it can drive more hard disks better than the IDE protocol. It is also better able to process parallel running commands.

Instead of a RAID controller, which can often be quite expensive, soft RAID is also able to take on these tasks. SuSE Linux offers the option of combining several hard disks into one soft RAID system with the help of YaST — a very reasonable alternative to Hardware RAID.

Common RAID Levels

RAID 0 This level improves the performance of your data access. Actually, this is not really a RAID, because it does not provide data backup, but the name "RAID 0" for this type of system has become the norm. With RAID 0, two hard disks are pooled together. The performance is very good — although the RAID system will be destroyed and your data lost, even if just one of the many remaining hard disks fails.

RAID 1 This level provides more than adequate backup for your data, because the data is copied to another hard disk 1:1. This is known as “hard disk mirroring” — if a disk is destroyed, a copy of its contents is located on another one. All of them except one could be damaged without endangering your data. The writing performance suffers a little in the copying process when using RAID 1 (ten to twenty percent slower), but read access is significantly faster in comparison to any one of the normal physical hard disks, because the data is duplicated so can be parallel scanned.

RAID 5 RAID 5 is an optimized compromise between the two other levels in terms of performance and redundancy. The hard disk potential equals the number of disks used minus one. The data is distributed over the hard disks as with RAID 0. “Parity blocks”, created on one of the partitions, are there for security reasons. They are linked to each other with XOR — thus enabling the contents, via XDR, to be reconstructed by the corresponding parity block in case of system failure. With RAID 5, no more than one hard disk can fail at the same time. If one is destroyed, it must be replaced as soon as possible to save the data.

Soft RAID Configuration with YaST

Access Soft RAID configuration by way of the ‘RAID’ module under ‘System’ or via the partitioning module under ‘Hardware’.

First Step: Partitioning

First, see a list of your partitions under ‘Expert Settings’ in the partitioning tool. If the Soft RAID partitions have already been set up, they will appear here. Otherwise, set them up from scratch. For RAID 0 and RAID 1, at least two partitions are needed — usually for RAID 1, exactly two and no more. If RAID 5 is used, at least three partitions will be required. It is recommended to only take partitions of the same size. The RAID partitions should be stored on various hard disks to insure against the risk of losing data if one is defective (RAID 1 and to optimize the performance of RAID 0.

Second Step: Setting Up RAID

Click ‘RAID’ to open a dialog in which to choose between RAID levels 0, 1, and 5. In the following screen, assign the partition to the new RAID. ‘Expert Options’ opens the settings options for the “chunk size” — for fine-tuning the performance. Checking ‘Persistent Superblock’ ensures that the RAID partitions will be recognized as such when booting.

After completing the configuration, you will then see the `/dev/md0` device and others indicated on the expert page in the partitioning module by “RAID”.

Troubleshooting

Find out whether a RAID partition has been destroyed by the file contents `/proc/mdstats`. The basic procedure in case of system failure is to shut down your Linux system and replace the defective hard disk with a new one partitioned the same way. Then restart your system and give the `raidhotadd /dev/mdX /dev/sdX` command. This will enable the hard disk to be integrated automatically into the RAID system and be fully reconstructed.

Configuration instructions and more details for Soft RAID can be found in the HOWTOs at:

- `/usr/share/doc/packages/raidtools/Software-RAID-HOWTO.html`
- `http://www.LinuxDoc.org/HOWTO/Software-RAID-HOWTO.html`

Linux RAID mailing lists are also available, such as `http://www.mail-archive.com/linux-raid@vger.rutgers.edu`.

Updating the System and Package Management

SuSE Linux provides the option of updating an existing system without completely reinstalling it. There are two types of updates: *updating individual software packages* and *updating the entire system*. Packages can also be installed by hand using the package manager RPM.

Updating SuSE Linux 40
Software Changes from Version to Version 45
RPM — the Package Manager 49

Updating SuSE Linux

Software tends to "grow" from version to version. Therefore, we recommend first taking a look at the available partition space with `df` *before* updating. If you suspect you are running short of disk space, secure your data before updating and repartition your system. There is no general rule of thumb regarding how much space each partition should have. Space requirements depend on your particular partitioning profile, the software selected, and the version numbers of SuSE Linux.

Note

It is recommended to read the `README` and, in DOS and Windows, `README.DOS` file on your CD. Find notes there regarding any additional changes made *after* this manual went to print.

Note

Preparations

Before you begin your update, copy the old configuration files to a separate medium just to be on the safe side. Such media can include streamers, removable disks, floppy drives, or ZIP drives. This primarily applies to files stored in `/etc`. Also, review the configuration files in `/var/lib`. Furthermore, it you may want to write the user data in `/home` (the `HOME` directories) to a backup medium. Back up this data as `root`. Only `root` has read permission for all local files.

Before starting your update, make note of the root partition. The command `df /` lists the device name of the root partition. In the example shown in Output 2, the root partition to write down is `/dev/hda7`.

```
Filesystem            Size  Used Avail Use% Mounted on
/dev/hda1             1.9G  189M  1.7G  10% /dos
/dev/hda7             3.0G  1.1G  1.7G  38% /
/dev/hda5              15M  2.4M   12M  17% /boot
shmfs                 141M     0  141M   0% /dev/shm
```

***Output 2:** List with df -h*

The root partition can be recognized as the one mounted as `/`.

Possible Problems

PostgreSQL Before updating PostgreSQL (package `postgres`), it is usually best to "dump" the databases. See the man page for `pg_dump` (`man pg_dump`). This is, of course, only necessary if you actually *used* PostgreSQL prior to your update.

Promise Controller The hard disk controller manufactured by Promise is currently found on high-end motherboards in numerous computer models, either as a pure IDE controller (for UDMA 100) or as an IDE-RAID controller. As of SuSE Linux 8.0, these controllers are directly supported by the kernel and treated as a standard controller for IDE hard disks. The additional kernel module `pdcraid` is required before you can aquire RAID functionality.

For some updates, hard disks on the Promise controller may be detected before disks on the standard IDE controller. If so, the system will no longer boot following a kernel update and usually exit with "Kernel panic: VFS: unable to mount root fs". In this case, the kernel parameter ide=reverse must be passed when booting to reverse this disk detection process. See *The Start Screen* on page 8. To apply this parameter universally when using YaST, enter it in the boot configuration. See **?**, chapter *User-Defined Installation, Booting (Boot Loader Installation)*.

Caution

Only the controllers activated in the BIOS are detectable. In particular, subsequently activating or deactivating the controllers in the BIOS has a direct effect on the device names. Use caution or risk being unable to boot the system.

Caution

Technical Explanation
The controller sequence depends on the motherboard. Each manufacturer wires its supplementary controllers differently. The `lspci` shows this sequence. If the Promise controller is listed before the standard IDE controller, the kernel parameter ide=reverse is required after updating. With the previous kernel (without direct Promise support), the controller was ignored so the standard IDE controller was detected first. The first disk was then `/dev/hda`. With the new kernel, the Promise controller is detected immediately and its (up to four) disks are registered as `/dev/hda`, `/dev/hdb`, `/dev/hdc`, and `/dev/hdd`. The previous `/dev/hda` disk becomes `/dev/hde` so is no longer detectable in the boot process.

Updating with YaST

Following the preparation procedure outlined in *Preparations* on page 40, you can now boot:

1. Boot the system for the installation (see User Guide). In YaST, choose a language, then select 'Update Existing System'. Do *not* select 'New Installation'.
2. YaST will determine whether there are several root partitions. If there is only one, continue with 3. If there are several, select the right partition and confirm with 'Next' (`/dev/hda7` was selected in the example in *Preparations* on page 40).

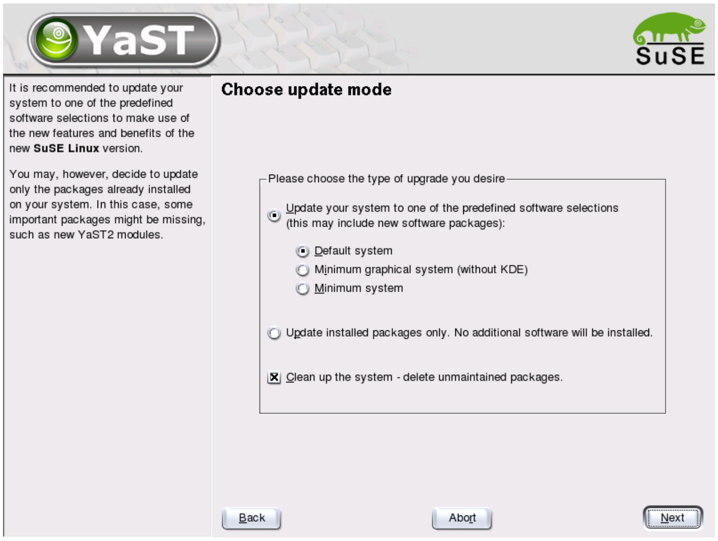
   YaST reads the "old" `fstab` on this partition to analyze and mount the file systems listed there.
3. Then you have the possibility to make a backup copy of the system files during the update. This option slows down the update process. Use this option if you do not have a recent system backup.
4. In the following dialog, either choose to update only the software that is already installed or to add important new software components to the system ("upgrade mode"). It is advisable to accept the suggested composition (e.g., 'Standard System'). Adjustments can be made later with YaST.

Manual Update

Updating the Base System

Because basic system components, such as libraries, must be exchanged when updating a base system, an update cannot be run from within a currently running Linux system. First, set up the update environment. This is normally done using the CD or DVD or with a custom boot disk. If you are carrying out manual modifications during the update or prefer to perform the entire update with YaST in text mode, follow the steps already described in detail in *Text-Based Installation with YaST* on page 8. Below is a summary of this procedure.

1. Immediately after booting the kernel from the "boot disk" or from the CD or DVD, linuxrc automatically starts.
2. In linuxrc, specify the language and keyboard settings under 'Settings' and click 'Ok' to confirm each setting.


It is recommended to update your system to one of the predefined software selections to make use of the new features and benefits of the new **SuSE Linux** version.

You may, however, decide to update only the packages already installed on your system. In this case, some important packages might be missing, such as new YaST2 modules.

Choose update mode

Please choose the type of upgrade you desire

- [✓ Update your system to one of the predefined software selections (this may include new software packages):]
  - [✓ Default system]
  - Minimum graphical system (without KDE)
  - Minimum system
- Update installed packages only. No additional software will be installed.

[✓ Clean up the system - delete unmaintained packages.]

***Figure 2.1:** Updating the Software*

3. You might need to load the required hardware and software drivers via 'Kernel Modules'. See section *The Basis: linuxrc* on page 9 for more details on how to proceed and *Loading Modules* on page 265 for a description of linuxrc.

4. Go to the menu items 'Start Installation / System' → 'Start Installation/Update' to select the source medium (see on page 266).

5. The installation environment is loaded from linuxrc then YaST started.

Following the selection of a language and the hardware detection by YaST, select 'Update existing system' in the YaST opening screen.

Next, YaST attempts to determine the root partition and displays the result for selection or confirmation. Select your root partition from the list (for example, `/dev/sda3`). In this way, prompt YaST to read the "old" `fstab` from this partition. YaST will analyze and mount the file systems listed there.

Then you have the possibility to make a backup copy of the system files during the update. In the following dialog, either choose to update only the software already installed or to add important new software components to the system ("upgrade mode"). It is advisable to accept the suggested composition (e.g., 'Standard system'). Adjustments can be made later with YaST.

In the warning dialog, select 'Yes' to start the installation of the new software from the source medium to the system hard disk.

First, the RPM database is checked, then the main system components are updated. YaST automatically creates backups of files modified in the running system since the last installation. In addition, old configuration files are backed up with the endings `.rpmorig` and `.rpmsave` (see *Managing Packages: Install, Update, and Uninstall* on page 51). The installation or update procedure is logged in `/var/adm/inst-log/installation-*` and can be viewed later at any time.

Updating the Rest of the System

After the base system is updated, you will be switched to YaST's update mode. This mode allows you to tailor the rest of the system update to your needs.

Complete the procedure as you would a new installation. Among other things, select a new kernel. The available options are presented by YaST.

Tip

If you boot with loadlin, save the *new* kernel and, possibly, the `initrd` into the `loadlin` directory of your DOS partition.

Tip

Possible Problems

- If certain shell environments no longer behave as expected after the update, check to see if the current "dot" files in the home directory are still compatible with your system. If not, use the current versions in `/etc/skel`. For example:

```
cp /etc/skel/.profile ~/.profile
```

Updating Individual Packages

Regardless of your overall updated environment, you can always update individual packages. From this point on, however, it is your responsibility to ensure that your system remains consistent. Update advice can be found at `http://www.suse.de/en/support/download/updates/`.

Select components from the YaST package selection list according to your needs. If you select a package essential for the overall operation of the system, YaST issues a warning. Such packages should be updated only in the update mode. For instance, numerous packages contain "shared libraries". If you update these programs and applications in the running system, things might malfunction.

Software Changes from Version to Version

The individual aspects changed from version to version are outlined in the following sections in detail. This summary indicates, for example, whether basic settings have been completely reconfigured, whether configuration files have been moved to other places, or whether common applications have been significantly changed. Only the modifications that would affect the daily use of the system at either the user or the administrator level are mentioned below. The list is by no means complete. The following also makes references to SDB (Support Database) articles. These articles are in the package `sdb_en`, series `doc`.

Problems and bugs for each version have been published on the web server as soon as they were recognized. See the links listed below. Important updates of individual packages can be accessed at `http://www.suse.de/en/support/download/`.

From 7.3 to 8.0

Problems and Special Issues:
`http://sdb.suse.de/sdb/en/html/bugs80.html`.

- Boot disks are shipped only as floppy images (previously `disks` directory, now `boot`). A boot disk is only required if you cannot boot from CD. Depending on your hardware or installation preferences, you can also create floppies from the images `modules1`, `modules2`, etc. Read *Creating a Boot Disk in DOS* on page 19 or *Creating a Boot Disk in a UNIX-Type System* on page 20 for information about creating these disks.
- YaST2 has completely replaced YaST1, even in the text and console mode. When the text says "YaST", it always refers to the new version.
- Some BIOSes require the kernel parameter `realmode-power-off`, which was known as `real-mode-poweroff` up to kernel version 2.4.12.
- The START variables of the `rc.config` for launching services are no longer required. Services are started if the respective links exist in the runlevel directories. These links are created with `insserv`.
- System services are configured by variable lines in the files located under `/etc/sysconfig`. The settings in `/etc/rc.config.d` will be applied to the update.

- /etc/init.d/boot has been split into several scripts and moved to other packages, where this made sense (see package kbd, package isapnp, package lvm, etc.). See on page 284.
- Some changes have been made in the network area. Read *Network Integration* on page 311 for more information.
- logrotate is used to manage log files. /etc/logfiles is no longer necessary. See *Log Files — the Package logrotate* on page 254.
- The root login over telnet or rlogin can be permitted by entering specifications in the files under /etc/pam.d. Due to security risks, ROOT_LOGIN_REMOTE can no longer be set to yes.
- PASSWD_USE_CRACKLIB can be activated with YaST.
- If NIS files for autofs will be distributed over NIS, the YaST NIS client module should be used for configuration. There, select 'Start Automounter'. This aspect has made the USE_NIS_FOR_AUTOFS variable obsolete.
- The locate tool for quickly finding files is no longer included in the standard software installation. If desired, install it (package find-locate). If installed, the updatedb process will be started automatically about fifteen minutes after the computer is booted, just as in previous versions.
- The mouse support for pine is activated. This means that pine in an xterm can also be operated with a mouse (or a similar input device) by clicking the menu items. This, however, also means that cut and paste only work by using ⇑ Shift when the mouse support is activated. This is deactivated with a new installation. It is, however, not excluded that the function is still active following an update (when an older ~/.pinerc is present). The option enable-mouse-in-xterm can be deactivated in the configuration for pine.

From 8.0 to 8.1

Problems and Special Issues:
http://sdb.suse.de/sdb/de/html/bugs81.html.

- Changes in the user and group names: To comply with UnitedLinux, some entries in /etc/passwd and /etc/group have been adjusted accordingly.

  - ▷ Changed users: `ftp` is now in group `ftp` (not in `daemon`).
  - ▷ Renamed groups: `www` (was `wwwadmin`); `games` (was `game`).
  - ▷ New groups: `ftp` (with GID `50`), `floppy` (with GID `19`), `cdrom` (with GID `20`), `console` (with GID `21`), `utmp` (with GID `22`).

- Changes related to FHS (see *File System Hierarchy Standard (FHS)* on page 252):
  - ▷ An example environment for HTTPD (Apache) is created at `/srv/www` (formerly `/usr/local/httpd`).
  - ▷ An example environment for FTP is created at `/srv/ftp` (formerly `/usr/local/ftp`). package `ftpdir` is required for this purpose.
- To ease access to the desired software, the single packages are not stored in a few bulky series any more, but rather in accessible "RPM groups". This also means the CDs do not contain spurious and cryptic directories under `suse` any more, but only few directories named after architectures, for example, `ppc`, `i586`, or `noarch`.
- The installation status of the following programs has changed for a new installation:
  - ▷ The boot loader GRUB, which offers much more possibilities than LILO. However, LILO is retained if the system is updated.
  - ▷ The mailer postfix instead of sendmail.
  - ▷ The modern mailing list application mailman is installed instead of majordomo.
  - ▷ Select harden_suse manually if needed and read the enclosed documentation.
- Split packages: `rpm` to `rpm` and `rpm-devel`; `popt` to `popt` and `popt-devel`; `libz` to `zlib` and `zlib-devel`.

  `yast2-trans-*` is now split by languages: `yast2-trans-cs` (Czech), `yast2-trans-de` (German), `yast2-trans-es` (Spanish), etc. Not all languages are installed to save hard disk space. Install the required packages for the YaST language support as needed.
- Renamed packages: `bzip` to `bzip2`.
- Packages no longer supplied: `openldap`, use `openldap2`; `su1`, use `sudo`.

From 8.1 to 8.2

Problems and Special Issues:
http://sdb.suse.de/sdb/en/html/bugs82.html.

- 3-D support for nVidia-based graphics cards (changes): The RPM packages NVIDIA_GLX/NVIDIA_kernel (including the script switch2nvidia_glx) are no longer included. Please download the nVidia installer for Linux IA32 from the nVidia web site (http://www.nvidia.com), install the driver with this installer, and use SaX2 or YaST for activating 3-D support.

- During a new installation, xinetd is installed instead of inetd and configured with secure values. See directory /etc/xinetd.d. However, during a system update, inetd is retained.

- The current PostgreSQL version is 7.3. When switching from version 7.2.x, perform a "dump/restore" with pg_dump. If your application queries the system catalogs, additional adaptions are necessary, as schemas were introduced in version 7.3. For more information, visit the following URL: http://www.ca.postgresql.org/docs/momjian/upgrade_tips_7.3

- Version 4 of stunnel no longer supports any command-line options. However, the enclosed script /usr/sbin/stunnel3_wrapper can convert the command-line options into a configuration file that is suitable for stunnel and use it when the program is started (replace ⟨*OPTIONS*⟩ with your options):

  ```
  /usr/sbin/stunnel3_wrapper stunnel ⟨OPTIONS⟩
  ```

  The generated configuration file will be printed to the default output, enabling the use of these specifications for generating a permanent configuration file.

- openjade (package openjade) is the DSSSL engine currently used instead of jade (package jade_dsl) when db2x.sh (package docbook-toys) is run. For compatibility reasons, the individual programs are also available without the prefix 'o'.

  If you own applications depend on the directory jade_dsl and the files previously installed there, you have to adapt your own applications to the new directory /usr/share/sgml/openjade or create a link as root:

```
cd /usr/share/sgml
rm jade_dsl
ln -s openjade jade_dsl
```

To avoid a conflict with package `rzsz`, the command-line tool `sx` continues to be called `s2x`/`sgml2xml` or `osx`.

From 8.2 to 9.0

Problems and Special Issues:
`http://sdb.suse.de/sdb/en/html/bugs90.html`.

- Version 4 of the RPM package manager is now available. The functionality for building packages has been shifted to the separate program `rpmbuild`. `rpm` continues to be used for the installation, updates, and database queries. See section 2.
- The package `footmatic-filters` is now available for printing. The content was split from the package `cups-drivers`, as it can be used for printing even if CUPS is not installed. In this way, YaST supports configurations that are independent from the print system (CUPS, LPRng). The configuration file for this package is `/etc/foomatic/filter.conf`.
- The packages `footmatic-filters` and `cups-drivers` are now also required for LPRng/lpdfilter.
- The XML resources of the enclosed software packages can be accessed by means of the entries in `/etc/xml/suse-catalog.xml`. This file should not be edited with `xmlcatalog`, as this would result in the deletion of structural comments required for correct updates. `/etc/xml/suse-catalog.xml` is accessed by means of a nextCatalog statement in `/etc/xml/catalog`, enabling XML tools like `xmllint` or `xsltproc` to find the local resources automatically.

RPM — the Package Manager

In SuSE Linux, RPM (Red Hat Package Manager) is used for managing the software packages. Its main programs are `rpm` and `rpmbuild`. Thus, the powerful RPM database can be queried by the users, the system administrators, and package builders for detailed information on the installed software.

Essentially, `rpm` has five modes: installing, uninstalling or updating software packages, rebuilding the RPM database, querying RPM bases or individual RPM archives, integrity checks of packages, and signing packages. `rpmbuild` can be used to build installable packages from pristine sources.

Installable RPM archives are packed in a special binary format. These archives consist of the program files to install and certain meta information used during the installation by `rpm` to configure the software package or stored in the RPM database for documentation purposes. RPM archives normally have the extension `.rpm`.

`rpm` can be used to administer LSB-compliant packages. Refer to *Linux Standard Base (LSB)* on page 252 for more information on LSB.

Tip

For a number of packages, the components needed for software development (libraries, headers, include files, etc.) have been put into separate packages. These development packages are only needed if you want to compile software *yourself*, for example, the most recent GNOME packages. They can be identified by the name extension `-devel`, such as the packages package `alsa-devel`, package `gimp-devel`, and package `kdelibs-devel`.

Tip

Verifying Package Authenticity

SuSE Linux RPM packages have a GnuPG signature:

```
1024D/9C800ACA 2000-10-19 SuSE Package Sign-
ing Key <build@suse.de>
Key fingerprint = 79C1 79B2 E1C8 20C1 890F  9994 A84E DAE8 9C80 0ACA
```

The command

```
rpm --checksig apache-1.3.12.rpm
```

can be used to verify the signature of an RPM package to determine whether it really originates from SuSE or from another trustworthy facility. This is especially recommended for update packages from the Internet. Our public package signature key normally resides in `/root/.gnupg/`. Since version 8.1, the key is additionally located in the directory `/usr/lib/rpm/gnupg/` to enable normal users to verify the signature of RPM packages.

Managing Packages: Install, Update, and Uninstall

Normally, the installation of an RPM archive is quite simple:

```
rpm -i ⟨package⟩.rpm
```

With this command, the package will be installed — but only if its dependencies are fulfilled and there are no conflicts with other packages. With an error message, `rpm` requests those packages that need to be installed to meet dependency requirements. In the background, the RPM database ensures that no conflicts arise — a specific file can only belong to one package. By choosing different options, you can force `rpm` to ignore these defaults, but this is only for experts. Otherwise, risk compromising the integrity of the system and possibly jeopardize the ability to update the system.

The options `-U` or `--upgrade` and `-F` or `--freshen` can be used to update a package.

```
rpm -F ⟨package⟩.rpm
```

This option will remove the files of the old version and immediately install the new files. The difference between the two versions is that `-U` installs packages that previously did not exist in the system, but `-F` merely updates previously installed packages. When updating, `rpm` updates configuration files carefully using the following strategy:

- If a configuration file was not changed by the system administrator, `rpm` will install the new version of the appropriate file. No action by the system administrator is required.
- If a configuration file was changed by the system administrator before the update, `rpm` will save the changed file with the extension `.rpmorig` or `.rpmsave` (backup file) and install the version from the new package, but only when the originally installed file and the newer version are different. If this is the case, compare the backup file (`.rpmorig` or `.rpmsave`) with the newly installed file and make your changes again in the new file. Afterwards, be sure to delete all `.rpmorig` and `.rpmsave` files to avoid problems with future updates.
- `.rpmnew` files appear if the configuration file already exists *and* if the `noreplace` label was specified in the `.spec` file.

Following an update, `.rpmsave` and `.rpmnew` files should be removed after comparing them, so they do not obstruct future updates. The `.rpmorig` extension is assigned if the file has not previously been recognized by the RPM database.

Otherwise, `.rpmsave` is used. In other words, `.rpmorig` results from updating from a foreign format to RPM. `.rpmsave` results from updating from an older RPM to a newer RPM. `.rpmnew` does not disclose any information as to whether the system administrator has made any changes to the configuration file. A list of these files is available in `/var/adm/rpmconfigcheck`. Some configuration files (like `/etc/httpd/httpd.conf`) purposely are not overwritten to enable a seamless takeover of the running operations using the personal settings.

The `-U` switch is *not* just an equivalent to uninstalling with the (`-e`) option and installing with the (`-i`) option. Use `-U` whenever possible.

To remove a package, enter the following command:

```
rpm -e ⟨paket⟩
```

`rpm` will only delete the package if there are no unresolved dependencies. It is theoretically impossible to delete Tcl/Tk, for example, as long as another application requires it. Even in this case, RPM calls for assistance from the database. If such a deletion is — for whatever reason and under unusual circumstances — impossible, even if *no* additional dependencies exist, it may be helpful to rebuild the RPM database using the option `--rebuilddb`. See *RPM Queries* on page 56 for more information about the RPM database.

RPM and Patches

To guarantee the operational security of a system, update packages must be installed in the system from time to time. Previously, a bug in a package could only be eliminated by replacing the entire package. Large packages with small bugs could easily result in large amounts of data. However, since SuSE 8.1, the SuSE RPM offers a new feature enabling the installation of patches in packages.

The most important considerations are demonstrated using pine as an example:

- Is the patch RPM suitable for my system?

  To check this, first query the installed version of the package. For pine, this can be done with the following command:

  ```
  rpm -q pine
  pine-4.44-188
  ```

  Then check if the patch RPM is suitable for this version of pine:

  ```
  rpm -qp --basedon pine-4.44-224.i586.patch.rpm
  pine = 4.44-188
  ```

```
pine = 4.44-195
pine = 4.44-207
```

This patch is suitable for three different versions of pine. The installed version in our example is also listed, so the patch can be installed.

- Which files are replaced by the patch?

  The files affected by a patch can easily be seen in the patch RPM. The `rpm` parameter `-P` serves the selection of special patch features. The list of files is displayed with the following command:

  ```
  rpm -qpPl pine-4.44-224.i586.patch.rpm
  /etc/pine.conf
  /etc/pine.conf.fixed
  /usr/bin/pine
  ```

  or, if the patch is already installed, with the following command:

  ```
  rpm -qPl pine
  /etc/pine.conf
  /etc/pine.conf.fixed
  /usr/bin/pine
  ```

- How can a patch RPM be installed in the system?

  Patch RPMs are used just like normal RPMs. The only difference is that a suitable RPM must already be installed.

- Which patches are already installed in the system, and for which package versions?

  A list of all patches installed in the system can be displayed with the command `rpm -qPa`. If only one patch is installed in a new system (like in our example), the list appear as follows:

  ```
  rpm -qPa
  pine-4.44-224
  ```

  If, at a later date, you want to know which package version was originally installed, this information is also available in the RPM database. For `pine`, this information can be displayed with the following command:

  ```
  rpm -q --basedon pine
  pine = 4.44-188
  ```

More information, including information on the patch feature of RPM, is available in the man page for `rpm` (`man 1 rpm`) and in the man page for `rpmbuild` (`man 1 rpmbuild`).

RPM Queries

With the `-q` option, `rpm` initiates queries, making it possible to inspect an RPM archive (by adding the option `-p`) and also to query the RPM database of installed packages. Several switches are available to specify the type of information required (see Table 2.1).

`-i`	Package information
`-l`	File list
`-f` ⟨*FILE*⟩	Query a package owned by ⟨*FILE*⟩ (the full path must be specified with ⟨*FILE*⟩)
`-s`	File list with status information (implies `-l`)
`-d`	List only documentation files (implies `-l`)
`-c`	List only configuration files (implies `-l`)
`--dump`	File list with complete details (to be used with `-l`, `-c`, or `-d`)
`--provides`	List features of the package that another package can request with `--requires`
`--requires`, `-R`	Capabilities the package requires
`--scripts`	Installation scripts (preinstall, postinstall, uninstall)

Table 2.1: *The Most Important RPM Query Options* (`-q [-p]` …⟨*package*⟩)

For example, the command `rpm -q -i wget` displays the information shown in Output 3.

```
Name        : wget                     Relocations: (not relocateable)
Version     : 1.8.1                        Vendor: SuSE AG, Nuern-
berg, Germany
Release     : 142                      Build Date: Fri Apr  5 16:08:13 2002
Install date: Mon Apr  8 13:54:08 2002 Build Host: knox.suse.de
Group       : Productivity/Networking/Web/Utilities   Source RPM: wget-
1.8.1-142.src.rpm
Size        : 2166418                     License: GPL
Packager    : http://www.suse.de/feedback
Summary     : A tool for mirroring FTP and HTTP servers
```

```
Description :
Wget enables you to retrieve WWW documents or FTP files from a server.
This might be done in script files or via command line.
[...]
```

Output 3: *rpm -q -i wget*

Option `-f` only works if you specify the complete file name with its full path. You can name as many file names as you want. For example, `rpm -q -f /bin/rpm /usr/bin/wget` results in:

```
rpm-3.0.3-3
wget-1.5.3-55
```

If only part of the file name is known, a shell script must be implemented, shown in File 1. Pass the partial file name to the script shown as a parameter when running it.

```
#! /bin/sh
for i in $(rpm -q -a -l | grep  $1); do
    echo "\"$i\" is in package:"
    rpm -q -f $i
    echo ""
done
```

File 1: *Script to Search for Packages*

The command `rpm -q -changelog rpm` displays a detailed list of information (updates, configuration, modifications, etc.) about a specific package.This example shows information on the package *rpm*. However, only the last five change entries in the RPM database are listed. All entries (dating back the last two years) are included in the package itself. This query only works if CD 1 is mounted at `/cdrom`:

```
rpm -qp --changelog /cdrom/suse/i586/rpm-3*.rpm
```

With the help of the installed RPM database, verification checks can be made. These checks are initiated with the option `-V`, `-y`, or `--verify`. With this option, `rpm` will show all files in a package that have been changed since installation. `rpm` uses eight character symbols to give some hints about the following changes:

`5`	MD5 check sum
`S`	File size
`L`	Symbolic link
`T`	Modification time
`D`	Major and minor device numbers
`U`	Owner
`G`	Group
`M`	Mode (permissions and file type)

Table 2.2: *RPM Verify Options*

In the case of configuration files, the letter `c` will be printed. Example for changes to `/etc/wgetrc` (package `wget`):

```
rpm -V wget
S.5....T c /etc/wgetrc
```

The files of the RPM database are placed in `/var/lib/rpm`. If the partition `/usr` has a size of 1 GB, this database can occupy nearly 30 MB, especially after a complete update. If the database is much larger than expected, it is useful to rebuild the database with the option `--rebuilddb`. Before doing this, make a backup of the old database. The `cron` script `cron.daily` makes daily copies of the database (packed with gzip) and stores them in `/var/adm/backup/rpmdb`. The number of copies is controlled by the variable ⟨*MAX_RPMDB_BACKUPS*⟩ (default: `5`) in `/etc/sysconfig/backup`. The size of a single backup is approximately 3 MB for 1 GB in `/usr`.

Installing and Compiling Source Packages

All source packages of SuSE Linux carry an `.src.rpm` extension (source RPM).

Tip

These packages can be handled in the same way as all other packages. The packages, however, will not be found in the RPM database (and are not marked with an `[i]` in YaST), as only "installed" software is listed. This is because the source packages are not incorporated in the RPM database. Only *installed* operating system software is listed in the RPM database.

Tip

The following directories must be available for `rpm` and `rpmbuild` in `/usr/src/packages` (unless you specified custom settings in a file such as `/etc/rpmrc`):

`SOURCES` this is for the original sources (`.tar.gz` files, etc.) and for distribution-specific adjustments (`.dif` files).

`SPECS` for the ".spec" files, similar to a meta Makefile, which control the "build" process.

`BUILD` All the sources are unpacked, patched, and compiled in this directory.

`RPMS` This is where the completed "binary" packages are stored.

`SRPMS` here are the "source" RPMs.

When you install a source package with YaST, all the necessary components will be installed in `/usr/src/packages`: the sources and the adjustments in `SOURCES` and the relevant `.spec` file in `SPECS`.

Note

Do not experiment with system components (package `glibc`, package `rpm`, package `sysvinit`, etc.), as this endangers the operability of your system.

Note

The following example uses the `wget.src.rpm` package. After you have installed the package with YaST, you should have the following files:

```
/usr/src/packages/SPECS/wget.spec
/usr/src/packages/SOURCES/wget-1.4.5.dif
/usr/src/packages/SOURCES/wget-1.4.5.tar.gz
```

`rpmbuild -b ⟨X⟩ /usr/src/packages/SPECS/wget.spec` starts the compilation. ⟨X⟩ is a wild card for various stages of the build process (see the output of `--help` or the RPM documentation for details). The following is merely a brief explanation:

`-bp` Prepare sources in `/usr/src/packages/BUILD`: unpack and patch.

`-bc` the same as `-bp`, but with additional compilation.

`-bi` the same as `-bp`, but with additional installation of the built software. Caution: if the package does not support the BuildRoot feature, you might overwrite configuration files.

`-bb` the same as `-bi`, but with the additional creation of the "binary" package. If the compile was successful, the binary should be in `/usr/src/packages/RPMS`.

`-ba` the same as `-bb`, but with the additional creation of the "source RPM". If the compilation was successful, the binary should be in `/usr/src/packages/SRPMS`.

`--short-circuit` lets you skip specific steps. This binary RPM can now be installed with `rpm -i` or, preferably, with `rpm -U`. Installation with `rpm` makes it appear in the RPM database.

Compiling RPM Packages with build

The danger with many packages is that during the build process, unwanted files are added to the running system. To prevent this, use the package `build`, which creates a defined environment in which the package is built. To establish this "chroot" environment, the `build` script must be provided with a complete package tree. This tree can be made available on the hard disk, via NFS, or from DVD. The respective position is specified with `build --rpms <path>`. In contrast to `rpm`, the `build` command looks for the SPEC file in the source directory. To build wget anew (like in the above example) and the DVD is mounted in the system under `/media/dvd`, use the following commands as `root`:

```
cd /usr/src/packages/SOURCES/
mv ../SPECS/wget.spec .
build --rpms /media/dvd/suse/ wget.spec
```

Subsequently, a minimum environment will be established at `/var/tmp/build-root`. The package will be built in this environment. Upon completion, the resulting packages are located in `/var/tmp/build-root/usr/src/packages/RPMS`

The `build` script offers a number of additional options. For example, you can cause the script to prefer your own RPMs, omit the initialization of the build environment, or limit the `rpm` command to one of the above-mentioned stages. Additional information can be accessed with the command `build --help` and in the man page for `build` (`man 1 build`).

Tools for RPM Archives and the RPM Database

Midnight Commander (`mc`) can display the contents of RPM archives and copy parts of them. It represents archives as virtual file systems, offering all usual menu options of Midnight Commander: the `HEADER` information can be displayed with F3, the archive structure can be viewed with the cursor keys and Enter, and archive components can be copied with F5. A front-end for rpm is also available for Emacs.

KDE offers the kpackage tool. GNOME offers gnorpm.

Using the Alien (`alien`) Perl script, it is possible to convert or install an "alien" binary package. This tries to convert "old" TGZ archives to RPM before installing. This way, the RPM database can keep track of such a package after it has been installed. Beware: `alien` is still "alpha" software, according to its author — even if it already has a high version number.

Part II

Configuration

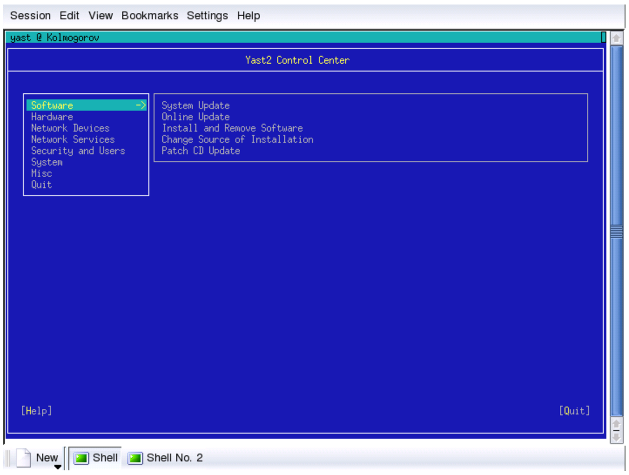
YaST in Text Mode (ncurses)

This chapter addresses system administrators and experts who do not run an X server on their systems and rely on the text-based installation tool. It provides basic information for starting and operating YaST in text mode (ncurses). It also explains how to update your system online automatically to keep it as up-to-date as possible.

Usage 64
Using the Modules 65
Starting the Individual Modules 66
YaST Online Update 67

Usage

The usage may be unfamiliar, but is very simple. Basically, the entire program can be controlled with (Tab), (Alt) + (Tab), (Space), the arrow keys ((↑) and (↓)), (Enter), and shortcuts. When Yast2 is started in text mode, the YaST Control Center appears first. It is shown in Figure 3.1.



```
Yast2 Control Center

Software  ->   System Update
Hardware       Online Update
Network Devices Install and Remove Software
Network Services Change Source of Installation
Security and Users Patch CD Update
System
Misc
Quit

[Help]                                   [Quit]
```

__Figure 3.1:__ The Main Screen of YaST in Text-Mode

There are three areas here. The left frame, which is surrounded by a thick white border, features the categories to which the various modules belong. The active category is indicated by a colored background. The right frame, which is surrounded by a thin white border, provides an overview of the modules contained in the active category. The bottom frame contains the buttons for 'Help' and 'Exit'.

When the YaST Control Center is started, the category 'Software' is selected automatically. Use the (↓) and (↑) keys to change the category. To start a module from the selected category, press (→). The module selection now appears with a thick border. Use the (↓) and (↑) keys to select the desired module. Keep the arrow keys pressed to scroll through the list of available modules. When a module is selected, the module title appears with a colorful background and a brief description is displayed in the bottom frame.

Press (Enter) to start the desired module. Various buttons or selection fields in the module contain a letter with a different color (yellow by default).

Use the combination Alt + letter to select a button directly without navigating there with Tab.

Exit the YaST Control Center by pressing the 'Exit' button or by selecting the item 'Exit' in the category overview and pressing Enter.

Restriction of Key Combinations

If your window manager uses Alt key combinations, the Alt combinations in YaST might not work. Keys like Alt or ⇑ Shift might be occupied by the settings of the terminal.

Replacing Alt with Esc: Alt shortcuts can be executed with Esc instead of Alt. For example, Esc + H replaces Alt + H.

Replacement of backward and forward navigation by Ctrl+F and Ctrl+B: If the Alt and ⇑ Shift combinations are occupied by the window manager or the terminal, the combinations Ctrl + F (forward) and Ctrl + B (backward) can be used instead.

Restriction of function keys: The F keys are also used for functions. Here, too, certain F key might be occupied by the terminal and may not be available for YaST. However, the Alt key combinations and F keys should always be fully available on a pure text console.

Using the Modules

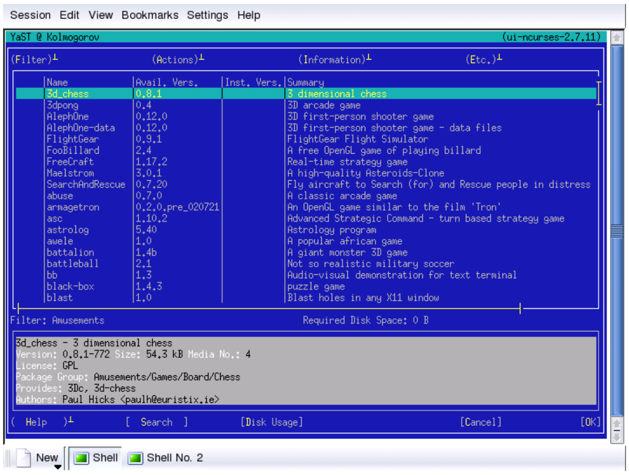
The following assumes that the Alt key combinations are functional. If necessary, replace the key combinations as described above or switch to a pure text console.

Navigation between buttons and selection lists With Tab and Alt + Tab, switch buttons or the frames containing selection lists.

Navigation in selection lists Use the arrow keys (↑ and ↓) to navigate among the individual elements in an active frame, for example, among the individual modules of a module group in the control center.

Checking of radio buttons and check boxes Select items with empty square brackets (check boxes) with Space or Enter. The buttons at the bottom of the individual modules are selected with Enter when they are selected (green background) or with Alt + yellow key. See Figure 3.2 on the next page.

The function keys The F keys (F1 to F12) enable quick access to the various buttons. Which function keys are actually mapped to buttons depends on which YaST module is active, as the different modules offer different buttons (such as details, info, add, and delete). The various functions mapped to the F keys are explained in the YaST help, which can be accessed with F1.



```
YaST @ Kolmogorov                                                    (ui-ncurses-2.7.11)
(Filter)               (Actions)               (Information)               (Etc.)

      |Name           |Avail. Vers.     |Inst. Vers.|Summary
      |3d_chess       |0.8.1            |           |3 dimensional chess
      |3dpong         |0.4              |           |3D arcade game
      |AlephOne       |0.12.0           |           |3D first-person shooter game
      |AlephOne-data  |0.12.0           |           |3D first-person shooter game - data files
      |FlightGear     |0.9.1            |           |FlightGear Flight Simulator
      |FooBillard     |2.4              |           |A free OpenGL game of playing billard
      |FreeCraft      |1.17.2           |           |Real-time strategy game
      |Maelstrom      |3.0.1            |           |A high-quality Asteroids-Clone
      |SearchAndRescue|0.7.20           |           |Fly aircraft to Search (for) and Rescue people in distress
      |abuse          |0.7.0            |           |A classic arcade game
      |armagetron     |0.2.0.pre_020721 |           |An OpenGL game similar to the film 'Tron'
      |asc            |1.10.2           |           |Advanced Strategic Command - turn based strategy game
      |astrolog       |5.40             |           |Astrology program
      |awele          |1.0              |           |A popular african game
      |battalion      |1.4b             |           |A giant monster 3D game
      |battleball     |2.1              |           |Not so realistic military soccer
      |bb             |1.3              |           |Audio-visual demonstration for text terminal
      |black-box      |1.4.3            |           |puzzle game
      |blast          |1.0              |           |Blast holes in any X11 window
Filter: Amusements                                  Required Disk Space: 0 B

3d_chess - 3 dimensional chess
Version: 0.8.1-772 Size: 54.3 kB Media No.: 4
License: GPL
Package Group: Amusements/Games/Board/Chess
Provides: 3Dc, 3d-chess
Authors: Paul Hicks <paulh@euristix.ie>

(  Help  )        [  Search  ]        [Disk Usage]                  [Cancel]        [OK]
```

Figure 3.2: The Software Installation Module

Starting the Individual Modules

To save time, the individual YaST modules can also be started directly. To start the modules, use `yast ⟨modulename⟩`. The network module, for example, is started with `yast lan`. A list of all module names available on your system can be viewed with the command `yast -l` or `yast --list`.

YaST Online Update

The YaST Online Update (YOU) can be controlled and started from the console. As `root`, enter the command

```
yast online_update
```

to load the latest patch list and all applicable rpms from the first server in the list `/etc/suseservers`. Use `-h` to get a list of all options available. Information about the patches is stored in `/var/lib/YaST2/you/<arch>/update/<version>/patches`. `root` permissions are required to read this. `<version>` refers to the respective version of SuSE Linux. `<arch>` refers to the architecture you run SuSE Linux on.

The advantage of this method is that it can be automated. For example, the system administrator can download the packages overnight and install the needed ones in the morning.

The cron Job for YOU

The following are basic instructions for creating a cron job to update the system automatically. Basically, there are two different possibilities for setting up a cron job. The simpler method for this is described here. The following steps are necessary:

1. Become `root`.
2. Start the crontab editor with `crontab -e`.
3. Press `i` for the insertion mode of vi.
4. Enter the following lines:

   ```
   MAILTO=” ”
   13 3 * * 0 /sbin/yast online_update
   53 3 * * 0 /sbin/yast online_update auto.install
   ```

   The first five elements of the last two lines have the following meaning when read from left to right: minutes, hours, day of the month, month of the year, day of the week (0 is Sunday). * disregards that value. In this example, the first entry starts the cron job every Sunday at 3:13 a.m. The second job starts forty minutes later at 3:53 a.m. The line `MAILTO” ”` prevents root from receiving the output as an e-mail and can, of course, be omitted.

Caution

Enter arbitrary times for the cron jobs and preferably not the times from the example above, because this could overload the FTP server.

Caution

5. Save the cron job by consecutively pressing Esc `:wq` and ↵ or Esc `ZZ`.

The cron daemon is automatically restarted and your cron job is added to `/var/spool/cron/tabs/root`.

Booting and Boot Managers

This chapter introduces various methods for booting your installed system. First, some of the technical details of the boot process are explained to help understanding the various methods. This is followed by a detailed description of GRUB (the current boot manager of SuSE Linux) and its predecessor LILO.

Booting a PC 70
Boot Concepts 71
Map Files, GRUB, and LILO 72
Booting with GRUB 73
Booting with LILO 82
Uninstalling the Linux Boot Loader 88
Creating Boot CDs 90

Booting a PC

After turning on your computer, the first thing that happens is that the BIOS (Basic Input Output System) takes control, initializes the screen and keyboard, and tests the main memory. At this point, no storage media or external devices are known to the system.

After that, the system reads the current date and time as well as information about the most important peripheral devices from the CMOS setup. After reading the CMOS, the BIOS should recognize the first hard disk, including details such as its geometry. It can then start to load the operating system (OS) from there.

To load the OS, the system loads a 512-byte data segment from the first hard disk into main memory and executes the code stored at the beginning of this segment. The instructions contained in it determine the rest of the boot process. This is why the first 512 bytes of the hard disk are often called the *Master Boot Record* (MBR).

Up to this point (loading the MBR), the boot sequence is independent of the installed operating system and is identical on all PCs. Also, all the PC has to access peripheral hardware are those routines (drivers) stored in the BIOS.

Master Boot Record

The layout of the MBR always follows a standard independent of the operating system. The first 446 bytes are reserved for program code. The next 64 bytes offer space for a partition table for up to four partitions (see Section *Partitioning for Experts* on page 23). Without the partition table, no file systems exist on the hard disk — the disk would be virtually useless without it. The last two bytes must contain a special "magic number" (`AA55`). An MBR containing a different number would be considered as invalid by the BIOS and by any PC operating system.

Boot Sectors

Boot sectors are the first sectors on a hard disk partition, except in the case of extended partitions which are just "containers" for other partitions. Boot sectors offer 512 bytes of space and are designed to contain code capable of launching an operating system on this partition. Boot sectors of formatted DOS, Windows, and OS/2 partitions do exactly that (and in addition, they contain some basic data about the file system structure). In contrast, the boot sector of a Linux partition is empty (even after creating a file system on it). Thus, a Linux partition can *not* bootstrap itself, even if it contains a kernel and a valid root file system.

A boot sector with a valid start code contains the same "magic number" as the MBR in its last two bytes (AA55).

Booting DOS or Windows 95/98

The DOS MBR of the first hard disk contains information that determines which partition of a hard disk is "active" — which partition should be searched for the operating system to boot. Therefore, DOS must be installed on the first hard disk. The executable code in the MBR ("first stage boot loader") tests whether the marked partition contains a valid boot sector.

If this is the case, the "second stage boot loader" can be started from there. DOS system programs can now be loaded and you will see the usual DOS prompt. In DOS, only primary partitions can be marked active. Therefore, you cannot use logical partitions inside an extended partition as bootable DOS partitions.

Boot Concepts

The simplest boot concept involves only one machine with one operating system installed. The boot process for this case has already been outlined. The same boot concept can be used for a Linux-only machine. In this case, you could theoretically skip the installation of LILO or GRUB. However, in this case you would not be able to pass additional parameters to the system kernel at boot time. As soon as there is more than one operating system installed, there are several possible boot concepts:

Booting Another OS from a Floppy Disk: One OS can be booted from the hard disk. Other operating systems can be booted using boot disks.

- *Requirements:* the floppy drive must be bootable
- *Example:* install Linux in addition to Windows, but boot Linux from a floppy disk
- *Advantage:* no boot loader needs to be installed
- *Disadvantage:* requires working boot disks and the boot process takes longer

- Depending on the purpose of the computer, it is an advantage or disadvantage that Linux cannot be booted without a disk.

Booting Another OS from a USB Storage Device: The system can also use a USB device to drive the boot process, which is very similar to the floppy method, only that the necessary data are fetched from the USB stick.

Installing a Boot Manager: This allows you to use several operating systems on a single machine, and to choose among the installed systems at boot time. Switching to another operating system requires a reboot. The only condition is that the boot manager must be compatible with all the operating systems installed on the machine.

Map Files, GRUB, and LILO

The main obstacle for booting an operating system is the fact the kernel usually is a file within a file system on a partition on a disk. These concepts are unknown to the BIOS. To circumvent this, "maps" and "map files" were introduced. These maps simply note the physical block numbers on the disk that comprise the logical files. When such a map is processed, the BIOS loads all the physical blocks in sequence as noted in the map, building the logical file in memory.

The main difference between LILO and GRUB is that LILO relies almost entirely on maps, whereas GRUB tries to get rid of fixed maps during boot as early as possible. This is accomplished by integrating file system code to the boot loader, so that files can be found by their path names rather than block numbers.

This difference has historical reasons: in the early days of Linux, many file systems were competing for dominance. Werner Almesberger wrote a boot loader that did not need to know in what kind of file system the kernel to boot actually resided. The idea behind the GRUB approach, however, is even older, from the ages of traditional Unix and BSD. These usually had a single file system of choice and often had a reserved space at its beginning in which to embed a boot loader. This boot loader knew the data structures of the file system in which it was embedded and kernels could be found by name in the root directory of that file system.

The following section describes the installation and configuration of a boot manager, using the Linux boot manager GRUB as an example. This is followed by a description of the differences when using LILO. A complete description of LILO is available in **?**, which is located in `/usr/share/doc/packages/lilo/user.dvi`.

You can view the text on screen with an application such as `kdvi`, or print it with the command: `lpr /usr/share/doc/packages/lilo/user.dvi`.

Note

Which boot manager will be installed by default?

If you update from a previous version of SuSE Linux where LILO was the boot manager, the new system will continue to use LILO. If you install SuSE Linux from scratch, the system will use GRUB, except where the root partition is installed on a RAID system of the following types:

- CPU controlled RAID controllers (such as many Promise and Highpoint controllers)
- software RAID
- LVM

Note

Booting with GRUB

Similar to LILO, GRUB (the Grand Unified Boot loader) consists of two stages. The first stage is just 512 bytes long. It is written to the MBR or to the boot sector of a disk partition or floppy disk. The second, larger stage is loaded after that and holds the program code as such. The only purpose of the first stage is to load the second one.

From here, however, GRUB works differently than LILO, because the second stage contains code to read file systems. Currently supported are Ext2, Ext3, ReiserFS, JFS, XFS, Minix, and the DOS FAT file system used by Windows. GRUB has the ability to access file systems even before the boot process as such, as long as they are on devices handled by the BIOS (floppies or hard disks). This means that changes to the GRUB configuration do not require a reinstallation of the boot manager. On booting, GRUB just rereads its menu file to gather information about the paths and partitions where the kernel and the initial RAM disk (`initrd`) reside and is then able to find these files itself.

Another big advantage of GRUB is that all boot parameters can easily be changed *before* the actual booting. If it turns out that the menu file contains an error, it is still possible to fix it "on the fly." GRUB also allows entering boot commands interactively through a prompt, which makes it possible to boot a system for which no entry has been written into the boot menu. Finally, GRUB is able to locate kernel and initrd images before the actual boot procedure.

The GRUB Boot Menu

GRUB displays a graphical splash screen or a text mode interface with a boot menu. The contents of this screen are controlled by the configuration file `/boot/grub/menu.lst`. This file contains all the information about the partitions or operating systems that can be selected from the boot menu.

This menu file is loaded by GRUB directly from the file system on each boot, so there is no need to update GRUB when the file has been modified. To reconfigure the boot loader, just edit the file via YaST or with your favorite editor.

The menu file contains commands GRUB should execute and its syntax is quite easy to grasp. Each line consists of a command, optionally followed by arguments that must be seperated by spaces, as is the case with shell commands. For historical reasons, there are some commands that allow an `'='` before their first argument. Lines beginning with a hash (`'#'`) are comments.

Each entry that should appear in the boot menu corresponds to a name in the configuration file, which must be preceded by the `title` keyword. In other words, the text string coming after `title` (including any spaces) is displayed as a selectable menu item. The following entries up to the next `title` entry are considered commands to execute when the menu item is selected.

A simple case of such a command is the chain loading of another operating system's boot loader. The command is called `chainloader` and the argument is usually another partition's boot block, written in the block notation of GRUB, for example:

```
chainloader (hd0,3)+1
```

GRUB's device naming scheme is explained in Section *Naming Conventions for Hard Disks and Partitions* on the next page. The above example specifies the first block of the fourth partition on the first hard disk.

The command to specify a kernel image is just `kernel`. The first argument is the path to the kernel image on a partition. The remainder are parameters to pass to that kernel upon booting.

If the kernel does not have the necessary built-in file system or disk drivers to access the root partition, also include the `initrd` command. This GRUB command takes only one argument, which is the path to the initrd file. The `initrd` command must follow after the `kernel` command, because the kernel (already loaded at this point) assumes a certain loading address of the initrd image.

The `root` command simplifies the specification of kernel and initrd images. `root` takes a device or partition (in GRUB notation) as its only argument.

GRUB then appends the value of `root` to the beginning of all kernel, initrd, or other file paths that do not explicitly specify a device. This applies up to the next `root` command. The command is not used in the default `menu.lst` file created during the installation.

The `boot` command is implied and thus automatically executed at the end of each menu entry, so it does not need to be written into the menu file. On the other hand, if you should ever be in a situation where you have to enter GRUB commands interactively at the prompt, remember to issue the `boot` command at the end. The command itself has no arguments, it just boots the corresponding kernel image or chain loader.

Once you have written all your menu entries, specify which entry to use as the `default`. Otherwise, the first one (number `0`) is booted by default. You can also specify a time-out in seconds after which this should occur. The `timeout` and `default` lines are usually written before the menu entries. A sample configuration file is described in Section *A Sample Menu File* on the following page.

Naming Conventions for Hard Disks and Partitions

GRUB names hard disks and partitions according to conventions which differ from the Linux device names that you might expect (such as `/dev/hda1`). The first hard disk is always referred to as `/dev/hd0`. The floppy drive is called `/dev/fd0`.

Note

Counting Partitions

With GRUB, partitions are counted beginning from zero. Accordingly, `hd0,0` refers to the first partition on the first hard disk. On a typical desktop machine with just one hard drive connected as primary master, this corresponds to the Linux device called `/dev/hda1`.

Note

The four primary partitions that are allowed per disk are numbered from `0` to `3`, and logical partitions are counted beginning with `4`:

```
(hd0,0)   first primary partition on first hard disk
(hd0,1)   second primary partition
(hd0,2)   third primary partition
(hd0,3)   fourth primary partition (usually an extended partition)
(hd0,4)   first logical partition
(hd0,5)   second logical partition
...
```

Note

IDE, SCSI, and RAID

GRUB does not distinguish between IDE, SCSI, or RAID devices. All hard disks as detected by the BIOS or other disk controllers are counted according to the boot sequence as set in the BIOS itself.

Note

The fact that BIOS device names do not correspond to Linux devices is a problem that exists for both LILO and GRUB. Both use similar algorithms to establish a mapping. GRUB, however, stores the result in a file (`device.map`) which can be edited. For more information about `device.map`, refer to Section *The File device.map* on page 78.

For GRUB, a path name must be specified as a device name written in parentheses, followed by a file name together with its full path on that device or partition. The path must always start with a slash. For example, on a system with a single IDE disk and Linux on the first partition, the bootable kernel might be specified with:

```
(hd0,0)/boot/vmlinuz
```

A Sample Menu File

The following example shows how the GRUB menu file works. This imaginary machine has a Linux boot partition on `/dev/hda5`, a root partition on `/dev/hda7`, and a Windows installation on `/dev/hda1`.

```
gfxmenu (hd0,4)/message
color white/blue black/light-gray
default 0
timeout 8

title linux
   kernel (hd0,4)/vmlinuz root=/dev/hda7 vga=791
   initrd (hd0,4)/initrd
title windows
   chainloader(hd0,0)+1
title floppy
   chainloader(fd0)+1
title failsafe
   kernel (hd0,4)/vmlinuz.shipped root=/dev/hda7 ide=nodma \
   apm=off acpi=off vga=normal nosmp maxcpus=0 3
   initrd (hd0,4)/initrd.shipped
```

The first part defines the splash screen configuration:

gfxmenu (hd0,4)/message The background image is located on `/dev/hda5` and has the name `message`.

color The color scheme: white as normal foreground, blue as normal background, black for the foreground of selected items, and light gray as the selection background. These colors do not affect the graphical splash screen as defined under `gfxmenu`, but the standard GRUB interface. On a SuSE Linux system, this interface can be accessed from the splash screen by pressing Esc.

default 0 The first menu entry `title linux` shall be booted by default.

timeout 8 After 8 seconds without user input, GRUB automatically boots the default entry.

The second, larger part defines the different operating systems to boot:

- The first entry (`title linux`) is responsible for booting SuSE Linux. The kernel (`vmlinuz`) is located on the first hard disk on the first logical partition (which is the boot partition in this case). The appended arguments are kernel parameters to specify the root partition and the video mode. The root partition is specified according to Linux conventions (`/dev/hda7`), because this is a parameter to be interpreted by the Linux kernel (and not by GRUB). The `initrd` image is located on the same logical partition of the first hard drive.
- The second entry is responsible for booting Windows, which is installed on the first partition of the first hard drive (`hd0,0`). The command `chainloader +1` causes GRUB to read and execute the first sector of the specified partition.
- The next entry enables booting from the floppy drive without changing any BIOS settings.
- The `failsafe` entry boots a Linux kernel with a number of specific kernel parameters to make it possible to boot on systems where the hardware is causing problems.

The menu file can be modified at any time. GRUB automatically reads the changes on the next boot. To make changes to the boot procedure that should be permanent, modify this file with the corresponding YaST module or with your favorite editor. To change the GRUB behavior on a temporary basis only, use the interactive edit function provided by GRUB.

Editing the Menu Entries

The graphical interface of GRUB not only allows selection of the system to boot (moving the cursor with the arrow keys), but also allows kernel parameters to be appended at the boot prompt (provided that the selection represents a Linux system). This was already possible with LILO, but GRUB takes this one step further. If you press Esc to leave the splash screen then E, GRUB enters editing mode, allowing you to directly change individual menu items. Changes made in this way are valid for the current boot action only. They are not be written to the configuration file.

Note

Keyboard Layout during the Boot Phase

The US keyboard layout is the only one available at boot time. Thus, you need to remember that some characters may need to be produced with different keys.

Note

After enabling the editing mode, use the arrow keys to navigate to the entry to change. To make the selected item editable, press E again. You can now correct any partitions or paths that may be wrong to avoid that they affect the boot procedure. Leave the editing mode with Enter and go back to the menu, where the changed entry can be booted by pressing E. In the lower part of the screen, GRUB displays some hints on other actions that you may take.

To make the changed boot options permanent, edit the file `menu.lst` as `root` and append any additional kernel parameters at the end of the existing line, each separated by a space:

```
title linux
   kernel (hd0,0)/vmlinuz root=/dev/hda3 <additional parameter>
   initrd (hd0,0)/initrd
```

GRUB takes any new parameters into account upon the next boot. An alternative way to make these changes is through the YaST boot loader module. Again, any new parameters need to be appended at the end, after a separating space.

The File device.map

The previously-mentioned file `device.map` maps GRUB device names to Linux device names. If your system has a hardware mix that includes both IDE and SCSI disks, GRUB tries determine the boot sequence according to a certain algorithm. However, GRUB is not able to access the BIOS setup to obtain this information. GRUB stores the result of this check in the file `/boot/grub/device.map`. For a system where the BIOS is set up to boot IDE devices before any SCSI devices, the file could look like this:

```
(fd0)  /dev/fd0
(hd0)  /dev/hda
(hd1)  /dev/hdb
(hd2)  /dev/sda
(hd3)  /dev/sdb
```

If GRUB boots with a given `device.map` file and encounters any problems, check the order of the devices in the file and use the GRUB shell to change it if necessary. Once you have successfully booted your Linux system, you can change the `device.map` file with the boot loader module of YaST or with any editor.

Any manual change to the `device.map` file requires that you update your GRUB installation. This is done with the following command:

```
grub --batch < /etc/grub.conf
```

The File /etc/grub.conf

In addition to `menu.lst` and `device.map`, GRUB stores another important part of its configuration in the file `grub.conf`. This file defines the parameters and options needed by the `grub` command to correctly install the boot loader:

```
root (hd0,4)
install /grub/stage1 d (hd0) /grub/stage2 0x8000 (hd0,4)/grub/menu.lst
quit
```

The individual entries have the following meaning:

root (hd0,4) This tells GRUB that all the following commands should be applied to the first logical partition on the first hard drive, where the boot files are located.

install ⟨*parameter*⟩ This tells `grub` to run its internal `install` command, specifying that it should install the first stage of the boot loader in the MBR of the first hard disk (`/grub/stage1 d (hd0)`) and that the memory address at which to load stage2 is `0x8000` (`/grub/stage2 0x8000`). The last parameter (`(hd0,4)/grub/menu.lst`) tells GRUB where to look for the menu file.

The GRUB Shell

GRUB actually consists of two parts: the boot loader and a normal Linux program (/usr/sbin/grub). This program is also called the *GRUB shell*. The functionality to install the boot loader on a hard disk or floppy is integrated into the GRUB shell through the internal commands install and setup. In other words, these commands can be executed using the GRUB shell on a running Linux system. However, these commands are *also* available *while* the system is booting with GRUB— before Linux is even running. This makes the repair of a defective system much easier.

The device mapping algorithm as mentioned above only matters when GRUB runs its shell. It then reads the file device.map to map GRUB device names to Linux devices as indicated by each line. Given that the order in which the BIOS addresses IDE, SCSI, and other hard drives depends on several factors and given that Linux cannot reliably determine this order, GRUB uses the device.map file where the correct order can specified by hand. If you have difficulties booting your machine, check that the order in this file is in line with your BIOS settings. The file is found in the directory /boot/grub. To learn more about the topic, read Section *The File device.map* on page 78.

Setting a Boot Password

Because GRUB is able to access file systems upon booting, it could also be used to read files that would not be accessible under normal circumstances — on a running system, users would need root permissions to read them. To put a stop to this, set a boot password. Such a password can be used to prevent unauthorized access to file systems at boot time and to prevent users from booting certain systems that are installed.

To create a boot password, log in as root root and perform these steps:

- Start the GRUB shell and encrypt the password:

```
grub> md5crypt
Password: ****
Encrypted: $1$lS2dv/$JOYcdxIn7CJk9xShzzJVw/
```

- Paste the encrypted string into the global section of the menu.lst file:

```
gfxmenu (hd0,4)/message
color white/blue black/light-gray
default 0
timeout 8
password --md5 $1$lS2dv/$JOYcdxIn7CJk9xShzzJVw/
```

From now on, executing GRUB commands from the boot prompt is impossible without knowing the password. Permission to do so is only granted after pressing P and entering the password. However, users can still boot all operating systems without any restriction.

- To keep users from booting certain systems, add a `lock` line for each entry in `menu.lst` where booting should be restricted to users knowing the password, like in this example:

```
title linux
        kernel (hd0,4)/vmlinuz root=/dev/hda7 vga=791
        initrd (hd0,4)/initrd
        lock
```

After rebooting, trying to boot this entry from the menu would result in the following error message:

```
Error 32: Must be authenticated
```

Return to the menu by pressing Enter. From the menu, pressing P prompts for the password. The selected system (Linux in our case) should boot after typing the password and pressing Enter.

Note

Boot Password and Splash Screen

Setting a boot password for GRUB disables the graphical splash screen as displayed by default.

Note

Troubleshooting and Further Reading

Note

Boot Errors with GRUB

The geometry of attached hard disks is checked by GRUB only upon booting. In those rare cases where the BIOS reports inconsistent values, GRUB aborts with a “GRUB Geom Error”. You may then need to use LILO instead or, if at all possible, update the BIOS.

Note

Extensive information about GRUB in English, German, and Japanese can be obtained at http://www.gnu.org/software/grub/, but the online GRUB manual itself is only available in English.

If you have texinfo installed on your system, you can view the GRUB info pages from a shell prompt by entering `info grub`. You can also look up "GRUB" as a keyword in the support database at http://sdb.suse.de/en/sdb/html/index.html to obtain information about special issues.

Booting with LILO

The Linux boot loader LILO is suitable for installation in the MBR. LILO has access to two real-mode hard disks and is able to find all the data it needs from the *raw* hard drives without any partitioning data. Therefore, operating systems can also be booted from the second hard disk. Unlike with the DOS boot process, the entries in the partition table are ignored when using LILO.

The main difference from the standard DOS boot process is the possibility to load diverse installed operating systems when booting. After loading the `MBR` into memory, LILO is started, allowing the user to select from the list of preinstalled systems. At system start-up, it can load boot sectors from partitions to boot an operating system from the respective partition or load the Linux kernel and boot Linux. It also provides the important possibility of passing a command to the kernel. For security reasons, some or all LILO services can be protected with a password.

Basics

The LILO boot mechanism consists of the following components:

- The *LILO boot sector* with the initial part ("first stage") of the LILO code that activates the actual LILO when the system is booted.
- The LILO machine code, located in `/boot/boot-menu.b`.
- A *map* file (`/boot/map`), where LILO enters the location of Linux kernels and other data during its installation.
- Optional: the *message file* `/boot/message`, which displays the graphical boot menu from which the operating system can be selected
- The different Linux kernels and boot sectors LILO should offer

Caution

Any write access (even through file movements) to any of these files corrupts the map file – unless LILO is *updated* (see *Updating After Changing the Configuration* on page 88). This is especially important when changing kernels.

Caution

The following locations are suitable for storing the LILO *boot sector*:

On a *floppy disk* This is the simplest, but also the slowest method for booting with LILO. Choose this alternative if you do not want to change the existing boot sector.

In the *boot sector* of a primary Linux partition on the first hard disk This leaves the MBR untouched. Before it can be booted, the partition must be marked active. Start fdisk as `root` with the command `fdisk -s <partition>`. The program will ask for a command. You can obtain a list of the available commands by entering `'m'`. The `'a'` command can be used to mark a partition as active.

In the *Master Boot Record* This variation offers the highest flexibility. It is the only possible alternative if all the Linux partitions reside on the second hard disk, and if there is no extended partition on the first drive. Every setting of the MBR must be edited with extreme care because errors may have severe consequences.

In a boot sector booted by *another boot manager* Try this if you are using another boot manager and want to continue using it. Depending on its flexibility and power, there are several variations. A common case: you have a primary Linux partition on the second hard disk from which you want to boot Linux. If your boot manager is able to boot this partition through its boot sector, you may install LILO into this boot sector and then tell your boot manager that the partition is active.

Configuring LILO

LILO is a flexible boot manager that offers many ways of adapting a configuration to your needs. The most important options and meanings are described below. For more detail, look at **?**.

The configuration of LILO is stored in the file `/etc/lilo.conf`. You should always make a backup of the last working `lilo.conf` file before changing it.

On the other hand, any changes in this file take effect only when reinstalling LILO i. e.after running the `lilo` command against the changed `/etc/lilo.conf` file. For details on this, refer to Section *Installing and Uninstalling LILO* on page 87.

Structure of lilo.conf

`/etc/lilo.conf` starts with a global section, followed by one or more system sections for each operating system LILO should start. Each system section starts with a line beginning with either `image` or `other`.

The order of entries in `/etc/lilo.conf` does matter, in the sense that the first one in the list is booted automatically if there is no user input at the boot screen (and unless the `default` option is used). This may happen after a certain interval which can be set with the `delay` and `timeout` options as explained below.

A sample configuration for a computer with both Windows and Linux is shown in File 2. The bootable systems include a newly installed Linux kernel (`/boot/vmlinuz`) and the original kernel which is used as a fallback (`/boot/vmlinuz.shipped`). There is also an entry to boot Windows on `/dev/hda1`, and an additional one to start the program MemTest86.

```
### LILO global section
boot    = /dev/hda           # LILO installation target: MBR
backup  = /boot/MBR.hda.990428  # backup file for the old MBR
                                # 1999-04-28
vga     = normal             # normal text mode (80x25 chars)
read-only
menu-scheme = Wg:kw:Wg:Wg
lba32                        # Use BIOS to ignore
                             # 1024 cylinder limit
prompt
password = q99iwr4           # LILO password (example)
timeout = 80                 # Wait at prompt for 8 s before
                             # default is booted
message = /boot/message      # LILO's greeting

### LILO Linux section (default)
  image   = /boot/vmlinuz     # Default
  label   = linux
  root    = /dev/hda7         # Root partition for the kernel
  initrd = /boot/initrd

### LILO Linux section (fallback)
  image   = /boot/vmlinuz.shipped
  label  = Failsafe
  root   = /dev/hda7
  initrd = /boot/initrd.suse
  optional

### LILO other system section (Windows)
  other  = /dev/hda1         # Windows partition
  label  = windows

### LILO memory test section (memtest)
  image  = /boot/memtest.bin
  label  = memtest86
```

File 2: *Sample Configuration of /etc/lilo.conf*

Anything between a `'#'` and the end of a line is regarded as a comment. Spaces and comments are ignored by LILO and can be used to improve readability. The entries in the above sample file include mandatory options which are explained in the list below, and others which are described in Section *Structure of lilo.conf* on the facing page.

- **Global section** (Parameter part)

  - ▷ boot=⟨*bootdevice*⟩
    The device on whose first sector LILO should be installed. ⟨*bootdevice*⟩ may be a floppy disk drive (`/dev/fd0`), a partition (e. g., `/dev/hdb3`), or an entire disk (e. g., `/dev/hda`). In the last case, LILO would be installed in the MBR. If this option is missing, LILO is installed on the current root partition by default.

  - ▷ lba32
    With this option, ignore the 1024-cylinder limit of LILO if your BIOS supports this.

  - ▷ prompt
    Forces the LILO prompt to be displayed. The default is not to display any prompt (see Section *Structure of lilo.conf* on the preceding page, option delay).
    This is recommended if LILO needs to manage more than one system. It should be used together with the timeout option, to guarantee that the default system is automatically booted if nothing is entered at the prompt.

▷ timeout=⟨*deciseconds*⟩ Sets a time-out for selecting an operating system to boot. The default system is booted after the time-out if there is no user input. The ⟨*deciseconds*⟩ value specifies the time-out in tenths of a second. Pressing ⇑ Shift or the arrow keys disables the time-out, causing LILO to wait for further user input. The default time-out is set to `80` (8 seconds).

■ **Linux section**

▷ image=⟨*kernelimage*⟩
This specifies the name of the kernel image to boot, including its directory location. With a new system, this is most likely `/boot/vmlinuz`.

▷ label=⟨*name*⟩
A name for the system in question (e. g., Linux) which may be freely chosen but must be unique as far as the contents of `/etc/lilo.conf` are concerned. Its maximum length is 15 characters, and it may only consist of letters, numbers, and underscores, i. e.no blanks or special characters. For more about the specific characters that are allowed, see **?**, Section 3.2.1. The default for this option is the file name of the corresponding kernel image (e. g., `/boot/vmlinuz`).
The same name is presented in the boot menu as one of the selectable items. If there are several systems installed, you may want to provide a more detailed description of the bootable systems by creating a message file, (see Section *Structure of lilo.conf* on page 84, option message).

▷ root=⟨*rootdevice*⟩
This is used by LILO to tell the kernel about the name of the root partition (e. g., `/dev/hda2`) of your Linux system. You should use this option to be on the safe side: if it is omitted, the kernel just assumes that the root partition is identical with its own root device (as derived from ⟨*kernelimage*⟩).

▷ append=⟨*parameter*⟩
In order to pass on additional boot parameters to the kernel, you can add the append option to an existing `lilo.conf` file, followed by a = and your parameters. Individual parameters must be seperated by spaces, and the parameter string as a whole must be enclosed in quotation marks. After saving the file, you still need to execute the `lilo` command as `root`, so that LILO reinstalls the boot loader and takes the changes into account during the next boot.

- **Linux part** (Linux — Safe Settings)

  Even if you installed a customized kernel, you are still able to boot the SuSE standard kernel.

  ▷ optional

  If you decide to delete `/boot/vmlinuz.shipped` (*not recommended*), this section will be skipped without an error message during LILO installation.

- **Other systems**

  ▷ other=⟨*partition*⟩

  other tells LILO to start the partitions of other systems (e. g., `/dev/hda1`).

  ▷ label=⟨*name*⟩

  Select a name for the system. This is recommended, because the default — the raw device name — is not very informative.

- **Memory Test**

  Entry for the memory test program memtest86.

This section merely covers the basic entries required in `/etc/lilo.conf`. Other useful settings can be found in the man page for `lilo.conf` (`man lilo.conf`).

Installing and Uninstalling LILO

Caution

Before you install LILO, make sure that any other existing operating systems can be booted from floppy disk (not possible for Windows XP/2000/NT). In particular, make sure that fdisk is available. As far as SuSE Linux is concerned, you can use the installation CD or DVD as a fallback boot medium.

Caution

Updating After Changing the Configuration

If any of the LILO components have changed, or if you have modified your configuration in `/etc/lilo.conf`, you must update the LILO boot loader. This is easily done by launching the map installer as `root`:

```
/sbin/lilo
```

LILO creates a backup of the target boot sector, writes its first stage into the boot sector, then generates a new map file (also see *Booting with LILO* on page 82). LILO issues a report on each installed system In the case of the sample configuration described above, it should look like this:

```
Added linux *
Added suse
Added windows
Added memtest86
```

Output 4: *Output After Launching LILO*

When the boot loader update is completed, you can reboot the machine by issuing this command as `root`:

```
shutdown -r now
```

While rebooting, the BIOS first performs its system test. Immediately afterwards, you should see LILO and its command prompt, where you can enter parameters and select a boot image. You can also hit Tab to see a list of the systems installed.

Uninstalling the Linux Boot Loader

To uninstall GRUB or LILO, the boot sector on which the boot loader is located needs to be overwritten with its original contents. With SuSE Linux, this is easily done provided that there is a valid backup of that former content. The YaST boot loader module can be used to create such a backup, to integrate such a backup in the boot loader menu later on, and to restore a standard MBR. The YaST boot loader module is described in the installation chapter of the *User Guide*.

Caution

A boot sector backup is no longer valid if the partition in question has a new file system. The partition table of an MBR backup becomes invalid if the hard disk in question has been repartitioned since the backup was created. Obsolete "backups" are time bombs. It is best to delete them as soon as possible.

Caution

Restoring the MBR (DOS/Win9x/ME

It is very simple to restore a DOS or Windows MBR. Just enter the MS-DOS command (available since DOS version 5.0):

```
fdisk /MBR
```

or, on OS/2:

```
fdisk /newmbr
```

These commands only write the first 446 bytes (the boot code) into the MBR and leave the partition table untouched, unless the MBR as a whole (see on page 70) is treated as invalid due to an incorrect magic number. In this case, the partition table is set to zero. After restoring the MBR, make sure that you mark the desired start partition as bootable (using fdisk again). This is required for the MBR routines of DOS, Windows, and OS/2.

Restoring the MBR of Windows XP

Boot from the Windows XP CD and press the Ⓡ key during the setup to start the recovery console. Select your Windows XP installation from the list and enter the administrator password. At the input prompt, enter the command `FIXMBR` and confirm with `y` when asked to do so. Then reboot the computer with `exit`.

Restoring the MBR of Windows 2000

Boot from the Windows 2000 CD and press the Ⓡ key and then Ⓒ in the next menu to start the recovery console. Select your Windows 2000 installation from the list and enter the administrator password. At the input prompt, enter the command `FIXMBR` and confirm with `y` when asked to do so. Then reboot the computer with `exit`.

Booting Linux after Restoring the MBR

After restoring the standard Windows MBR, you can set up one of the Linux boot managers available, to continue using the Linux system installed on your machine.

GRUB

Even when installed in the MBR, GRUB will write its stage1 data into the Linux partition. After having restoring the MBR with YaST or with the Windows tools mentioned above, you need to mark that partition as active, which can be done with fdisk. To do so, log in as `root` und execute the command `fdisk /dev/⟨harddisk⟩`. The fdisk screen will prompt you for a command to run. Enter 'm' to obtain a list of the commands that are available. The 'a' command allows you to select one of the existing primary partitions as active, which in our case should be the Linux partition which holds the stage1 copy. After making this change, you can check the partition table by entering 'p' (print) from within fdisk.

LILO

LILO can be reinstalled after restoring the Windows MBR if there is a backup file available. Check whether the size of the backup file is exactly 512 bytes, then restore the sector with the following commands:

- If LILO resides in partition yyyy (e. g., hda1, hda2,. . .):

  ```
  dd if=/dev/yyyy of=name-of-new-file bs=512 count=1
  dd if=name-of-backup-file of=/dev/yyyy
  ```

- If LILO resides in the MBR of disk zzz (e. g., hda, sda):

  ```
  dd if=/dev/zzz of=name-of-new-file bs=512 count=1
  dd if=name-of-backup-file of=/dev/zzz bs=446 count=1
  ```

The last command is a safe version which does not overwrite the partition table. Again, you still need to use `fdisk` to mark the corresponding partition as active (bootable).

Creating Boot CDs

This concerns problems arising when attempting to boot a system with the LILO boot manager configured with YaST. The creation of a system boot disk fails with more recent SuSE Linux versions because the space available on a floppy disk is no longer sufficient for the start-up files.

Procedure

It is possible to create a bootable CD-ROM containing the Linux start-up files if your system has an installed CD writer. This solution is only a work-around. It should normally be possible to configure LILO properly. Refer to the documentation about this subject in `/usr/share/doc/packages/lilo/README`, the man page for `lilo.conf` (`man lilo.conf`), and the man page for `lilo` (`man lilo`).

Boot CD with ISOLINUX

It is easiest to create a bootable CD with the ISOLINUX boot manager. The SuSE installation CDs are also made bootable with isolinux.

- Boot the installed system first using the following alternate procedure:
  - ▷ Boot from the installation CD or DVD as for installation.
  - ▷ Choose the preselected option 'Installation' during the boot sequence.
  - ▷ Choose the language and keyboard map next.
  - ▷ In the following menu, choose 'Boot installed system'.
  - ▷ The root partition is automatically detected and the system is booted from it.
- Install package `syslinux` with YaST.
- Open a root shell. The following commands create a temporary directory and copy the files required for the booting of the Linux system (the isolinux boot loader as well as the kernel and the initrd) into it:

```
earth:~ #  mkdir /tmp/CDroot
earth:~ #  cp /usr/share/syslinux/isolinux.bin /tmp/CDroot/
earth:~ #  cp /boot/vmlinuz /tmp/CDroot/linux
earth:~ #  cp /boot/initrd /tmp/CDroot
```

- Create the boot loader configuration file `/tmp/CDroot/isolinux.cfg` with your preferred editor. Enter the following content:

```
DEFAULT linux
LABEL linux
  KERNEL linux
  APPEND initrd=initrd root=/dev/hdXY [boot parameter]
```

Enter your root partition for the parameter `root=/dev/hdXY`. It is listed in the file `/etc/fstab`. Enter additional options for the setting `[boot parameter]`, which should be used during booting. The configuration files could, for example, look like this:

```
DEFAULT linux LABEL linux KERNEL linux APPEND initrd=initrd
root=/dev/hda7 hdd=ide-scsi
```

- The following command (entered at a command prompt) then creates an ISO-9660 file system for the CD.

  ```
  mkisofs -o /tmp/bootcd.iso -b isolinux.bin -c boot.cat
    -no-emul-boot -boot-load-size 4
    -boot-info-table /tmp/CDroot
  ```

  The complete command must be entered as one line.

- The file `/tmp/bootcd.iso` can be written to CD after that with either graphical CD writing applications, like KonCD or XCDroast, or simply at a command prompt:

  ```
  cdrecord -v speed=2 dev=0,0,0 /tmp/bootcd.iso -eject
  ```

  The parameter `dev=0,0,0` must be changed according to the SCSI ID of the writer. This can be determined with the command `cdrecord -scanbus`. Also, refer to the man page for `cdrecord` (`man cdrecord`).

- Test the boot CD. Reboot the computer to verify whether the Linux system is started correctly from the CD.

The X Window System

The X Window System is the de facto standard GUI for UNIX. Yet the X Window System is far more than this — X11 is a network-based system. Applications running on the machine `earth` can display their results on the machine `sun`, provided the two machines are connected via a network. The network could be a local one (LAN) or a connection between computers thousands of miles away via the Internet.

Among other things, the following sections draw attention to the program xf86config, which can be used instead of SaX2 to configure the monitor, graphics card, keyboard, and mouse. Another focus is the configuration of OpenGL and 3D. See **?** for the description of the YaST modules.

Historical Background 94
Version 4.x of XFree86 94
Configuration Using xf86config 96
Optimizing the Installation of the X Window System 105
OpenGL — 3D Configuration 113

Historical Background

X11 was first developed as an enterprise of DEC (Digital Equipment Corporation) and the project Athena at MIT (Massachusetts Institute of Technology). The first release of X11R1 was in September 1987. Since release 6, the X Consortium, Inc. has been responsible for the development of the X Window System.

XFree86 ™ is a freely available implementation of X servers for PC systems. It was developed by a handful of ambitious programmers who founded the XFree86 team in 1992. In 1994, this team went on to found The XFree86 Project, whose aim is to continue research and development on X11 and to provide it to the public. The completely revised major release XFree86-4.0 has been available for download from `http://www.XFree86.org` since March 2000. By default, SuSE Linux installs XFree86-4.0. Below, take a closer look at the features of this version.

The following sections cover the configuration of the X server, introducing the two programs SaX2 and xf86config, which can be used to configure the X Window System. To use the available hardware (mouse, graphics card, monitor, keyboard) in the best way possible, the configuration can be optimized manually. Certain aspects of this optimization will be explained. Others are not covered in detail. For more information about configuring the X Window System, refer to the directory `/usr/share/doc/packages/xf86` and to the man page for `XF86Config` (`man XF86Config`).

Caution

Be very careful when configuring your X Window System. Never start the X Window System until the configuration is finished. A wrongly configured system can cause irreparable damage to your hardware (this applies especially to fixed-frequency monitors). The authors of this book and SuSE cannot be held responsible for damage. This information has been carefully researched, but this does not guarantee that all methods presented here are correct and will not damage your hardware.

Caution

Version 4.x of XFree86

This version of SuSE Linux comes with version 4.x of XFree86, which differs from the previously used version 3.3 in a number of ways. Overall, there are hardly any differences for the user when operating the graphical desktop. Applications, such as the graphical desktops KDE or GNOME, behave with the new version in the same way as version 3.3.6 included in earlier distributions.

Advantages

The new X server is no longer a monolithic program, but just a relatively small basic scaffolding to which the necessary program modules can later be added, if and when required. For example, there are no longer many different X servers for different graphics cards as in the previous version, but just one executable program called XFree86, which can be found in the directory `/usr/X11R6/bin`. This is also the actual X server. The graphics driver, which then takes on the task of controlling the graphics card, is a loadable module.

A similar method is used to support the various input devices, fonts, or X protocols. This again consists of individual modules that can be later loaded by the X server. As a rule, you do not need to worry about these modules. The configuration of the modules to operate the graphical desktop on your computer is managed, as far as possible, by SaX2.

Through this module concept, it is easy for a vendor to implement a driver for exotic hardware, such as touch screens or new graphics cards. The developers have even ensured that the necessary modules for various operating systems only need to be made available once, which means that a graphics driver module compiled in FreeBSD, for example, can also be used in Linux and vice versa. This portability, however, is limited to the same hardware platform: a module compiled for Linux on PowerPCs cannot be used on an Intel PC.

Support for the mouse has also been significantly improved. Especially under heavy loads, the reaction of the mouse to mouse movements is considerably faster and more direct than with the previous XFree86 X server. Overall, the output speed has also been improved, so graphics operations are generally performed more quickly than on the old X server due to the completely revised XAA (*XFree86 Acceleration Architecture*).

Compared to XFree86 3.3.x, the configuration file has a slightly different format and is now located in `/etc/X11/XF86Config`. For fine-tuning your X configuration, details on the structure of the configuration file and how it functions can be found in *Optimizing the Installation of the X Window System* on page 105.

Error logging has also been improved. The X server creates a very detailed log file, which you can always find after the X server has started in the file `/var/log/XFree86.0.log`. One of the further features of this version is the support of special options, such as True Type fonts. Other features also include the 3D protocol extension, glx, gamma correction of the screen, and the support of multiple graphics cards for multihead configurations. More information about this can be found in *Optimizing the Installation of the X Window System* on page 105.

Configuration Using xf86config

In most cases, SaX is superior to xf86config for the simple configuration of the X Window System. However, if the configuration does not work with SaX, just use xf86config, which almost always works.

XFree86 4.x includes a similar text-based program, xf86config. At some points, this contains dialogs that have been somewhat modified. It writes the configuration file to `/etc/X11/XF86Config`. Usually XFree86 4.x does not require the use of xf86config, because "problem" graphics cards can also be configured with the framebuffer or with the vga module.

Make sure you have the following information available:

- mouse type, port to which the mouse is connected, and baud rate (the baud rate is normally optional)
- specifications of the graphics card
- monitor data (frequencies, etc.)

If these settings are known or you have your manuals at hand, start the configuration. Only `root` can do this. The configuration is started with:

```
earth:/root # xf86config
```

Mouse

Following the welcome screen, select the mouse type from the following:

```
1. Microsoft compatible (2-button protocol)
2. Mouse Systems (3-button protocol)
3. Bus Mouse
4. PS/2 Mouse
5. Logitech Mouse (serial, old type, Logitech protocol)
6. Logitech MouseMan (Microsoft compatible)
7. MM Series
8. MM HitTablet
```

Output 5: *Mouse Selection for X*

While selecting the mouse, bear in mind that many of the new Logitech mice are either Microsoft compatible or use the MouseMan protocol. The selection Bus Mouse refers to any bus mouse, including Logitech.

Selection is made by entering the relevant number. There may be a question as to whether to activate "ChordMiddle". This is necessary for some Logitech mice or track balls for activation of the middle mouse button.

```
Please answer the following question with either 'y' or 'n'.
Do you want to enable ChordMiddle?
```

If you have a two-button mouse, emulate the third button by answering 'y' to the next question.

```
Please answer the following question with either 'y' or 'n'.
Do you want to enable Emulate3Buttons?
```

The middle button is emulated by simultaneously pressing the two mouse buttons.

Next, specify the mouse's interface:

```
Now give the full device name that the mouse is connected to,
for example /dev/tty00.
Just pressing enter will use the default, /dev/mouse.
Mouse device:
```

If you have already entered a port for your mouse during the system installation, just enter /dev/mouse.

Keyboard

Next, determine whether to assign Meta (ESC) to the left Alt key and to assign ModeShift (AltGr) to the right Alt key.

```
Please answer the following question with either 'y' or 'n'.
Do you want to enable these bindings for the Alt keys?
```

If you answer 'y', the left Alt key can serve as the meta key for Emacs and the keys that need ModeShift (AltGr) can be entered.

Monitor

Next, specify your monitor. Be extremely careful with vertical and horizontal frequencies. These values can be found in your monitor manual.

Caution

Setting frequencies incorrectly can lead to irreparable damage to your monitor. The X Window System only addresses video modes that operate the monitor in the given frequency range. Entering frequencies for which the monitor was not designed can cause severe damage to it.

Caution

Some monitors are listed under `/usr/X11R6/lib/X11/doc/Monitors`. However, we cannot be held liable if this information is inaccurate.

To enter the horizontal frequency, the following selection is displayed:

```
hsync in kHz; monitor type with characteristic modes
 1 31.5;               Standard VGA, 640x480 @ 60 Hz
 2 31.5 - 35.1;        Super VGA, 800x600 @ 56 Hz
 3 31.5, 35.5;         8514 Compatible, 1024x768 @ 87 Hz interl.
                       (no 800x600)
 4 31.5, 35.15, 35.5;  Super VGA, 1024x768 @ 87 Hz il.,
                       800x600 @ 56 Hz
 5 31.5 - 37.9;        Extended Super VGA, 800x600 @ 60 Hz,
                       640x480 @ 72 Hz
 6 31.5 - 48.5;        Non-Interlaced SVGA, 1024x768 @ 60 Hz,
                       800x600 @ 72 Hz
 7 31.5 - 57.0;        High Frequency SVGA, 1024x768 @ 70 Hz
 8 31.5 - 64.3;        Monitor that can do 1280x1024 @ 60 Hz
 9 31.5 - 79.0;        Monitor that can do 1280x1024 @ 74 Hz
10 Enter your own horizontal sync range
Enter your choice (1-10):
```

Output 6: *Input of Horizontal Frequencies of the Monitor*

Only choose one of the predefined modes if you are unsure of the settings for your monitor. Use selection '10' to enter your own frequencies. The next screen asks you to enter your monitor's vertical frequency. It will also provide a selection:

```
 1 50-70
 2 50-90
 3 50-100
```

```
4 40-150
5 Enter your own vertical sync range
Enter your choice (1-5):
```

Output 7: *Detailed Vertical Frequencies*

Again, using the known values is preferable to using one of the items '1' to '4'.

Next, enter a name, vendor name, and model for your monitor:

```
Enter an identifier for your monitor definition:

Enter the vendor name of your monitor:

Enter the model name of your monitor:
```

These are just descriptive names used to document your configuration, which do not affect the configuration itself. Merely pressing ↵ will select the default values, which are usually sufficient.

Your monitor configuration is now complete.

Graphics Cards and X Server

Next, specify your graphics card:

```
Do you want to look at the card database?
```

If you enter 'y', a selection of predefined cards is presented. Here, select your card by pressing the corresponding number. Do not trust this list blindly, because there can be differences in clock chip and RAMDAC[1] settings.

This is why a menu item appears later for selecting a RAMDAC and a clock chip, although you have entered them already. Then the predefined settings for this card will be presented as an extra option.

The card definitions contain information on clock chips, RAMDAC, and the X server to use. Furthermore, some valuable information concerning the card is written to the device section in `XF86Config`.

If your card is not listed, do not panic. Switch back to the normal configuration by selecting 'q'. Only select one of the defined cards if it matches your card exactly. Selecting a card with a similar name is not recommended. Similar names do not necessarily refer to similar hardware.

More information about how to configure your card is given in *Optimizing the Installation of the X Window System* on page 105.

The X server is configured next.

[1]**R**andom **A**ccess **M**emory **D**igital-to-**A**nalogue **C**onverter

```
1 The XF86_Mono server. This a monochrome server that should work on
  any VGA-compatible card, in 640x480 (more on some SVGA chip sets).
2 The XF86_VGA16 server. This is a 16 color VGA server that should
  work on any VGA-compatible card.
3 The XF86_SVGA server. This is a 256 color SVGA server that supports
  a number of SVGA chip sets. It is accelerated on some Cirrus and WD
  chip sets. It supports 16 and 32-bit color on certain Cirrus
  configurations.
4 The accelerated servers. These include XF86_S3, XF86_Mach32,
  XF86_Mach8, XF86_8514, XF86_P9000, XF86_AGX, XF86_W32, and
  XF86_Mach64.

These four server types correspond to the four different "Screen"
sections in XF86Config (vga2, vga16, svga, accel).

5 Choose the server from the card definition, XF86_S3.

Which one of these four screen types do you intend to run
by default (1-4)?
```

Output 8: *Selecting the X Server*

1 A server for monochrome (black and white) monitors. This should run on any VGA compatible graphics card and at least offer a resolution of 640x480.

2 16 colors server XF86_VGA16. Should run with any VGA compatible card.

3 SVGA server XF86_SVGA. This server supports a wide variety of SVGA cards. Graphic acceleration is used with some Cirrus or WD cards. The 16-bit or 32-bit color mode can be activated with some Cirrus cards.

4 Server for accelerated cards (see below).

5 This item only exists if you have entered a card definition in the previous selection. Here, the server is selected (default) that suits the selected card.

When you have selected a server, you are asked if you want to create a symbolic link to `/usr/X11R6/bin/X`. If you answer with ‘y’, you are asked whether to put it in `/var/X11R6/bin/X`.

```
Do you want to set it in /var/X11R6/bin?
```

Reply with ‘y’, because it may not always be possible to write to `/usr` tree.

Afterwards, if you have selected ‘4’ (the accelerated servers) in the previous selection, a menu is presented of all available accelerated X servers.

```
 Select an accel server:

 1 XF86_S3
 2 XF86_Mach32
 3 XF86_Mach8
 4 XF86_8514
 5 XF86_P9000
 6 XF86_AGX
 7 XF86_W32
 8 XF86_MACH64

 Which accel server:
```

These servers support each card listed above. To create links, the appropriate server must already be installed. This means you must already have selected the correct server during the installation of your X Window System.

After selecting your X server, configure your graphics. First, specify the amount of memory the video card has.

```
How much memory do you have on your graphics card:

 1 256K
 2 512K
 3 1024K
 4 2048K
 5 4096K
 6 Other

 Enter your choice:
```

Output 9: *Specifying the Video Memory*

Next, enter the name, vendor name, and type for your graphics card. If you earlier selected a card from the predefined list, pressing ↵ will enter this as the default.

```
Enter an identifier for your graphics card definition:

Enter the vendor name of your graphics card:

Enter the model (board) name of your graphics card :
```

If you chose an accelerated X server, you must enter the RAMDAC settings. This only applies to the S3 and AGX servers.

```
 1  AT&T 20C490 (S3 server)             att20c490
 2  AT&T 20C498/21C498/22C498 (S3)      att20c498
 3  AT&T 20C505 (S3)                    att20c505
 4  BrookTree BT481 (AGX)               bt481
 5  BrookTree BT482 (AGX)               bt482
 6  BrookTree BT485/9485 (S3)           bt485
 7  Sierra SC15025 (S3, AGX)            sc15025
 8  S3 GenDAC (86C708) (autodetected)   s3gendac
 9  S3 SDAC (86C716) (autodetected)     sdac
10  STG-1700 (S3)                       stg1700
11  TI 3020 (S3)                        ti3020
12  TI 3025 (S3)                        ti3025
13  TI 3020 (S3, autodetected)                      ti3020
14  TI 3025 (S3, autodetected)                      ti3025
15  TI 3026 (S3, autodetected)                      ti3026
16  IBM RGB 514 (S3, autodetected)
ibm_rgb514
17  IBM RGB 524 (S3, autodetected)
ibm_rgb524
18  IBM RGB 525 (S3, autodetected)
ibm_rgb525
19  IBM RGB 526 (S3)
ibm_rgb526
20  IBM RGB 528 (S3, autodetected)
ibm_rgb528
21  ICS5342 (S3, ARK)                               ics5342
22  ICS5341 (W32)                                   ics5341
23  IC Works w30C516 ZoomDac (ARK)                  zoomdac
24  Normal DAC                                      normal
```

Output 10: *Setting RAMDACs*

It is usually best to press ↵ and not make any custom selections. If you specified a graphics card that supports a given RAMDAC setting, it will be included in the selection list.

After answering these questions, enter a clock chip for accelerated cards, if you have one. Entering a clock chip avoids clock lines, as the clocks needed can be programmed.

```
1  Chrontel 8391                                       ch8391
2  ICD2061A and compatibles (ICS9161A, DCS2824)
icd2061a
3  ICS2595
ics2595
4  ICS5342 (similar to SDAC, but not completely compatible)
```

```
 ics5342
 5  ICS5341
 ics5341
 6  S3 GenDAC (86C708) and ICS5300 (autodetected)
 s3gendac
 7  S3 SDAC (86C716)
 s3_sdac
 8  STG 1703 (autodetected)
 stg1703
 9  Sierra SC11412
 sc11412
10  TI 3025 (autodetected)                          ti3025
11  TI 3026 (autodetected)                          ti3026
12  IBM RGB 51x/52x (autodetected)
 ibm_rgb5xx
```

Output 11: *Setting the Clock Chip*

If a card without a clock chip is selected, just press ↵ (thus not selecting a clock chip). If a card has been selected, the clock chip is set as default (if there is one).

If no clock chip has been set, xf86config suggests running X -probeonly to determine the clock timings supported. These are automatically written in `XF86Config` in a separate *clocks* line.

Automatically defined settings can be *very risky*: if the card has a programmable clock chip, the X server, when probing, cannot distinguish between the different clocks and only recognizes clocks 0, 1, and sometimes, 2. All other values are more or less random numbers (normally, clocks 0, 1, and 2 are repeated and are replaced by zeros).

All clocks apart from 0 and 1 are strongly influenced by the preprogrammed clock chip. Thus, clock 2 could have a different setting when probed (and which was written to the file `XF86Config`) than when the X server is later started. Then all the timings would be wrong and the monitor could be severely damaged.

A good indication of a programmable clock chip (and the problems this might entail) is the multiple zeros or repeating timing values. Absolutely, under no circumstances, ever write such values to `XF86Config`.

To configure clock chips, follow these steps:

- The best way is to enter an existing (*programmable*) clock chip if there is one. It will be programmed accordingly and your `XF86Config` will not contain clock lines. Compare chips on the card with the chips offered in the menu. Most newer S3 cards have a programmable clock chip.

- If you *do not have a programmable* clock chip, launch X -probeonly and compare these values with those in the manual. If these values correspond (± 2), enter them in `XF86Config`.

  Unless the manual offers some pertinent advice, the values can be determined by running X -probeonly (this works best on an unloaded machine). Check whether the values are accurate, as clock values cannot be determined for every card. Many zeros or repeating values are a sign of invalid settings. Enter the correct values into `XF86Config`. Do not omit any values. Do not try to rearrange them or change them in any way. The values must be entered in their exact order.

  If the P9000 server is used, the order is irrelevant. Just enter the modes for the desired clock in the *clocks line*.

- In general: if there is a programmable clock chip, there should be *no* clocks line in `XF86Config` (exception, P9000). For cards without a programmable clock chip, there should be a *clocks line* in `XF86Config`. This avoids the tedious (and sometimes even risky) clock probe at each start. Furthermore, for cards with unreadable values, there are no invalid values and there is no risk to your monitor.

After having read the previous section, if you want to let clocks be recognized automatically, just answer 'y' to the following question:

```
Do you want me to run 'X -probeonly' now?
```

Now the screen will turn black before the list of probed clocks appears or a message will appear that no clocks could be found. If you have selected a clock chip, this question will not appear, because the clocks will then be programmed automatically. If this is the case, this section will be skipped.

Caution

If the previous question has been answered with 'y' and the screen remains black for more than thirty seconds, cancel testing immediately with Ctrl + Alt + ←, or Ctrl + C. If this does not work, switch off the monitor and the computer to prevent damage to your hardware.

Caution

Saving Your Configuration

Now write the configuration file. It is recommended to write it to `/etc/XF86Config` to ensure that, even in a networking environment, each machine has its own configuration file — even if they share the `/usr` file system.

Specify '/etc/XF86Config' at this point. This concludes xf86config and the configuration of the X Window System.

Optimizing the Installation of the X Window System

This section describes the configuration file, /etc/X11/XF86Config. Each *section* starts with the keyword Section <name of section> and ends with EndSection. Below is a rough outline of the most important sections.

Afterwards, learn how to integrate additional fonts, how to configure input devices, and how 3D acceleration is implemented. This is also managed in certain sections of the XF86Config file, of course, although integrating an additional font requires the help of external programs, which are included with SuSE Linux. The methods discussed here aim to illustrate the possibilities available and serve as an incentive, but they do not claim to cover all eventualities.

The programs SaX2 and xf86config (for XFree86-4.0) create the file XF86Config, by default in /etc/X11. This is the primary configuration file for the X Window System. Find all the settings here concerning your graphics card, mouse, and monitor.

XF86Config is divided into several sections, each one dealing with a certain aspect of the configuration. A section always has the same form:

```
Section ⟨name of section⟩
  entry 1
  entry 2
  entry n
EndSection
```

The following types of sections exist:

Files	This section describes the paths used for fonts and the RGB color table.
ServerFlags	General switches are set here.
InputDevice	Input devices are configured in this section. Unlike in XFree86-3.3, keyboards, mice, and special input devices (touch pad, joysticks, etc.) are configured via this section. Important terms here are Driver and the options defined by Protocol and Device.

***Table 5.1:** continued overleaf…*

Monitor	Describes the monitor used. The individual elements of this are the name, which is referred to later in the Screen definition, the bandwidth, and the allowed sync frequencies (HorizSync and VertRefresh). Settings are given in MHz, kHz, and Hz. Normally, the server refuses any mode line that does not correspond with the specification of the monitor. This is to prevent too high frequencies from being sent to the monitor by accident.
Modes	The mode line parameters are stored here for the specific screen resolutions. These parameters can be calculated by SaX2 on the basis of the values given by the user and normally do not need to be changed. Intervene manually at this point, if, for example, you want to connect a fixed frequency monitor. An exact explanation of the individual parameters would be too much for this book. Find details on the meaning of individual number values in the HOWTO file `/usr/share/doc/howto/en/XFree86-Video-Timings-HOWTO.gz`.
Device	This section defines a specific graphics card. It is referenced by its descriptive name.
Screen	This section puts together a Driver (e. g., vga2), a monitor, and a Device to form all the necessary settings for XFree86. In the Display subsection, specify the size of the virtual screen (Virtual, the ViewPort, and the Modes) used with this virtual screen.
ServerLayout	This section defines the layout of a single or multihead configuration. The input devices InputDevice and the display devices Screen are combined into one section.

Table 5.1: *Sections in* `/etc/X11/XF86Config`

Monitor, Device, and Screen are explained in more detail in the following. Further information about the other sections can be found in the man page for `XFree86` (`man XFree86`) and the man page for `XF86Config` (`man XF86Config`).

There can be several different Monitor sections in `XF86Config`. Even multiple Screen sections are possible. Which one is started depends on the server started.

Screen Section

First, we will take a closer look at the screen section. As mentioned above, this combines a monitor with a device section and determines what resolution and color depth should be used. A screen section might resemble the example in File 3.

```
Section "Screen"
  DefaultDepth  16
  SubSection "Display"
    Depth       16
    Modes       "1152x864" "1024x768" "800x600"
    Virtual     1152x864
  EndSubSection
  SubSection "Display"
    Depth       24
    Modes       "1280x1024"
  EndSubSection
  SubSection "Display"
    Depth       32
    Modes       "640x480"
  EndSubSection
  SubSection "Display"
    Depth       8
    Modes       "1280x1024"
  EndSubSection
  Device        "Device[0]"
  Identifier    "Screen[0]"
  Monitor       "Monitor[0]"
EndSection
```

File 3: *The Screen Section of the File /etc/X11/XF86Config*

The line Identifier (here Screen[0]) gives this section a defined name with which it can be uniquely referenced in the following ServerLayout section. The lines Device and Monitor specify the graphics card and the monitor that belong to this definition. These are just links to the Device and Monitor sections with their corresponding names or "identifiers". These sections are discussed later in more detail.

Using DefaultColorDepth, select which color depth mode the server will use if this is not explicitly stated. There is a Display subsection for each color depth. Depth assigns the color depth valid for this subsection. Possible values for Depth are 8, 16, 24, and 32. Not every X server supports all these modes. For most cards, 24 and 32 are basically the same. Some take 24 for packed pixel 24bpp mode. Others choose 32 for padded pixel mode.

After the color depth, a list of resolutions is set (Modes). This list is checked by the server from left to right. For each resolution, a suitable Modeline is searched, which must correspond to one of the given clock rates or a clock rate to program the card.

The first resolution found is the Default mode. With Ctrl + Alt + + (on the number pad), switch to the next resolution in the list to the right. With Ctrl + Alt + – (on the number pad), switch to the left. This enables you to vary the resolution while X is running.

The last line of the Display subsection with Depth 16 refers to the size of the virtual screen. The maximum possible size of a virtual screen depends on the amount of memory installed on the graphics card and the desired color depth, not on the maximum resolution of the monitor. Because modern graphics cards have a large amount of video memory, you can create very large virtual desktops. However, you may no longer be able to use 3D functionality if you fill most of the video memory with a virtual desktop. If the card has 16 MB video RAM, for example, the virtual screen can be up to 4096x4096 pixels in size at 8-bit color depth. Especially for accelerated cards, however, it is not recommended to use up all your memory for the virtual screen, because this memory on the card is also used for several font and graphics caches.

Device Section

A device section describes a specific graphics card. You can have as many device entries in `XF86Config` as you like, as long as their names are differentiated, using the keyword Identifier. As a rule — if you have more than one graphics card installed — the sections are simply numbered in order the first one is called Device[0], the second one Device[1], and so on. In File 4, see the section from the Device section of a computer in which a Matrox Millennium PCI graphics card is installed.

```
Section "Device"
  BoardName     "MGA2064W"
  BusID         "0:19:0"
  Driver        "mga"
  Identifier    "Device[0]"
  VendorName    "Matrox"
  Option        "sw_cursor"
EndSection
```

***File 4:** The Device Section of the File /etc/X11/XF86Config*

If you use SaX2 for configuring, the device section should look something like the above diagram. Both the Driver and BusID are dependent on the hardware installed in your computer and are detected by SaX2 automatically. The BusID defines the PCI or AGP slot in which the graphics card is installed. This matches the ID displayed by the command lspci. The X server wants details in decimal form, but lspci displays these in hexadecimal form.

Via the Driver parameter, specify the driver to use for this graphics card. If the card is a Matrox Millennium, the driver module is called mga. The X server then searches through the ModulePath defined in the Files section in the `drivers` subdirectory. In a standard installation, this is the directory `/usr/X11R6/lib/modules/drivers`. For this purpose, simply `_drv.o` is added to the name, so, in the case of the mga driver, the driver file mga_drv.o is loaded.

The behavior of the X server or of the driver can also be influenced through additional options. An example of this is the option sw_cursor, which is set in the device section. This deactivates the hardware mouse cursor and depicts the mouse cursor using software. Depending on the driver module, there are various options available, which can be found in the description files of the driver modules in the directory `/usr/X11R6/lib/X11/doc`. Generally valid options can also be found in the man page for `XF86Config` (`man XF86Config`) and the man page for `XFree86` (`man XFree86`).

Monitor Section

Monitor sections each describe, in the same way as the device sections, one monitor. The configuration file `/etc/X11/XF86Config` can contain as many Monitor sections as desired. The server layout section specifies which monitor section is relevant.

Monitor definitions should only be set by experienced users. A critical part of the monitor section is the mode lines, which set horizontal and vertical timings for the appropriate resolution. The monitor properties, especially the allowed frequencies, are stored in the monitor section.

Caution

Unless you have an in-depth knowledge of monitor and graphics card functions, nothing should be changed in the mode lines, as this could cause severe damage to your monitor.

Caution

For those who want to develop their own monitor descriptions, the documentation in `/usr/X11/lib/X11/doc` might come in handy. The section **?** deserves a special mention. It describes, in detail, how the hardware functions and how mode lines are created.

A "manual" setting of the mode lines is hardly ever needed nowadays. If you are using a modern multisync monitor, the allowed frequencies and optimal resolutions can, as a rule, be read directly from the monitor by the X server via DDC, as described in the SaX2 configuration section. If this is not possible for some reason, you can also use one of the VESA modes included in the X server. This will function with practically all graphics card and monitor combinations.

Integrating Additional (True Type) Fonts

A standard X11R6 X server installation also includes a large number of fonts. These can be found in the directory `/usr/X11R6/lib/X11/fonts`, each divided into logically connected groups in subdirectories. Make sure only subdirectories of the X server are used that:

- are entered in the files section, Files of the file `/etc/X11/XF86Config` as FontPath
- contain a valid `fonts.dir` file
- were not closed while the X server was running using the command xset −fp or were started while the X server was running using the command xset +fp

Since version 4.0, XFree86 can use not only its own format Type1 (a Postscript format) for scalable fonts and pcf for bitmap ones, but also the ttf (True Type font) fonts. As described in *Version 4.x of XFree86* on page 94, this support is provided via loadable modules of the X server. Thus, you can also use directories containing True Type fonts together with the X server. To do this, hardly any preparation is needed.

A big advantage of most True Type fonts, apart from their very good scalability, is that these fonts almost always contain more than the normal 255 characters of the font for western Europe coded in "iso-8859-1". With these fonts, you can display Cyrillic, Greek, or eastern European languages without any problem and, with special software, even Asian languages.

This description is essentially about the use of fonts as 8-bit character sets. If you want to use characters of Asian languages (Japanese, Chinese, etc.), use special editors, which are also available in SuSE Linux.

An 8-bit character set contains 255 characters and basically consists of the US-ASCII character set, which defines only the first 128 of 255 possible characters, and expands it with further characters. One text character occupies 8-bits in the computer memory. As 127 characters are certainly not enough to record the special characters, for example, of all European languages, the various languages are combined into groups and this group is then given a short name. The relevant character set is named according to the appropriate norm as the "iso-8859-x" character set, where the x stands for a number from 1 to 15. The exact order of characters in the iso-8859-1 character set can be found in the man page for `iso-8859-1` (`man iso-8859-1`).

The more well-known codings are listed in Table 5.2: further ones can be taken from the above-mentioned manual page.

Font	**Supported regions, contains special characters**
iso-8859-1	West European languages: Spanish, German, French, Swedish, Finnish, Danish, and others
iso-8859-2	Central and Eastern Europe: Czech, Rumanian, Polish, German, and others
iso-8859-5	Cyrillic characters for Russian
iso-8859-7	Greek characters for Greek
iso-8859-9	Turkish characters
iso-8859-15	As `iso-8859-1`, but with characters for Turkish and the Euro sign.

Table 5.2: *Important Font Codings*

The user must then, depending on the language used, select the matching encoding. Especially when transferring texts between different computers, the encoding used must also be transferred. The advantage of this procedure is obvious: To receive support for regional special characters, you only need to select the correct encoding and immediately most programs will be able to portray these special characters, since almost all programs use an 8-bit value (one byte) to represent a text character. If the wrong encoding is chosen, the special characters will be wrongly depicted. With most X applications, as well as with the KDE desktop, you can usually select the coding of the character set when you are configuring the font to use. In X applications, the encoding is usually referred to as Encoding.

The disadvantage of this method is that some language combinations are impossible: You cannot, for example, easily write a German text with umlauts in which you mention Russian place names in Cyrillic.

This dilemma can only be solved using a different approach — with the use of Unicode. Unicode codes characters, unlike ASCII, with two or even more bytes, allowing considerably more characters to be represented. Only if you use Unicode can you depict Asian languages with more than 127 characters, such as Chinese, Japanese, or Korean, on the computer. The disadvantage of this method is that most existing software cannot handle these characters and that you can only read or write texts yourself with Unicode characters using special software. For more information about using Unicode fonts in Linux, see `http://www.unicode.org`. It is expected that, in the future, more and more programs will support Unicode characters. SuSE Linux offers the program yudit to enter texts in Unicode. The program yudit can be found in the package `yudit` and, after installation, via the SuSE menu, under Office →Editors.

This background information is followed by a step-by-step description of the installation of additional fonts. In this example, the installation of TrueType fonts is described. Locate the fonts you want to install in your X Window System. If you already have licensed TrueType fonts on your system, you can simply use these. Mount the partition containing the fonts and change to a font directory. In SuSE Linux, you can copy the respective fonts to the directory `/usr/X11R6/lib/X11/fonts/truetype`.

Create symbolic links to the `ttf` files, replacing ⟨*/path/to/the/fonts*⟩ with the respective path under which these fonts are available. Then execute SuSEconfig, which will generate the required entries in the file `fonts.dir`.

```
earth:/usr/X11R6/lib/X11/fonts/truetype #
     ln -s ⟨/path/to/the/fonts⟩/*.ttf .
earth:/usr/X11R6/lib/X11/fonts/truetype #
     SuSEconfig -module fonts
```

If the X server is already running, you can now make the fonts dynamically available. To do this, enter `xset fp rehash`.

Tip

The `xset` command accesses the X server via the X protocol. It must have access permissions for the X server currently running. Find more about this in the man page for `xauth` (`man xauth`).

Tip

Check if the fonts were set up correctly. To do this, use the command `xlsfonts`. If the fonts are correctly installed, the list of all installed fonts, including the newly installed True Type Fonts, is displayed.

You can also use the KDE font manager, which displays the installed fonts with an sample text. This can be started in the KDE Control Center. These newly installed fonts can then be used in all X applications.

OpenGL — 3D Configuration

In Linux, the OpenGL interface is available for programs. Direct3D from Microsoft is not available in Linux.

Hardware Support

SuSE Linux includes several OpenGL drivers for 3D hardware support. Table 5.3 provides an overview.

OpenGL Driver	**Supported Hardware**
nVidia-GLX / XFree86 4.x	nVidia Chips: all but Riva 128(ZX)
DRI / XFree86 4.x	3Dfx Voodoo Banshee 3Dfx Voodoo-3/4/5 Intel i810/i815/i830M Intel 845G/852GM/855GM/865G Matrox G200/G400/G450/G550 ATI Rage 128(Pro)/Radeon

Table 5.3: *Supported 3D Hardware*

If you are installing with YaST for the first time, activate 3D acceleration during installation, if YaST finds hardware for which it is supported. nVidia graphics chips are the only exception. For these, the "dummy" driver included must be replaced by the official nVidia driver. Download it from the nVidia web server (`http://www.nvidia.com`) and install it. Because of licensing restrictions, only the "dummy" nVidia driver package is available in the distribution.

If an update is carried out instead of a new installation or a 3Dfx add-on graphics adapter (Voodoo Graphics or Voodoo-2) needs to be set up, the procedure for configuring 3D hardware support is different. This depends on which OpenGL driver is used. Further details are described in the following section.

OpenGL Driver

nVidia-GLX and DRI

These OpenGL drivers can be quite easily configured using SaX2. In the case of nVidia adapters, the SuSE dummy driver package needs to be replaced with the official driver packages from the nVidia server (`http://www.nvidia.com`). The command `3Ddiag` tests whether nVidia-GLX or DRI have been configured properly.

For security reasons, only users belonging to the group `video` may access the 3D hardware. Verify that all users working locally on the machine are members of this group. Otherwise, the rather slow *Software Rendering Fallback* of the OpenGL driver will be used. Use the command `id` to check whether the current user belongs to the group `video`. If this is not the case, use YaST to add the user to the group.

The Diagnosis Tool 3Ddiag

The diagnosis tool 3Ddiag allows verification of the 3D configuration in SuSE Linux. This is a command line tool that must be started in a terminal. `3Ddiag -h` provides information about options for 3Ddiag.

The application checks, for example, the XFree86 configuration to verify that all packages required for 3D support are installed and the proper OpenGL library is used with the GLX extension. Follow the directions in 3Ddiag if "failed" messages appear. Ideally, you will only see "done" messages on the screen.

OpenGL Test Applications

For testing OpenGL, the program `glxgears` and games like `tuxracer` and `armagetron` (packages have the same names) can be useful. If 3D support has been activated, it should be possible to play these smoothly on a fairly new computer. Without 3D support, it is not possible to play these games or they run only very slowly. Use the `glxinfo` command to verify that 3D is active, in which case the output will contain a line stating "direct rendering: Yes".

Troubleshooting

If the OpenGL 3D test results are negative (the games cannot be smoothly played), use 3Ddiag to make sure no errors exist in the configuration ("failed" messages). If correcting these does not help or if failed messages have not appeared, take a look at the XFree86 log files.

Often, you will find the line "DRI is disabled" in the XFree86 4.x file `/var/log/XFree86.0.log`. The exact cause can only be discovered by closely examining the log file — a task requiring some experience.

In such cases, no configuration error exists, as this would have already been detected by 3Ddiag. Consequently, at this point, the only choice is to use the software rendering fallback of the DRI driver, which does not feature 3D hardware support. You should also go without 3D support if you get OpenGL representation errors or instability. Use SaX2 to disable 3D support completely.

Installation Support

Apart from the software rendering fallback of the DRI driver, all OpenGL drivers in Linux are in developmental phases and are therefore considered experimental. The drivers are included in the distribution because of the high demand for 3D hardware acceleration in Linux. Considering the experimental status of OpenGL drivers, SuSE cannot offer any installation support for configuring 3D hardware acceleration or provide any further assistance with related problems. The basic configuration of the graphical user interface X11 does not include 3D hardware acceleration configuration. If you experience problems with 3D hardware acceleration, it is recommended to disable 3D support completely.

Additional Online Documentation

- DRI: `/usr/X11R6/lib/X11/doc/README.DRI` (package `XFree86-doc`)
- Mesa/Glide: `/usr/share/doc/packages/mesa3dfx/` (package `mesa3dfx`)
- Mesa general: `/usr/share/doc/packages/mesa/` (package `mesa`)

Printer Operation

This chapter provides some background information about the operation of printers. Numerous examples show how the different parts of the printing system interact. This chapter should help in finding suitable solutions for possible problems and in avoiding unsuitable solution attempts.

Printing Basics 118
Preconditions for Printing 122
Configuring a Printer with YaST 126
Configuring Applications 131
Manual Configuration of Local Printer Ports 132
Manual Configuration of LPRng and lpdfilter 137
The LPRng Print Spooler 137
Command-Line Tools for LPRng 138
The Print Filter of the LPRng and lpdfilter Printing System . 142
The CUPS Printing System 152
Printing from Applications 158
Command-Line Tools for the CUPS Printing System 159
Working with Ghostscript 163
Working with a2ps 166
Reformatting PostScript with psutils 167
ASCII Text Encoding 171
Printing in a TCP/IP Network 173

Printing Basics

On a Linux system, printers are managed via *print queues*. Before any data is printed, it is sent to the print queue for temporary storage. From there, the print spooler sends the data to the printer.

However, this data is predominantly not available in a form that can be processed by the printer. A graphical image, for example, first needs to be converted into a format the printer can understand. This conversion into a *printer language* is achieved with a *print filter*, a program run by the print spooler to translate data as needed so the printer can process it.

Important Standard Printer Languages

ASCII text Most printers are at least able to print ASCII text. The few devices that cannot print ASCII text directly should be able to understand one of the other standard printer languages mentioned below.

PostScript PostScript is the established printer language under Unix and Linux. PostScript output can be printed directly by PostScript printers. However, these printers are relatively expensive, because PostScript is a powerful yet complex language that requires a lot of computing in the PostScript printer before actually putting something on paper. Adding to the price of PostScript printers are licensing costs.

PCL3, PCL4, PCL5e, PCL6, ESC/P, ESC/P2, and ESC/P raster If a PostScript printer is not available, the print filter uses the program Ghostscript to convert PostScript data into one of these other standard languages. Ghostscript uses different drivers for different printers to make use of specific features offered by the various models, such as color settings.

Processing Print Jobs

1. A print job is started by the user either from the command line or from an application.
2. The corresponding print data is temporarily stored in the print queue. It is retrieved from there by the print spooler, which sends it to the print filter.
3. The print filter performs the following steps:
   (a) The filter determines the format of print data.

(b) If the print data is not in PostScript format, it is first converted to the standard language PostScript. Usually, ASCII text is also converted to PostScript.

(c) The PostScript data is converted into another printer language, if necessary.

- If the printer is a PostScript model, the data is sent to it with no further processing.
- If the printer is not a PostScript printer, the program Ghostscript is run and uses one of its drivers to convert data into the language of the printer model. This generates the data that is finally sent to the printer.

4. As soon as all the data of the print job has been sent to the printer, the print spooler deletes it from the print queue.

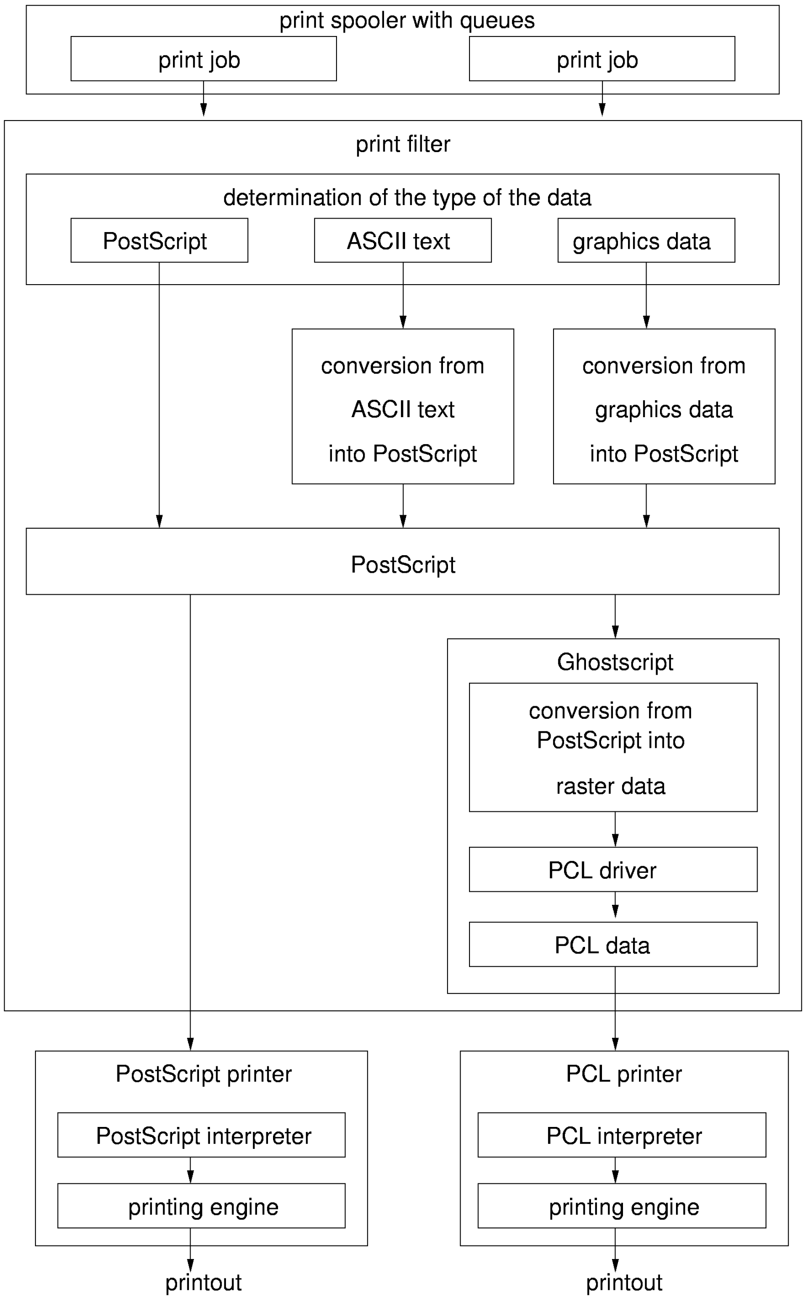


Figure 6.1: *The Printing Workflow*

Various Printing Systems

SuSE Linux supports two different printing systems:

LPRng and lpdfilter This is a traditional printing system consisting of the print spooler LPRng and the print filter lpdfilter. The configuration of this system must be entirely defined by the system administrator. Normal users can only choose between different print queues that have already been configured. To allow users to choose between different options for a given printer, a number of print queues should be defined beforehand — each for a different printer configuration. For plain black-and-white printers, such as most laser printers, it is sufficient to define just one configuration (the standard queue). For modern color inkjet printers, define several configurations, for example, one for black-and-white printing, one for color printing, and maybe another one for high-resolution photograph printing. Setting up the printer with predefined configurations has the advantage that the system administrator has a lot of control over the way in which the device is used. On the other hand, there is the disadvantage that users cannot set up the printer according to the job at hand, so maybe they will not be able to use the many options offered by modern printers unless the administrator has defined the corresponding print queues beforehand.

CUPS CUPS allows users to set different options for each print job and does not require the entire configuration of the print queue to be predefined by the system administrator. With CUPS, printer options are stored in a PPD (PostScript printer description) file for each queue. These can be made available to users in printer configuration dialogs. By default, the PPD file gives users control over all printer options, but the system administrator may also limit printer functionality by editing the PPD file.

Under normal conditions, it is not possible to install these two printing systems *concurrently*, as there are conflicts between them. However, you can switch between the two print systems with YaST (see *User Guide*, Section *YaST — Configuration, Printers*).

Preconditions for Printing

General Requirements

- Your printer must be supported by SuSE Linux. To see whether this is the case, consult the following sources:

  SuSE Printer Database `http://cdb.suse.de` or `http://hardwaredb.suse.de/` (click 'Englisch' to get the English version).

  The linuxprinting.org Printer Database `http://www.linuxprinting.org/`
  `http://www.linuxprinting.org/database.html` or
  `http://www.linuxprinting.org/printer_list.cgi`

  Ghostscript `http://www.cs.wisc.edu/~ghost/`

  The SuSE Linux Ghostscript Driver List `file:/usr/share/doc/packages/ghostscript/catalog.devices` This file lists the Ghostscript drivers enclosed with the respective version of SuSE Linux. This is important, as the web pages sometimes refer to a Ghostscript driver not included in SuSE Linux. For license reasons, SuSE Linux comes with GNU Ghostscript. In most cases, GNU Ghostscript offers a suitable driver for your printer.

- The printer has been properly connected to the interface over which it will communicate. For details, read *Manual Configuration of Local Printer Ports* on page 132 and *Manual Configuration* on page 129.

- You should be using one of the standard kernels included on CD, *not* a custom kernel. If you have problems with your printer, install one of the SuSE standard kernels first and reboot before looking further into the problem.

- The 'Default System' is installed to make sure all required packages are available. As long as you have not uninstalled any of the packages of the standard system, things should be ready. Otherwise, install the 'Default System' with YaST. None of the 'Minimum System' selections are sufficient for printing.

Finding the Right Printer Driver

PostScript printers do not require a special printer driver (see *Processing Print Jobs* on page 118). Other printer types need a Ghostscript driver to produce the data. For non-PostScript devices, choosing the right Ghostscript driver and the right options for it has a big influence on output quality. The Ghostscript drivers available for specific models are listed in the sources mentioned in *General Requirements* on the facing page.

If you cannot find a Ghostscript driver for your printer, ask the manufacturer which printer language your model understands. Some manufacturers supply special Ghostscript drivers for their printers. Even if the manufacturer is not able to provide any Linux-specific information on your printer model, he can still provide the following information to facilitate the selection of a suitable printer driver:

- Find out whether your printer is compatible with a model supported by Linux. You may then be able to use the driver for the compatible model. For printers to be *compatible*, they should be able to work correctly using the same binary control sequences. Both printers must understand the same language on the hardware level without relying on additional driver software to emulate it.

  A similar model name does not always mean the hardware is really compatible. Printers that appear very similar on the outside sometimes do not use the same printer language at all.

- Check if your printer supports a standard printing language by asking the manufacturer or checking the technical specifications in the printer manual.

  PCL5e or PCL6 Printers that understand the *PCL5e* or *PCL6* language natively should work with the ljet4 Ghostscript driver and produce output at a resolution of 600x600 dpi. Often, PCL5e is mistaken for PCL5.

  PCL4 or PCL5 Printers that understand the *PCL4* or *PCL5* language natively should work with one of the following Ghostscript drivers: laserjet, ljetplus, ljet2p, or ljet3. Output resolution is limited to 300x300 dpi, however.

  PCL3 Printers that understand the *PCL3* language natively should work with one of these Ghostscript drivers: deskjet, hpdj, pcl3, cdjmono, cdj500, or cdj550.

  ESC/P2, ESC/P, or ESC/P raster Printers that understand *ESC/P2*, *ESC/P*, or *ESC/P* raster natively should work with the stcolor Ghostscript driver or with the uniprint driver in combination with a suitable `*.upp` parameter file (e. g., `stcany.upp`).

The Issue with GDI Printers

Since the printer drivers for Linux are usually not developed by the hardware manufacturer, it is crucial that the printer can be addressed with one the common printer languages (*PostScript*, *PCL*, and *ESC/P*). Normal printers understand at least one of the common printer languages. However, *GDI printers* only work with the operating system versions for which the manufacturer has enclosed drivers, as they can only be addressed with special control sequences. As these printers cannot be addressed with any known standard, their use with Linux is either impossible or difficult.

GDI is a programming interface developed by Microsoft for graphical devices. There is not much of a problem with the interface itself, but the fact that GDI printers can *only* be controlled through the proprietary language they use *is* an issue. A better name for them would be "proprietary-language-only printers."

On the other hand, there are printers that can be operated both in GDI mode and in a standard language mode, but they need to be switched accordingly. If you use Linux together with another operating system, it may be possible that the driver set the printer to GDI mode when you last used it. As a result, the printer will not work under Linux. There are two solutions for this: switch the printer back to standard mode under the other operating system before using it under Linux or use only the standard mode, even under the other operating system. In the latter case, it may turn out that printing functionality is limited, such as to a lower resolution.

There are also some very special printers that implement a rudimentary set of a standard printer language, such as the commands needed for printing raster images. Sometimes these printers can be used in a normal way, as the Ghostscript drivers normally only use commands for printing raster images. In this case it may be impossible to print ASCII text directly. This should not be too much of a problem, however, as ASCII text is mostly printed through Ghostscript and not directly. However, printers that first have to be toggled with special control sequences are problematic. This cannot be done with a normal Ghostscript driver, but requires a specially adapted driver.

For some GDI printers, you may be able to obtain Linux drivers directly from the manufacturer. There is no guarantee that such vendor-made drivers will work with other or future Linux versions.

In any case, the above is only true for GDI models. By contrast, printers that understand one of the standard languages do not depend on a particular operating system nor do they require a particular Linux version. However, they often produce the highest quality of output when used with a vendor-made driver.

To sum all this up, SuSE Linux does support the GDI printers listed below. They can be configured using the printer configuration module of YaST. Be aware that their use will always be rather problematic. Some models might refuse to work at all or their functionality might be limited, for example, to low-resolution black-and-white printing. SuSE does not test GDI printers, so cannot guarantee this list is correct.

- Brother HL 720/730/820/1020/1040, MFC 4650/6550MC/9050, and compatible models.
- HP DeskJet 710/712/720/722/820/1000 and compatible models.
- Lexmark 1000/1020/1100/2030/2050/2070/3200/5000/5700/7000/7200, Z11/42/43/51/52, and compatible models.
- Oki Okipage 4w/4w+/6w/8w/8wLite/8z/400w and compatible models.
- Samsung ML-200/210/1000/1010/1020/1200/1210/1220/4500/5080/6040 and compatible models.

To our knowledge, the following GDI printers are *not supported* by SuSE Linux (this list is not complete by any means):

- Brother DCP-1000, MP-21C, WL-660
- Canon BJC 5000/5100/8000/8500, LBP 460/600/660/800, MultiPASS L6000
- Epson AcuLaser C1000, EPL 5500W/5700L/5800L
- HP LaserJet 1000/3100/3150
- Lexmark Z12/22/23/31/32/33/82, Winwriter 100/150c/200
- Minolta PagePro 6L/1100L/18L, Color PagePro L, Magicolor 6100DeskLaser, Magicolor 2 DeskLaser Plus/Duplex
- Nec SuperScript 610plus/660/660plus
- Oki Okijet 2010
- Samsung ML 85G/5050G, QL 85G
- Sharp AJ 2100, AL 1000/800/840/F880/121

Configuring a Printer with YaST

Print Queues and Configurations

In most cases, you will want to set up more than one print queue for the following reasons:

- If you have more than one printer, you need at least one queue for each of them.
- The print filter can be configured differently for each print queue. By having different queues for one printer, operate it with different configurations. This is not necessary in CUPS, as the user can specify the desired settings. See *Various Printing Systems* on page 121.

If your model is a plain black-and-white printer, such as most laser printers, it will be sufficient to configure just one standard queue. Color inkjets, on the other hand, require at least two different queues (configurations):

- A standard configuration for quick and inexpensive black-and-white printouts.
- A `color` configuration or queue used for color printing.

Printer Configuration with YaST: The Basics

Start the YaST printer configuration by selecting it from the YaST Control Center or by entering `yast2 printer` in a command line as `root`. Enter `yast2 printer .nodetection` to suppress printer autodetection. For more details about autodetection, see *Parallel Ports* on page 132.

Not all printers are capable of being configured for both print systems. Some options are only supported by either CUPS or LPRng and lpdfilter. YaST provides information about this whenever necessary.

You can easily switch back and forth between CUPS and LPRng/lpdfilter using a submenu of the YaST printer configuration which can be accessed with the 'Advanced' button.

The YaST printer configuration module offers the following printing system selections:

CUPS as server (default in standard installations) If a printer is connected locally, CUPS must be running in server mode. If no local queue is configured with YaST, the CUPS daemon cupsd is not started automatically. If you still want cupsd to start, the 'cups' service must be activated (normally for the runlevels 3 and 5). See *Quick Configuration of a Client Machine* on page 174. The following packages are installed for this print system:

- `cups-libs`
- `cups-client`
- `cups`
- `footmatic-filters`
- `cups-drivers`
- `cups-drivers-stp`

CUPS in Client-Only Mode If there is a CUPS network server in the local network (see *Terminology* on page 173) and you exclusively want to print by way of its queues, it is sufficient to run CUPS as client — see *Quick Configuration of a Client Machine* on page 174. The following packages are sufficient for this mode:

- `cups-libs`
- `cups-client`

LPRng Select this if you want to use the LPRng and lpdfilter print system or if the network only has an LPD server (see *Terminology* on page 173) whose queues you want to use for printing — see *Quick Configuration of a Client Machine* on page 174. The following packages are required for this setup:

- `lprng`
- `lpdfilter`
- `footmatic-filters`
- `cups-drivers`

The package `cups-client` and the package `lprng` should not be installed concurrently. The package `cups-libs` must always be installed, as several packages (such as `Ghostscript`, `KDE`, `Samba`, `Wine`, and the YaST printer configuration) need the CUPS libraries.

The printing system as a whole requires a number of additional packages, although the 'Default system' should include them. The most important ones are:

- `ghostscript-library`
- `ghostscript-fonts-std`
- `ghostscript-x11`
- `libgimpprint`

The YaST printer configuration modules display all configurations that could be created without errors.

As the configurations are not generated until the YaST printerconfiguration module is terminated, you should restart the YaSTprinter configuration to make sure everything is OK.

The YaST printer configuration also strictly distinguishes between queues created through YaST itself (YaST queues) and queues created through other means (non-YaST queues). Non-YaST queues will never be touched by YaST. Conflicts only arise if queues have identical names. When editing a queue, you can determine whether it should be managed by YaST. If you turn a YaST queue into a non-YaST queue, you can edit the configuration manually (without YaST) and prevent these changes from being overwritten by YaST. Likewise, you can turn a non-YaST queue into a YaST queue to overwrite an existing configuration deliberately with YaST.

Automatic Configuration

Depending on how much of your hardware can be autodetected and on whether your printer model is included in the printer database, YaST will either autoconfigure your printer or offer a reasonable selection of settings that then need to be adjusted manually. If this is not the case, the user must enter the needed information in the dialogs. YaST can configure your printer automatically if the following conditions are fulfilled:

- The parallel port or USB interface was set up automatically in the correct way and the printer model connected to it was autodetected.
- Your printer's ID, as supplied to YaST during hardware autodetection, is included in the printer database. As this ID may be different from the actual model designation, you may need to select the model manually.

Each configuration should be tested with the print test function of YaST to see whether it works as expected. In many cases, configuration data not explicitly supported by the printer manufacturer must be used. For this reason, operability cannot be guaranteed for all settings.

Furthermore, the YaST test page provides important information about the respective configuration.

Manual Configuration

If one of the conditions for automatic configuration is not fulfilled or if you want your own customized setup, the configuration must be performed manually. The following is an overview of the options to set during manual configuration:

Hardware Port (Interface)

- If YaST was able to autodetect the printer model, you may safely assume that the printer connection works as far as the hardware is concerned. You may then leave this part untouched.
- If YaST has not autodetected the printer model, there may have been some problem on the hardware level. Some manual intervention is needed to configure the physical connection. Manual configuration requires specification of the port to which the printer is connected. `/dev/lp0` is the first parallel port. `/dev/usb/lp0` is the port for a USB printer. Always test this setting from within YaST to see whether the printer is actually responding at the selected interface.

  It is safest to connect a printer to the first parallel port. In this case, the BIOS settings for this port should look like this:

  - IO address: `378` (hexadecimal)
  - Interrupt: (not relevant)
  - Mode: `Normal`, `SPP`, or `Output-Only`.
  - DMA: Disabled

  If the printer does not respond at the first parallel port with these settings, you may need to change the IO address to have the explicit form of `0x378` under the BIOS menu item that lets you configure the advanced settings for parallel ports. If your machine has two parallel ports with IO addresses 378 and 278 (hexadecimal), change them to read `0x378` and `0x278`, respectively. For further details on the topic, see *Parallel Ports* on page 132.

Queue Name The name of the queue is used frequently when issuing print commands. The name should be rather short and consist of lowercase letters (and maybe numbers) only.

Ghostscript Driver and Printer Language (Printer Model) The Ghostscript driver and the printer language depend on the printer model and are determined by selecting a predefined configuration suitable for the printer model. It can be customized in a separate dialog, if necessary. In other words, the selection of the manufacturer and the model actually represents the selection of a printer language and a Ghostscript driver with suitable driver settings for your printer.

For non-PostScript models, all printer-specific data is produced by the Ghostscript driver. Therefore, the driver configuration (both choosing the right driver and the correct options for it) is the single most important factor determining the output quality. Your settings affect the printer output on a queue-by-queue basis.

If your printer was autodetected, which means the model is included in the printer database, you will be presented with a choice of possible Ghostscript drivers and with several output options such as:

- black-and-white printing
- color printing at 300 dpi
- color printing at 600 dpi

Each default configuration includes a suitable Ghostscript driver and, if available, a number of driver-specific settings related to the output quality.

Any driver-specific settings can be customized in a separate dialog. Click the respective values to view and access any indented submenu entries.

Not all combinations of driver options work with every printer model. This is especially true for higher resolutions. Always check whether your settings work as expected by printing the YaST test page. If the output is garbled (for example, with several pages almost empty), you should be able to stop the printer by first removing all sheets then stopping the test print from within YaST. However, in some cases the printer will refuse to resume work if you do so. It may be better to stop the test print first and wait for the printer to eject all pages itself.

If your model was not found in the printer database, you can select one of the generic Ghostscript drivers for the standard printing languages. These are listed under a generic "manufacturer".

Other Special Settings Unless you are sure about what these options mean, do not change the default settings.

For the CUPS printing system, the following special settings are available:

- Restricting printer use for certain users.
- Queue status: whether the queue is started or stopped and whether it is ready to accept new print jobs.
- Banner page: whether to print out a banner (cover) page at the beginning of each print job and which one. Similarly, whether to add a banner page at the end of each print job and which one.

For the LPRng and lpdfilter printing system, change the following hardware-independent settings:

- The page layout can be changed for ASCII text printouts (but not for graphics or documents created with special application programs).
- You can define an `ascii` print queue for special cases. The `ascii` queue forces the print filter to produce ASCII text output, which may be necessary for some text files that the print filter does not automatically recognize as such, for example, PostScript source code.
- Country-specific settings can be changed to ensure the correct character encoding when sending ASCII text to the printer and when printing plain text in HTML pages from Netscape.

Configuring Applications

Applications use the existing queues for printing from the command line. In applications, printer options are not configured directly, but rather through the existing queues.

On the command line, you can print with the following command:

```
lpr -Pcolor ⟨filename⟩
```

Replace ⟨*filename*⟩ with the name of the file you want to print. The option `-P` can be used to specify the queue. For example, `-Pcolor` uses the queue `color`.

Manual Configuration of Local Printer Ports

Parallel Ports

For the most part, printers are connected to a Linux system through a parallel port. Printers on parallel ports are handled by the `parport` subsystem of the Linux kernel. The basics of parallel port configuration with YaST are described in *Manual Configuration* on page 129. The paragraphs below provide more in-depth information on the topic.

The `parport` subsystem manages parallel ports only through the corresponding architecture-specific kernel modules after these are loaded. Among other things, this allows for several devices, such as a parallel port ZIP drive and a printer, to be linked to one parallel port at the *same* time. Device files for parallel printers are counted beginning with `/dev/lp0`. With a SuSE Linux standard kernel, printing over the parallel port requires that the modules `parport`, `parport_pc`, and `lp` are loaded. This is achieved by kmod (the kernel module loader). Normally, these modules are loaded automatically as soon as some process requests access to the device file.

If the kernel module `parport_pc` is loaded without any parameters, it tries to autodetect and autoconfigure all available parallel ports. This may not work in some very rare cases and cause a system lock-up. If that happens, configure it manually by explicitly providing the correct parameters for the `parport_pc` module. This is also the reason why printer autodetection can be disabled for YaST as described in *Configuring a Printer with YaST* on page 126.

Manual Configuration of Parallel Ports

The first parallel port (`/dev/lp0`) is configured with an entry in `/etc/modules.conf`, as shown in File *Manual Configuration of Parallel Ports* on the current page.

```
alias parport_lowlevel parport_pc
options parport_pc io=0x378 irq=none
```

File 5: */etc/modules.conf: First Parallel Port*

Under `io`, enter the IO address of the parallel port. Under `irq`, keep the default `none` for polling mode. Otherwise, provide the IRQ number for the parallel port. Polling mode is less problematic than interrupt mode as it helps to avoid interrupt conflicts.

However, there are combinations of motherboards and printers that only function well if this is set to interrupt mode. Apart from that, interrupt mode ensures a continuous data flow to the printer even when the system is under very high load.

To make the above configuration work, you may still need to change the parallel port settings made available through your machine's BIOS or firmware:

- IO address: `378` (hexadecimal)
- Interrupt: `7` (not relevant for polling mode)
- Mode: `Normal`, `SPP`, or `Output-Only` (other modes will not always work)
- DMA: `Disabled` (should be disabled as long as the mode is set to `Normal`)

If interrupt `7` is still free, enable in `/etc/modules.conf` as shown in File *Manual Configuration of Parallel Ports* on this page.

```
alias parport_lowlevel parport_pc
options parport_pc io=0x378 irq=7
```

File 6: */etc/modules.conf: Interrupt Mode for the First Parallel Port*

Before activating the interrupt mode, check the file `/proc/interrupts` to see which interrupts are already in use. Only the interrupts that are currently in use are displayed. This may change depending on which hardware components are active. The interrupt used for the parallel port must not be occupied by any other device. If you are not sure, use the polling mode.

Enabling and Testing a Parallel Port

After configuration, the parallel port is enabled when you reboot the machine. If you do not want to reboot, run the following commands as `root` to update the module dependency list and to unload all kernel modules related to parallel ports.

```
depmod -a 2>/dev/null
rmmod lp
rmmod parport_pc
rmmod parport
```

After this, reload the modules with:

```
modprobe parport
modprobe parport_pc
modprobe lp
```

If the printer is capable of direct ASCII text printing, the following command as `root` should print a single page with the word `Hello` on it:

```
echo -en "\rHello\r\f" >/dev/lp0
```

In the above command, the word `Hello` is enclosed in two `\r` ASCII characters to produce carriage returns. The closing ASCII character `\f` is included to produce a form feed. To test a second or third parallel port in the same way, use `/dev/lp1` or `/dev/lp2`, respectively.

USB Ports

First, make sure the interrupt is enabled for USB in your machine's BIOS. In an Award BIOS, for example, go to the menu 'PNP AND PCI SETUP' and set the entry 'USB IRQ' to `Enabled`. The wording of these menus and entries may vary depending on the BIOS type and version.

Test whether the USB printer is responding by entering the command (as `root`):

```
echo -en "\rHello\r\f" >/dev/usb/lp0
```

If there is only one USB printer connected to the machine and this printer is able to print ASCII text directly, this should print a single page with the word `Hello`.

Some USB printers may need a special control sequence before accepting data over a USB line. Further information can be found in the Support Database `http://sdb.suse.de/en/sdb/html`. Enter the keywords "Epson" and "usb".

In most cases, you should be able to get information about the printer manufacturer and the product name by entering:

```
cat /proc/bus/usb/devices
```

If this does not display any information, it will usually be for one of these reasons:

- The USB system has not detected the device (yet), maybe even because it is disconnected from power, so there is no communication between the system and the printer.
- The USB system has detected the device, but neither the manufacturer or the product name are known to it. Accordingly, nothing is displayed, but the system can communicate with the printer.

Sometimes it may happen that the USB printer does not respond anymore, for instance, after unplugging it in the middle of a print job. In such a case, the following commands should be sufficient to restart the USB system:

```
rchotplug stop
rchotplug start
```

If you are not successful with these commands, terminate all processes that use `/dev/usb/lp0`. Use `lsmod` to check which USB modules are loaded (`usb-uhci`, `usb-ohci`, or `uhci`) and how they depend on each other. For instance, the following entry in the output of `lsmod` shows that the module `usbcore` is being used by modules `printer` and `usb-uhci`:

```
usbcore ... [printer usb-uhci]
```

Accordingly, modules `printer` and `usb-uhci` need to be unloaded before unloading `usbcore`. As `root`, enter the following commands (replace `usb-uhci` with `uhci` or `usb-ohci` depending on your USB system):

```
fuser -k /dev/usb/lp0
rchotplug stop
rmmod printer
rmmod usb-uhci
umount usbdevfs
rmmod usbcore
modprobe usbcore
mount usbdevfs
modprobe usb-uhci
modprobe printer
rchotplug start
```

If you have more than one USB printer connected to the system, there is a special issue to consider: All connected devices are autodetected by the USB subsystem with the first USB printer being addressed as device `/dev/usb/lp0` and the second one as `/dev/usb/lp1`. Depending on the model, USB printers can be detected even when they are powerless. Some have the built-in capability to be queried by the system even when powered off. Therefore, to avoid that the system confuses different printers, switch on all printers before booting and try to leave them connected to power all the time.

The IrDA Printer Interface

With IrDA, the system uses an infrared interface to emulate a parallel port. To do so, the Linux drivers provide a simulated parallel port under the device name of `/dev/irlpt0`. A printer connected through infrared is handled in the same way as any other parallel printer except it is made available to the system under the name of `/dev/irlpt0` instead of `/dev/lp0`.

Test the connection to an IrDA printer by entering the command (as `root`):

```
echo -en "\rHello\r\f" >/dev/irlpt0
```

If the printer is able to print ASCII text directly, this should print a single page with the word `Hello` on it.

Regardless of the outcome of the above test, the printer should appear in the output of `irdadump`. If the irdadump command is not available, install the package `irda`. If irdadump does not display the printer, it is not possible to address the printer. If nothing is displayed, most likely the IrDA system service has not been started, as it is not started automatically when the system is booted. Enter the following commands to start and stop the IrDA systems service:

```
rcirda start
rcirda stop
```

Serial Ports

The use of the LPRng spooler with a printer connected to the serial port is described in the *LPRng-Howto* under `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html` (especially under `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#SECSERIAL`) and in the man page for `printcap` (`man printcap`). Information is also availabe in the Support Database under the keyword “serial”.

Manual Configuration of LPRng and lpdfilter

Normally, the printing system is configured with YaST as described in *Configuring a Printer with YaST* on page 126. SuSE Linux also includes the program lprsetup, which is a bare-bones command-line tool for the configuration of the LPRng and lpdfilter printing system.

When setting up a printer with YaST, it collects all necessary data then runs lprsetup internally with all the necessary options to write the actual LPRng and lpdfilter configuration.

lprsetup is intended as an expert tool. As such, it will not provide any help to find the correct values for printer options. To see a brief list of the available command line options for `lprsetup`, enter `lprsetup -help` or refer to the man page for `lprsetup` (`man lprsetup`) and the man page for `lpdfilter` (`man lpdfilter`) for further details.

For information regarding Ghostscript drivers and driver-specific options, read *Finding the Right Printer Driver* on page 122 and *Working with Ghostscript* on page 163.

The LPRng Print Spooler

The print spooler used by the LPRng and lpdfilter printing system is LPRng (package `lprng`).

The print spooler lpd, or line printer daemon, is usually started automatically on boot. More specifically, the script `/etc/init.d/lpd` is run as part of the boot procedure. After this, the print spooler runs as a in the background. Start and stop it manually with these commands:

```
rclpd start
rclpd stop
```

These are the configuration files of LPRng:

/etc/printcap definitions of the system's print queues

/etc/lpd.conf global print spooler configuration

/etc/lpd.perms permission settings

According to the script `/etc/init.d/lpd`, the command `rclpd start` also runs the command `checkpc -f` as a subprocess, which in turn creates spool directories with the appropriate permissions in `/var/spool/lpd` according to the queues defined in `/etc/printcap`.

When started, the print spooler first reads the entries in `/etc/printcap` to see which print queues have been defined. The spooler's task is then to manage any jobs queued for printing. In particular, the spooler:

- manages local queues by passing the print data of each job to a print filter (if necessary) then sending it to the printer or to another queue
- handles jobs in the order in which they have been queued
- monitors the status of queues and printers and provides status information when requested
- listens on port 515 to accept or reject print jobs from remote hosts destined for local queues, depending on the configuration
- forwards print jobs to remote print spoolers (listening on port 515 on other hosts) for printing through remote queues.

To learn more about the details of this mechanism, read the *LPRng Howto* (`file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html`) or consult the man page for `printcap` (`man printcap`) and the man page for `lpd` (`man lpd`).

Printing from Applications

Applications use the `lpr` command for printing. In the application, select the name of an existing queue (such as `color`) or enter a suitable print command (such as `lpr -Pcolor`) in the print dialog of the application.

On the command line, you can print with the command `lpr -Plp ⟨filename⟩`. Replace ⟨*filename*⟩ with the name of the file you want to print. The option `-P` can be used to specify the queue. For example, `-Pcolor` uses the queue `color`.

Command-Line Tools for LPRng

This section only provides a short overview of the available tools. For details, consult the *LPRng Howto*, in particular, section `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#LPRNGCLIENTS`.

Managing Local Queues

Printing Files

Details on how to use the `lpr` command can be found in the *LPRng Howto* (`file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#LPR`). The following only covers some basic operations.

To print a file, you normally must enter `lpr -P`⟨*queuename*⟩ ⟨*filename*⟩. If you leave out the `-P`⟨*queuename*⟩ parameter, the printing system defaults to the value of the environment variable PRINTER. The same is true for the commands `lpq` and `lprm`. See the man page for `lpr` (`man lpr`), the man page for `lpq` (`man lpq`), and the man page for `lprm` (`man lprm`) for more information. The environment variable PRINTER is set automatically on login. Display its current value with `echo $PRINTER`. Change it to expand to another queue by entering `export PRINTER=`⟨*queuename*⟩.

Checking the Status

By entering `lpq -P`⟨*queuename*⟩, check the status of print jobs handled by the specified queue. If you specify `all` as the queue name, `lpq` displays information for all jobs in all queues.

With `lpq -s -P`⟨*queuename*⟩, tell `lpq` to display only a minimum of information. `lpq -l -P`⟨*queuename*⟩ tells `lpq` to be more verbose.

With `lpq -L -P`⟨*queuename*⟩, `lpq` displays a detailed status report, which will come in handy when trying to track down errors.

For further information, see the man page for `lpq` (`man lpq`), and section `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#LPQ` of the *LPRng Howto*.

Removing Jobs from the Queue

The command `lprm -P`⟨*queuename*⟩ ⟨*jobnumber*⟩removes the print job with the specified number from the specified queue, if you own the job. A print job is owned by the user who started it. Display the owner and the job number of print jobs with `lpq`.

The command `lprm -Pall all` removes all print jobs from all queues for which you have the required permissions. `root` may remove any jobs in any queues regardless of permissions.

More information can be obtained in the man page for `lprm` (`man lprm`) and in the *LPRng Howto* (`file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#LPRM`).

Controlling the Queues

The command `lpc option` ⟨*queuename*⟩ displays the status of the specified queue and allows changing it. The most important options are:

`help` Display a short overview of the available options.

`status` ⟨*queuename*⟩ Display status information.

`disable` ⟨*queuename*⟩ Do not accept new jobs for the specified queue.

`enable` ⟨*queuename*⟩ Accept new jobs for the specified queue.

`stop` ⟨*queuename*⟩ Stop printing from the specified queue. If a job is being printed, it will be completed.

`start` ⟨*queuename*⟩ Enable printing from the specified queue.

`down` ⟨*queuename*⟩ Has the effect of `disable` and `stop` combined.

`up` ⟨*queuename*⟩ Has the effect of `enable` and `start` combined.

`abort` ⟨*queuename*⟩ Has the effect of `down`, but aborts all current print jobs immediately. Aborted jobs are preserved, however, and can be resumed after restarting the queue with `up`.

`root` permissions are required to control printer queues with the above commands. Options can be supplied to `lpc` directly on the command line (as in `lpc status all`). You can also run the program without any options, which starts it in dialog mode — it opens the lpc> command prompt. Then enter the options at the prompt. To leave the program, enter either `quit` or `exit`.

If you were to enter `lpc status all`, the output could look like this:

```
Printer         Printing Spooling Jobs Server Subserver
lp@earth         enabled  enabled    2    123       456
color@earth     disabled disabled    0   none      none
laser@earth     disabled  enabled    8   none      none
```

This gives the following information: Queue `lp` is completely enabled and holds two print jobs, one of which is being printed at the moment. Queue `color`, on the other hand, is completely stopped. Finally, the `laser` queue does not print at the moment, but jobs (there are currently eight of them) are still accepted for the queue and are accumulating in the spooler.

Further information can be obtained from the man page for `lpc` (`man lpc`) and the *LPRng Howto* (`file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#LPC`).

Managing Remote Queues

For each of the commands explained below, replace ⟨*printserver*⟩ with the name or IP address of your print server. ⟨*queuename*⟩ must be a queue on the print server.

Printing Files

With the LPRng spooler, even remote queues can be addressed directly, using the `lpr` command with the syntax `lpr -P⟨queuename⟩@⟨printserver⟩ ⟨file⟩`. This is only possible if the print server is configured to accept remote print jobs on its queues. This is enabled by default with LPRng.

Checking the Status

Check the status of a queue on a remote host by entering:

```
lpq -P⟨queuename⟩@⟨printserver⟩
lpq -s -P⟨queuename⟩@⟨printserver⟩
lpq -l -P⟨queuename⟩@⟨printserver⟩
lpq -L -P⟨queuename⟩@⟨printserver⟩
```

and

```
lpc status ⟨queuename⟩@⟨printserver⟩
lpc status all@⟨printserver⟩
```

To list the names of and display status information on all queues of a print server, use either `lpq -s -Pall@⟨printserver⟩` or `lpc status all@⟨printserver⟩`, provided that LPRng is used on the print server.

If printing over a remote queue does not work, querying the status of the queues helps determine the cause of the problem. If LPRng is installed on the print server, enter `lpq -L -P⟨queuename⟩@⟨printserver⟩` to get a detailed status report for remote diagnosis.

Removing Jobs from the Queue

With the following command delete all print jobs in remote queues that have been issued under your user name:

```
lprm -P⟨queuename⟩@⟨printserver⟩ ⟨jobnumber⟩
lprm -P⟨queuename⟩@⟨printserver⟩ all
lprm -Pall@⟨printserver⟩ all
```

`root` has no special privileges on remote queues. The parameter `all` only works if LPRng is used on the print server host as well.

Using Command-Line Tools for LPRng Troubleshooting

Print jobs are kept in the queue even if you shut down a machine during a printout so are still there after rebooting. To remove a faulty print job, use the commands described above. Rebooting will not remove them.

For example, it sometimes happens that the host-to-printer connection suffers some kind of fault, after which the printer is unable to interpret data correctly. This can cause it to spit out large amounts of paper with meaningless characters on it.

1. In the case of an inkjet model, remove all paper from the trays. Open the paper tray if you have a laser model.
2. In most cases, the print job is still in the queue after that. Print jobs are removed from the queue only after all data has been sent to the printer. Check with `lpq` or `lpc status` to see which queue is printing then delete the job in question with `lprm`.
3. The printer may produce some output even after deleting the job from the queue. To stop this, use the commands `fuser -k /dev/lp0` for a printer on the first parallel port or `fuser -k /dev/usb/lp0` for the first USB printer to terminate all processes still using the printer device.
4. Do a complete reset of the printer by switching it off. Wait a few seconds before putting the paper back into the trays and switching the device back on.

The Print Filter of the LPRng and lpdfilter Printing System

The print filter used in conjunction with LPRng is lpdfilter, which is installed as a package with the same name. The following is a detailed description of the steps involved in processing a print job. If you need to know about the inner workings of the print filter, read the scripts powering it (in particular, `/usr/lib/lpdfilter/bin/if`) and probably also follow the steps described in *Troubleshooting Hints for lpdfilter* on page 151.

1. The print filter (`/usr/lib/lpdfilter/bin/if`) determines which options to use as passed to it by the print spooler and specified by the print

job's control file. Options for the queue to use are also gathered from `/etc/printcap` and `/etc/lpdfilter/`⟨*queuename*⟩`/conf` (where ⟨*queuename*⟩ is the name of the actual queue).

2. If the `ascii` queue has been specified, the print filter is forced to treat the file as ASCII text. If a queue other than `ascii` has been specified, the printer filter tries to autodetect the file type. The filter determines the file type using the script `/usr/lib/lpdfilter/bin/guess` to run `file` on each file in question. The output of `file` is used to determine the type according to the entries in the file `/etc/lpdfilter/types`.

3. The file is converted into a printer-specific data stream according to the file type and the type of queue to use:

   - If the `raw` queue has been specified, print data is usually sent straight to the printer or forwarded to another queue. However, data may also undergo a simple conversion through `recode`, if so specified in `/etc/lpdfilter/`⟨*queuename*⟩`/conf`. To have an "absolute" `raw` filter — one that bypasses lpdfilter entirely — remove the line `:if=/usr/lib/lpdfilter/bin/if:\` for the corresponding queue in `/etc/printcap`.
   - If the queue specified is not a `raw` queue:

     (a) If the data is not in PostScript format, it is first converted into PostScript by running `/usr/lib/lpdfilter/filter/type2ps` on it (where `type` is the actual file type determined for the data in question). For example, ASCII text is converted into PostScript with `/usr/lib/lpdfilter/filter/ascii2ps`, which in turn relies on a2ps to obtain the correct character encoding defined for the queue. This ensures that country-specific special characters are printed correctly in plain text files. For details, see the man page for `a2ps` (`man a2ps`).

     (b) If necessary, PostScript data can be converted again if a suitable script is placed in `/etc/lpdfilter/`⟨*queuename*⟩`/pre` (where ⟨*queuename*⟩ is the name of the actual queue to use).

     (c) PostScript data is converted into another printer language, as needed.

       ▷ If the printer is PostScript capable, the data is sent directly to the printer (or forwarded to another queue). However, data can be further processed using the Bash functions "duplex" and "tray", which are defined in `/usr/lib/lpdfilter/global/functions`, to enable duplex printing and paper tray selection through PostScript commands (which requires that the PostScript printer has this functionality).

▷ If the printer is not PostScript capable, Ghostscript uses a driver suitable for the native printer language of the model to produce the printer-specific data that is finally sent to the printer (or forwarded to another queue).
Ghostscript-relevant parameters are stored either in the `cm` line of `/etc/printcap` or in the file `/etc/lpdfilter/`⟨*queuename*⟩`/upp` (where ⟨*queuename*⟩ is the name of the actual queue to use).
If so desired, the Ghostscript output can be reformatted again, if a suitable script is placed in `/etc/lpdfilter/`⟨*queuename*⟩`/post` (where ⟨*queuename*⟩ is the name of the actual queue to use).

(d) The printer-specific data is transferred to the printer (or to another queue). Control sequences for a specific printer can be sent to the printer both before and after the data stream. These must be specified in `/etc/lpdfilter/`⟨*queuename*⟩`/conf`.

Configuration of lpdfilter

Normally, the printing system is configured with YaST (as described in *Configuring a Printer with YaST* on page 126), which includes the setup of `lpdfilter`.

Some of the more special settings, however, can only be changed by editing the configuration files of the print filter by hand. For each queue, a dedicated configuration file is written to `/etc/lpdfilter/`⟨*queuename*⟩`/conf` (where ⟨*queuename*⟩ is the name of the actual queue to be used).

Customization of lpdfilter

1. By default, files not in PostScript format are converted into that format with `/usr/lib/lpdfilter/filter/type2ps` (where `type` is the actual type of the file in question).

   If a suitable script is placed in `/etc/lpdfilter/`⟨*queuename*⟩/type2ps, it will be used for the PostScript conversion of the file. The script must be able to accept data on `stdin` and to output data in PostScript format on `stdout`.

2. If so desired, an additional step can be performed to reformat PostScript data, which requires a suitable script be placed in `/etc/`

`lpdfilter/`⟨*queuename*⟩`/pre`. This may be a script to add custom PostScript preloads, for example. The script must be able to accept data on `stdin` and to output data in PostScript format on `stdout`. Some programs to reformat PostScript are included in the package `psutils`. In particular, the program pstops is capable of performing extensive transformations. See the man page for `pstops` (`man pstops`) for details.

3. Special Ghostscript parameters: When writing the configuration with YaST, Ghostscript parameters are stored in `/etc/lpdfilter/`⟨*queuename*⟩`/upp` (where ⟨*queuename*⟩ is the name of the actual queue to use), but custom Ghostscript parameters can also be added to this file manually. For details on Ghostscript parameters, read *Working with Ghostscript* on page 163.

4. If so desired, data can be reformatted again after conversion by Ghostscript. This requires a suitable script be placed in `/etc/lpdfilter/`⟨*queuename*⟩`/post` (where ⟨*queuename*⟩ is the name of the actual queue to use). This script must be able to accept data on `stdin` and to output a data stream suitable for the specific printer model on `stdout`.

A Hardware-Independent Example

For the purposes of this example, suppose there is a queue called `testqueue`, which should be configured so ASCII text is printed with line numbers along the left margin. Apart from that, all files should be printed with two pages scaled to fit on one sheet. The scripts `/etc/lpdfilter/testqueue/ascii2ps` and `/etc/lpdfilter/testqueue/pre`, as shown below, would achieve that:

```
#!/bin/bash
cat -n - | a2ps -1 --stdin=' ' -o -
```

File 7: */etc/lpdfilter/testqueue/ascii2ps: ASCII to PostScript Conversion*

```
#!/bin/bash
pstops -q '2:0L@0.6(20cm,2cm)+1L@0.6(20cm,15cm)'
```

File 8: */etc/lpdfilter/test/pre: PostScript Reformatting*

These scripts need to be made executable for all users, which can be achieved with the `chmod` command:

```
chmod -v a+rx /etc/lpdfilter/test/ascii2ps
chmod -v a+rx /etc/lpdfilter/test/pre
```

Reformatting files with `pstops` only works with PostScript files created to allow such transformations, as is usually the case.

Using Custom PostScript Preloads

PostScript preloads are small files containing PostScript commands that preceed the print data stream to initialize the printer or the Ghostscript program in the desired way. PostScript preloads are mostly used to enable duplex printing on PostScript printers or to activate a special paper tray. They can also be used for margin and gamma adjustments.

To use preloads, the PostScript printer or Ghostscript must be able to interpret the special commands. Ghostscript, for instance, does not interpret commands related to duplex printing or paper trays.

For this example, the queue `testqueue` is again used:

Duplex Printing To enable or disable duplex printing, create the files `/etc/lpdfilter/testqueue/duplexon.ps` and `/etc/lpdfilter/testqueue/duplexoff.ps` with the following contents:

```
%!PS
statusdict /setduplexmode known
{statusdict begin true setduplexmode end} if {} pop
```

File 9: */etc/lpdfilter/testqueue/duplexon.ps: Enabling Duplex Printing*

```
%!PS
statusdict /setduplexmode known
{statusdict begin false setduplexmode end} if {} pop
```

File 10: */etc/lpdfilter/testqueue/duplexoff.ps: Disabling Duplex Printing*

The following PostScript code can be used to revolve the back by 180 degrees for duplex printing:

```
%!PS
statusdict /setduplexmode known
{statusdict begin true setduplexmode end} if {} pop
statusdict /settumble known
{statusdict begin true settumble end} if {} pop
```

Paper Tray Selection To enable the default paper tray 0 or tray number 2, create the files `/etc/lpdfilter/testqueue/tray0.ps` and `/etc/lpdfilter/testqueue/tray2.ps`:

```
%!PS
statusdict /setpapertray known
{statusdict begin 0 setpapertray end} if {} pop
```

***File 11:** /etc/lpdfilter/testqueue/tray0.ps: Enabling Tray 0*

```
%!PS
statusdict /setpapertray known
{statusdict begin 2 setpapertray end} if {} pop
```

***File 12:** /etc/lpdfilter/testqueue/tray2.ps: Enabling Tray 2*

Margin Settings To adjust margin settings, create a file like `/etc/lpdfilter/testqueue/margin.ps`.

```
%!PS
<<
/.HWMargins [left bottom right top]
/PageSize [width height]
/Margins [left-offset top-offset]
>>
setpagedevice
```

***File 13:** /etc/lpdfilter/testqueue/margin.ps: Margin Adjustments*

The margin settings `left`, `bottom`, `right`, and `top` and the paper size measures `width` and `height` are specified in points (with one point equaling 1/72 inches or about 0.35 mm). The margin offsets `left-offset` and `top-offset` are specified in pixels, so depend on the resolution of the output device.

To change only the position of the printed area, it is sufficient to create a file like `/etc/lpdfilter/testqueue/offset.ps`.

```
%!PS
<< /Margins [left-offset top-offset] >> setpagedevice
```

File 14: */etc/lpdfilter/testqueue/offset.ps: Changing the Position of the Printed Area*

Gamma Correction To adjust the gamma distribution between colors, use a file like `/etc/lpdfilter/testqueue/cmyk.ps` or `/etc/lpdfilter/testqueue/rgb.ps`:

```
%!PS
{cyan exp} {magenta exp} {yellow exp} {black exp}
setcolortransfer
```

File 15: */etc/lpdfilter/testqueue/cmyk.ps: CMYK Gamma Correction*

```
%!PS
{red exp} {green exp} {blue exp} currenttransfer
setcolortransfer
```

File 16: */etc/lpdfilter/testqueue/rgb.ps: RGB Gamma Correction*

You need to know which color model is used by your printer (either CMYK or RGB) to make this work. The values to use for `cyan`, `magenta`, `yellow`, and `black` or for `red`, `green`, and `blue` should be determined through testing. Normally, these should be in the range between `0.001` and `9.999`.

To get a rough idea of the effect of the above filtering actions on the output, display them on screen. To see how a sample file looks without gamma correction, enter:

```
gs -r60 \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps
```

To see how it looks with gamma correction according to the above sample filters:

```
gs -r60 /etc/lpdfilter/test/cmyk.ps \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps
gs -r60 /etc/lpdfilter/test/rgb.ps \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps
```

End the test by pressing Ctrl + C.

Resetting the Printer To reset the printer to its original state each time, use a file like `/etc/lpdfilter/testqueue/reset.ps`:

```
%!PS
serverdict begin 0 exitserver
```

File 17: */etc/lpdfilter/testqueue/reset.ps: Printer Reset*

To activate one of the above PostScript preloads, create a file similar to `/etc/lpdfilter/testqueue/pre`:

```
#!/bin/bash
cat /etc/lpdfilter/testqueue/preload.ps -
```

File 18: */etc/lpdfilter/testqueue/pre: Activating a PostScript Preload*

In this file, replace `preload.ps` with the name of your custom preload file. In addition, make this script executable and readable for all users, which can be achieved with `chmod` in the following way:

```
chmod -v a+rx /etc/lpdfilter/test/pre
chmod -v a+r /etc/lpdfilter/test/preload.ps
```

Use the mechanism described above to insert PostScript commands not only before the print data, but also after it. For instance, with a script like `/etc/lpdfilter/testqueue/pre`, reset the printer to its original state after each print job is finished:

```
#!/bin/sbash
cat /etc/lpdfilter/test/preload.ps - /etc/lpdfilter/test/reset.ps
```

File 19: */etc/lpdfilter/testqueue/pre: Inserting a PostScript Preload and a PostScript Reset*

A Sample GDI Printer Configuration

This section provides an example for the customized configuration of a `gdi` print queue. As explained in *The Issue with GDI Printers* on page 124, it is often nearly impossible to make such printers run under Linux. However, special driver programs are available for some GDI models. In most cases, they are designed to run as Ghostscript add-ons with the driver reformatting the Ghostscript output into the printer's own language. Often these drivers make limited use of the printer's functionality, however, allowing only black-and-white printing, for example. If such a driver is available, Ghostscript can be used with it in the following way (also see *Working with Ghostscript* on page 163):

1. Ghostscript converts the PostScript data into a raster of pixel dots then uses one of its drivers to convert the rasterized image into a format appropriate for the GDI driver at a suitable resolution. Data is then passed to the GDI driver.
2. The rasterized image is converted by the GDI driver into a data format suitable for the printer model.

For the steps described below, it is assumed that a GDI printer driver suitable for SuSE Linux is already installed or can be downloaded from the Internet. It is also assumed that the driver works in the way described above. In some cases, you may need some familiarity with the way source code is handled under Unix or how to handle these installations (from `.zip` or `.tar.gz` archives or maybe from `.rpm` packages).

After unpacking such an archive, you will often find the latest installation instructions included in some of the files, typically in `README` or `INSTALL`, or even in a `doc` subdirectory. If you have downloaded a `.tar.gz` archive, you usually need to compile and install the driver yourself.

For the purposes of the example explained below, the following setup is assumed:

- The driver program has been installed as `/usr/local/bin/printerdriver`.
- The required Ghostscript driver is `pbmraw` with an output resolution of 600 dpi.
- The printer is connected to the first parallel port — `/dev/lp0`.

The Ghostscript driver and the resolution may be different for your printer. Read the documentation included with the driver to find out about these.

First, create the `gdi` queue. To do so, log in as `root` and run lprsetup, as follows:

```
lprsetup -add gdi -lprng -device /dev/lp0 \
-driver pbmraw -dpi 600 -size a4dj -auto -sf
```

Now, create the script `/etc/lpdfilter/gdi/post`:

```
#!/bin/bash
/usr/local/bin/printerdriver ⟨gdi_driver_parameters⟩
```

Read the documentation of the driver program to find out what options exist for it. Specify them under ⟨*gdi_driver_parameters*⟩ as needed. Make the script executable for all users and restart the print spooler:

```
chmod -v a+rx /etc/lpdfilter/gdi/post
```

```
rclpd stop
rclpd start
```

From now on, users should be able to print with this command:

```
lpr -Pgdi ⟨file⟩
```

Troubleshooting Hints for lpdfilter

Enable different debug levels for `lpdfilter` by uncommenting (removing the '#' sign in front of) the corresponding line of the main filter script `/usr/lib/lpdfilter/bin/if`.

```
# DEBUG="off"
# DEBUG="low"
# DEBUG="medium"
# DEBUG="high"
```

File 20: */usr/lib/lpdfilter/bin/if: Debug Levels*

With `DEBUG="low"` enabled, the program logs its `stderr` output to the file `/tmp/lpdfilter.if-$$.XXXXXX` (where `$$` is the process ID and `XXXXXX` a unique random string).

With `DEBUG="medium"` enabled, the program logs, in addition to its own error output, the `stderr` output of the scripts in `/usr/lib/lpdfilter/filter` if these scripts are run by `/usr/lib/lpdfilter/bin/if`. The debugging output is written to `/tmp/lpdfilter.name-$$.XXXXXX` (where `name` is the name of the script run and `$$.XXXXXX` a string composed in the way described above).

With `DEBUG="high"` enabled, all error output is logged as above. Additionally, all output normally destined to the printer is redirected to a log file named `/tmp/lpdfilter.out-$$.XXXXXX` (where `$$.XXXXXX` is a string composed in the way described above).

To avoid losing control over the logging activity, you may want to remove the log files with `rm -v /tmp/lpdfilter*` before each new test run.

The CUPS Printing System

Naming Conventions

Client or *client program* refers to a program that sends print jobs to a print daemon. A *print daemon* is a local service that accepts print jobs either to forward them or to process them locally. *Server* refers to a daemon able to deliver print data to one or more printers. Each server functions as a daemon at the same time. In most cases, however, there is no special distinction to make between a server and a daemon, neither from the developer or from the user standpoint.

IPP and Server

Print jobs are sent to servers by CUPS-based programs, such as `lpr`, `kprinter`, or `xpp`, and with the help of the *Internet Printing Protocol*, IPP. IPP is defined in RFC-2910 and RFC-2911 (see `http://www.rfc-editor.org/rfc.html`). IPP is somewhat similar to HTTP with identical headers but different content data. It also uses its own dedicated communication port 631, which has been registered with IANA (the Internet Authority for Number Allocation).

Print data is transferred to a CUPS daemon, which is also acting as a local server in most cases. Other daemons can be addressed using the environment variable CUPS_SERVER.

With the help of the broadcast function of the CUPS daemon, locally managed printers can be made available elsewhere in the network (using UDP port 631). They then appear as print queues on all other daemons configured to accept and use these broadcast packets. This makes it possible to “see” printers on other hosts after booting without configuring them locally, something that may be quite useful in corporate networks. On the other hand, this feature may pose a security risk if the host is connected to the Internet. When enabling printer broadcasting, make sure the daemon broadcasts into the local network only, access is limited to clients on the LAN, and the public IP address (the one used for the Internet connection) is not within the local IP range. Otherwise, remote users relying on the same ISP would be able to “see” and use the broadcast printers as well. In addition to that, such broadcasts mean more network traffic so may increase connection costs. Prevent a local printer from broadcasting IPP packets into the Internet by configuring the SuSE Firewall (package `SuSEfirewall2`) accordingly. No extra configuration is needed to receive broadcast IPP packets. A broadcast address must only be specified for outgoing print jobs. This may be configured with YaST, for example.

IPP is used for the communication between a local and a remote CUPS daemon or server. More recent network printers also have built-in support for this protocol (there are a number of models from different makers). Find more information about this on the web pages of manufacturers or in your printer's manual. IPP is also supported by Windows 2000 and newer Microsoft systems, although originally the implementation was somewhat flawed. These problems may have disappeared or it may be necessary to install a Service Pack to repair them.

Configuration of a CUPS Server

There are many ways to set up a printer with CUPS and to configure the daemon: with command-line tools, with YaST, with the KDE Control Center, or even through a web browser interface. The following sections are limited to the command-line tools and YaST.

Caution

When using the web browser interface for CUPS configuration, be aware that there is a risk of compromising the `root` password. The password will be transmitted as plain text if the URL specified includes the real host name. Therefore, you should always use `http://localhost:631/` as the host address.

Caution

For the above reason, the CUPS daemon can only be accessed for administration if addressed as `localhost` (which is identical to the IP address `127.0.0.1`) by default. Entering a different address returns an error message, even if it is valid.

To configure a locally connected printer, first set up a CUPS daemon on the local host. To do so, install package `cups` together with the PPD files provided by SuSE as included in package `cups-drivers` and package `cups-drivers-stp`. After that, start the server as `root` with the command `/etc/rc.d/cups restart`. If you configure it with YaST, the above steps are already covered by selecting CUPS as the printing system and installing a printer.

PPD (PostScript Printer Description) files contain options for printer models in the form of a standard set of PostScript commands. They are required for printer installation under CUPS. SuSE Linux comes with precompiled PPD files for many printers from a number of manufacturers. Manufacturers may also offer PPD files for their PostScript printers on web sites and installation CDs (often in an area called something like “Windows NT Installation”).

The local daemon can also b started so printers of all broadcasting servers are available locally, although there is no local printer. This facilitates the use of these printers from within KDE applications and OpenOffice.org, for example.

Broadcasting can be enabled either with YaST. Alternatively, enable it by setting the `Browsing` directive to `On` (the default) and the `BrowseAddress` directive to a sensible value, like `192.168.255.255`, in the file `/etc/cups/cupsd.conf`. After that, tell the CUPS daemon explicitly to grant access to incoming packets, either under `<Location /printers>` or, preferably, under `<Location />`, where you would have to include a line like `Allow From some-host.mydomain` (see `file:/usr/share/doc/packages/cups/sam.html`). When finished editing the file, tell the daemon to reread its configuration by entering the command `/etc/rc.d/cups reload` as `root`.

Network Printers

Network printers are printers that have a built-in print server interface (such as the JetDirect interface in some HP printers) or printers connected to a print server box or a router box enabled as a print server. Windows machines offering printer shares are not print servers in the strict sense (although CUPS can handle them easily in a way similar to print servers).

In most cases, a network printer supports the LPD protocol, which uses port 515 for communication. Check lpd availability with the command:

```
netcat -z ⟨rechnername⟩.⟨domain⟩ 515 && echo ok || echo failed
```

If such a server is available, CUPS can be configured to access it under a *device URI*, an address in the form `lpd://server/queue`. Read about the concept of device URIs in `file:/usr/share/doc/packages/cups/sam.html`.

However, you should probably not use the LPD protocol for a network printer, but rather the printer's built-in port 9100 if available (HP, Kyocera, and many others) or port 35 (QMS). In this case, the device URI must have the form as follows:

```
socket://Server:Port/
```

To use printers made available through Windows, install package `samba-client` first and configure this package — enable the correct work group and make other settings. A device URI for Windows printers may be specified in several ways, but the most frequent one has the syntax `smb://user:password@host/printer`. For other configurations, see `file:/usr/share/doc/packages/cups/sam.html` and the man page for `smbspool` (`man smbspool`).

If you have a small network consisting of several (Linux) machines and have set up a print server for it, avoid configuring the printer for each and every client host by enabling the broadcast function of the daemon (see above). Thus, when you modify the configuration (for instance, to use the new standard paper size `Letter`), it is sufficient to do this once on the server side (also see *Specifying Options for Queues* on page 160). Although the configuration is saved locally on the server side, it is propagated to all clients in the network with the help of the CUPS tools and the IPP protocol.

Internal CUPS Print Job Processing

Conversion into PostScript

Basically the CUPS daemon should be able to handle any file type, although PostScript is always the safest bet. CUPS processes non-PostScript files by identifying the file type according to `/etc/cups/mime.types` first then converting the file into PostScript by calling the appropriate conversion tool for it as defined in `/etc/cups/mime.convs`. With CUPS, files are converted into PostScript on the server side rather than on the client side. This feature was introduced to ensure that special conversion operations necessary for a particular printer model are only performed on the corresponding server machine.

Accounting

After conversion into PostScript, CUPS calculates the number of pages for each print job. This is done with the help of pstops (an internal version of the program located at `/usr/lib/cups/filter/pstops`). The accounting data for print jobs are written to `/var/log/cups/page_log`. Each line in this file contains the following information:

- printer name (for example, `lp`)
- user name (for example, `root`)
- job number
- date and time (in square brackets)
- current page number
- number of copies

Other Filtering Programs

CUPS can also use other, special filters, if the corresponding printing options have been enabled. These are the most important ones:

psselect	Allows limiting the printout to certain pages of a document.
ps-n-up	Allows printing several pages on one sheet.

Read `file:/usr/share/doc/packages/cups/sum.html` for information about how to enable the various options.

Conversion into the Printer-Specific Language

The next step is the launch of the filter needed for generating printer-specific data. These filters are located in `/usr/lib/cups/filter/`. The suitable filter is determined in the PPD file in the `*cupsFilter` entry. If this entry does not exist, the print system assumes that the printer is a PostScript model. All device-specific printing options, such as the resolution and paper size, are processed in this filter.

Writing a custom printer-specific filter script is not a trivial task; see the SDB article *Using Your Own Filters to Print with CUPS* (keywords: “cups” + “filter”).

Transferring Data to the Printer

As the final step, CUPS calls one of its back-ends. A back-end is a special filter that transfers print data to a device or to a network printer (see `file:/usr/share/doc/packages/cups/overview.html`). The back-end maintains the communication with the device or network printer (as specified through a device URI during configuration). If the back-end is `usb`, for example, CUPS runs `/usr/lib/cups/backend/usb`, which in turn opens (and locks) the corresponding USB device file, initializes it, and passes the data coming from the print filter. When the job is finished, the back-end closes the device and unlocks it.

The following back-ends are currently available: `parallel`, `serial`, `usb`, `ipp`, `lpd`, `http`, `socket` (included in package `cups`). Also available are `canon` and `epson`, included in `cups-drivers-stp`, and `smb`, included in `samba-client`.

Filterless Printing

To print files without any filtering, use the `lpr` command with `-l` or use the `lp` command with the `-oraw` option. Usually, the printout will not work, as no printer-specific conversion is performed or other important filters are omitted. The options are similar for other CUPS tools.

Tips and Tricks

OpenOffice.org

When printing from OpenOffice.org applications, CUPS is supported such that a running CUPS daemon is autodetected and queried for available printers and options (this is different from StarOffice 5.2, where it was still necessary to perform a setup for each printer). An extra CUPS setup from within OpenOffice.org should not be necessary.

Printing to or from Windows

Printers connected to a Windows machine can be addressed through a device URI, such as `smb://server/printer`. To print from a Windows machine to a CUPS server, set the entries `printing = CUPS` and `printcap name = CUPS` in the Samba configuration file `/etc/samba/smb.conf` (this is preset in SuSE Linux). Following modifications in `/etc/samba/smb.conf`, the Samba server must be restarted. See `file:/usr/share/doc/packages/cups/sam.html` for details.

Setting up a Raw Printer

A raw printer can be set up by leaving out the PPD file during configuration, which effectively removes all filtering and accounting features from CUPS. For this purpose, the data must be sent in the printer-specific data format.

Custom Printer Options

The configuration options, such as a different default resolution, can be modified and saved for each user. The configuration is saved in the file `~/.lpoptions`. If such a reconfigured printer is removed on the server side, it will still be visible in various tools, such as `kprinter` and `xpp`. You can still select it even if it no longer exists, which causes problems. Experienced users can easily remove the superfluous lines from `~/.lpoptions` with an editor. Refer to the Support Database article *Print Settings with CUPS*.

Compatibility with LPR

CUPS can also receive print jobs from LPR systems. The needed configuration in `/etc/xinetd.d/cups-lpd` can be handled manually or with YaST.

Troubleshooting in CUPS

By default, the configuration file `/etc/cups/cupsd.conf` contains the following section:

```
# LogLevel: controls the number of messages logged to the ErrorLog file
#     and can be one of the following:
#
#     debug2    Log everything.
#     debug     Log almost everything.
#     info      Log all requests and state changes.
#     warn      Log errors and warnings.
#     error     Log only errors.
#     none      Log nothing.
#
LogLevel info
```

To detect errors in CUPS, set `LogLevel debug` and use `rccups reload` to have cupsd use the modified configuration file. Subsequently, `/var/log/cups/error_log` will contain detailed messages that assist in detecting the cause of problems.

With the following command print a label before starting to run the test:

```
echo "LABEL $(date)" | tee -a /var/log/cups/error_log
```

This label will be entered in `/var/log/cups/error_log`. This makes it easier to find the messages after the test.

Printing from Applications

Applications use the existing queues for printing from the command line. In applications, printer options are not configured directly, but rather through the existing queues.

Because package `cups-client` includes some command-line tools to print with CUPS, such as `lpr` command, applications can use the `lpr` command for printing (e. g., `lpr -Plp` or `lpr -Pcolor`). However, to be able to enter print commands, the print dialog in KDE has to be set to 'Print through an external program'. See *Quick Configuration of a Client Machine* on page 174.

In addition, graphical printer dialog programs such as xpp or the KDE program kprinter allow you to select a queue and modify standard CUPS options and printer-specific options in the PPD file by means of graphical selection menus.

In order to use kprinter as the default print dialog for various applications, enter the print command `kprinter` or `kprinter --stdin` in the print dialog of the applications. Subsequently, whenever you enter the application-specific print command, the kprinter dialog will be displayed after the print dialog of the application, allowing you to specify the queue and other options. When using this approach, make sure there is no conflict between the settings in the print dialog of the application and those in kprinter. If possible, print settings should only be specified in kprinter.

Command-Line Tools for the CUPS Printing System

The command-line tools of the CUPS printing system and their manual pages are included in package `cups-client`. Further documentation is provided by the package `cups` and installed in `/usr/share/doc/packages/cups`, in particular the *CUPS Software Users Manual*, found at `/usr/share/doc/packages/cups/sum.html` and the *CUPS Software Administrators Manual* at `/usr/share/doc/packages/cups/sam.html`. If a CUPS daemon runs locally on your host, you should also be able to access the documentation at `http://localhost:631/documentation.html`.

As a general rule, it is useful to remember that CUPS command-line tools sometimes require options be supplied in a certain order. Consult the corresponding manual pages if you are unsure about specific options.

Managing Local Queues

Printing Files

To print a file, enter the "System V style" print command
`lp -d ⟨queuename⟩ ⟨file⟩` or a "Berkeley style" command like
`lpr -P⟨queuename⟩ ⟨file⟩`.

Additional information can be obtained with the man page for `lpr` (`man lpr`) and the man page for `lp` (`man lp`), as well as in the section "Using the Printing System" of the *CUPS Software Users Manual* (`file:/usr/share/doc/packages/cups/sum.html#USING_SYSTEM`).

The `-o` parameter allows specification of a number of important options, some of which directly influence the type of printout. More information is available in the man page for `lpr` (`man lpr`) and the man page for `lp` (`man lp`) as well as in the section “Standard Printer Options” of the *CUPS Software Users Manual* (`file:/usr/share/doc/packages/cups/sum.html#STANDARD_OPTIONS`).

Checking the Status

To check the status of a queue, enter the “System V style” command `lpstat -o` ⟨*queuename*⟩ `-p` ⟨*queuename*⟩ or the “Berkeley style” command `lpq -P`⟨*queuename*⟩.

If you do not specify a queue name, the commands will display information on all queues. With `lpstat -o`, the output will show all active print jobs in the form of a ⟨*queuename*⟩-⟨*jobnumber*⟩ listing.

With `lpstat -l -o` ⟨*queuename*⟩ `-p` ⟨*queuename*⟩, the output is more verbose. `lpstat -t` or `lpstat -l -t` displays the maximum amount of available information.

For additional information, consult the man page for `lpq` (`man lpq`), the man page for `lpstat` (`man lpstat`), and the section “Using the Printing System” of the *CUPS Software Users Manual* (`file:/usr/share/doc/packages/cups/sum.html#USING_SYSTEM`).

Removing Jobs from the Queue

Enter the “System V style” command `cancel` ⟨*queuename*⟩-⟨*queuename*⟩ or the “Berkeley style” command `lprm -P`⟨*queuename*⟩ ⟨*queuename*⟩ to remove the job with the specified number from the specified queue. For additional information, consult the man page for `lprm` (`man lprm`), the man page for `cancel` (`man cancel`), and the section “Using the Printing System” of the *CUPS Software Users Manual* (`file:/usr/share/doc/packages/cups/sum.html#USING_SYSTEM`).

Specifying Options for Queues

To see how to specify hardware-independent options that affect the type of printout, read the section “Standard Printer Options” in the *CUPS Software Users Manual* (`file:/usr/share/doc/packages/cups/sum.html#STANDARD_OPTIONS`). The section “Saving Printer Options and Defaults”, which is found at `file:/usr/share/doc/packages/cups/sum.html#SAVING_OPTIONS`, explains how to save option settings.

Printer-specific options affecting the type of printout are stored in the PPD file for the queue in question. They can be listed with the command `lpoptions -p` ⟨*queuename*⟩ `-l`. The output has the following form:

```
option/text: value value value ...
```

The currently active setting is marked with an asterisk (`'*'`) to the left, for example:

```
PageSize/Page Size: A3 *A4 A5 Legal Letter
Resolution/Resolution: 150 *300 600
```

According to the above output, the `PageSize` is set to `A4` and the `Resolution` to `300` dpi.

The command `lpoptions -p ⟨queuename⟩ -o option=value` changes the value for the given option.

With the above sample settings in mind, use the following command to set the paper size for the specified queue to Letter:

```
lpoptions -p ⟨queuename⟩ -o PageSize=Letter
```

If the above `lpoptions` command is entered by a normal user, the new settings are stored for that user only in the file `~/.lpoptions`.

By contrast, if the `lpoptions` command is entered by `root`, the settings specified are stored in `/etc/cups/lpoptions` and become the default for all local users of the queue. The PPD file is not touched by this, however.

If (and only if) you change the contents of a PPD file for a given queue, the new settings apply to all users in the local network who print through this queue. The system administrator can change the defaults of a PPD file with a command like:

```
lpadmin -p ⟨queuename⟩ -o PageSize=Letter
```

For more information, refer to the Support knowledgebase article *Print Settings with CUPS*.

Managing Remote Queues

For each of the commands explained below, replace ⟨*printserver*⟩ with the name or IP address of your print server. ⟨*queuename*⟩ must be a queue on the print server.

This section merely covers the basic commands. Additional options and information sources are referred to in *Managing Local Queues* on page 159.

Printing Files

You can use the "System V style" command
`lp -d ⟨queuename⟩ -h ⟨printserver⟩ ⟨file⟩` to generate a print job for the specified queue on the specified print server This is only possible if the print server was configured to accept remote print jobs on its queues. This is not enabled by default in CUPS, but can easily be configured in the CUPS server settings in a submenu of the YaST printer configuration module.

Checking the Status

Check the status of a queue on the print server with the "System V style" command
`lpstat -h ⟨printserver⟩ -o ⟨queuename⟩ -p ⟨queuename⟩`.

Removing Jobs from the Queue

The "System V style" command
`cancel -h ⟨printserver⟩ ⟨queuename⟩-⟨jobnumber⟩` removes the print job with the specified job number from the specified queue on the print server.

Using Command-Line Tools for CUPS Troubleshooting

In the case of a broken print job, the troubleshooting procedure is basically the same as the one described in *Using Command-Line Tools for LPRng Troubleshooting* on page 142, with the difference that CUPS requires different commands for the second step:

1. Remove all paper from the printer so the printer stops working.
2. Check which queue is currently printing by entering `lpstat -o` (or `lpstat -h ⟨printserver⟩ -o`) then remove the problematic print job with `cancel ⟨queuename⟩-⟨jobnumber⟩` (or with `cancel -h ⟨printserver⟩ ⟨queuename⟩-⟨jobnumber⟩`).
3. If necessary, use the `fuser` command to kill leftover programs.
4. Do a complete reset of the printer.

Working with Ghostscript

Ghostscript is a program that accepts PostScript and PDF files as input then converts them into several other formats. Ghostscript includes a number of drivers to achieve this. These are sometimes also referred to as "devices."

Ghostscript converts files in two steps:

1. PostScript data is rasterized — the graphical image is broken into a fine-grained raster of pixel dots. This step is performed independently from the Ghostscript driver used later. The finer the raster (the higher the resolution), the higher the output quality. On the other hand, doubling the resolution both horizontally and vertically (for example) means that the number of pixels must quadruple. Accordingly, the computer needs four times the CPU time and amount of memory to double the resolution.

2. The dot matrix that makes up the image is converted into the desired format (a printer language, for example) with the help of a Ghostscript driver.

Ghostscript can also process PostScript files to display them on screen or convert them into PDF documents. To display PostScript files on screen, you should probably use the program gv (rather than relying on bare Ghostscript commands), which gives a more convenient graphical interface.

Ghostscript is a very big program package and has a number of command-line options. Apart from the information available with the the man page for `gs` (`man gs`), the most important part of the documentation is the list of Ghostscript drivers, which is found in:

`file:/usr/share/doc/packages/ghostscript/catalog.devices` and the files:

`file:/usr/share/doc/packages/ghostscript/doc/index.html`
`file:/usr/share/doc/packages/ghostscript/doc/Use.htm`
`file:/usr/share/doc/packages/ghostscript/doc/Devices.htm`
`file:/usr/share/doc/packages/ghostscript/doc/hpdj/gs-hpdj.txt`
`file:/usr/share/doc/packages/ghostscript/doc/hpijs/hpijs_readme.html`
`file:/usr/share/doc/packages/ghostscript/doc/stp/README`

When executed from the command line, Ghostscript processes any options then presents its own GS> prompt. Exit from this dialog mode by entering `quit`.

If you enter `gs -h`, Ghostscript displays its most important options and lists the available drivers. This listing, however, only includes generic driver names, even for drivers that support many different models, such as `uniprint` or `stp`. The parameter files for `uniprint` and the models supported by `stp` are explicitly named in `file:/usr/share/doc/packages/ghostscript/catalog.devices`.

Sample Operations with Ghostscript

Find a number of PostScript examples in the directory `file:/usr/share/doc/packages/ghostscript/examples`. The color circle in `file:/usr/share/doc/packages/ghostscript/examples/colorcir.ps` is well suited for test printouts.

Displaying PostScript under X

Under X, the graphical environment, use `gs` to view a PostScript file on screen. To do so, enter the following command as a single line, omitting the backslash ('\'):

```
gs -r60 \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps
```

In the above command, the `-r` option specifies the resolution, which must be appropriate for the output device (printer or screen). Test the effect of this option by specifying a different value, for example, `-r30`. To close the PostScript window, press Ctrl + C in the terminal window from which `gs` was started.

Conversion into PCL5e

The conversion of a PostScript file into the printer-specific format of a PCL5e or PCL6 printer can be achieved with a command like

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.prn \
-sDEVICE=ljet4 -r300x300 \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps \
quit.ps
```

Again, the command must be entered as a single line and without any backslash ('\'). With this command, it is assumed that the file `/tmp/out.prn` does not exist yet.

Conversion into PCL3

The conversion of a PostScript file into the printer-specific format for a PCL3 printer can be achieved with a command such as the following:

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.prn \
-sDEVICE=deskjet -r300x300 \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps \
quit.ps
```

Depending on the model, you can replace ⟨*deskjet*⟩ with `cdjmomo`, `cdj500`, or `cdj550` or use the alternative driver `hpdj`:

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.prn \
-sDEVICE=hpdj -r300x300 \
-sModel=500 -sColorMode=mono -dCompressionMethod=0 \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps \
quit.ps
```

The individual commands can also be entered without `'\'` in a *single line*.

Conversion into ESC/P, ESC/P2, or ESC/P Raster

These are some sample commands to convert a PostScript file into the printer-specific format of an ESC/P2, ESC/P, or ESC/P raster printer.

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.prn \
@stcany.upp \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps \
quit.ps
```

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.prn \
-sDEVICE=stcolor -r360x360 \
-dBitsPerPixel=1 -sDithering=gsmono -dnoWeave \
-sOutputCode=plain \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps \
quit.ps
```

The above commands also show that the `uniprint` Ghostscript driver, which is called through a parameter file (`stcany.upp` in our example), requires a different command syntax than "regular" Ghostscript drivers. Because all driver options are stored in the `uniprint` parameter file, they do not have to be specified on the Ghostscript command line itself.

Sending the Output Directly to the Printer

With each of the above commands, the output is written in the corresponding printer language and stored in the file `/tmp/out.prn`. This file can be sent directly to the printer by `root` without the use of a print spooler or any filtering. For a printer connected to the first parallel port, this can be achieved with the command `cat /tmp/out.prn >/dev/lp0`.

Processing PostScript and PDF Files

Ghostscript can generate PostScript and PDF files, convert both formats to each other, and even merge PostScript and PDF files in mixed order.

Conversion from PostScript to PDF:

```
gs -q -dNOPAUSE -dSAFER \
-sOutputFile=/tmp/colorcir.pdf -sDEVICE=pdfwrite \
/usr/share/doc/packages/ghostscript/examples/colorcir.ps \
quit.ps
```

Conversion of the generated PDF file `/tmp/colorcir.pdf` to PostScript:

```
gs -q -dNOPAUSE -dSAFER \
-sOutputFile=/tmp/colorcir.ps -sDEVICE=pswrite \
/tmp/colorcir.pdf quit.ps
```

Following the reconversion from PDF to PostScript, the file `/tmp/colorcir.ps` does not match the original file `/usr/share/doc/packages/ghostscript/examples/colorcir.ps`. However, there should be no visible difference in the printout.

Merging PostScript and PDF files into a PostScript file:

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.ps \
-sDEVICE=pswrite \
/usr/share/doc/packages/ghostscript/examples/escher.ps \
/tmp/colorcir.pdf quit.ps
```

Merging PostScript and PDF files into a PDF file:

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.pdf \
-sDEVICE=pdfwrite /tmp/out.ps \
/usr/share/doc/packages/ghostscript/examples/golfer.ps \
/tmp/colorcir.pdf quit.ps
```

Depending on the files you use, it may not be possible to merge some PostScript and PDF files.

Working with a2ps

Before an ASCII file can be printed through Ghostscript, it needs to be converted into PostScript, because this is the input format that Ghostscript expects. This conversion can be achieved with a2ps (package `a2ps` package). As package `a2ps` is not installed by default, you will normally have to install it yourself.

The a2ps program is a powerful, versatile tool that lets you convert simple text files into high-quality PostScript output. It has a large number of command-line options. Learn about these in the man page for `a2ps` (`man a2ps`) or read the full documentation of a2ps as an info page.

Using a2ps to Prepare a Text File for Printing

As a first example, `a2ps` can be used to convert a text file into PostScript, with two pages scaled down so they fit on one sheet. This can be achieved with the command:

```
a2ps -2 ---medium=A4dj ---output=/tmp/out.ps textfile
```

The output of a2ps can then be displayed under X with

```
gs -r60 /tmp/out.ps
```

to get a preview of the printout. If the printout is more than one sheet, hit ↵ in the terminal window from which `gs` was started to scroll down to the next page. To exit `gs`, enter Ctrl + C.

Take the output of a2ps and convert it into your printer's language by entering:

```
gs -q -dNOPAUSE -dSAFER -sOutputFile=/tmp/out.prn \
⟨driverparameter⟩ /tmp/out.ps quit.ps
```

In the above command, specify your own driver parameters under ⟨*driverparameters*⟩ as described in the previous section.

As `root`, you can send the output of Ghostscript directly to the printer without relying on a spooler or any further filtering with the command

```
cat /tmp/out.prn >/dev/lp0
```

It is assumed here that the printer is connected to the first parallel port (`/dev/lp0`).

Reformatting PostScript with psutils

To use one of the reformatting programs described below, generate a PostScript input file by printing to a file, such as `/tmp/in.ps`, from within an application. Check with `file /tmp/in.ps` to see whether the generated file is really in PostScript format.

The package `psutils` includes a number of programs to reformat PostScript documents. The program `pstops`, in particular, allows you to perform extensive transformations.

Details can be obtained in the man page for `pstops` (`man pstops`). The package `psutils` is not included in the standard setup of SuSE Linux, so you may need to install it.

The following commands only work if the application program has created a PostScript file appropriate for such reformatting operations. This should mostly be the case, but there are some applications that cannot generate PostScript files in the required way.

psnup

The command `psnup -2 /tmp/in.ps /tmp/out.ps` takes `/tmp/in.ps` as its input and transforms it into the output file `/tmp/out.ps` in such a way that two pages are printed side by side on one sheet. However, with the contents of two pages being included on one, the complexity of the resulting document is much higher and some PostScript printers may fail to print it, especially if they are equipped with only a small amount of standard memory.

pstops

The program `pstops` allows you to change the size and positioning of PostScript documents:

```
pstops '1:0@0.8(2cm,3cm)' /tmp/in.ps /tmp/out.ps
```

This command scales the document by a factor of 0.8, which effectively scales down an A4 page from about 21x30 cm to about 17x24 cm. This, in turn, leaves an additional margin of about 4 cm on the right and 6 cm on the top. Therefore, the document is also shifted by 2 cm towards the right and 3 cm towards the top to get roughly the same margins everywhere.

This `pstops` command shrinks the page by quite an amount and also provides for relatively wide margins, so it should generate a page that is almost always printable — even with those applications that are far too optimistic about the limits set by your printer. You can use a command like the above for those cases where the application's printer output in `/etc/in.ps` is too large for the printable area.

As another example: `pstops '1:0@0.8(2cm,3cm)' /tmp/in.ps`

```
/tmp/out1.ps
psnup -2 /tmp/out1.ps /tmp/out.ps
```

These commands place two heavily scaled-down pages on one sheet, leaving quite a lot of space between them. To improve this, include instructions to position each of the pages individually:

```
pstops '2:0L@0.6(20cm,2cm)+1L@0.6(20cm,15cm)' \
/tmp/in.ps /tmp/out.ps
```

The above command must be entered as a single line without the `'\'`.

The following is a step-by-step explanation of the page specifications as expressed by `pstops '2:0L@0.6(20cm,2cm)+1L@0.6(20cm,15cm)'`:

2:0 ... +1 Two pages are merged into one and pages are counted modulo 2, which means that the pages modulo 2 are alternately counted as page 0 (modulo 2) and page 1 (modulo 2).

0L@0.6(20cm,2cm) Pages with the logical number 0 are turned to the left by 90 degrees and scaled down by a factor of 0.6. They are then shifted to the right by 20 cm and to the top by 2 cm.

1L@0.6(20cm,15cm) To match the above reformatting, pages with the logical number 1 are turned to the left by 90 degrees, and scaled down by a factor of 0.6. They are then shifted to the right by 20 cm and to the top by 15 cm.

In the case of PostScript files, the origin of the coordinates is located in the bottom left corner of a page in normal orientation, as indicated by the `'+'` (see Figure 6.2 on the next page):

1. One page 0 (modulo 2) with three lines of text.
2. Rotated to the left by 90 degrees.
3. Scaled by factor 0.6.
4. Moved 20 cm to the right and 2 cm up.
5. Merged with a page 1 (modulo 2) with two lines of text.
6. After rotating page 1 (modulo 2) to the left by 90 degrees.
7. After scaling page 1 (module 2) by factor 0.6.
8. After moving page 1 (modulo 2) 20 cm to the right and 15 cm up.

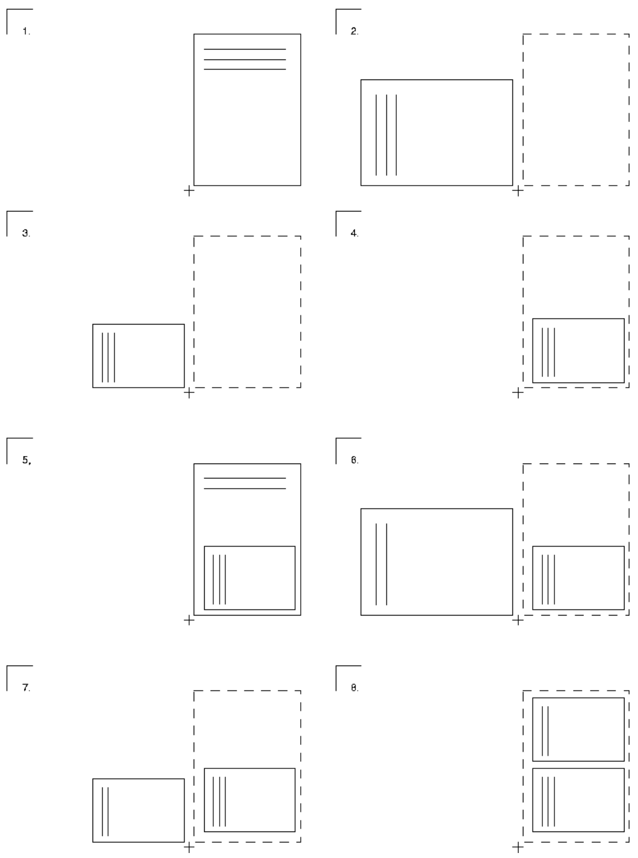


Figure 6.2: *The Individual Steps with pstops*

psselect

psselect enables the selection of individual pages. With `psselect -p2-5 /tmp/in.ps /tmp/out.ps`, pages 2, 3, 4, and 5 are selected from `/tmp/in.ps` and written to `/tmp/out.ps`. The command `psselect -p-3 /tmp/in.ps /tmp/out.ps` selects all pages up to page 3. The command `psselect -r -p4- /tmp/in.ps /tmp/out.ps` selects the pages from page 4 to the last page and prints them in reverse order.

Using Ghostscript to View the Output

On a graphical display, the PostScript file `/tmp/out.ps` can be viewed with `gs -r60 /tmp/out.ps`. Scroll through the pages by pressing ↵ in the terminal window from which you started Ghostscript. Terminate with Ctrl + C.

As a graphical front-end for Ghostscript, use `gv`. To view the above-mentioned output file, for example, enter `gv /tmp/out.ps`. The program is especially useful whenever there is a need to zoom in or out on a document or to view it in landscape orientation (although this has no effect on the file contents). It can also be used to select individual pages, which can then be printed directly from within `gv`.

ASCII Text Encoding

In plain text files, each character is represented as a certain numeric code. Characters and their matching codes are defined in code tables. Depending on the code tables used by an application and by the print filter, the same code may be represented as one character on the screen and as another one when printed.

Standard character sets only comprise the range from code 0 to code 255. Of these, codes 0 through 127 represent the pure ASCII set, which is identical for every encoding. It comprises all "normal" letters as well as digits and some special characters, but none of the country-specific special characters. Codes 128 through 255 of the ASCII set are reserved for country-specific special characters, such as umlauts.

However, the number of special characters in different languages is much larger than 128. Therefore, codes 128 to 255 are not the same for each country. Rather, the same code may represent different country-specific characters, depending on the language used.

The codes for Western European languages are defined by ISO-8859-1 (also called Latin 1). The ISO-8859-2 encoding (Latin 2) defines the character sets for Central and Eastern European languages. Code 241 (octal), for example, is defined as the (Spanish) inverted exclamation mark in ISO-8859-1, but the same code 241 is defined as an uppercase A with an ogonek in ISO-8859-2. The ISO-8859-15 encoding is basically the same as ISO-8859-1, but, among other things, it includes the Euro currency sign, defined as code 244 (octal).

A Sample Text

The commands below must be entered as a single line without any of the backslashes (`'\'`) at the end of displayed lines.

Create a sample text file with:

```
echo -en "\rCode 241(octal): \
\241\r\nCode 244(octal): \244\r\f" >example
```

Visualizing the Sample with Different Encodings

Under X, enter these commands to open three terminals:

```
xterm -fn -*-*-*-*-*-*-14-*-*-*-*-*-iso8859-1 -title iso8859-1 &
xterm -fn -*-*-*-*-*-*-14-*-*-*-*-*-iso8859-15 -title iso8859-15 &
xterm -fn -*-*-*-*-*-*-14-*-*-*-*-*-iso8859-2 -title iso8859-2 &
```

Use the terminals to display the sample file in each of them with `cat example`.

The “iso8859-1” terminal should display code 241 as the inverted (Spanish) exclamation mark and code 244 as the general currency symbol.

The “iso8859-15” terminal should display code 241 as the inverted (Spanish) exclamation mark and code 244 as the Euro symbol.

The “iso8859-2” terminal should display code 241 as an uppercase A with an ogonek and code 244 as the general currency symbol.

Due to the fact that character encodings are defined as fixed sets, it is not possible to combine all the different country-specific characters with each other in an arbitrary way. For example, the A with an ogonek cannot be used together with the Euro symbol in the same text file.

To obtain more information (including a correct representation of each character), consult the corresponding man page in each terminal — the man page for `iso_8859-1` (`man iso_8859-1`) in the “iso8859-1” terminal, the man page for `iso_8859-15` (`man iso_8859-15`) in the “iso8859-15” terminal, and the man page for `iso_8859-2` (`man iso_8859-2`) in the “iso8859-2” terminal.

Printing the Sample with Different Encodings

When printed, ASCII text files, such as the `example` file, are treated in a similar way according to the encoding set for the print queue used. However, word processor documents should not be affected by this, because their print output is in PostScript format (not ASCII).

Consequently, when printing the above `example` file, characters are represented according to the encoding set for ASCII files in your printing system. You can also convert the text file into PostScript beforehand to change the character encoding as needed. The following `a2ps` commands achieves this for the `example` file:

```
a2ps -1 -X ISO-8859-1 -o example-ISO-8859-1.ps example
a2ps -1 -X ISO-8859-15 -o example-ISO-8859-15.ps example
a2ps -1 -X ISO-8859-2 -o example-ISO-8859-2.ps example
```

When printing the files `example-ISO-8859-1.ps`, `example-ISO-8859-15.ps`, and `example-ISO-8859-2.ps`, the files are printed with the encoding determined with `a2ps`.

Printing in a TCP/IP Network

Find extensive documentation about the LPRng printing system in the *LPRng-Howto* in `/usr/share/doc/packages/lprng/LPRng-HOWTO.html` and on the CUPS printing system in the *CUPS Software Administrators Manual* in `/usr/share/doc/packages/cups/sam.html`.

Terminology

print server *Print server* refers to a complete, dedicated printing host with the required CPU power, memory, and hard disk space.

Print server box or network printer

- *Print server box* refers to a computer with relatively limited resources, which is equipped with both a TCP/IP network link and a local printer port. This includes "router boxes" with a built-in printer port.
- A *network printer* is a printer device with its own TCP/IP port. Basically, it is a printer with an integrated print server box. Network printers and print server boxes are handled in essentially the same way.

There is an important distinction to be made between a network printer or a print server box on the one hand and a true print server on the other. As a somewhat special case, there are large printer devices that have a complete print server included with them to make them network-capable. These are treated like print servers because clients will talk to the printer only through the server and not directly.

LPD server An *LPD server* is a print server that is addressed with the LPD protocol. This is the case if the print server runs the *LPRng* and *lpdfilter* print system (lpd, to be precise) or the *CUPS* print system configured in a way that the machine can be addressed with the LPD protocol (cups-lpd, to be precise).

IPP server or CUPS server An "IPP server" or *CUPS server* is a print server that is addressed with the IPP protocol. This is the case if the print server runs the CUPS print system (cupsd, to be precise).

CUPS network server The term "CUPS network server" refers to a CUPS server that was specifically configured to share its queues with other network hosts via UDP broadcast (via UDP port 631).

Quick Configuration of a Client Machine

Usually, client machines in a network do not have any locally connected printers. Rather, the client sends print jobs to a print server. If you have a print server and an additional local printer is connected to the client, you need a client configuration as well as a configuration for the local printer. The print system on the client machine should be selected in accordance with the print system on the print server.

Client Configuration for an LPD Server

If there is no CUPS network server in the network, but only an LPD server, use the LPRng and lpdfilter print system on the client. In this case, the client machine does not require any further configuration, as even remote queues can be addressed directly when using the LPRng spooler. See *Command-Line Tools for LPRng* on page 138.

However, this is only possible if the LPD server was configured to allow the client to print to its queues. To print from applications, enter
`lpr -P⟨queuename⟩@⟨printserver⟩`
in the application. This corresponds to the procedure described in *Managing Remote Queues* on page 141. However, no file name is specified.

Some applications are preconfigured to use CUPS and must be switched to LPRng. Especially KDE and the KDE printing program kprinter must be set to 'Print through an external program'. If this is not done, it will not be possible to enter the print command.

Client Configuration for a CUPS Network Server

If the print server is a CUPS network server, start the YaST printer configuration module, click 'Change' then 'Advanced' and select one of the following options:

CUPS as server (default in standard installations) If no printer is connected locally, no local queue was configured with YaST. In this case, cupsd is not started automatically, Activate the 'cups' service to start cupsd (normally for the runlevels 3 and 5).

The client machine does not require any further configuration, as a CUPS network server broadcasts its queues to all network hosts at regular intervals. Therefore, the queues of the network server will automatically be available on the client machine after a short time.

However, this is only possible if the broadcasting function is enabled on the CUPS network server, the broadcast address used is suitable for the client machine, and the client machine is permitted to print to the queues of the CUPS network server.

CUPS in client-only mode If you merely want to print via the queues of the CUPS network server, CUPS can be run in client-only mode. In the YaST *client-only* printer configuration, specify the name of the CUPS network server.

In this mode, the client machine does not run cupsd and the file `/etc/printcap` does not exist. However, applications that cannot be configured to use CUPS will only offer the queues listed in the local `/etc/printcap`. In this case, it is advisable to run CUPS in server mode, as the local cupsd will automatically generate an `/etc/printcap` containing the queue names of the CUPS network server.

Protocols for Printing in TCP/IP Networks

The following lists the different methods that can be used to implement printing on a TCP/IP network. The decision of which one to use does not so much depend on the hardware, but more on the possibilities offered by each protocol. Accordingly, the YaST printer configuration asks you to select a protocol and not a hardware device when setting up network printing.

Nevertheless, the first step in the printer configuration with YaST is the selection of the hardware category for printing (e.g., via CUPS network server, via LPD network server, or direct printing on a network printer or print server box). Accordingly, available protocols are offered for selection. The protocol that should work in most cases is preselected. If only one protocol is possible, there is no selection. Examples:

- Print via CUPS Network Server
  - ▷ IPP protocol (single option)
- Print via LPD-Style Network Server
  - ▷ LPD protocol (single option)
- Print directly on a network printer or using a print server box
  - ▷ TCP socket
  - ▷ LPD protocol
  - ▷ IPP protocol

Data can only be transmitted from the sender to the recipient if both parties support the respective protocol. the software running on the sender and recipient must support the respective protocol.

Ultimately, it does not matter which kind of hardware and software is used, as long as both the sender and the recipient support the respective protocol. Depending on the protocol, print jobs or raw data are transmitted.

Apart from the print data, a print job contains additional information such as the user on whose host the print job was generated as well as any special print options (such as the paper size to use for printing, duplex mode, and so on).

Printing via the LPD protocol

The sender sends a print job to a queue on the recipient via the LPD protocol. According to the LPD protocol, the recipient is expected to receive print jobs on port 515. Therefore, a service receiving the print jobs on port 515 (normally this service is called lpd) and a queue in which received print jobs can be placed are needed on the receiving host.

Senders supporting the LPD protocol:

Linux host with LPRng print system:

- LPRng supports sending via the LPD protocol using the lpd. On the sender host, a queue is needed from which the lpd of the sender takes the print job and forwards it to the lpd of the recipient.
- LPRng also supports sending via the LPD protocol without a local lpd. Using the LPD protocol, the lpr program in the lprng package can directly forward the print job to the lpd of the recipient.

Linux host with CUPS server print system:

- CUPS supports sending via the LPD protocol using the CUPS daemon (cupsd). On the sender host, a queue is needed from which the cupsd takes the print job and forwards it to the lpd of the recipient.

Linux host with CUPS client print system:

- Sending via the LPD protocol is not supported by the CUPS client print system.

Host with non-Linux operating system:

- As the LPD protocol is very old, all operating systems should support this protocol at least as the sender. If the support is not available by default, suitable software may have to be installed.

Recipients supporting the LPD protocol:

Linux host with LPRng print system:

- LPRng supports reception via the LPD protocol using the lpd.

Linux host with CUPS server print system:

- CUPS supports reception via the LPD protocol using the cups-lpd. The cups-lpd has to be activated by means of inetd or xinetd.

Linux host with CUPS client print system:

- The CUPS client print system does not support reception via the LPD protocol.

Print servers and print server boxes/network printers:

- As the LPD is very old, every normal print server, print server box, and network printer should support this protocol.
- For print server boxes and network printers, the name of the queue varies from model to model or there are several queues with different characteristics.

Printing via the IPP Protocol

The sender sends a print job to the queue on the recipient via the IPP protocol. According to the IPP protocol, the recipient is expected to receive print jobs on port 515. Therefore, a service receiving the print jobs on port 631 (in CUPS, this service is called cupsd) and a queue in which received print jobs can be placed are needed on the receiving host.

Senders supporting the IPP protocol:

Linux host with LPRng print system:

- LPRng does not support the IPP protocol.

Linux host with CUPS server or CUPS client print system:

- CUPS also supports sending via the IPP protocol without a local cupsd. The programs lpr or lp from the cups-client package, the program xpp, and the KDE program kprinter can forward the print job directly to the recipient via the IPP protocol.

Host with non-Linux operating system:

- The IPP protocol is relatively new, so support may not be available in all cases.

Recipients supporting the IPP protocol:

Linux host with LPRng print system:

- LPRng does not support the IPP protocol.

Linux host with CUPS server print system:

- CUPS supports reception via the IPP protocol using the cupsd. On the receiving host, a queue is required in which the cups-lpd can place the print job received from the sender.

Linux host with CUPS client print system:

- The CUPS client print system does not support reception via the IPP protocol.

Print servers and print server boxes/network printers:

- The IPP protocol is relatively new, so support may not be available in all cases.

Direct remote printing through TCP sockets

With this method, no print job is sent to a remote queue, as there is no protocol (LPD or IPP) which can handle print jobs and queues. Rather, the raw data are sent directly to a remote TCP port via TCP socket. Usually, this approach is used for sending printer-specific data to print server boxes and network printers. In many cases, the TCP port 9100 is used for this purpose.

Senders supporting printing directly via TCP socket:

Linux host with LPRng print system:

- LPRng supports sending directly via TCP socket using the lpd. On the sender host, a queue is needed from which the lpd of the sender takes the print job and sends the print data to the TCP port of the recipient.
- With LPRng, this also works without a local lpd. Using the -Y option, the lpr program from the lprng package can send the print data directly to the TCP port of the recipient via TCP socket. Refer to the man page of lpr.

Linux host with CUPS server print system:

- CUPS supports sending directly via TCP socket using the cupsd. On the sender host, a queue is needed from which the cupsd takes the print job and sends the print data to the TCP port of the recipient.

Linux host with CUPS client print system:

- The CUPS client print system does not support direct sending via TCP socket.
- Nevertheless, data can be sent to a port on a host using a command such as the following:

```
cat ⟨filename⟩ | netcat -w 1 ⟨host⟩ ⟨port⟩
```

Recipients supporting printing directly via TCP socket:

Linux host with LPRng, CUPS server, or CUPS client print system:

- No print system is required for receiving directly via TCP socket, and there is no print system that supports this directly, as it makes little sense to send raw data when there is a print system that supports real print jobs and a suitable protocol (LPD or IPP).
- Nevertheless, in the CUPS print system data can be received via port 9100 and forwarded to a queue by entering in `/etc/inetd.conf`:

```
9100 stream tcp nowait lp /usr/bin/lp lp -d ⟨queue⟩
```

  If filtering isn't wanted, append `-o raw` as an option.
- Moreover, you can emulate the properties of a print server box that receives data via port 9100 and directly forwards them to the printer. To do this, append a line such as the following in `/etc/inetd.conf`:

```
9100 stream tcp nowait lp /bin/dd dd of=/dev/lp0
```

Print server box or network printer:

- The support status varies from case to case.
- The port depends on the model. For HP network printers and HP JetDirect print server boxes, the default port is 9100. For JetDirect print server boxes with two or three local printer ports, the ports are 9100, 9101, and 9102. The same ports are used by many other print server boxes. If you are not sure, ask the manufacturer or consult the printer manual to find out which port is used to address the printer directly. Additional information about this can be found in the `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html`
(especially under `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#SECNETWORK`),
`file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#SOCKETAPI`,
and `file:/usr/share/doc/packages/lprng/LPRng-HOWTO.html#AEN4858`.

Examples

Case 1: Several workstations, one print server, and one or more print server boxes or network printers:

Print server with LPRng print system:

- The workstations should also use the LPRng print system.
- A special queue is available on the print server for every network printer or every printer connected to a print server box.
- Via the LPD protocol, the workstations send the print jobs to the print server queue associated with the printer.
- Depending on which print server box or network printer supports which protocol, the print server uses the LPD protocol or direct data transmission via TCP socket for sending the print data to the print server box or network printer.

Print server with CUPS server print system:

- The workstations should also use the CUPS print system. In this case, the CUPS client print system is sufficient.
- A special queue is available on the print server for every network printer or every printer connected to a print server box.
- Via the IPP protocol, the workstations send the print jobs to the print server queue associated with the printer.

- Depending on which print server box or network printer supports which protocol, the print server uses the LPD protocol or direct data transmission via TCP socket for sending the print data to the print server box or network printer.

Case 2: A few workstations, no print server, and one or several print server boxes or network printers:

Workstations with LPRng print system or CUPS server print system:

- A special queue is available on each workstation for every network printer or every printer connected to a print server box. As all queues have to be configured on all workstations, this only makes sense if there are only a few workstations.
- Depending on which print server box or network printer supports which protocol, the print server uses the LPD protocol or direct data transmission via TCP socket for sending the print data to the print server box or network printer.
- If several workstations concurrently send data to the same print server box or network printer, data loss and other problems may occur, especially if the LPD protocol is used for the data transmission. The implementation of the LPD recipient in the print server box or network printer is often inadequate, as there is usually not enough storage space for buffering several print jobs. If, however, the data transmission is performed exclusively via TCP socket, the system can be quite reliable, depending on the print server box or network printer.

Filtering for Network Printers

The previous section described how print jobs or raw data are transmitted from the workstation to the printer. The filtering process (the conversion of the original data to printer-specific data) is yet another subject. The conversion to printer-specific data for network printing occurs in the same way as for a printer locally connected to a stand-alone system. The print filter for network printing and stand-alone system is identical, though the data flow from the workstation to the printer is more complicated and goes through several stages such as the following:

```
Workstation → Print Server → Print Server Box → Printer
```

At this point in the chain, the source file must be converted into the format that the printer is able to print (PostScript, PCL, ESC/P).

The conversion is handled by a print filter which should run on a machine with sufficient computing power and storage space – on the workstation or on a print server, but not in a print server box or network printer. Usually, print server boxes and network printers do not have any built-in print filter.

Thus, they can only receive printer-specific data and forward them to the printer or printing unit.

A queue can configured with or without a filter. In the YaST printer configuration, the first step is the selection of the "Hardware" category for printing ((e.g., via CUPS network server, via LPD network server, or direct printing on a network printer or print server box). Therefore, the default setting (with or without filtering) should normally work. If necessary, the default setting can be changed in the YaST printer configuration.

The default settings are as follows:

Print via CUPS Network Server: no filtering (as this is usually done on the CUPS network server)

Print via LPD-Style Network Server no filtering (as this is usually done on the LPD network server)

Print directly on a network printer or using a print server box: Filtering

If the queue is configured with filtering, the original data are buffered in the queue and subsequently filtered on the host on which the queue is located. Then the converted data are sent to the recipient (see Figure 6.3).

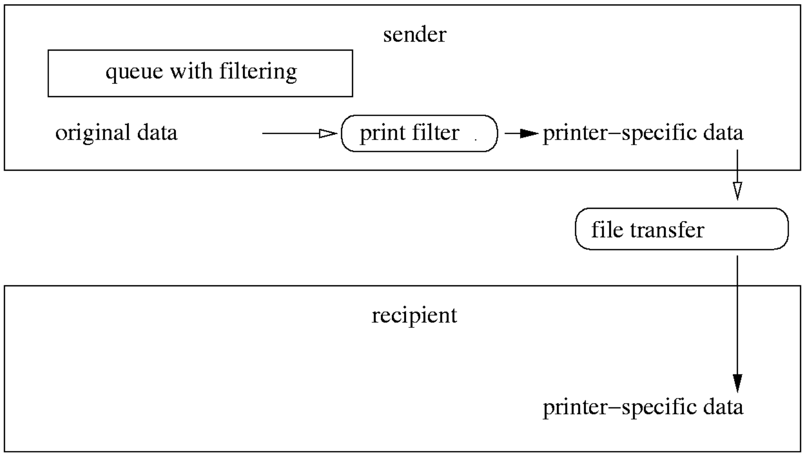


Figure 6.3: *Overview of the Filtering Procedure*

The following paragraphs describe the filtering options for the above examples.

Case B1 Several workstations, one print server, and one or more print server boxes or network printers:

The easiest and most suitable configuration is shown in Figure 6.4.

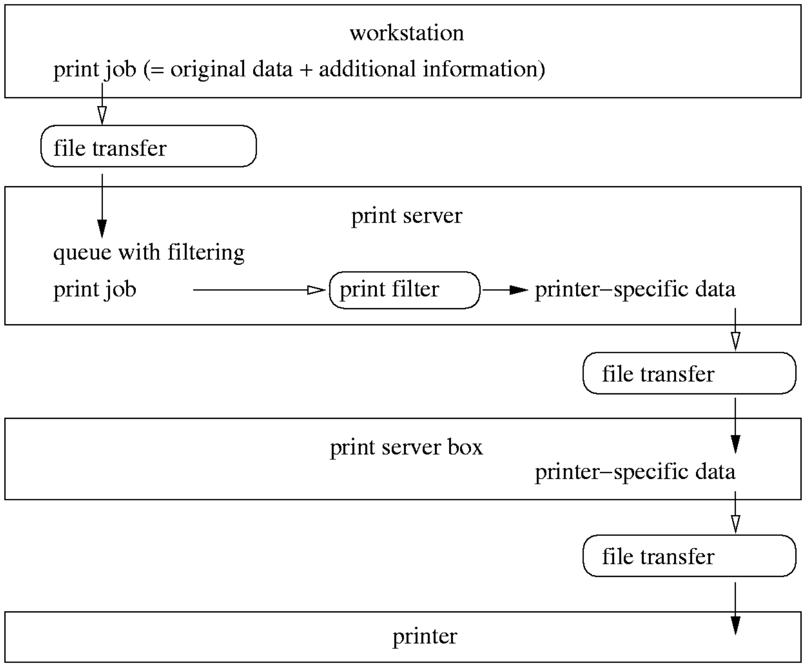


Figure 6.4: *Configuration 1*

Case B1b For every queue with filtering on the print server, a queue without filtering can be configured on every workstation. Thus, the print jobs can be buffered in the workstation in the event of a temporary print server failure or overload. In this way, printouts can always be generated on the workstations without having to wait until the print server is available. The disadvantage of this approach is that all queues have to be configured on all workstations (though without filtering) and certain modifications of the queues on the print server (such as renaming, addition, or deletion of queues) require an adaption of the configurations on all workstations. Changes in the filtering process do not require any adaption.

This high-level configuration is shown in Figure 6.5.

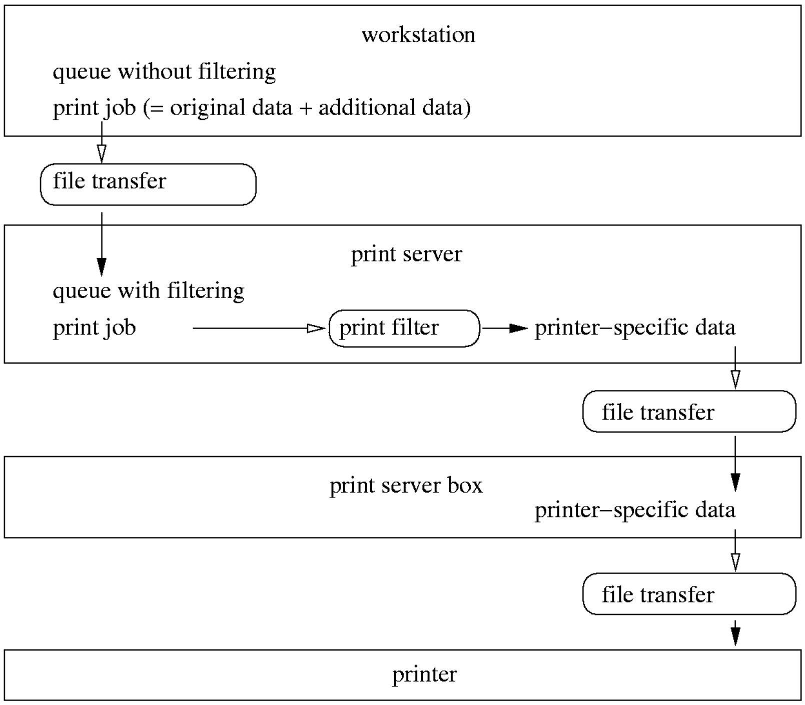


***Figure 6.5:** Configuration 2*

Case B1c Theoretically, the filtering process could take place on the individual workstations. In this case, the only function of the print server would be the transmission of the printer-specific data to the print server boxes or network printers. However, this would degrade the print server to an oversized print server box, which is usually not very practical, unless the print server's performance is not sufficient for filtering. The disadvantage of this approach is that all queues have to be configured on all workstations (with filtering) and all changes would require the adaption of the configurations on all workstations.

Figure 6.6 on the next page shows this configuration.

Case B2 A few workstations, no print server, and one or several print server boxes or network printers:

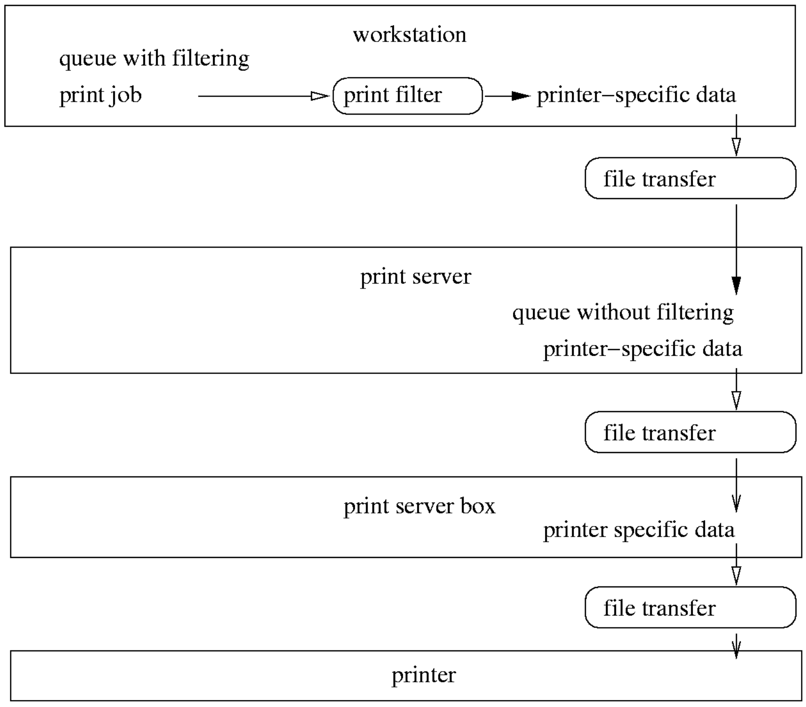


Figure 6.6: *Configuration 3*

The only possible configuration is to have a queue with filtering for each printer on every workstation. The disadvantage of this approach is that all queues have to be configured on all workstations (with filtering) and all changes would require the adaption of the configurations on all workstations.

Figure 6.7 on the facing page shows this configuration.

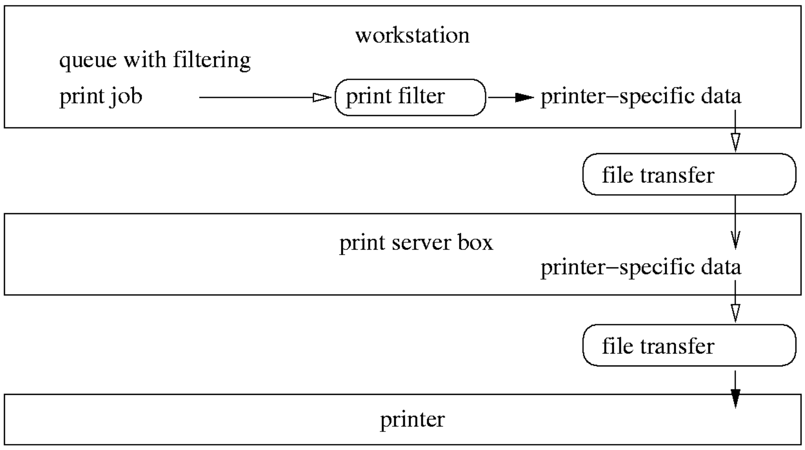


Figure 6.7: *Configuration 4*

Case B3 The previous constellations looks almost the same as the configuration for a stand-alone system with a locally connected printer.

Figure 6.8 is what the configuration looks like for a stand-alone system.

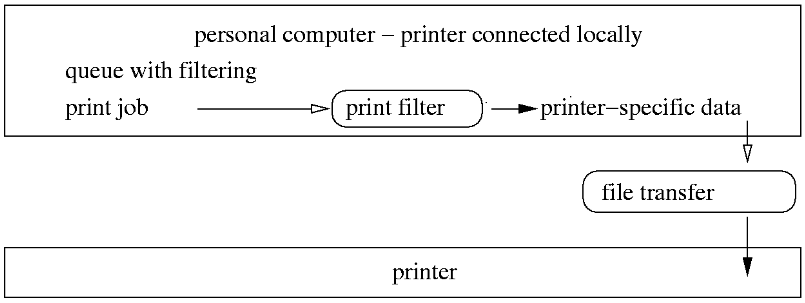


Figure 6.8: *Configuration 5*

If you consider the above cases in reverse order, you will see the development from the configuration on a stand-alone system with a locally connected printer to a high-level configuration for several workstations with a print server for several print server boxes or network printers.

Remote Printer Troubleshooting

Checking the TCP/IP network First, make sure everything is in order with the TCP/IP network in general, including name resolution.

Checking the filter configuration Connect the printer to the first parallel port of your computer. To test the connection, initially set it up as a local printer to exclude any network-related problems. If the printer works locally, you have found the correct Ghostscript driver and other configuration options.

Testing a remote lpd The following command tests whether `lpd` can be reached via TCP on port 515 of ⟨*host*⟩:

```
netcat -z ⟨host⟩ 515 && echo ok || echo failed
```

If `lpd` cannot be reached in this way, it is either not running at all or there is some basic network problem.

This way you can get a (possibly very long) status report about the `queue` on the `host`, if `lpd` is running and the host is reachable. As `root`, enter the following command:

```
echo -e "\004⟨queue⟩" \
| netcat -w 2 -p 722 ⟨host⟩ 515
```

If the lpd does not respond, the lpd is either inactive or there are basic network problems. If the lpd responds, the response should indicate why `queue` on `host` cannot be used for printing. Examples:

```
lpd: your host does not have line printer access
lpd: queue does not exist
printer: spooling disabled
printer: printing disabled
```

Output 12: *Error message of lpd*

If you receive such a response from the lpd, the problem is caused by the remote lpd.

Testing a remote cupsd By default, a CUPS network server broadcasts its queue every 30 seconds via the UDP port `631`. Thus, the following command can be used to test if a CUPS network server exists in the network:

```
netcat -u -l -p 631 & PID=$! ; sleep 40 ; kill $PID
```

By default, CUPS network servers broadcasts its queues via port 631 at thirty-second intervals. After waiting for forty seconds, the output should appear as follows if a broadcasting CUPS network server exists:

```
... ipp://⟨host⟩.⟨domain⟩:631/printers/⟨queue⟩
```

Output 13: *CUPS Network Server Broadcast*

The following command tests whether `cupsd` can be reached via TCP on port 631 of ⟨*host*⟩:

```
netcat -z ⟨host⟩ 631 && echo ok || echo failed
```

If `cupsd` cannot be reached in this way, it is either not running at all or there is some basic network problem.

```
lpstat -h ⟨host⟩ -l -t
```

With this command you can get a (possibly very long) status report about all queues on ⟨*host*⟩, provided `cupsd` is running and the host is reachable.

```
echo -en "\r" \
| lp -d ⟨queue⟩ -h ⟨host⟩
```

This command sends a print job consisting of a single carriage return character to test if the ⟨*queue*⟩ on ⟨*host*⟩ accepts any print jobs. This test command should not print out anything or only cause the printer to eject an empty page.

Testing a remote SMB server To test the basic operability of an SMB server, enter:

```
echo -en "\r" \
| smbclient '/⟨HOST⟩/⟨SHARE⟩' '⟨PASSWORD⟩' \
-c 'print -' -N -U '⟨USER⟩' \
&& echo ok || echo failed
```

For ⟨*HOST*⟩, enter the host name of the Samba server. For ⟨*SHARE*⟩, enter the name of the remote queue (i.e., the name of the Samba share). For ⟨*PASSWORD*⟩, enter the password string. Replace ⟨*USER*⟩ with the user name. This test command should not print out anything or only cause the printer to eject an empty page.

The following command displays any shares on the ⟨*host*⟩ that are currently available. Details on this can be obtained from the man page for `smbclient` (`man smbclient`).

```
smbclient -N -L ⟨host⟩
```

Troubleshooting an unreliable network printer or print server box Spoolers on print server boxes often become unreliable when having to deal with relatively high printing volumes. As the cause of this lies with the server side spooler, there is mostly no way to fix this. As a workaround, however, circumvent the spooler on the print server box by using TCP sockets to directly stream data to the printer connected to the host.

This turns the print server box into a mere data converter between the two different data streams (TCP/IP network and local printer line), which effectively makes the printer behave like a local printer although it is connected to the print server box. Without the spooler acting as an intermediary, this method also gives much more direct control over the printer device in general. To use this method, you need to know the corresponding TCP port on the print server box. If the printer is switched on and properly connected, you should be able to determine the TCP port a minute or so after booting the print server box with the program `nmap`.

Running `nmap` on the print server box may return an output similar to this:

```
Port       State       Service
  23/tcp     open        telnet
  80/tcp     open        http
  515/tcp    open        printer
  631/tcp    open        cups
  9100/tcp   open        jetdirect
```

This output means:

- You can log in on the above print server box with `telnet` to look for important information or to change basic configuration options.
- The above print server runs an HTTP daemon, which can provide detailed server information or allow you to set specific printing options.
- The print spooler running on the print server box can be reached over the LPD protocol on port 515.

- The print spooler running on the print server box can also be reached over the IPP protocol on port 631.
- The printer connected to the print server box can be accessed directly via TCP sockets on port 9100.

Print Servers Supporting Both LPD and IPP

LPD, IPP and CUPS

By default, the CUPS daemon only supports the IPP protocol. However, the program `/usr/lib/cups/daemon/cups-lpd` from the cups package enables the CUPS server to accept print jobs sent to port 515 via the LPD protocol. For this purpose, the respective service has to be activated for `xinetd`. This can be done with YaST or manually by activating the respective line in the file `/etc/xinetd.d/cups-lpd`.

Supporting Both Protocols by Using LPRng and lpdfilter with CUPS

There may be situations where you want to run both LPRng and lpdfilter and CUPS on one system, maybe because you want to enhance the functionality of LPD with some CUPS features or because you need the LPRng and lpdfilter system as an add-on for certain special cases.

Running the two systems together on the same system will lead to a number of problems, however. Below, we list the most important of these and briefly explain the limitations resulting from them. The topic is too complex to describe them in any greater detail here. There are several ways to solve these issues, depending on the individual case.

- You should not rely on YaST for configuration if you install both printing systems. The printer configuration module of YaST has not been written with this case in mind.
- There is a conflict between package `lprng` and package `cups-client`, because they contain a number of files with identical names, such as `/usr/bin/lpr` and `/usr/bin/lp`. You should, therefore, not install package `cups-client`. This, however, means that no CUPS-based command-line tools are available, but only those included with LPRng. You are still able to print through CUPS print queues from the X Window System with `xpp` or `kprinter`, however, as well as from all application programs with built-in support for CUPS.

- By default, `cupsd` creates the `/etc/printcap` file when started and writes the names of CUPS queues to it. This is done to maintain compatibility with applications that expect queue names in `/etc/printcap` to offer them in their print dialogs. With both printing systems installed, disable this `cupsd` feature to reserve `/etc/printcap` for exclusive use by the LPRng and lpdfilter printing system. As a result, applications that get queue names only from `/etc/printcap` can use only these local queues, but not the remote queues made available by CUPS through the network.

Hotplugging Services

Hardware components that can be connected and disconnected from the system while it is running are growing more common. As well as USB, the most prominent example for this kind of component, there are PCI, PCMCIA, Firewire, SCSI, and other interfaces.

Hotplug systems are responsible for recognizing newly-connected or installed hardware and automatically making it available for use. Components that will be removed again need, furthermore, to be prepared for this event. If removed without prior warning, resources must be freed again.

Hotplugging in Linux 194
Hotplugging and Coldplugging 194
USB 195
PCI and PCMCIA 196
Network 197
Other Devices and Further Development 198

Hotplugging in Linux

Little programs called daemons watch parts of a system for external events. The inetd daemon, for example, watches incoming network requests. The daemon for hotplugging is the kernel itself. The driver for an interface must be able to recognize new devices and report them to the system in a standardized way. USB, PCMCIA, Firewire, the network subsystem, and, to some extent, PCI are able to do this in the 2.4 kernel. This part of hotplugging is firmly built into the corresponding modules and cannot be influenced without changing the kernel.

Note

PCMCIA devices are only being handled by the hotplugging service if they are CardBus cards and the PCMCIA system kernel was selected. They then appear as PCI devices. More detailed information about this can be found in the section on PCMCIA.

Note

The second part of the hotplugging service initiates the necessary steps for the respective registration and release of devices and is a collection of scripts in the directory `/etc/hotplug` with the main script `/sbin/hotplug`. This script is the interface between the kernel and the collection of hotplugging scripts. These scripts are referred to as the "hotplug system" for the course of this chapter.

When a hot-pluggable device is connected or removed, the kernel calls the `/sbin/hotplug/` script and passes additional information to the corresponding hardware component. This script directs the tasks — depending on the type of hardware — to additional scripts. These insert or remove the modules respectively and call other programs for the configuration of the components. These programs are located in `/etc/hotplug` and always end with `.agent`.

Hotplugging and Coldplugging

Although the kernel always passes hotplug events to `/sbin/hotplug`, the hotplug system needs to be started initially with the command `rchotplug start`. All hotplug events are discarded if hotplug has not been started.

Aside from this, there are components recognized by the kernel even before the file system can be accessed. These events are simply lost. This is why the scripts `/etc/hotplug/*.rc` attempt to create these events artificially for already existing hardware.

The term “coldplugging” is used in this respect. If the USB base modules have not been loaded until then, they are loaded and the USB device file system `usbdefs` is mounted.

After hotplug has been stopped by calling `rchotplug stop`, no more events can be evaluated. Hot-plugging can be completely deactivated if the hardware configuration is never changed during operation. This, however,requires other methods of installing USB or PCMCIA devices.

The path `/etc/sysconfig/hotplug` contains a few variables that control the behavior of hotplug. For instance, the variable ⟨*HOTPLUG_DEBUG*⟩ influences the verbosity of hotplug. The variables ⟨*HOTPLUG_START_USB*⟩, ⟨*HOTPLUG_START_PCI*⟩, and ⟨*HOTPLUG_START_NET*⟩ determine that only events of a certain type are evaluated. All the other variables are explained in detail in the corresponding subsections. All the hotplug messages are logged in the file `/var/log/messages` — the system log.

USB

When a new USB device is connected, the script `/etc/hotplug/usb.agent` determines an appropriate driver and ensures that it is loaded. This driver is not necessarily a kernel module. Many USB cameras, for instance, are directly accessed by applications.

The assignment of drivers to hardware is multistaged: First, the file `/etc/hotplug/usb.usermap` is checked for an entry that specifies whether this hardware should be handled by an application or by a dedicated initialization script. If neither is the case, an individual assignment to a kernel module is searched for in `/etc/hotplug/usb.handmap`. If nothing is found there (which is most often the case), the assignment table of the kernel, `/lib/modules/`⟨*kernelversion*⟩`/modules.usbmap`, is queried. An additional USB hardware scan is run at this point, which triggers further actions if KDE is used. An appropriate YaST configuration module is presented, for instance, for devices connected for the first time or applications are run for using the new device. This mechanism runs in parallel to the other actions triggered by `/etc/hotplug/usb.agent`.

USB devices are differently by the usb.agent, according to type:

storage devices hard disks, for example, are handled by the script `/usr/sbin/checkhotmounts` as soon as the required drivers are loaded.

network devices create their own hotplug event in the kernel as soon as these are registered. The `usb.agent` merely records hardware information which is later used by the network event. This is only a transient solution for the 2.4 kernel and fails whenever more than one USB network devices are employed. This however happens only very rarely.

cameras are accessed by way of the hardware-scanning KDE mechanism. The access permissions of the device file are additionally set by `/etc/hotplug/usb/usbcam` to those of the logged-in user so he can access the device when using KDE.

mice only require a loaded module that, in this case, is loaded for immediate use.

keyboards needed during booting so are not handled by hotplug.

ISDN modem not installed automatically yet.

There are some USB-specific variables in `/etc/sysconfig/hotplug`. ⟨*HOTPLUG_USB_HOSTCONTROLLER_LIST*⟩ contains the driver for the USB controller in the order in which loading is attempted. When a driver is loaded successfully, those modules that need to be unloaded on removal of the component are listed in ⟨*HOTPLUG_USB_MODULES_TO_UNLOAD*⟩. All remaining USB modules are not unloaded, because it cannot be determined with certainty whether they are still required by a device. The variable ⟨*HOTPLUG_USB_NET_MODULES*⟩ contains the names of those modules that provide a network interface. A hardware descriptor for later reference on network events is stored when one of these modules is loaded. This process is logged in the system log.

PCI and PCMCIA

PCMCIA cards require a careful scrutiny because hotplug only handles CardBus cards. This handling is furthermore only done if the PCMCIA system of the kernel is activated. This condition is explained in more detail in the software section of the PCMCIA chapter.

CardBus cards are, technically-speaking, almost PCI devices. This is why both are handled by the same hotplug script — `/etc/hotplug/pci.agent`. It essentially determines a driver for the card and loads it. In addition to this, a record of where the new card has been connected (PCI bus or PCMCIA slots and the slot designator) is stored, so a later hotplug network event can read this information and select the correct configuration.

The determination of the drive is two-staged in this case: the file `/etc/hotplug/pci.handmap` is searched for individual settings and, if nothing was found, the PCI driver table of the kernel `/lib/modules`⟨*kernelversion*⟩`/modules.pcimap` is subsequently searched. To change the driver assignment, the file `/etc/hotplug/pci.handmap` should be altered, as the other list is overwritten on a kernel update.

Unlike with USB, no special actions are executed depending on the type of PCI or CardBus card. The kernel creates a hotplug network event for network cards, which induces the installation of the interface. Further action must ensue manually for all other cards. The hotplug system is, however, still being expanded in this respect.

As soon as the card is removed, the employed modules are unloaded again. Should this lead to problems with certain modules, this can be prevented by writing the names of those modules into ⟨*HOTPLUG_PCI_MODULES_NOT_TO_UNLOAD*⟩.

Network

When a new network interface is registered or unregistered in the kernel, the kernel creates a hotplug network event. This is evaluated by `/etc/hotplug/net.agent`. Only ethernet, token ring, and wireless LAN interfaces are currently taken into account. Other mechanisms exist for all other kinds of networks, like modems or ISDN. Network interfaces which are provided by PCMCIA cards and are handled by cardmanager instead of hotplug are likewise not handled here. A message then appears in the system log.

First, which hardware provides the interface is determined. Because the 2.4 kernel cannot provide such information, a record created following the USB or PCI event is used. Although this works well in most cases, it is regarded as a temporary quick fix only. For this reason, two network cards cannot be connected simultaneously. To use multiple hotplug-enabled network cards, connect them subsequently with the computer. A latency of a few seconds between connections is sufficient. This transmission of information is logged in `/var/log/messages`.

Insert additional individual actions to execute following the installation of a new network device in `/sbin/ifup`. Details about this can be found in the man page for `ifup` (`man ifup`). It is also possible to apply different default routing depending on the connected hardware. Refer to the man page for `route` (`man route`) for details.

If the probing of the hardware behind the interface fails and only one hotplug network device is used, the description of the network hardware in `/etc/sysconfig/hotplug` can be written to the variable ⟨*HOTPLUG_NET_DEFAULT_HARDWARE*⟩. This string must correspond to what should be used by `/sbin/ifup` for the allocation of the correct configuration. The variable ⟨*HOTPLUG_NET_TIMEOUT*⟩ determines for how long `net.agent` waits for a dynamically-created hardware desciption.

Other Devices and Further Development

All the kinds of hotplugging-enabled devices not described above are currently not handled. Hotplugging, however, is undergoing massive development that depends heavily on the abilities of the kernel. It is expected that better possibilities will be offered with the kernel 2.6.

Configuring and Using Laptop Computers

Laptop computers have unique needs. These include Power Management (APM and ACPI), infrared interfaces (IrDA), and PC cards (PCMCIA). Occasionally, such components can also be found in desktop computers. These are essentially no different than those used in laptops. For this reason, their use and configuration is summarized in this chapter.

PCMCIA 200
SCPM – System Configuration Profile Management 210
APM and ACPI — Power Management 217
IrDA — Infrared Data Association 230

PCMCIA

PCMCIA stands for "Personal Computer Memory Card International Association." It is used as a general term for all hardware and software involved.

The Hardware

The essential component is the PCMCIA card. There are two distinct types:

PC cards These are currently the most used cards. They use a 16-bit bus for data transmission, are usually relatively cheap, are generally stable, and are fully supported.

CardBus Cards This is a more recent standard. It uses a 32-bit bus, which makes them faster, but also more expensive. Because the data transfer rate is frequently restricted at another point, it is often not worth the extra cost. There are now many drivers for these cards, although some are still unstable. This also depends on the available PCMCIA controller.

If the PCMCIA service is active, determine the type of the inserted card with the command `cardctl ident`. A list of supported cards can be found in `SUPPORTED.CARDS` in `/usr/share/doc/packages/pcmcia`. The current version of the PCMCIA-HOWTO is also located there.

The second necessary component is the PCMCIA controller or the PC card or CardBus bridge. This establishes the connection between the card and the PCI bus and, in older devices, the connection to the ISA bus as well. These controllers are almost always compatible with the Intel chip i82365. All common models are supported. The type of controller is shown with the command `pcic_probe`. If this is a PCI device, the command `lspci -vt` also shows some interesting information.

The Software

Differences Between PCMCIA Systems

There are currently two PCMCIA systems — external PCMCIA and kernel PCMCIA. The external PCMCIA system by David Hinds is the older system, which makes it better tested. It is still being developed. The sources of the modules used are not integrated in the kernel sources, which is why it is called an "external" system.

From kernel 2.4, there are alternative modules in the kernel sources. These form the kernel PCMCIA system. The basic modules were written by Linus Torvalds. They support the more recent CardBus bridges better.

Unfortunately, these two systems are not compatible. There are various sets of card drivers in both systems. For this reason, only one system can be used, depending on the hardware involved. The default in SuSE Linux is the more recent kernel PCMCIA. It is possible to change the system, however. To do this, the variable ⟨*PCMCIA_SYSTEM*⟩ in the file `/etc/sysconfig/pcmcia` must be given either the value `external` or `kernel`. Then PCMCIA must be restarted with `rcpcmcia restart`. For temporary changes, use the commands `rcpcmcia restart external` or `rcpcmcia restart kernel`. If pcmcia is not running, use the option start instead of restart. Detailed information about this can be found in `/usr/share/doc/packages/pcmcia/README.SuSE`

The Base Module

The kernel modules for both systems are located in the kernel packages. In addition, the packages `pcmcia` and `hotplug` are required. When PCMCIA is started, the modules `pcmcia_core`, `i82365` (external PCMCIA) or `yenta_socket` (kernel PCMCIA), and `ds` are loaded. In some very rare cases, the module `tcic` is required instead of `i82365` or `yenta_socket`. They initialize the existing PCMCIA controller and provide basic functionality.

The Card Manager

Because PCMCIA cards can be changed while the system is running, a daemon to monitor the activity in the slots is required. Depending on the PCMCIA system chosen and the hardware used, this task is performed by the card manager or the hotplug system of the kernel. With external PCMCIA, only the card manager is used. For kernel PCMCIA, the card manager only handles PC Card cards. CardBus cards are handled by hotplug. The card manager is started by the PCMCIA start script after the base modules have been loaded. Because hotplug manages other subsystems apart from PCMCIA, it has its own start script. See also *Hotplugging Services* on page 193.

If a card is inserted, card manager or hotplug determines the type and function of the card then loads the corresponding modules. If this is successful, card manager or hotplug starts certain initialization scripts, depending on the function of the card, which in turn establish a network connection, mount partitions from external SCSI hard drives, or carry out other hardware-specific actions. The scripts for the card manager are located in `/etc/pcmcia`. The scripts for hotplug can be found in `/etc/hotplug`.

If the card is removed, card manager or hotplug terminates the various card activities using the same scripts. Finally, those modules that are no longer required are unloaded.

Both the start process of PCMCIA and card events are recorded in the system log (`/var/log/messages`). Here, it is specified which PCMCIA system is currently used and which daemons have been used by which scripts to set up things. In theory, a PCMCIA card can simply be removed. This works very well for network, modem, or ISDN cards as long as there are no open network connections. It does not work in connection with partitions mounted to an external hard drive or with NFS directories. Here, ensure that these units are synchronized and cleanly unmounted. This is no longer possible, of course, if the card has already been removed. In case of doubt, the command `cardctl eject` may be of help. This command deactivates all cards still in the laptop. To deactivate one card, also specify the slot number, for example, `cardctl eject 0`.

Configuration

Whether PCMCIA or hotplug is started when booting can be specified with the YaST runlevel editor or on the command line using `chkconfig`. In `/etc/sysconfig/pcmcia`, there are four variables:

⟨***PCMCIA_SYSTEM***⟩ Specifies which PCMCIA system to use.

⟨***PCMCIA_PCIC***⟩ Contains the name of the module that addresses the PCMCIA controller. Normally, the start script detects this name on its own. The module is only entered here if this goes wrong. Otherwise, this variable should be left empty.

⟨***PCMCIA_CORE_OPTS***⟩ Intended for parameters for the module `pcmcia_core`. They are only rarely required, however. These options are described in the man page for `pcmcia_core` (`man pcmcia_core`).

⟨***PCMCIA_PCIC_OPTS***⟩ Parameters for the module `i82365`. Refer to the man page for `i82365` (`man i82365`). If `yenta_socket` is used, these options are ignored, because `yenta_socket` has no options.

The assignment of drivers to PCMCIA cards for the card manager can be found in the files `/etc/pcmcia/config` and `/etc/pcmcia/*.conf`. First, `config` is read then the `*.conf` in alphabetical order. The last entry found for a card is decisive. Details on the syntax of these files can be found in the man page for `pcmcia` (`man pcmcia`). The assignment of drivers to PCMCIA cards for hotplug is described in *Hotplugging Services* on page 193).

Network Cards (Ethernet, Wireless LAN, and Token Ring)

These can be set up with YaST like normal network cards. Select 'PCMCIA' as the card type. All other details about setting up the network can be found in the network chapter. Read the notes there about hotpluggable cards.

ISDN

Even for ISDN PC cards, configuration is done to a large extent using YaST, as with other ISDN cards. It is not important which PCMCIA card offered there is chosen, but only that it is a PCMCIA card. When setting up hardware and provider, make sure the operating mode is set to `hotplug` and not to `onboot`.

ISDN modems also exist for PCMCIA cards. These are modem cards or multi-function cards with an additional ISDN connection kit. They are treated like an ordinary modem.

Modem

For modem PC cards, there are normally no PCMCIA-specific settings. As soon as a modem is inserted, it is available under `/dev/modem`.

There are also "soft modems" for PCMCIA cards. As a rule, these are not supported. If there are some drivers, they must be integrated individually into the system.

SCSI and IDE

The corresponding driver module is loaded by the card manager or hotplug. When a SCSI or IDE card is inserted, the devices connected to it are available. The device names are detected dynamically. Information about existing SCSI or IDE devices can be found in `/proc/scsi` or `/proc/ide`.

External hard drives, CD-ROM drives, and similar devices must be switched on before the PCMCIA card is inserted into the slot. SCSI devices must be actively terminated.

Note

Before a SCSI or IDE card is removed, all partitions on the devices connected must be unmounted. If you have forgotten to do this, you can only access these devices again after rebooting the system, even if the rest of the system continues to run in a stable manner.

Note

You can also install Linux entirely on these external hard drives. However, the boot process is then somewhat more complicated.

A boot disk is required in all cases — containing the kernel and an initial ramdisk (initrd). More information about this can be found in *Booting with the Initial Ramdisk* on page 259. The initrd contains a virtual file system that includes all required PCMCIA modules and programs. The boot disk and boot disk images are constructed in the same way. With these, you could always boot your external installation. It is, however, tiresome to load the PCMCIA support every time by hand. More advanced users might create their own boot floppy disk, customized to their own particular system. Hints for doing this can be found in the PCMCIA-HOWTO in the section *Booting from a PCMCIA Device*.

Switching Configurations — SCPM

Often with mobile computers, various configuration profiles are required. With PCMCIA devices, this was never a problem, thanks to the PCMCIA schemes. Because the users of the built-in network cards or USB and firewire devices would also like to use different profiles for system configuration, there is, from SuSE Linux 8.0, the package SCPM (System Configuration Profile Management). For this reason, SuSE no longer supports the PCMCIA schemes. To continue to use these, the configuration must be modified by hand under `/etc/pcmcia`. We recommend using SCPM instead, because any part of the system configuration can be administered here — not just the PCMCIA parts.

Troubleshooting

Occasionally, there are problems with certain laptops and certain cards when using PCMCIA. Most difficulties can be solved with little trouble, if you approach the problem systematically.

Caution

Because both external PCMCIA and kernel PCMCIA are available in parallel in SuSE Linux, consider one special feature when loading modules manually. The two PCMCIA systems use modules of the same name and are located in different subdirectories under `/lib/modules/`⟨*kernelversion*⟩. The subdirectories are named `pcmcia` for kernel PCMCIA and `pcmcia-external` for external PCMCIA. For this reason, the subdirectory must be specified when loading modules manually, either with `insmod /lib/modules/`⟨*kernel version*⟩`/`⟨*subdirectory*⟩`/`⟨*file name of module*⟩ or with `modprobe -t` ⟨*subdirectory*⟩ ⟨*module name*⟩.

Caution

First, find out if the problem is with the card or with the PCMCIA-based system. For this reason, always start the computer first without the card inserted. Only insert the card when the base system appears to function correctly. All meaningful messages are recorded in `/var/log/messages`. The file should therefore be viewed, with `tail -f /var/log/messages` while the necessary tests are made. In this way, the error can be narrowed down to one of the two following cases.

Nonfunctional PCMCIA Base System

If the system hangs when booting with the message PCMCIA: "Starting services" or other strange things happen, starting PCMCIA the next time the system is booted can be prevented by entering `NOPCMCIA=yes` at the boot prompt. To isolate the error further, the base modules of the PCMCIA system used are manually loaded.

These commands are used to do this:

```
earth:~ #  modprobe -t ⟨dir⟩ pcmcia_core
earth:~ #  modprobe -t pcmcia-external i82365  (for external PCMCIA) or
earth:~ #  modprobe -t pcmcia yenta_socket  (for kernel PCMCIA)
```

or, in very rare cases,

```
earth:~ # modprobe -t ⟨dir⟩ tcic
```

and

```
earth:~ #  modprobe -t ⟨dir⟩ ds
```

The critical modules are the first two.

If the error occurs when `pcmcia_core` is loaded, the manual pages for `pcmcia_core` can help. The options described there can first be tested using `modprobe`. As an example, switch off the APM support for the PCMCIA module. In a few cases, there could be problems with this. Use the setting `do_apm=0` to deactivate power management:

```
modprobe -t ⟨dir⟩ pcmciacore do_apm=0
```

If the chosen option is successful, it can be written to the variable ⟨*PCMCIA_CORE_OPTS*⟩ in the file `/etc/sysconfig/pcmcia`:

```
PCMCIA_CORE_OPTS="do_apm=0"
```

Checking free IO areas can lead to problems in isolated cases if other hardware components are disturbed by this. Get around this with `probe_io=0`.

If several options should be used, they must be separated by spaces:

```
PCMCIA_CORE_OPTS="do_apm=0 probe_io=0"
```

If errors occur when loading the module `i82365`, refer to the man page for `i82365` (`man i82365`).

A problem in this context is a resource conflict — if an interrupt, IO port, or memory area is occupied twice. Although the module `i82365` checks these resources before they are made available to a card, sometimes just this check will lead to problems. Thus, checking the interrupt 12 (PS/2 devices) on some computers leads to the mouse or keyboard hanging. In this case, the parameter `irq_list=`⟨*`List of IRQs`*⟩ can help. The list should contain all IRQs to use. For example, enter the command `modprobe i82365 irq_list=5,7,9,10` or permanently add the list of IRQs to `/etc/sysconfig/pcmcia`:

```
PCMCIA_PCIC_OPTS="irq_list=5,7,9,10"
```

In addition, there are `/etc/pcmcia/config` and `/etc/pcmcia/config.opts`. These files are evaluated by card manager. The settings made in them are only relevant when loading the driver modules for the PCMCIA cards. In `/etc/pcmcia/config.opts`, IRQs, IO ports, and memory areas can be included or excluded. The difference from the option `irqlist` is that the resources excluded in `config.opts` are not used for a PCMCIA card, but are still checked by the base module i82365.

Improperly Functioning or Nonfunctional PCMCIA Card

Here, there are basically three variations: the card is not detected, the driver cannot be loaded, or the interface made available by the driver is set up incorrectly.

Determine whether the card is managed by the card manager or hotplug. For external PCMCIA, card manager always takes control, for kernel PCMCIA, card manager manages PC card cards and hotplug manages CardBUS cards. Here, only card manager is discussed. Hotplug problems are discussed in *Hotplugging Services* on page 193.

- **Unrecognized Card**
  If the card is not recognized, the message "Unsupported Card in Slot x" appears in `/var/log/messages`. This message means card manager cannot assign a driver to the card. To do this, `/etc/pcmcia/config` or `/etc/pcmcia/*.conf` are required. These files function as the driver database. This driver database can be easily extended if you take existing entries as a template. Find out, with the command `cardctl ident`, how the card identifies itself. More information about this can be found

in the PCMCIA-HOWTO Section 6 and in the man page for `pcmcia` (`man pcmcia`). After modifying `/etc/pcmcia/config` or `/etc/pcmcia/*.conf`, the driver assignment must be reloaded with the command `rcpcmcia reload`.

- **Driver Not Loaded**
  One reason for this occurring is that a wrong assignment has been made in the driver database. This can happen, for example, if a vendor uses a different chip in an apparently unchanged card model. Sometimes there are also alternative drivers that work better for certain models than the default driver. In these cases, precise information about the card is required. It can also be useful here to ask a mailing list or the Advanced Support Service.

  Another cause is a resource conflict. For most PCMCIA cards, it is irrelevant with which IRQ, IO port, or memory area they are operated, but there are exceptions. First test only one card and, if necessary, switch off other system components, such as the sound card, IrDA, modem, or printer. The allocation of system resources can be viewed with the command `lsdev` (it is quite normal that several PCI devices share the same IRQ).

  One possible solution would be to use a suitable option for the module `i82365` (see PCMCIA_PCIC_OPTS). Many card driver modules also have options. Find these using the command `modinfo /lib/modules/`⟨*the correct pcmcia directory*⟩/⟨*driver*⟩.o (the complete path is needed to locate the correct driver). There is also a manual page for most modules. `rpm -ql pcmcia | grep man` lists all manual pages contained in package `pcmcia`. To test the options, the card drivers can also be unloaded by hand. Again, ensure that the module is using the correct PCMCIA system.

  When a solution has been found, the use of a specific resource can, in general, be allowed or forbidden in the file `/etc/pcmcia/config.opts`. There is even room here for options for card drivers. If the module `pcnet_cs` should be operated exclusively with IRQ 5, for example, the following entry is required:

  ```
  module pcnet_cs opts irq_list=5
  ```

  One problem that sometimes occurs with 10/100-Mbit network cards is incorrect automatic identification of the transmission method. Use the command `ifport` or `mii_tool` to view and modify the transmission method. To have these commands run automatically, the script `/etc/pcmcia/network` must be individually adjusted.

- **Incorrectly Configured Interface**
  In this case, it is recommended to check the configuration of the interface to eliminate rare configuration errors. For network cards, the dialog rate of the network scripts can be increased by assigning the value `DEBUG=yes` to the variable in `/etc/sysconfig/network/config`. For other cards or if this is of no help, there is still the possibility of inserting the line `set -x` into the script run by card manager (see `/var/log/messages`). With this, each individual command of the script is recorded in the system log. If you have found the critical part in a script, the corresponding commands can be entered in a terminal and tested.

Installation via PCMCIA

PCMCIA is already required for installation if you want to install via network or if the CD-ROM is operated via PCMCIA. To do this, start with a boot floppy disk. In addition, one of the module floppy disks is required.

After booting from floppy disk (or after selecting 'Manual Installation' booting from CD), the program `linuxrc` is started. Select 'Kernel Modules (Hardware Drivers)' → 'Load PCMCIA Module'. Two entry fields appear in which to enter options for the modules `pcmcia_core` and `i82365`. Normally, these fields can be left blank. The manual pages for `pcmcia_core` and `i82365` are available as text files on the first CD in the directory `docu`.

SuSE Linux 8.2 is then installed with the external PCMCIA system. During the installation, system messages are sent to various virtual consoles. Switch to them using Alt + function key.

During the installation, there are terminals on which commands can be run. As long as linuxrc is running, use console 9 (a very spartan shell). After YaST starts, there is a bash shell and many standard system tools on console 2.

If the wrong driver module for a PCMCIA card is loaded during installation, the boot floppy disk must be modified manually. This requires a detailed knowledge of Linux, however. When the first part of the installation is finished, the system is partially or completely rebooted. In rare cases, it is possible that the system will hang when the PCMCIA is started. At this point the installation is already at an advanced stage, so Linux can be started without PCMCIA using the boot option `NOPCMCIA=yes`, at least in text mode. See also *Troubleshooting* on page 204. It is possible that you can change some settings for the system on console 2 before the first part of the installation is completed, so the reboot will run successfully.

Other Utilities

cardctl is an essential tool for obtaining information from PCMCIA and carrying out certain actions. In cardctl, find many details. Enter just `cardctl` to obtain a list of the valid commands.

There is also a graphical front-end for this program — cardinfo, shown in Figure 8.1) — with which the most important things can be controlled. For this to work, the package `pcmcia-cardinfo` must be installed.

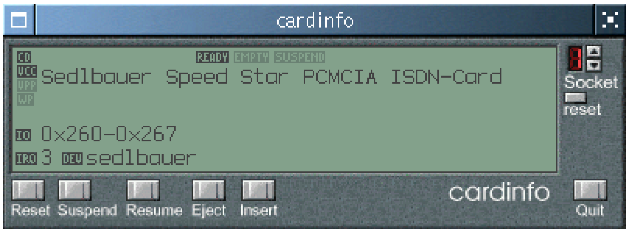


***Figure 8.1:** The cardinfo Program*

Additional helpful programs from the `pcmcia` package are `ifport`, `ifuser`, `probe`, and `rcpcmcia`. These are not always required. To find out about everything contained in the package `pcmcia`, use the command `rpm -ql pcmcia`.

Updating the Kernel or PCMCIA Package

If you want to update the kernel, you should use the kernel packages provided by SuSE. If it is necessary to compile your own kernel, the PCMCIA modules must also be recompiled. It is important that the new kernel is already running when these modules are recompiled, because various information is extracted from it. The `pcmcia` package should already be installed, but not started. In case of doubt, run the command `rcpcmcia stop`. Install the PCMCIA source package and enter

```
rpm -ba /usr/src/packages/SPECS/pcmcia.spec
```

The new packages will be stored in `/usr/src/packages/RPMS`. The package `pcmcia-modules` contains the PCMCIA modules for external PCMCIA. This package must be installed with the command `rpm --force`, because the module files belong officially to the kernel package.

For More Information

For more information about specific laptops, visit the Linux Laptop home page at `http://linux-laptop.net`. Another good source of information is the Moblix home page at`http://tuxmobil.org/`. As well as a lot of interesting information, also find a Laptop-Howto and an IrDA-Howto. In addition, there is also the article Laptops and Notebooks (PCMCIA) in the SuSE Support Database at `http://sdb.suse.de/en/sdb/html/laptop.html` (or locally at `file:/usr/share/doc/sdb/en/html/laptop.html`).

SCPM – System Configuration Profile Management

There are situations when a modified configuration of the computer system is required. This would mostly be the case for mobile computers that are operated in varying locations. It could, however, also be that a desktop system temporarily uses other hardware components or you simply want to experiment a little. In all these cases, returning to the original system should be made an easy task. It would be even better if this modification of the configuration could be easily reproduced.

Up to the present, there had only been a solution to this problem for PCMCIA hardware. Various configurations could be stored there in certain profiles. SCPM was developed from there, lifting the restriction to PCMCIA. The "System Configuration Profile Management" allows to keep an arbitrarily chosen part of the system configuration in customized profiles. It is like making snapshots of the system configuration that can be restored at any time and the framing can be deliberately chosen.

The main application is network configuration on laptops, but different network configurations also often require different settings of other services, such as e-mail or proxies. Then other elements follow, like different printers at home and at the office (even offices), a separate X server configuration for the video beamer at conferences, special power-saving settings for the road, or the differing time zone in the agency abroad. Increasing use of this tool leads to the continuous discovery of new requirements. Feel free to contact us and share your thoughts and ideas about SCPM with us. SCPM is based on a flexible framework in an effort to allow even server-based profile management. Please give your wishes, inspirations, and error descriptions via our web front-end at `http://www.suse.de/feedback/`.

Basic Terminology and Concepts

The following are some terms that are used across the rest of the SCPM documentation and in the YaST module.

- The term *system configuration* means the complete configuration of the computer. It covers all fundamental settings, like the use of partitions, network settings, time zone selection, and keyboard mappings.
- A *profile*, also called a *configuration profile*, is a state that has been preserved and can be restored at any time.
- *Active profile* designates the profile last selected. This does not mean that the current system configuration corresponds exactly to this profile, because the configuration can be customized at any time.
- A *resource* in the SCPM context is an element that contributes to the system configuration. This can be a file or a softlink including its metadata, like user, permissions, or access time. This can also be a system service that runs in this profile, but is deactivated in another one.
- There are preconfigured *resource sets* for the most common application cases. The selection of such a resource set allows easy determination of which elements of the system configuration should be handled by SCPM. Customized resource sets can be also created at any time as needed. All profiles use the same set in the current stage of development of SCPM. A further development of profiles that handle different resources has, however, already been taken into account.

SCPM YaST Module and Additional Documentation

A YaST module serves as a graphical front-end to SCPM and is provided an alternative to the command line front-end. Because the functionality of both front-ends is substantially the same and the knowledge of the command line front-end is useful in many cases, only the latter is described here. The operation of the YaST module for SCPM becomes very easy in combination with the help texts provided there. The few differring features of the YaST module are mentioned where appropriate.

The most current documentation is always the info pages for SCPM. Read these with tools like Konqueror (with the command `konqueror info:scpm`) or emacs. On the console, use `info` or `pinfo`. Technical information is provided at `/usr/share/doc/package/scpm`. Running `scpm` without any arguments returns a command option summary.

Configuring SCPM

SCPM must be activated before it can be used. By default SCPM handles network and printer settings as well as the XFree86 configuration. If you need to manage special services or configuration files, you have to activate appropriate Resource Groups. In order to list the predefined Resource Groups you may use the list `scpm list_groups`. If you just want to see the already activated Groups, use `scpm list_groups -a`. These commands have to be issued as user root on the command line. Activation or deactivation of a group is done with the command `scpm activate_group NAME` or `scpm deactivate_group NAME`, where NAME has to be susbtituted by the relevant group name. All the Resource Groups may also be configured with the YaST profile manager.

Activate SCPM with `scpm enable`. When run for the first time, SCPM is initialized, which takes a few seconds. Deactivate SCPM with `scpm disable` at any time to prevent the unintentional switching of profiles. A subsequent reactivation simply resumes the initialization.

Creating and Managing Profiles

A profile named `default` already exists after SCPM is activated. Get a list of all available profiles with `scpm list`. This so far only existing profile is thus also the active one which can be verified with `scpm active`. The profile `default` is a basic configuration from which the other profiles are derived. This is why all settings that should be identicaly in all profiles should be made first. These modifications are then stored in the active profile with `scpm reload`. The profile `default` can however be arbitrarily used, renamed or deleted.

There are two possibilities to add a new profile. If the new profile (named `work` here) should be based on the profile `default`, create it with `scpm copy default work`. The command `scpm switch work` changes into the new profile, which can then be modified. Sometimes the system configuration was modified for special purposes that should be kept in a new profile. The command `scpm add work` creates a new profile by saving the current system configuration in the profile `work` and marking it as active. Running `scpm reload` then saves changes to the profile `work`.

Rename or delete profiles with the commands `scpm rename x y` and `scpm delete x`. For example, to rename `work` to `project` use `scpm rename work project`. Delete `project` with `scpm delete project`. Only the active profile cannot be deleted.

The available commands are:

`scpm list` lists all available profiles

`scpm active` returns the active profile

`scpm add` ⟨*name*⟩ saves the current system configuration to a new profile and activates it

`scpm copy` ⟨*source*⟩ ⟨*destination*⟩ copies a profile

`scpm rename` ⟨*source*⟩ ⟨*destination*⟩ renames a profile

`scpm delete` ⟨*name*⟩ deletes a profile

The YaST module only offers an 'Add' button. Pressing it opens a dialog in which to select whether an existing profile should be copied or the current system configuration should be saved. Use 'Edit' for renaming.

Switching Configuration Profiles

The command `scpm switch work` switches to another profile (the profile `work`, in this case). You can switch to the active profile to save modified settings of the system configuration. Alternatively, use `scpm reload` to do this.

When switching profiles, SCPM first checks which resources of the active profile have been modified. It then queries whether the modification of each resource should be added to the active profile or dropped. These questions only concern the profile being left.

SCPM then compares the current system configuration with the profile to which to switch. In the phase, SCPM evaluates which system services need to be stopped or restarted due to mutual dependencies or to reflect the changes in configuration. This is like a partial system reboot that concerns only a small part of the system while the rest continues operating without change.

It is only at this point that

1. the system services are stopped
2. all modified resources (usually configuration files) are written
3. the system services are restarted

Advanced Profile Settings

You can enter a description to every profile that is displayed with `scpm list`. For the active profile it may be set with `scpm set description “text”`. Provide the name of the profile for inactive profiles, for instance, `scpm set description “text” work`. It is sometimes desired to perform additional actions which are not (yet) provided by SCPM while switching from one profile to another. Up to four executable programs or scripts can be attached to the profile for this purpose. They are called in various phases of the switching process. These phases are:

prestop prior to stopping services when leaving the profile

poststop after stopping services when leaving the profile

prestart prior to starting services when activating the profile

poststart after starting services when activating the profiles

Switching from profile `work` to profile `home` thus proceeds as follows:

1. The prestop action of the profile `work` is executed.
2. The services are stopped.
3. The poststop action of the profile `work` is executed.
4. The system configuration is changed.
5. The prestart action of the profile `home` is executed.
6. The services are started.
7. The poststart action of the profile `home` is executed.

These actions can also be attached with the command `set` by entering `scpm set prestop ⟨filename⟩`, `scpm set poststop ⟨filename⟩`, `scpm set prestart ⟨filename⟩`, or `scpm set poststart ⟨filename⟩`. The call must be made to an executable — scripts must refer to the correct interpreter and must be executable at least for the superuser.

All additional settings entered with `set` can be queried with `get`. The command `scpm get poststart`, for instance, returns the name of the poststart call or simply nothing if nothing has been attached.

Such settings can be reset by overwriting with `""`. This means that the command `scpm set prestop` "" removes the attached prestop program.

All `set` and `get` commands can be applied to an arbitrary profile in the same manner as comments are added. For example, `scpm get prestop` ⟨*filename*⟩ `work` or `scpm get prestop work`.

Caution

These scripts or programs should not be modifiable by arbitrary users because they are executed with the rights of the superuser. It is recommended to make scripts only readable to the superuser because they can contain sensitive information. It is best to provide these programs with the permissions `-rwx---- root root` with the commands `chmod 700 variablefilename` and `chown root.root` ⟨*filename*⟩.

Caution

Profile Selection during Boot

It is possible to select a profile during the boot process by providing the boot parameter `PROFILE=`⟨*name-of-the-profile*⟩ at the boot prompt. In the boot loader configuration (`/boot/grub/menu.lst`), the option `title` reflects the name of the profile. For example:

```
gfxmenu (hd0,5)/boot/message
color white/green black/light-gray
default 0
timeout 8

title work
   kernel (hd0,5)/boot/vmlinuz root=/dev/hda6 PROFILE=work
   initrd (hd0,5)/boot/initrd

title home
   kernel (hd0,5)/boot/vmlinuz root=/dev/hda6 PROFILE=home
   initrd (hd0,5)/boot/initrd

title road
   kernel (hd0,5)/boot/vmlinuz root=/dev/hda6 PROFILE=road
   initrd (hd0,5)/boot/initrd
```

File 21: *The File /boot/grub/menu.lst*

Systems that still use LILO as the boot loader may use File 22 as an example.

```
boot    = /dev/hda
change-rules
reset
read-only
menu-scheme = Wg:kw:Wg:Wg
prompt
timeout = 80
message = /boot/message

  image  = /boot/vmlinuz
  label  = home
  root   = /dev/hda6
  initrd = /boot/initrd
  append = "vga=0x317 hde=ide-scsi PROFILE=home"

  image  = /boot/vmlinuz
  label  = work
  root   = /dev/hda6
  initrd = /boot/initrd
  append = "vga=0x317 hde=ide-scsi PROFILE=work"

  image  = /boot/vmlinuz
  label  = road
  root   = /dev/hda6
  initrd = /boot/initrd
  append = "vga=0x317 hde=ide-scsi PROFILE=road"
```

File 22: *File /etc/lilo.conf*

Then you can select the desired profile at the boot prompt.

Common Problems and Solutions

In most cases, SCPM should function smoothly. There are however some pitfalls, which are described here.

SCPM is currently not able to survive a system update. The difficulty lies in the fact that, with a system update, the data stored in the profiles is not cleanly updated by the automatic mechanisms. SCPM then detects a system update and refuses to work. In this situation, you should get an error message from SCPM that contains "your operating system installation changed/is unknown, read man page!" In this case, reinitialize SCPM with `scpm -f enbale`. Your profiles, however, will be lost and you must set them up again.

Sometimes it can also occur that SCPM stops working during a switch procedure. This may be caused by some outside effect, such as a user abort, a power fault, another similar problem, or even an error in SCPM itself. In this case, an error message saying SCPM is locked appears the next time you start SCPM. This is for system safety, because the data stored in its database may differ from the state of the system. To solve this issue, delete the lock file with `rm /var/lib/scpm/#LOCK` then update your database with `scpm -s reload`. After this procedure, proceed as usual.

If you want to change the Resource Group Configuration of an already initialized SCPM, there is no real problem doing so. However, you must run `scpm rebuild` after adding or deleting groups. This adds new resources to all profiles and removes the deleted ones. The deleted ones are then lost to the system, which may cause problems if they are configured specifically in your profiles. The only exception is the current profile, because it is not touched by SCPM. If you reconfigure your system with YaST, you do not need to rebuild manually because YaST does it.

APM and ACPI — Power Management

Power management requires correspondingly designed hardware and existing BIOS routines. Most notebooks and many modern desktop computers meet these requirements. The APM (Advanced Power Management) standard has generally been used so far for this. These are basically functions implemented in the BIOS of the computer. This is why power management does not work equally well on all devices. It is currently advisable to use APM on laptops with a functioning implementation of it. This is because there are manufacturers that dropped APM in favor of completely relying on the more recent ACPI (Advanced Configuration and Power Interface) standard. ACPI is, however, based on a more complex concept and requires a good cooperation of hardware manufacturers, BIOS programmers, and operating system experts. The Linux implementation of ACPI is still incomplete and therefore only partially usable. A substantial improvement in this matter can only be expected for the 2.6 kernel.

Power Saving Functions

While many of these functions are of general interest, they become really important in mobile environments. These functions are described below along with the systems on which they can be used.

Standby This operating mode only turns the display off and in some systems throttles the processor load. Not every APM offers this function. This corresponds to the ACPI state S1.

Suspend (to memory) The complete state of the system is written to random access memory (RAM) and the entire system is subsequently put to sleep. The computer consumes only very little power in this state, allowing battery power to span stretches of time between twelve hours up to several days. The advantage of this state is the ability to resume work at the same point within a few seconds without having to boot and load necessary applications first. It is sufficient with most modern devices to close the lid to suspend and to simply open to resume work. This corresponds to the ACPI state S3.

Hibernation (suspend to disk) The computer can last for longer than a winter in this operating state (the term hibernation alludes to this), because the state of the system is completely written to hard disk and the system is subsequently turned off. Resuming from hibernation takes between half a minute and one and a half minutes and the state upon suspension is likewise completely restored. Some manufacturers offer sensible hybrid variations of this mode (for instance, RediSafe in IBM Thinkpads). Hibernation corresponds to the ACPI state S4. Linux also offers a pure software solution, which, however, is not included in SuSE Linux. Information is available at `http://falcon.sch.bme.hu/~seasons/linux/swsusp.html`.

Monitoring the state of the battery Apart from monitoring the charge status, it is equally important to take appropriate action when the power reserves run out. This is also handled by the BIOS APM routines in most cases. The `apmdacpid` or `klaptopdaemon` can be alternatively used for this.

Automatic power-off The computer is completely turned off following a shutdown. This is especially of importance when an automatic shutdown is executed shortly before the battery runs out.

Shutdown of system components The substantial component for conserving power is the hard disk, which can be spun down for a shorter or longer amount of time depending on the reliability of the whole system. However, the risk of a loss of data rises with the duration of the rest periods. Other components can be deactivated via ACPI (at least theoretically) or permanently in the BIOS setup. The infrared port should, where applicable, be deactivated for as long as its services are not required (see *IrDA — Infrared Data Association* on page 230).

Processor speed control APM generally only offers the possibility to select from various settings in the BIOS setup. Special tools are available for controlling hardware-specific settings on some devices, such as `tpctl` and `apmiser` from the package `tpctl` for IBM Thinkpads. The processor speed can be controlled with the procspeed application from the package `apmd`. The processor speed can only be influenced directly with ACPI. Therefore, these possibilities are covered in the ACPI section.

APM

Some of the power saving functions are executed by the APM itself. Standby and suspend can be activated with key combinations or by closing the lid on many laptops. There is, at first, basically no need for contribution to this on part of the operating system. Corresponding packages and a suitable kernel must be installed if it is desired to invoke these functions by command, if it is necessary to execute certain actions before suspension, or to simply check the battery level.

APM support is integrated in the precompiled kernels of SuSE Linux. However, it is only activated if ACPI is not implemented in the kernel and an APM BIOS is detected. The APM support can be activated at the boot prompt with `acpi=off`. The command `cat /proc/apm` can be used to check if APM was activated. Everything is in order if a line containing various numbers is returned. Now, the command `shutdown -h` should shut down the computer.

Spurious behavior can occasionally arise from some incompletely compliant BIOS implementations. Some problems can be circumvented with special boot parameters, which previously were kernel configuration options. All parameters are entered at the boot prompt in the form `apm=⟨parameter⟩`:

on or off activate or deactivate APM support

(no-)allow-ints Allow interrupts during the execution of BIOS functions

(no-)broken-psr The BIOS has a broken “GetPowerStatus” function

(no-)realmode-power-off Reset the processor to “real mode” before shutdown

(no-)debug Log APM events in the system log.

(no-)power-off Power off the system after shutting down.

bounce-interval=⟨*n*⟩ Blackout time in 1/100ths of a second following a suspend event during which additional suspend events are ignored.

idle-threshold=⟨*n*⟩ Percentage of system activity under which the BIOS function idle is called (0=always, 100=never)

idle-period=⟨*n*⟩ Period of time in hundredths of a second during which the system activity is evaluated

The APM Daemon (apmd)

The apmd daemon monitors the battery and can invoke certain actions when a standby or a suspend event occurs. It is located in the package `apmd`. It is not indispensable for operation, yet can be helpful for some problems.

apmd is not started automatically on boot. The settings for the system services, however, can be modified with the YaST runlevel module if necessary. The `chkconfig` utility can alternatively be used. The service can be called manually with the command `rcapmd start`.

A few configuration variable are present in `/etc/sysconfig/powermanagement`. Only a few hints are provided here because the file is commented.

APMD_ADJUST_DISK_PERF This determines that the behavior of the hard disk follows the state of power supply. There is a also series of other variables that either begin with `APMD_BATTERY` or `APMD_AC`. The former contain settings for the operation with battery power, the latter for the operation with external power supply.

APMD_BATTERY/AC_DISK_TIMEOUT After how long a period of disk inactivity should it be spun down. The values are described in *Rest for the Hard Disk* on page 229 or in the man page of `hdparm`, option `-S`.

APMD_BATTERY/AC_KUPDATED_INTERVAL The time between runs of the kernel update daemon.

APMD_BATTERY/AC_DATA_TIMEOUT The maximum age of buffered data.

APMD_BATTERY/AC_FILL_LEVEL The maximum fill level of the hard disk buffer.

APMD_PCMCIA_EJECT_ON_SUSPEND Problems sometimes occur despite PCMCIA being compiled into kernels with APM support. Some of the card drivers do not resume correctly from a suspend (`xirc2ps_cs`). This is why apmd can deactivate the PCMCIA system prior to a suspend and can reactivate it afterwards. The variable `APMD_PCMCIA_EJECT_ON_SUSPEND` is set to `yes` for this.

APMD_INTERFACES_TO_STOP Network interfaces that should be stopped prior to a suspend and started afterwards can be entered here.

APMD_INTERFACES_TO_UNLOAD This variable should be used if the driver modules of the interfaces mentioned before should equally be unloaded.

APMD_TURN_OFF_IDEDMA_BEFORE_SUSPEND It is also sometimes the case that resuming from a suspend does not work if an IDE device (hard disk) remained in DMA mode.

Furthermore, there are additional options, like for adjusting the key repeat rate or the system clock after a suspend or for shutting down the laptop properly when the APM BIOS sends a "battery critical" event. The script `/usr/sbin/apmd_proxy`, which performs the jobs described above, can be adjusted to any requirements for even more specialized actions.

Further Commands

package `apmd` contains a few additional handy utilities. The utility apm checks and returns the current battery charge level or puts the system into standby (`apm -S`) or suspend (`apm -s`) mode. Refer to the man page for `apm` (`man apm`).

The command `apmsleep` suspends the system for a given time.

`tailf` can be used instead of `tail -f` to watch a log file without preventing the hard disk from spinning down.

There are of course also tools for the X Window System. The package `apmd` also contains the xapm utility for displaying the charge level of the battery. The kbatmon applet displays the charge level of the rechargeable battery to users of the KDE desktop and can also suspend the system. The xosview monitoring utility is likewise interesting as an alternative.

ACPI

ACPI is the abbreviation for Advanced Configuration and Power Interface. ACPI is designed to enable the operating system to configure and control the individual hardware components. Accordingly, ACPI supersedes both PnP as well as APM. The part of ACPI responsible for initializing the hardware is not covered in this chapter. Additionally, there is little to do for the user in this regard.

The BIOS provides tables containing information about the individual components and methods for the access to the hardware. This information is used by the operating system for tasks such as assigning interrupts or activating or deactivating components as needed. However, as operations performed by the operating system perform operations integrated in the BIOS, the functionality depends on the BIOS implementation. The boot messages are logged to `/var/log/boot.msg`. Here ACPI reports which tables it was able to find and read.

DSDT Differentiated System Description Table: Contains information about the components of the computer and how these can be configured.

FADT Fixed ACPI Description Table: Contains information about the implementation of the ACPI hardware register block and the physical address of the DSDT.

MADT Multiple APIC Description Table: Describes the implementation and configuration of the APIC.

RSDT Root System Description Table: Table containing pointers to the other tables. The pointer to the RSDT (RSDP) must be located in the low memory range.

SSDT Secondary System Description Table: This table is a continuation of the DSDT. There can be several SSDTs. The distribution to several tables increases the flexibility especially for OEM.

XSDT Extended Root System Description Table: Contains the same information as RSDT, but can also accommodate pointers to description headers larger than 32 bits. Alternatively, the RSDP can also point to the XSDT.

The ACPI standard defines a variety of system states. The main states are as follows:

G0 System working

G1 System sleeping, change to G0 without booting the OS (suspend)

G2 Soft-off, OS must boot when switched on

G3 Mechanical off, system is without power (mechanical main switch is off)

Furthermore, there are six sleep states that further distinguish G0, G1, and G2:

S0 System working

S1 Standby (less power consumption, rapid wake-up)

S2 Another type of standby that is rarely implemented in devices.

S3 Suspend (very low power consumption, rapid wake-up).

S4 Hibernation or suspend to disk (no power consumption, wake-up takes a little longer — twenty to one hundred seconds, depending on the hardware).

S5 Soft-off (G2)

Furthermore, the states D0–D3 are available for all hardware components. In these states, the individual components are active, suspended, or off. There are special states for specific operational situations only known to the processor. The C states are introduced by CPU commands and cannot be influenced directly:

C0 Processor working

C1 Processor issues special low power instructions that consume less energy but allow rapid return to working state.

C2 Like C1, with even less power consumption but longer wake-up time.

C3 Like C2, even more savings, but the first-level cache is rendered inconsistent (only implemented in few devices and rarely used).

The performance states are associated with special processor technologies, such as Speedstep (Intel) or PowerNow (AMD), and involve changes in the clock frequency and the CPU core voltage:

P0 Maximum clock frequency and core voltage

P1 First saving stage, reduced frequency and voltage

P2 Next saving stage (if available)

P3 …

The third possibility to give the processor some rest is throttling. In this approach, the clock signal of the CPU is interrupted temporarily.

T0 0% clock throttling

T1 12% clock throttling

T2 25% clock throttling

T4 ...

The P and T states can be set directly by the user (or a daemon). The main difference is the level of energy saving. Throttling merely yields linear savings, e.g., 25% clock throttling corresponds to 25% less performance and 25% less energy consumption (only for the processor). In contrast, the energy savings due to a performance change resulting from the reduced core voltage exceed the performance loss. The performance cutback is also used for "passive cooling", unlike the active cooling by means of the fan. It is also meaningful if you want to charge the battery quicker while you are using the computer.

In addition, ACPI provides information about the battery, AC adapter, temperature, and fan. It also reports system events such as "close lid" or "low battery".

ACPI in Action

If the kernel detects an ACPI BIOS when the system is booted, ACPI is activated automatically (and APM is deactivated). The boot parameter `acpi=on` might be necessary for some older machines. The computer must support ACPI 2.0 or later. Check the boot messages of the kernel in `/var/log/boot.msg` to see if ACPI was activated. In this case, there is also a directory `/proc/acpi`, which will be described later.

Then a number of modules must be loaded for OSPM ("Operating System Power Management"). These are loaded by the start script of the ACPI daemon. If any of these modules causes problems, it can be excluded from the loading or unloading process in `/etc/sysconfig/powermanagement`. The system log (`/var/log/messages`) contains the messages of the modules. Here, see which components were detected.

In `/proc/acpi`, you will now find a number of files that provide information on the system state or which can be used to actively change some states. However, many features do not work yet, either because they are still under development or because they are not implemented by the manufacturer.

Caution

To date, neither suspend to RAM or suspend to disk (hibernation) work with ACPI. Due to kernel-specific reasons, these features will only be available starting with kernel 2.6 (or kernel 2.5). If you think you can do it, you can integrate the sw-susp patch in your kernel.

Caution

All files (except dsdt and fadt) can be read with `cat`. In some of the files, settings can be modified by using `echo X > file` to specify suitable values for

X (all objects in `/proc` are not real files on the hard disk but an interface for the kernel). Here is a description of the most important files:

/proc/acpi/info General information about ACPI

/proc/acpi/alarm Here, specify when the system should wake from sleep. The time is set with `echo year-month-day hour:minute:second > /proc/acpi/alarm`. However, as the sleep states do not work yet, it is folly to set an alarm.

/proc/acpi/sleep Provides information about the possible sleep states. In the future, it will be possible to actuate a suspend here. Currently, the only states that might work are S1 (standby) and S5 (off, off immediately, no clean shutdown): `echo 1 > /proc/acpi/sleep`.

/proc/acpi/event All events are reported here. These are processed by a daemon, such as 'acpid' or 'ospmd'. If no daemon accesses this file, the events can be read with `cat /proc/acpi/event` (terminate with Ctrl + C). A brief click on the power button or closing the lid are some of these events.

/proc/acpi/dsdt and /proc/acpi/fadt These files contain the ACPI tables DSDT and FADT. These files can be read with `acpidmp`, `acpidisasm`, and `dmdecode`. These programs and their documentation are located in the package `pmtools`. Example: `acpidmp DSDT | acpidisasm`.

/proc/acpi/ac_adapter/AC/state Is the AC adapter connected?

/proc/acpi/battery/BAT*/{alarm,info,state} Detailed information about the battery state. To read the battery charge level, last full capacity from info is compared with remaining capacity from state. This can be done more conveniently with special programs. The charge level at which a battery event is triggered can be specified in alarm.

/proc/acpi/button This directory contains information about various switches.

/proc/acpi/fan/FAN/state Shows if the fan is currently active. It can also be switched on and off manually by writing 0 (on) or 3 (off) into this file. However, both the ACPI code in the kernel and the hardware (or the BIOS) overwrite this setting when it gets too warm.

/proc/acpi/processor/CPU0/info Information about the energy saving possibilities of the processor.

/proc/acpi/processor/CPU0/power Information about the current processor state. An asterisk next to C2 indicates that the processor is idle. This is the prevailing state, as you can see from the figure for usage.

/proc/acpi/processor/CPU0/performance Here you can read or set the performance — use the Speedstep or PowerNow capabilities of the CPU.

/proc/acpi/processor/CPU0/throttling This file enables further linear throttling of the processor.

/proc/acpi/processor/CPU0/limit If performance and throttling are automatically controlled by a daemon, the limits that should not be exceeded can be specified here. There are limits defined by the system and a user-definable limit. With `echo 1:5 > /proc/acpi/processor/CPU0/limit`, prevent the states P0 or T0–T4 from being used.

/proc/acpi/thermal_zone/ There is a subdirectory for each thermal zone. A thermal zone is an area with similar thermal properties whose number and names are selected by the hardware manufacturer. However, many of the possibilities offered by ACPI are rarely implemented. Rather, the temperature control is handled in the conventional way directly by the BIOS. The operating system is not given much opportunity to intervene, as the life span of the hardware is at stake. Therefore, the some of the following descriptions only have a theoretical value.

/proc/acpi/thermal_zone/*/temperature The current temperature of the thermal zone.

/proc/acpi/thermal_zone/*/state The states indicates if everything is “ok” or if ACPI uses “active” or “passive” cooling. Everything is “ok” in the case of ACPI-independent fan control.

/proc/acpi/thermal_zone/*/cooling_mode Here, select the preferred cooling method under full ACPI control, either passive (less performance, but very economical) or active (always full performance and uninterrupted fan noise).

/proc/acpi/thermal_zone/*/trip_points Here, determine the temperature at which something like passive or active cooling, a suspend (“hot”), or a shutdown (“critical”) should be actuated.

/proc/acpi/thermal_zone/*/polling_frequency If the value in “temperature” is not updated automatically as soon as the temperature changes, switch to “polling mode” here. The command `echo X > /proc/acpi/thermal_zone/*/polling_frequency` causes the temperature to be queried every X seconds. Set X=0 to deactivate the “polling”.

The ACPI Daemon (acpid)

The ACPI daemon processes events similarly to the APM daemon. These are currently merely some switching events, like the operation of the power button or the closing of the lid. All events are logged in the system log. The variables `ACPI_BUTTON_POWER` and `ACPI_BUTTON_LID` contain instructions for these events. The script `/usr/sbin/acpid\_proxy` can be modified as well as the configuration of the acpid utility in `/etc/acpi/` for more control options.

Unlike `apmd`, little is preconfigured here, as ACPI in Linux is still in a very dynamic development stage. If necessary, configure `acpid` yourself. If you have any suggestions on preparatory actions, please send an e-mail to `http://www.suse.de/feedback`.

Speedstep of PowerNow

CPUs for mobile devices have the possibility to adjust the processor frequency to the current system demands. The system interface to this technology is available outside the ACPI subsystem. In `/proc/cpufreq`, read the current frequency and adjust it in `/proc/sys/cpu/0/speed*`. More information is available in `/usr/src/linux/Documentation/cpufreq/`.

To adapt the CPU frequency automatically, use the cpufreqd daemon. This is not started by default. More information about starting system services is available in Section *The YaST Runlevel Editor* on page 286. The documentation for cpufreqd is found in `/usr/share/doc/packages/cpufreqd/README.SuSE` and in the manual page (`man cpufreqd`). All system settings are configured in `/etc/sysconfig/powermanagement`.

Troubleshooting

There are two different types of problems. On one hand, there might be error in the ACPI cord of the kernel that was not detected in time. In this case, a solution will be made available for download. On the other hand, there might be problems in the BIOS of a computer. This happens more often and is more annoying. Unfortunately, deviations from the ACPI specifications are sometimes purposely integrated in the BIOS to circumvent errors of the ACPI implementation in other widespread operating systems. Hardware components that have serious mistakes in the ACPI implementation are recorded in a blacklist to prevent the Linux kernel from using ACPI for these components.

If you encounter a problem, the first thing you should do is update the BIOS. This will solve many problems. If the computer does not boot properly, one of the following boot parameters may be helpful:

pci=noacpi Do not use ACPI for configuring the PCI devices.

acpi=oldboot Only perform a simple resource configuration. Do not use ACPI for other purposes.

acpi=off Disable ACPI.

Another important step is to take a closer look at the boot messages. To do this, use the command `dmesg | grep -2i acpi` (or all other messages, since the problem may be due to something else than ACPI) the computer has booted. If an error occurs with the parsing of an ACPI table, at least the most important table — the DSDT — can be replaced by integrating an improved table in an individual kernel. This will cause the faulty DSDT of the BIOS to be ignored. However, this is not a simple task and requires some assistance by an expert. Bug-fixed DSDTs are available on the Internet for some computers.

For the kernel configuration, there is a switch that activates ACPI debug messages. If you compiled and installed a kernel with ACPI debugging, experts looking for an error can be supported with detailed information.

If you experience BIOS or hardware problems, it is always advisable to contact the manufacturer of the device. Although the manufacturers may not always be able to provide assistance for Linux, it is still important that they hear the word "Linux" as often as possible. The manufacturers will only take it seriously if they realize that an adequate number of their customers utilize Linux. Of course you can also contact the manufacturer to tell him that you use Linux on the hardware without any difficulties.

Additional documentation and help is available in the following sources:

- `http://www.columbia.edu/~ariel/acpi/acpi_howto.txt` (slightly outdated ACPI HowTo, incomplete)
- `http://www.cpqlinux.com/acpi-howto.html` (more detailed ACPI HowTo, contains patches of DSDT)
- `http://www.intel.com/technology/iapc/acpi/faq.htm` (ACPI FAQ @Intel)
- `http://www.brodo.de/english/pub/acpi/proc/processor.html` (description of the subdirectory `/proc/acpi/processor`)
- `http://acpi.sourceforge.net/` (the ACPI4Linux project at Sourceforge)
- `http://www.brodo.de/english/pub/acpi/index.html` (ACPI patches)
- `http://codecs.home.sapo.pt/acpi/index.html` (ACPI patches)

- `http://www.poupinou.org/acpi/` (DSDT patches by Bruno Ducrot)
- `http://www.brodo.de/cpufreq/` (the Linux CPUFreq project)
- `http://falcon.sch.bme.hu/~seasons/linux/swsusp.html` (kernel hibernation: swsusp project)

Rest for the Hard Disk

An idling hard disk can be spun down in Linux. The hdparm utility serves the purpose of modifying various settings of a hard disk. The `-y` option puts the hard disk instantly into standby mode and the `-Y` option turns it off completely. The command `hdparm -S` ⟨*x*⟩ results in the hard disk spinning down after a certain time of inactivity. The ⟨*x*⟩ variable has a nonlinear scale: `0` turns the mechanism off and the hard disk runs continuously. Values between `1` and `240` are multiplied by five seconds. Values between `241` and `251` correspond to one to eleven times thirty minutes.

One problem is the number of processes in Linux that write to the hard disk, continuously waking it up. It is hence important to understand how Linux handles data that is supposed to be written to the hard disk.

All data is first written into a buffer in random access memory. This buffer is watched by the kernel update daemon kupdated.The buffer is flushed to the hard disk every time the data reaches a certain age or the buffer becomes filled to a certain degree. The size of the buffer is dynamic and depends on the size of the memory and the system load. kupdated is set by default to small time intervals because the preservation of data integrity is a primary goal. It checks the buffer every five seconds and informs the bdflush daemon when data is older than thirty seconds or the buffer is filled by more than thirty percent. The bdflush daemon then writes the data to the hard disk. It also writes independently of kupdated, for instance, when the buffer is full. Operators of a stable system can modify these settings. They must, however, be aware that this is done by risking data corruption.

The settings can be read with `cat /proc/sys/vm/bdflush`. The first value is the the flushing threshold of the buffer. The sixth value is the maximum age limit for buffered data in hundredths of a second. The fifth value is the checking interval for kupdated and is likewise given in hundredths of a second. For instance, to increase the kupdated interval to one minute, the new values are entered into this file with

```
echo 30 500 0 0 6000 > /proc/sys/vm/bdflush
```

The unchanged values are simply copied from the output and the trailing values can be omitted. Thus, entering

```
echo 60 > /proc/sys/vm/bdflush
```

changes the flushing threshold of the buffer to sixty percent. The remaining values are described in the file `Documentation/filesystems/proc.txt` of the kernel sources.

Note

Changes to the settings of the kernel update daemon influence data intergrity. If in doubt, leave them be.

Note

The settings for the hard disk time-out, the kupdated interval, the buffer threshold, and the maximum age of data can be duplicated in `/etc/sysconfig/powermanagement`: one set for battery operation and one set for external power supply. The variables are described in the section about apmd and within the file itself. "Journaling file systems", like reiserfs or ext3, write their metadata independently of bdflush, which prevents the hard disk from spinning down. At the time of writing, ext3 and jbd respect the fifth value of `/proc/sys/vm/bdflush` and also write their metadata less often if this value were raised. This is not yet the case for reiserfs. It is best to rely on the ext2 file system in cases of doubt.

It is necessary to observe how any used applications behave. Good text editors, for instance, regularly keep hidden backups of the currently changed file on disk. This will repeatedly wake up the hard disk. Such program features can also be turned off, but this endangers data integrity.

IrDA — Infrared Data Association

IrDA ("Infrared Data Association") is an industry standard for wireless communication with infrared light. Many laptops sold nowadays are equipped with an

IrDA compatible transceiver that enables communication with other devices, such as printers, modems, LANs, or other laptops. The transfer speed ranges from 2400 bps up to 4 Mbps.

There are two IrDA operation modes. The standard mode SIR accesses the infrared port through a serial interface. This mode works on almost all systems and is sufficient for most requirements. The faster mode FIR requires a special driver for the IrDA chip. There are not, however, such drivers for all chips. The desired mode additionally must be set in the BIOS setup of the computer. This is also where it can be determined which serial interface is used for the SIR mode.

Information about IrDA can be found in the IrDA how-to by Werner Heuser at `http://tuxmobil.org/Infrared-HOWTO/Infrared-HOWTO.html` and on the web site of the Linux IrDA Project `http://irda.sourceforge.net/`.

Software

The necessary kernel modules are included in the kernel package. The package `irda` provides the necessary helper applications for supporting the infrared interface. The documentation can be found at `/usr/share/doc/packages/irda/README` after the installation of the package.

Configuration

The IrDA system service is not started automatically by the booting process. Use the YaST runlevel module to change the settings of the system services. The application `chkconfig` can be used alternatively. IrDA unfortunately consumes noticeably more battery power, because a "discovery packet" is sent every few seconds to detect other peripheral devices automatically. This is why IrDA should only be started when needed. The interface can always be activated manually with the command `rcirda start` or deactivated with the `stop` parameter. All necessary kernel modules are automatically loaded when the interface is activated.

The file `/etc/sysconfig/irda` contains only the one variable ⟨*IRDA_PORT*⟩. This is where the interface used in SIR mode is set. The script `/etc/irda/drivers` of the infrared support package sets this variable.

Usage

Data can be sent to the device file `/dev/irlpt0` for printing. The device file `/dev/irlpt0` acts just like the normal `/dev/lp0` cabled interface except the printing data is sent wireless with infrared light.

Printers used with the infrared interface are installed just like printers connected to the parallel or serial ports. Make sure the printer is in visible range of the infrared interface and the infrared support is started.

Communication with other hosts and with mobile phones or other similar devices is conducted through the device file `/dev/ircomm0`. The Siemens S25 and Nokia 6210 mobile phones, for instance, can dial and connect to the Internet with the wvdial application using the infrared interface. A data synchronization with a Palm Pilot is equally possible in this way when the device setting of the corresponding application has been set to `/dev/ircomm0`.

Only those devices can be accessed without any other adjustments that support the printer or IrCOMM protocols. Devices that support the IROBEX protocol, such as the 3Com Palm Pilot, can be accessed with special applications like irobexpalm and irobexreceive. Refer to the IR-HOWTO on this subject. The protocols supported by the device are stated in brackets behind the name of the device in the output of irdadump. IrLAN protocol support is still a "work in progress" — it is unfortunately not stable yet but will surely also be available for Linux in the near future.

Troubleshooting

The superuser `root` can check with the command `irdadump` whether the other device has been recognized by the system in case devices do not work at the infrared interface.

Something similar to Output 14 appears regularly when a Canon BJC-80 printer is in visible range of the computer:

```
21:41:38.435239 xid:cmd 5b62bed5 > ffffffff S=6 s=0 (14)
21:41:38.525167 xid:cmd 5b62bed5 > ffffffff S=6 s=1 (14)
21:41:38.615159 xid:cmd 5b62bed5 > ffffffff S=6 s=2 (14)
21:41:38.705178 xid:cmd 5b62bed5 > ffffffff S=6 s=3 (14)
21:41:38.795198 xid:cmd 5b62bed5 > ffffffff S=6 s=4 (14)
21:41:38.885163 xid:cmd 5b62bed5 > ffffffff S=6 s=5 (14)
21:41:38.965133 xid:rsp 5b62bed5 < 6cac38dc S=6 s=5 BJC-80
                        hint=8804 [ Printer IrCOMM ] (23)
21:41:38.975176 xid:cmd 5b62bed5 > ffffffff S=6 s=* erde
                        hint=0500 [ PnP Computer ] (21)
```

Output 14: *IrDA: irdadump*

Check the configuration of the interface in case there is no output or the other device does not reply. Verify that the correct interface is used. The infrared interface is sometimes located at `/dev/ttyS2` or at `/dev/ttyS3` and another interrupt than IRQ 3 is used sometimes. These settings can be checked and modified in the BIOS setup menu of almost every laptop.

A simple CCD video camera can also help in determining whether the infrared LED lights up at all. Most video cameras can see infrared light, whereas the human eye cannot.

Part III

System

SuSE Linux on AMD64 Systems

AMD presented its Athlon64 processor to the public in September 2003. This new processor is a 64-bit processor and is therefore able to execute new 64-bit AMD64 programs. It also supports the execution of existing 32-bit x86 programs at the same level of performance.

64-bit programs have a larger address space and offer better performance by providing modern calling conventions and additional registers which are only supported in 64-bit mode.

SuSE Linux supports the new processor with this product in two ways.

- 32-bit SuSE Linux for x86 supports this processor as 32-bit processor just like it supports the AMD Athlon and the Intel Pentium processors.
- The new 64-bit SuSE Linux for AMD64 supports the processor in 64-bit mode. The execution as well as the development of 32-bit x86 programs is still supported.

Note

The output of `uname -m` is **x86_64** due to historical reasons as this was the name of the first AMD specification.

Note

64-bit SuSE Linux for AMD64

Hardware

From the perspective of the user, hardware relates to the AMD64 just like it does with AMD Athlon systems. The common interfaces and buses are the same on both platforms and are equally supported.

Since the hardware drivers for Linux on AMD64 have to be 64-bit drivers, some of them still need to be adapted. While some older cards are currently not functional, the support of current hardware should be the same in 32-bit and 64-bit.

Software

Almost all packages are 64-bit on the software side. The execution if 32-bit programs is additionally supported. Dedicated 32-bit library packages were developed to this end and are installed in the default installation. In order to install 32-bit and 64-bit libraries with the same name on one system, the 32-bit libraries are installed in the directory /lib while the 64-bit libraries are installed in the /lib64 directory. This especially makes the installation of 32-bit rpms possible without any modifications.

Non-64-bit packages include OpenOffice and some commercial packages, like the Acrobat Reader.

From the perspective of the administrator or the user, there is no directly discernable difference between 32-bit and 64-bit. All programs look and feel the same.

Installation of 32-bit Software

32-bit software which calls `uname` in order to probe for the architecture possibly needs to be persuaded to run on an AMD64 system. This can be achieved with the application `linux32`, which changes the output of `uname -m`:

```
$ uname -m
x86_64
$ linux32 uname -m
i686
```

Software Development in a 64-bit Environment

A SuSE Linux for AMD64 system supports the development of 32-bit applications as well as 64-bit applications. The GNU compiler usually create 64-bit AMD64 code. The switch `-m32` invokes the creation of 32-bit x86 code which then also runs on a 32-bit AMD Athlon or Intel Pentium system.

The 64-bit libraries have to be used for the development of 64-bit code. The paths `/lib64` and `/usr/lib64` are always searched, yet an option `-L/usr/X11R6/lib64` needs to be added for X11 code. Some adaptation of the Makefiles is thus necessary.

GDB can be used for the debugging of code. While the application for 64-bit AMD64 code is called gdb, it is called gdb32 for 32-bit x86 code. The strace tool can examine 32-bit as well as 64-bit programs and the library tracer ltrace also comes in a separate 32-bit version called ltrace32.

Additional Information

The websites of AMD (`www.amd.com`) and the project page of the Linux port to AMD64 (`www.x86-64.org`) provide additional information on the subject.

The Linux Kernel

The kernel is the heart of a Linux system. Although the following sections will not teach you how to be a kernel "hacker", they will tell you how to install a SuSE update kernel and introduce the basics of compiling a customized kernel. If you proceed as outlined in this chapter, you can keep your current functional kernel. Later, if your new kernel works as desired, change it to the default.

Kernel Update 242
Kernel Sources 243
Kernel Configuration 243
Kernel Modules 244
Settings in the Kernel Configuration 247
Compiling the Kernel 247
Installing the Kernel 248
Cleaning Your Hard Disk After Compilation 249

The standard SuSE kernel, located in the directory `/boot`, is configured to support as wide a range of hardware as possible. There is no need to compile your own kernel, unless you want to test experimental features and drivers. Several `Makefiles` are provided with the kernel to automate the process. All you need to do is select the hardware settings and other kernel features. As you need to know your computer system pretty well to make the right selections, we recommend modifying an existing and working configuration file for your first attempt.

Kernel Update

To install an official SuSE update kernel, download the update rpm from the SuSE FTP server or a mirror like `ftp://ftp.gwdg.de/pub/linux/suse/`. If you want to find out your current kernel version, you have several possibilities to do so. You may just look at the version string:

```
cat /proc/version
```

You may also check which package the kernel (`/boot/vmlinuz`) belongs to:

```
rpm -qf /boot/vmlinuz
```

Before installing this package, it is recommended to save the current kernel and initrd under a different name. As `root`, enter the following two commands:

```
cp /boot/vmlinuz /boot/vmlinuz.old
cp /boot/initrd /boot/initrd.old
```

Now, install the new kernel with the command `rpm -Uvh ⟨Paketname⟩` Replace ⟨*packagename*⟩ with the exact name of the kernel rpm to install.

Since SuSE Linux 7.3, reiserfs is the standard file system. It requires the use of an "initial ramdisk". Therefore, use the command `mk_initrd` to write the new initial ramdisk. In current SuSE Linux versions this is done automatically when installing the new kernel.

To be able to boot the old kernel, configure the boot loader accordingly (for more information refer to *Booting and Boot Managers* on page 69). Finally, reboot to load the new kernel.

To reinstall the original kernel from the SuSE Linux CDs, the procedure is almost the same, except you copy the kernel rpm from the directory `boot` on CD 1 or the DVD. Now, install as described above. If you receive an error message saying that a newer kernel rpm is already installed, add the option `--force` to the above rpm command.

Kernel Sources

To build a kernel, the package `kernel-source` must be installed. Additional packages, like the C compiler (package `gcc`), the GNU binutils (package `binutils`), and the include files for the C compiler (package `glibc-devel`), are selected for installation automatically by YaST.

After installation, the kernel sources are located in `/usr/src/linux-`⟨*kernel-version*⟩`.SuSE`. If you plan to experiment with different kernels, unpack them in different subdirectories and create a symbolic link to the current kernel source. As there are software packages that rely on the sources being in `/usr/src/linux`, maintain this directory as a symbolic link to your current kernel source. YaST does this automatically.

Kernel Configuration

The most recently compiled configuration is stored in the file `/boot/vmlinuz.config`. To modify the configuration of the currently-used kernel, go to the directory `/usr/src/linux` as user `root` and enter `make cloneconfig` to generate the file `.config`. Alternatively, copy the configuration file with the command `cp /boot/vmlinuz.config .config`.

The kernel configuration tools will read the file `.config` and offer all settings for modification. The kernel can be configured at the command line, in a menu in text-mode, or in a menu in the X Window System. The following is a short overview of these three methods.

Configuration on the Command Line

To configure the kernel, make sure your working directory is `/usr/src/linux` and enter `make config`. Choose the options you want supported by the kernel. There are two or three possibilities: Y, N, or M. `'m'` means that this device is not compiled directly into the kernel, but loaded as a module instead. Any driver needed to boot the system should be integrated into the kernel, not loaded as a module. With ↵, confirm the default settings read from the file `.config`. Pressing any other key accesses a short help text about the current option.

Configuration in Text Mode

A much more convenient way of configuring the kernel is to use `make menuconfig`. With `menuconfig`, you do not have to go through all the questions.

Instead, select the areas of interest from the menu. The default settings are read from the file `.config`. To load another configuration, select 'Load an Alternate Configuration File' and enter the file name.

Configuration in the X Window System

If you have installed and configured the X Window System (package `xf86`) and Tcl/Tk (package `tcl` and package `tk`), you can use `make xconfig`. It uses a GUI (Graphical User Interface) that makes kernel configuration very user-friendly. If you have not logged in to the X Window System as `root`, enter the command `xhost +localhost` (replacing `localhost` with the name of the local host) to allow `root` to take over the display. The default settings are taken from the file `/usr/src/linux/.config`. Please consider that the grafical configuration with xconfig is not as well maintained as the other configuration possibilities. Therefore you should run the command `make oldconfig` after configuring the kernel.

Do not forget to regenerate the kernel dependencies after you reconfigure the kernel. Regardless of the configuration method you should issue the following command after finishing with your configuration:

```
make dep
```

This is especially necessary if you want to build kernel modules for commercial software.

Kernel Modules

There is a wide variety of PC hardware components. To use this hardware properly, you need a "driver" with which the operating system (in Linux, the "kernel"), can access this hardware. There are basically two ways of integrating drivers into your system:

- The drivers can be compiled directly into the kernel. Such a kernel ("in one piece") is referred to as a *monolithic* kernel. Some drivers are only available in this form.
- Drivers can be loaded into the kernel on demand. In this case, the kernel is referred to as a *modularized* kernel. This has the advantage that only those drivers really needed are loaded and the kernel thus contains nothing unnecessary.

Which drivers to compile into the kernel and which to load as run-time modules is defined in the kernel configuration. Basically, components not required for booting the system should be built as modules. This makes sure the kernel does not get too big to be loaded by the BIOS or a boot loader. Drivers for `ext2`, the SCSI drivers on a SCSI-based system, and similar drivers should be compiled into the kernel. In contrast, items such as `isofs`, `msdos`, or `sound`, which are not needed for starting your computer system, should definitely be built as modules. Kernel modules are located in `/lib/modules/⟨Version⟩`, where ⟨*Version*⟩ is the current kernel version.

Hardware detection with the help of hwinfo

Within SuSE Linux the program hwinfo is at your disposal that can not only detect the hardware of your system, but also select the drivers that are needed to run this hardware. You get a small introduction to this command with:

```
hwinfo --help
```

If you need e.g. information about your SCSI-Devices, you may use the command:

```
hwinfo --scsi
```

All of this information is also available in YaST in the module hardware information.

Handling Modules

The following commands are available:

- `insmod`
  insmod loads the requested module after searching for it in a subdirectory of `/lib/modules/⟨Version⟩`. It is better, however, to use `modprobe` (see below) rather than `insmod`.

- `rmmod`
  Unloads the requested module. This is only possible if this module is no longer needed. For example, the isofs module cannot be unloaded while a CD is still mounted.

- `depmod`
  Creates the file `modules.dep` in `/lib/modules/`⟨*Version*⟩ that defines the dependencies of all the modules. This is necessary to ensure that all dependent modules are loaded with the selected ones. This file will be built after the system is started if it does not exist.

- `modprobe`
  Loads or unloads a given module while taking into account dependencies of this module. This command is extremely powerful and can be used for a lot of things (e. g., probing all modules of a given type until one is successfully loaded). In contrast to insmod, modprobe checks `/etc/modules.conf` and therefore is the preferred method of loading modules. For detailed information on this topic, refer to the corresponding man page.

- `lsmod`
  Shows which modules are currently loaded as well as how many other modules are using them. Modules started by the kernel daemon are tagged with `autoclean`. This label denotes that these modules will automatically be removed once they reach their idle time limit.

- `modinfo`
  Shows module information.

/etc/modules.conf

`/etc/modules.conf` affects how modules are loaded. Refer to the man page for depmod (`man depmod`).

Enter the parameters for modules that access hardware directly in this file. Such modules may need system-specific options (e. g., CD-ROM driver or network driver). The parameters entered here are, for the most part, identical to those given to the boot prompt of the kernel. However, in many cases the names used at the boot prompt are different. If a module failed to load, try specifying the hardware in this file and use modprobe instead of insmod to load the module.

Kmod — the Kernel Module Loader

The kernel module loader is the most elegant way to use modules. Kmod performs background monitoring and makes sure the required modules are loaded by modprobe as soon as the respective functionality is needed in the kernel.

To use Kmod, set the corresponding variable in the kernel configuration 'Kernel module loader' (CONFIG_KMOD). Kmod is not designed to automatically unload modules. The potential saving in memory is only marginal for the RAM capacity of computers today. See also `/usr/src/linux/Documentation/kmod.txt`. For reasons of performance, it is better for server machines, which have special tasks to perform and need only a few drivers, to have a "monolithic" kernel.

Settings in the Kernel Configuration

All the kernel's configuration options cannot be covered here in detail. Make use of the numerous help texts available on kernel configuration. The latest kernel documentation is always in `/usr/src/linux/Documentation`.

Compiling the Kernel

We recommend compiling a "bzImage". As a rule, this avoids the problem of the kernel getting too large, as can easily happen if you select too many features and create a "zImage". You will then get error messages like "kernel too big" or "System is too big".

After customizing the kernel configuration, start compilation by entering:

```
earth:/usr/src/linux #  make dep
earth:/usr/src/linux #  make clean
earth:/usr/src/linux #  make bzImage
```

These three commands can be entered on one line as well:

```
earth:/usr/src/linux #  make dep clean bzImage
```

After a successful compilation, you will find the compressed kernel in `/usr/src/linux/arch/\suselxarch{}/boot`. The kernel image — the file that contains the kernel — is called `bzImage`. If you cannot find this file, an error probably occurred during the kernel compilation. In the Bash shell, enter the following command to launch the kernel compilation again and write the output to a file `kernel.out`:

```
earth:/usr/src/linux #  make bzImage 2>&1 | tee kernel.out
```

If you have configured parts of your kernel to load as modules, launch the module compilation. Do this with `make modules`.

Installing the Kernel

After the kernel is compiled, it must be installed so it can be booted. If you use LILO, LILO must be updated as well. To prevent unpleasant surprises, it is recommended that you keep the old kernel (e.g., as `/boot/vmlinuz.old`), so you can still boot it if the new kernel does not function as expected:

```
earth:/usr/src/linux #  cp /boot/vmlinuz /boot/vmlinuz.old
earth:/usr/src/linux #  cp arch/i386/boot/bzImage /boot/vmlinuz
earth:/usr/src/linux #  lilo
```

The Makefile target `make bzlilo` performs these three steps in one go.

Note

If you are using GRUB as the boot loader, it does not need to be reinstalled. Therefore only carry out the first two steps to copy the kernel to the right place in the system.

Note

Now the compiled modules need to be installed. By entering:

```
earth:/usr/src/linux #  make modules_install
```

copy these to the correct directories in `/lib/modules/`⟨*Version*⟩. This overwrites the old modules with the same kernel version. However, the original modules can be reinstalled together with the kernel from the CDs.

Tip

You should make sure that modules whose functionality may now have been directly compiled into the kernel are removed from `/lib/modules/`⟨*Version*⟩. Otherwise, unexpected effects could occur. This is one reason why the inexperienced user is *strongly* advised against compiling the kernel.

Tip

To enable GRUB or LILO to boot the old kernel (now `/boot/vmlinuz.old`), add an image entry with label Linux.old in your `/boot/grub/menu.lst` or `/etc/lilo.conf` respectively. This procedure is described in detail in *Booting and Boot Managers* on page 69. When you have adapted `/etc/lilo.conf` to your needs, enter `lilo`. If you are using LILO as the boot loader, LILO must be reinstalled after modifications to `/etc/lilo.conf` with the command `lilo`. GRUB does not need to be reinstalled.

The file `/System.map` contains kernel symbols required by the modules to ensure successful launching of kernel functions. This file depends on the current kernel. Therefore, once you have compiled and installed the kernel, copy `/usr/src/linux/System.map` to the directory (/boot). This file is regenerated each time the kernel is recompiled. If you create your kernel using `make bzlilo` or `make zlilo`, this is done for you automatically. If you get an error message like "System.map does not match current kernel", `System.map` probably has not been copied.

Cleaning Your Hard Disk After Compilation

If you are low on hard disk space, delete the object files generated during kernel compilation using `make clean` in the `/usr/src/linux` directory. If you have plenty of disk space and plan to reconfigure the kernel on a regular basis, you might want to skip this. Recompiling the kernel is considerably faster then, because only the parts affected by changes will actually be recompiled.

Special Features of SuSE Linux

This chapter provides information about the *Filesystem Hierarchy Standard* (FHS) and *Linux Standard Base* (LSB). Various software packages and special features, such as booting with "initrd", linuxrc, and the rescue system, are described in detail.

Linux Standards 252
Example Environments for FTP and HTTP 252
Hints on Special Software Packages 253
Booting with the Initial Ramdisk 259
linuxrc 263
The SuSE Rescue System 267
Virtual Consoles 274
Keyboard Mapping 274
Local Adjustments — I18N/L10N 275

Linux Standards

File System Hierarchy Standard (FHS)

SuSE Linux strives, as far as possible, to conform to the *File system Hierarchy Standard* (FHS, package `fhs`). See also `http://www.pathname.com/fhs/`. For this reason, it is sometimes necessary to move files or directories to their "correct" places in the file system.

Linux Standard Base (LSB)

SuSE supports the *Linux Standard Base* project. Current information on this can be found at `http://www.linuxbase.org`.

The LSB specification version for 9.0 is 1.3. From now on, the Filesystem Hierarchy Standard (FHS) is included in the specification and defines settings, such as the package format and the initialization of the system. See Chapter *The SuSE Linux Boot Concept* on page 279.

teTeX — TEX in SuSE Linux

TEX is a complete typesetting system which runs on various platforms. It is expandable with macro packages like LATEX. It consists of very many single files that have to be assembled according to the *TEX Directory Structure* (TDS) (ref. `ftp://ftp.dante.de/tex-archive/tds/` teTeX is a compilation of current TEXapplications.

teTeX is employed in SuSE Linux with a configuration that complies with the requirements of both the TDS and the FHS.

Example Environments for FTP and HTTP

About FTP

To make it easier to set up an FTP server, the package `ftpdir` includes an example environment. This is installed in `/srv/ftp`.

About HTTP

Apache is the standard web server in SuSE Linux. Together with the installation of Apache, some example documents are made available in `/srv/www`. To set up your own web server, include your own DocumentRoot in `/etc/httpd/httpd.conf` and store your files (documents, picture files) accordingly.

Hints on Special Software Packages

Package bash and /etc/profile

1. `/etc/profile`
2. `~/.profile`
3. `/etc/bash.bashrc`
4. `~/.bashrc`

Users can make personal entries in `~/.profile` or in `~/.bashrc` respectively. To ensure the correct processing of these files, it is necessary to copy the basic settings from `/etc/skel/.profile` or `/etc/skel/.bashrc` respectively into the home directory of the user. It is recommended to copy the settings from `/etc/skel` following an update. Execute the following shell commands to prevent the loss of personal adjustments:

```
mv ~/.bashrc ~/.bashrc.old
cp /etc/skel/.bashrc ~/.bashrc
mv ~/.profile ~/.profile.old
cp /etc/skel/.profile ~/.profile
```

The personal adjustments then need to be copied back from the files `*.old`.

cron Package

The cron tables are now located in `/var/cron/tabs`. `/etc/crontab` serves as a system-wide cron table. Enter the name of the user who should run the command directly after the time table (see File 23, here `root` is entered). Package-specific tables, located in `/etc/cron.d`, have the same format. See the man page for `cron` (`man 8 cron`).

```
1-59/5 * * * * root test -x /usr/sbin/atrun && /usr/sbin/atrun
```

File 23: *Example of an Entry in /etc/crontab*

`/etc/crontab` cannot be processed with `crontab -e`. It must be loaded directly into an editor, modified, then saved.

A number of packages install shell scripts to the directories `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, and `/etc/cron.monthly`, whose instructions are controlled by `/usr/lib/cron/run-crons`. `/usr/lib/cron/run-crons` is run every fifteen minutes from the main table (`/etc/crontab`). This guarantees that processes that may have been neglected can be run at the proper time.

The daily system maintenance jobs have been distributed to various scripts for reasons of clarity (package `aaa_base`). Apart from `aaa_base`, `/etc/cron.daily` thus contains for instance the components `backup-rpmdb`, `clean-tmp` or `clean-vi`.

Log Files — the Package logrotate

There are a number of system services ("daemons"), which, along with the kernel itself, regularly record the system status and specific events to log files. This way, the administrator can regularly check the status of the system at a certain point in time, recognize errors or faulty functions, and troubleshoot them with pinpoint precision. These log files are normally stored in `/var/log` as specified by FHS and grow on a daily basis. The package `logrotate` package helps control the growth of these files.

Changing to logrotate

The old settings listed below will be adopted when updating from a version older than SuSE Linux 8.0:

- Entries from `/etc/logfile` not associated with a particular package are moved to `/etc/logrotate.d/aaa_base`.
- The variable MAX_DAYS_FOR_LOG_FILES from the former `rc.config` file is mapped as dateext and maxage in the configuration file. Refer to the man page for `logrotate` (`man 8 logrotate`).

Configuration

Configure logrotate with the file /etc/logrotate.conf. In particular, the include specification primarily configures the additional files to read. SuSE Linux ensures that individual packages install files in /etc/logrotate.d (e.g., syslog or yast).

```
# see "man logrotate" for details
# rotate log files weekly
weekly

# keep 4 weeks worth of backlogs
rotate 4

# create new (empty) log files after rotating old ones
create

# uncomment this if you want your log files compressed
#compress

# RPM packages drop log rotation information into this directory
include /etc/logrotate.d

# no packages own lastlog or wtmp - we’ll rotate them here
#/var/log/wtmp {
#    monthly
#    create 0664 root utmp
#    rotate 1
#}

# system-specific logs may be also be configured here.
```

***File 24:** Example for /etc/logrotate.conf*

logrotate is controlled through cron and it is called daily by /etc/cron.daily/logrotate.

Note

The create option reads all settings made by the administrator in /etc/permissions*. Ensure that no conflicts arise from any personal modifications.

Note

Man Pages

For some GNU applications (e. g., tar) the man pages are no longer maintained. They have been replaced by info files. info is GNU's hypertext system. Typing `info info` gives a starting help for using `info`. `info` can be launched via `emacs -f info` or on its own with `info`. The programs `tkinfo` and `xinfo` are easy to use or you can access the SuSE help system.

The Command ulimit

With the `ulimit` (*user limits*) command, it is possible to set limits for the use of system resources and to have these displayed. `ulimit` is especially useful for limiting the memory available for applications. With this, an application can be prevented from using too much memory on its own, which could bring the system to a standstill.

`ulimit` can be used with various options. To limit memory usage, use the options listed in Table 11.1.

`-m`	maximum size of physical memory
`-v`	maximum size of virtual memory (swap)
`-s`	maximum size of the stack
`-c`	maximum size of the core files
`-a`	display of limits set

Table 11.1: `ulimit`*: Setting Resources for the User*

System-wide settings can be made in `/etc/profile`. There, creating core files must be enabled, needed by programmers for "debugging". A normal user cannot increase the values specified in `/etc/profile` by the system administrator, but he can make special entries in his own `~/.bashrc`.

```
# Limits of physical memory:
ulimit -m 98304

# Limits of virtual memory:
ulimit -v 98304
```

File 25: *ulimit: Settings in ~/.bashrc*

Details of memory must be specified in KB. For more detailed information, see the man page for `bash` (`man bash`).

Note

Not all shells support `ulimit` directives. PAM (for instance, `pam_limits`) offers comprehensive adjustment possibilities should you depend on encompassing settings for these restrictions.

Note

The free Command

The `free` command is somewhat misleading if your goal is to find out how much RAM is currently being used. The relevant information can be found in `/proc/meminfo`. These days, users, who have access to a modern operating system such as Linux, should not really have to worry much about memory. The concept of "available RAM" dates back to before the days of unified memory management. The slogan *free memory is bad memory* applies well to Linux. As a result, Linux has always made the effort to balance out caches without actually allowing free or unused memory.

Basically, the kernel does not have direct knowledge of any applications or user data. Instead, it manages applications and user data in a "page cache". If memory runs short, parts of it will be either written to the swap partition or to files, from which they can initially be read with the help of the `mmap` command (see the man page for `mmap` (`man 2 mmap`)).

Furthermore, the kernel also contains other caches, such as the "slab cache" where the caches used for network access are stored. This may explain differences between the counters in `/proc/meminfo`. Most, but not all of them, can be accessed via `/proc/slabinfo`.

The File /etc/resolv.conf

Domain name resolution is handled through the file `/etc/resolv.conf`. Refer to *DNS — Domain Name System* on page 323 on this.

This file is updated by the script `/sbin/modify_resolvconf` exclusively, with no other program having permission to modify `/etc/resolv.conf` directly. Enforcing this rule is the only way to guarantee that the system's network configuration and the relevant files are kept in a consistent state.

Settings for GNU Emacs

GNU Emacs is a complex work environment. More information is available at http://www.gnu.org/software/emacs/. The following sections cover the configuration files processed when GNU Emacs is started.

On start-up, Emacs reads several files containing the specifications of the user, system administrator, and distributor for customization or preconfiguration. The initialization file ~/.emacs is installed to the home directories of the individual users from /etc/skel. .emacs, in turn, reads the file /etc/skel/.gnu-emacs. If a user wants to customize the program, the .gnu-emacs should be copied to the home directory and the desired settings should be specified there:

```
cp /etc/skel/.gnu-emacs  /.gnu-emacs
```

.gnu-emacs defines the file ~/.gnu-emacs-custom as custom-file. If users specify settings with the customize options, these will be saved to ~/.gnu-emacs-custom.

When the package emacs is installed in SuSE Linux, the file site-start.el is installed in the directory /usr/share/emacs/site-lisp. The file site-start.el is loaded *before* the initialization file ~/.emacs. Among other things, site-start.el makes sure that special configuration files distributed with Emacs add-on packages are loaded automatically (e.g., the package psgml). Configuration files of this type are also located in /usr/share/emacs/site-lisp and always begin with suse-start-. The local system administrator can specify system-wide settings in default.el.

More information about these files is available in the Emacs info file under *Init File*: info:/emacs/InitFile. Information about how to prevent these files from loading is also provided at this location.

The components of Emacs are split in several packages:

- The base package emacs.
- Usually, the package emacs-x11 should be installed. This package contains the program *with* X11 support.
- The package emacs-nox contains the program *without* X11 support.
- The package emacs-info: online documentation in info format.
- The package emacs-el contains the uncompiled library files in Emacs Lisp. These are not required at run-time.

- Numerous add-on packages that can be installed if needed: the package `emacs-auctex` (for LaTeX), the package `psgml` (for SGML and XML), the package `gnuserv` (for client/server operation), and others.

Booting with the Initial Ramdisk

As soon as the Linux kernel has been booted and the root file system (`/`) mounted, programs can be run and further kernel modules can be integrated to provide additional functions. To mount the root file system, certain conditions must be met. The kernel needs the corresponding drivers to access the device on which the root file system is located (especially SCSI drivers). The kernel must also contain the code needed to read the file system (`ext2`, `reiserfs`, `romfs`, etc.). It is also conceivable that the root file system is already encrypted. In this case, a password is needed to mount the file system.

For the problem of SCSI drivers, a number of different solutions are possible: the kernel could contain all imaginable drivers. This might be a problem because different drivers could conflict with each other. Also, the kernel will become very large because of this. Another possibility is to provide different kernels, each one containing just one or a few SCSI drivers. This method also has the problem that a large number of different kernels are required, a problem then increased by the differently optimized kernels (Pentium optimization, SMP). The idea of loading the SCSI driver as a module leads to the general question answered by the concept of an *initial ramdisk*: creating a way of being able to run user space programs even before the root file system is mounted.

Concept of the Initial Ramdisk

The *initial ramdisk* (also called "initdisk" or "initrd") solves precisely the problems described above. The Linux kernel provides an option of having a small file system loaded to a RAM disk and running programs there before the actual root file system is mounted. The loading of `initrd` is handled by the boot loader (GRUB, LILO, etc.). Boot loaders only need BIOS routines to load data from the boot medium. If the boot loader is able to load the kernel, it can also load the initial ramdisk. Special drivers are not required.

The Order of the Booting Process with initrd

The boot loader loads the kernel and the `initrd` to memory and starts the kernel. The boot loader informs the kernel that an `initrd` exists and where it is located in memory.

If the initrd was compressed (which is typically the case), the kernel decompresses the initrd and mounts it as a temporary root file system. A program called linuxrc is then started. This program can now do all the things necessary to mount the proper root file system. As soon as linuxrc finishes, the temporary initrd is unmounted and the boot process continues as normal with the mounting of the proper root file system. Mounting the initrd and running linuxrc can be seen as a short interlude during a normal boot process.

The kernel tries to remount initrd to the /initrd directly after the actual root partition is booted. If this fails because the mount point /initrd does not exist, for example, the kernel will attempt to unmount initrd. If this does not work, the system is fully functional, but the memory taken up by initrd can no longer be unlocked and thus will no longer be available.

linuxrc

These are the only requirements for the program linuxrc in the initrd. It must have the special name linuxrc and it must be located in the root directory of the initrd. Apart from this, it only needs to be executable by the kernel. This means that linuxrc may be dynamically linked. In this case, the "shared libraries" in /lib must be completely available in initrd. linuxrc can also be a shell script. For this to work, a shell must exist in /bin. In short, initrd must contain a minimal Linux system that allows the program linuxrc to be run. When SuSE Linux is installed, a statically-linked linuxrc is used to keep initrd as small as possible (space on boot disks is very limited). linuxrc is run with root permissions.

The Real Root File System

As soon as linuxrc terminates, initrd is unmounted and discarded, the boot process carries on as normal, and the kernel mounts the real file system. What is mounted as the root file system can be influenced by linuxrc. It just needs to mount the /proc file system and write the value of the real root file system in numerical form to /proc/sys/kernel/real-root-dev.

Boot Loaders

Most boot loaders (above all, GRUB, LILO, and syslinux) can handle initrd. Individual boot loaders are given instructions for how to use initrd as follows:

GRUB Enter the following line in /boot/grub/menu.lst:

```
initrd (hd0,0)/initrd
```

Because the loading address of the initrd is written to the loaded kernel image, the `initrd` command must follow the `kernel` command.

LILO

Enter the following line in `/etc/lilo.conf`:

```
initrd=/boot/initrd
```

The file `/boot/initrd` is the *initial ramdisk*. It can be, but does not have to be, compressed.

syslinux

Enter the following line in `syslinux.cfg`:

```
append initrd=initrd ⟨further parameters⟩
```

Using initrd in SuSE

Installing the System

The `initrd` has already been used for some time for the installation: the user can load modules and make the entries necessary for an installation (above all, for the source medium). linuxrc then starts YaST, which carries out the installation. When YaST has finished, it tells linuxrc where the root file system of the freshly installed system is located. linuxrc writes this value to `/proc`, terminates, and informs the kernel to continue booting into the newly installed system.

For an installation of SuSE Linux, you are, from the very beginning, booting the system being installed. A real reboot after installation only takes place if the kernel does not match the modules installed in the system. Because SuSE Linux uses a kernel for uniprocessor systems during installation, a reboot is only necessary if an SMP kernel was installed in the system with the corresponding modules.

Booting the Installed System

In the past, YaST has provided more than forty kernels for installing in the system, with the only basic difference a specific SCSI driver. This was necessary to be able to mount the root file system after booting. Further drivers could then be loaded afterwards as modules. Because optimized kernels are now available, this concept is no longer feasible — by now, over one hundred kernel images would be needed.

This is why an `initrd` is used now, even to start the system normally. The way it is used is similar to that for an installation. The linuxrc used here, however, is simply a shell script with the task of loading a given module. Typically, this is just one single module — the very SCSI driver needed to access the root file system.

Creating an initrd

An `initrd` is created by means of the script `mkinitrd` (previously `mk_initrd`). In SuSE Linux, the modules to load are specified by the variable INITRD_MODULES in `/etc/sysconfig/kernel`. After installation, this variable is automatically occupied by the correct values (the installation linuxrc knows which modules were loaded). The modules are loaded in exactly the order in which they appear in INITRD_MODULES. This is especially important if a number of SCSI drivers are used, because otherwise the names of the hard disks would change. Strictly speaking, it would be sufficient just to load those drivers needed to access the root file system. Because the automatic loading of additional SCSI drivers may cause problems (how should it be "triggered" if hard disks hang on the second SCSI adapter), all SCSI drivers needed at the installation are loaded by means of `initrd`.

Note

Because the loading of the `initrd` with the boot loader runs in the same way as loading the kernel itself (LILO notices, in its `map` file, the location of the files), you must run `lilo` if LILO after every change in `initrd`, if LILO is used as the boot loader. If grub is used for booting, this step is not needed.

Note

Possible Difficulties — Self-Compiled Kernels

A self-compiled kernel can often lead to the following problem: out of habit, the SCSI driver is hard-linked to the kernel, but the existing `initrd` remains unchanged. When you boot, the following occurs. The kernel already contains the SCSI driver, so the hardware is detected. `initrd`, however, now tries to load the driver again as a module. With some SCSI drivers, especially with `aic7xxx`, this leads to the system blocking. Strictly speaking, this is a kernel error. An already existing driver should not be allowed to be loaded again as a module. The problem is already known from another context, however (serial drivers).

There are several solutions to the problem: either configure the driver as a module (then it will be correctly loaded in the `initrd`) or remove the entry for `initrd` from the file `/etc/lilo.conf`. An equivalent to the latter solution is to remove the variable INITRD_MODULES then run `mkinitrd`, which then realizes that no `initrd` is needed.

Prospects

It is quite possible in the future that an `initrd` will be used for many more and much more sophisticated things than loading modules needed to access `/`.

- High-end EIDE drivers
- Root file system on RAID software (linuxrc sets up the `md` devices)
- Root file system on the LVM
- Root file system is encrypted (linuxrc asks for the password)
- Root file system on a SCSI hard disk on a PCMCIA adapter

For More Information

`/usr/src/linux/Documentation/ramdisk.txt`
`/usr/src/linux/Documentation/initrd.txt`
the man page for `initrd` (`man 4 initrd`)

linuxrc

linuxrc is started during the boot of the kernel, usually as a prelude to a Linux system installation, before the "actual" booting commences (the kernel must first be properly configured, of course). This allows you to boot a small, modularized kernel and to load the few drivers needed as modules from a floppy disk.

If needed, linuxrc assists in loading the related drivers.

You can also use linuxrc as a boot tool for an already installed system. You can even start a totally independent RAM disk–based rescue system, for example, if something serious should happen to your hard disk or you have simply forgotten your `root` password. More about this below, in Section *The SuSE Rescue System* on page 267.

Main Menu

After you have selected the language and keyboard, find yourself in linuxrc's main menu (see Figure 1.2 on page 11). Normally, linuxrc is used to start Linux. Go to the start menu to start an installation ('Start installation / system').

Settings / Preferences

Specify your settings in respect to 'Language', 'Screen' (Color/monochrome), 'Keyboard Layout', and 'Debug (Experts)'.

System Information

In 'System Information' (Figure 11.1), check a number of other things, besides kernel messages, such as the I/O addresses of PCI cards or the size of the main memory recognized by Linux.
You can check some system information in 'System information'. Here, check the used interrupts, I/O ports used, main memory, and recognized PCI devices as detected by Linux.

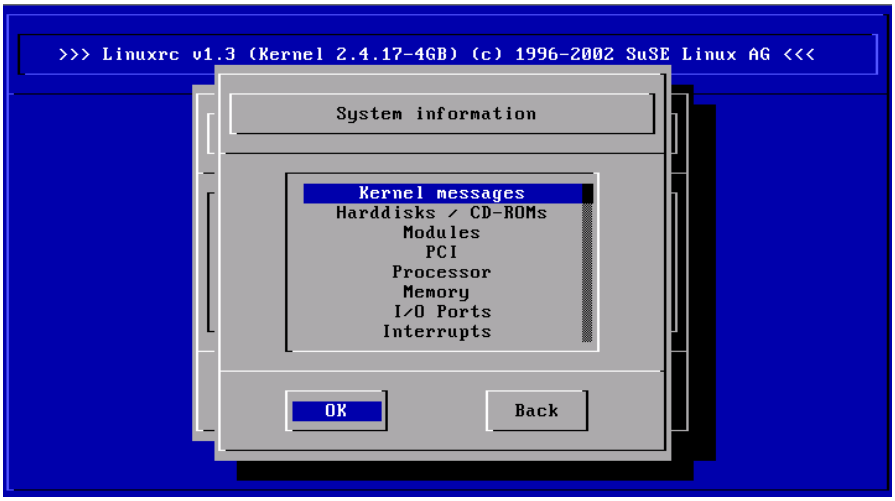


Figure 11.1: *System Information*

The next lines show how a hard disk and a CD-ROM connected to an (E)IDE controller announce their start. In this case, you do not need to load additional modules:

```
hda: ST32140A, 2015MB w/128kB Cache, LBA, CHS=1023/64/63
hdb: CD-ROM CDR-S1G, ATAPI CD-ROM drive
Partition check:
 hda: hda1 hda2 hda3 < hda5 >
```

If you booted a kernel that already had a SCSI driver compiled, you do not need this SCSI driver as a module as well. Quite typical announcements when loading SCSI adapters and connected devices might look like this:

```
scsi : 1 host.
Started kswapd v 1.4.2.2
scsi0 : target 0 accepting period 100ns offset 8 10.00MHz FAST SCSI-II
scsi0 : setting target 0 to period 100ns offset 8 10.00MHz FAST SCSI-II
  Vendor: QUANTUM   Model: VP32210           Rev: 81H8
  Type:   Direct-Access                      ANSI SCSI revision: 02
Detected scsi disk sda at scsi0, channel 0, id 0, lun 0
scsi0 : target 2 accepting period 236ns offset 8 4.23MHz synchronous SCSI
scsi0 : setting target 2 to period 248ns offset 8 4.03MHz synchronous SCSI
  Vendor: TOSHIBA   Model: CD-ROM XM-3401TA  Rev: 0283
  Type:   CD-ROM                             ANSI SCSI revision: 02
scsi : detected 1 SCSI disk total.
SCSI device sda: hdwr sector= 512 bytes. Sectors= 4308352 [2103 MB] [2.1 GB]
Partition check:
 sda: sda1 sda2 sda3 sda4 < sda5 sda6 sda7 sda8 >
```

Loading Modules

Select which kinds of modules you need. If you booted via disk, the corresponding data must be read by linuxrc and displayed in a list.

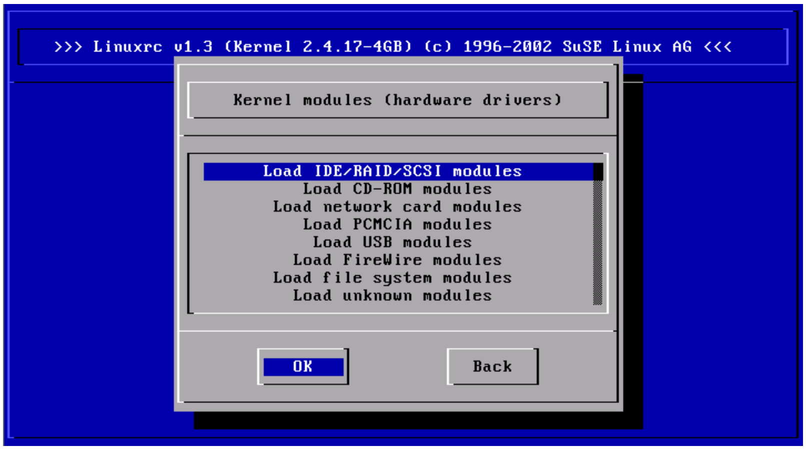
If you have booted from CD or from DOS (via loadlin), these modules are already set in linuxrc. This saves tedious loading, but requires additional memory.

linuxrc offers a list of available drivers. On the left is the name of the module and, on the right, a short description of its usage. For some components, there are a variety of drivers from which to choose (even newer alpha drivers).

Passing Parameters

When you have found a suitable driver, move to it with the cursor and press ↵. This opens a dialog box in which to add additional parameters for this module.

Beware that — in contrast to entering the parameters at the kernel prompt (as in MILO, LILO, or SYSLINUX) — multiple parameters for the same module must be separated here by a blank space.



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Kernel modules (hardware drivers)

Load IDE/RAID/SCSI modules
Load CD-ROM modules
Load network card modules
Load PCMCIA modules
Load USB modules
Load FireWire modules
Load file system modules
Load unknown modules
```

Figure 11.2: *Load Modules*

In most cases, it is not necessary to specify the hardware in detail. Most drivers find their components automatically. Specifying parameters is only necessary if you have a network card or an older CD-ROM drive with a proprietary controller card. If in doubt, just try pressing ↵.

Recognizing and initializing certain hardware can take some time. Switching to virtual console 4 (Alt + F4) lets you watch the kernel messages while loading. SCSI drivers need a while, as they have to wait for each device to load.

The messages are displayed by linuxrc so you can verify that everything ran smoothly. If it fails, the messages might give a hint as to why.

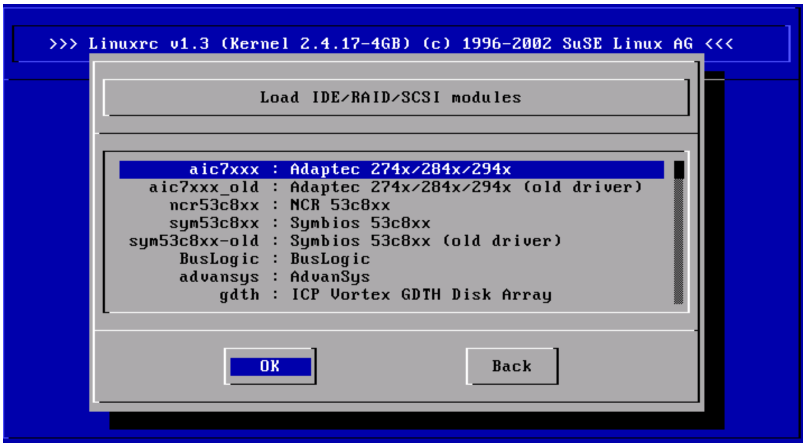
Start Installation / System

Once you have set up hardware support via modules, proceed to the 'Start installation / system' menu.

From here, a number of procedures can be started: 'Start installation' (an update is also started from this item), 'Boot installed system' (the root partition must be known), 'Start rescue system' (refer to Section *The SuSE Rescue System* on the next page), and 'Eject CD'.

'Start Live-CD' is only available if you booted a "LiveEval CD". Download ISO images from the FTP server (`live-eval-<VERSION>`):

`ftp://ftp.suse.com/pub/suse/i386/`



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

                 Load IDE/RAID/SCSI modules

        aic7xxx : Adaptec 274x/284x/294x
    aic7xxx_old : Adaptec 274x/284x/294x (old driver)
      ncr53c8xx : NCR 53c8xx
      sym53c8xx : Symbios 53c8xx
  sym53c8xx-old : Symbios 53c8xx (old driver)
       BusLogic : BusLogic
       advansys : AdvanSys
           gdth : ICP Vortex GDTH Disk Array
```

Figure 11.3: *Selection of SCSI Drivers*

Tip

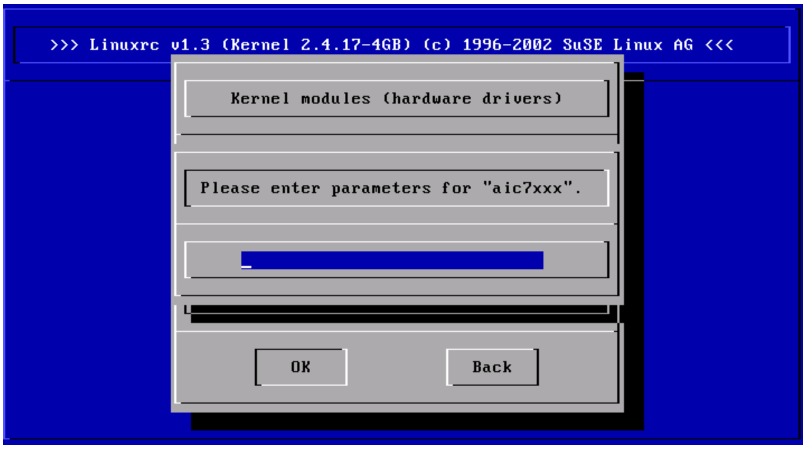
The item 'Start Live-CD' can be of great use if, for example, you want to test, without actually installing, if the computer in question or the laptop you might want to buy is at all compatible with SuSE Linux — such a test ought to be possible in every modern PC shop, without any trouble.

Tip

For the installation (Figure 11.5 on page 269), choose various sources for the installation and similarly for the rescue system (see Figure 11.5 on page 269).

The SuSE Rescue System

SuSE Linux contains several Linux rescue systems so that, in emergencies, your Linux partitions on the hard disks are reachable "from the outside": via a boot disk or the "Rescue" System, loaded from disk, CD, the network, or the SuSE FTP server. There is also a bootable SuSE Linux CD (the *"LiveEval CD"*) that can be used as a rescue system. The rescue system includes several help programs with which you can remedy large problems with inaccessible hard disks, misconfigured configuration files, or other similar problems.



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Kernel modules (hardware drivers)

Please enter parameters for "aic7xxx".
```

Figure 11.4: *Entering Parameters for a Module to Load*

Another aspect of the rescue system is Parted, which is used for modifying the partition size. This program can be launched from inside the rescue system itself, if you do not want to take advantage of the resizer integrated in YaST. Information on Parted can be found at:

`http://www.gnu.org/software/parted/`

Tip

Always have a boot and rescue disk at hand, because the slight effort for creating and maintaining the disk is negligible in comparison to the time wasted and work involved when, in the case of emergency, you cannot access your system or your CD-ROM drive.

Tip

Preparations

For setting up your rescue system, you need two disks free of errors: one as a future boot disk and the other for the compressed image of a small root file system. The image file `bootdisk` for booting the system and the file `rescue` for the root file system can be found on the first CD in the `boot` directory.

There are three ways to set up the root file system on the disk:

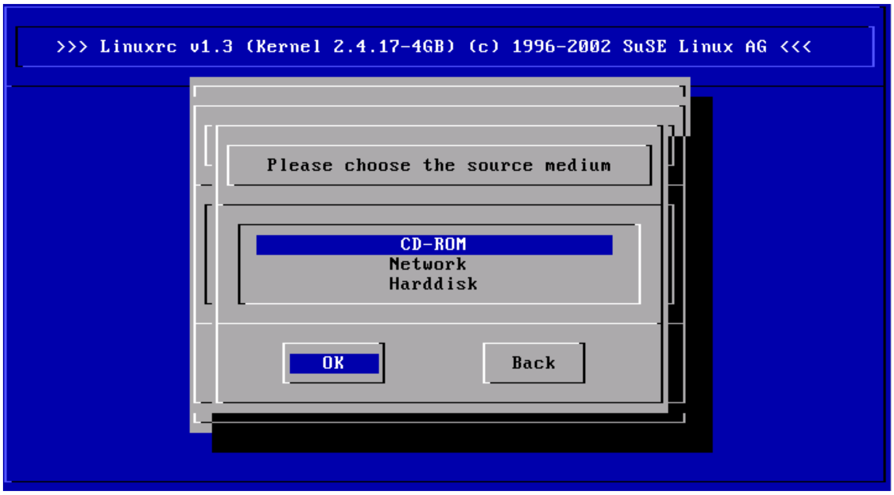

```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<
```

Figure 11.5: Selection of Source Media in linuxrc

- with YaST
- in a console using the Linux commands

```
earth:~ #  /sbin/badblocks -v /dev/fd0 1440
earth:~ #  dd if=/media/cdrom/boot/rescue of=/dev/fd0 bs=18k
```

- at the DOS prompt (where the CD-ROM drive is `Q:`)

```
Q:\> cd \dosutils\rawrite Q:\dosutils\rawrite> rawrite.exe
```

As of Version 8.0, the rescue disk is currently based on libc5 (SuSE Linux 5.3), since it is possible in this to save some programs, such as an editor, fdisk, or e2fsck to a disk.

Note

The rescue disk cannot be mounted, because it is not a file system. It only contains the compressed images of one. Directions for reading the file system are in the following paragraph.

Note

To read the image, you will need to decompress the image file then mount the decompressed image as user `root`. If your Linux kernel support the *loop device*, the procedure is as follows:

```
earth:~ #  cp /media/cdrom/boot/rescue /root/rescue.gz
earth:~ #  gunzip /root/rescue.gz
earth:~ #  mount -t ext2 -o loop /root/rescue /mnt
```

Starting the Rescue System

The rescue system is launched by the SuSE boot disk you created or by your bootable CD or DVD. It is required that the disk and CD-ROM or DVD drives are bootable. If necessary, change the boot series in the CMOS setup. Following are the steps for starting the rescue system:

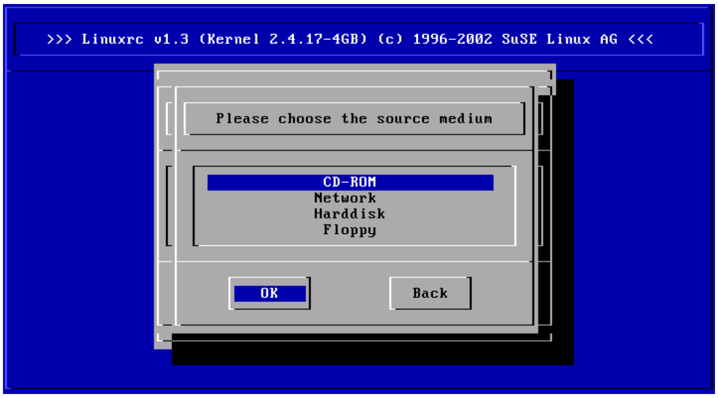
1. Start your system with the SuSE boot disk created yourself or with the first SuSE Linux CD or DVD inserted into the corresponding drive.
2. Launch the entire system or choose 'Manual Installation' so that 'boot options' can be entered and kernel modules to load can be defined.
3. Make the respective settings for language and keyboard.
4. Select the item 'Installation/Start system' in the main menu.
5. If you started with the boot disk, now insert the installation CD or the `rescue` disk with the compressed image of the rescue system.
6. In the menu 'Start installation/system' select the item 'Start rescue system' (see Figure 1.3 on page 12) then specify the desired source medium (Figure 11.6 on the next page).

   Subsequently, we will introduce a few tips on selection options:

   'CD-ROM': When loading the rescue system, the path `/cdrom` is exported. This makes the installation from *this* CD possible.

   'Network': For starting the `rescue` system over a network connection, the network card's driver must be loaded first. See the general information on this in Section *Installation from a Network Source* on page 17. Several protocols exist for this purpose (see Figure 11.7 on page 272), such as NFS, FTP, or SMB.

   'Hard disk': Load the `rescue` system from the hard disk.



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Please choose the source medium

CD-ROM
Network
Harddisk
Floppy
```

Figure 11.6: *Source Medium for the Rescue System*

'Floppy Disk': The `rescue` system can also be started from the floppy disk, especially if the computer only has a small amount of working memory.

Regardless of the medium chosen, the rescue system will be decompressed, loaded onto a RAM floppy disk as a new root file system, mounted, and started. Now it is ready for use.

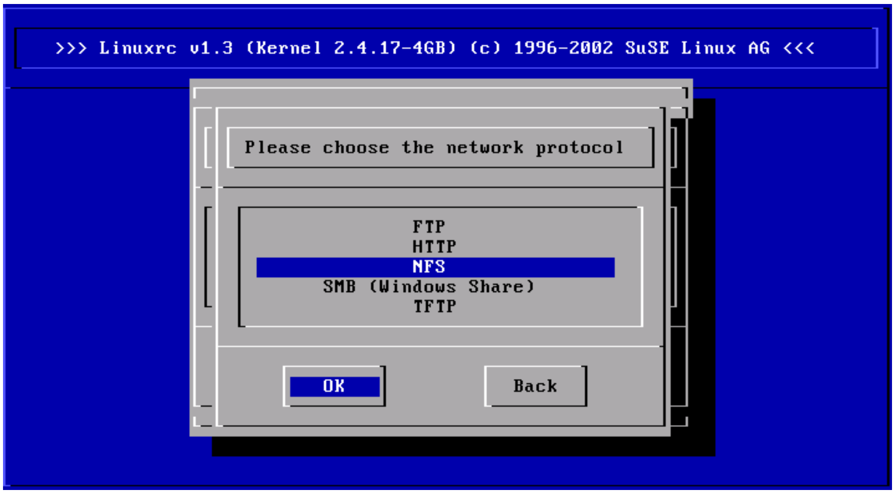
Working with the Rescue System

The rescue system provides three virtual consoles on keys Alt + F1 to Alt + F3. Here, `root` may log in without a password. Alt + F4 accesses the system console, where you can view the kernel and syslog messages.

A shell and lots of other useful utilities (net tools), such as the mount program, can be found in the `/bin` directory. In `sbin`, find important file and network utilities for reviewing and repairing the file system (e.g., e2fsck).

Furthermore, this directory contains the most important binaries for system maintenance, such as fdisk, mkfs, mkswap, mount, mount, init, and shutdown, as well as ifconfig, route, and netstat for maintaining the network.

An editor, vi, is located in `/usr/bin`. Also, tools like grep, find, and less, along with telnet are available.



```
>>> Linuxrc v1.3 (Kernel 2.4.17-4GB) (c) 1996-2002 SuSE Linux AG <<<

Please choose the network protocol

FTP
HTTP
NFS
SMB (Windows Share)
TFTP
```

Figure 11.7: Network Protocols

Accessing Your Normal System

To mount your SuSE Linux system using the rescue system, use the mount point `/mnt`. You can also use or create another directory.

As an example, assume your normal system is put together according to the `/etc/fstab` shown in the example File 26.

```
/dev/sdb5       swap        swap        defaults    0   0
/dev/sdb3       /           ext2        defaults    1   1
/dev/sdb6       /usr        ext2        defaults    1   2
```

File 26: Sample /etc/fstab

Caution

Pay attention to the order of steps outlined in the following section for mounting the various devices.

Caution

To access your entire system, mount it step-by-step in the `/mnt` directory using the following commands:

```
earth:/ #  mount /dev/sdb3 /mnt
earth:/ #  mount /dev/sdb6 /mnt/usr
```

Now, you can access your entire system and, for example, correct mistakes in configuration files such as `/etc/fstab`, `/etc/passwd`, and `/etc/inittab`. The configuration files are now located in the `/mnt/etc` directory instead of in `/etc`.

To recover even completely lost partitions with the fdisk program by simply setting it up again, determine where on the hard disk the partitions were previously located and make a printout of the `/etc/fstab` directory as well as the output of the command

```
earth:~ #  fdisk -l /dev/⟨disk⟩
```

Instead of the ⟨*disk*⟩ variable, insert, in order, the device names of your hard disks, such as `hda`.

Repairing File Systems Damaged file systems are tricky problems for the rescue system. This could happen after an unscheduled shutdown caused by power failure or a system crash. Generally, file systems cannot be repaired on a running system. If you encounter really severe problems, you may not even be able to mount your root file system so the system boot ends in a "kernel panic". Here, the only chance is to repair the system from the “outside” using a rescue system.

The SuSE Linux rescue system contains the utilities e2fsck and dumpe2fs (for diagnosis). These should remedy most problems.

In an emergency, man pages often are not available. That is why we have included them in this manual in Appendix C on page 535.

Example: If mounting a file system fails due to an *invalid* superblock, the e2fsck program would probably fail, too. If this were the case, your superblock may be corrupted, too. There are copies of the superblock located every 8192 blocks (8193, 16385, etc.). If your superblock is corrupted, try one of the copies instead. This is accomplished by entering the command:

```
earth:~ #  e2fsck -f -b 8193 /dev/damaged_partition
```

The `-f` option forces the file system check and overrides e2fsck’s error so that — since the superblock copy is intact — everything is fine.

Virtual Consoles

Linux is a multiuser and multitasking system. The advantages of these features can be appreciated, even on a stand-alone PC system.

In text mode, there are six virtual consoles available. Switch between them using Alt + F1 to Alt + F6. The seventh console is reserved for X11. More or fewer consoles can be assigned by modifying the file `/etc/inittab`.

To switch to a console from X11 without leaving X11, use Ctrl + Alt + F1 to Ctrl + Alt + F6. Alt + F7 then returns to X11.

Keyboard Mapping

To standardize the keyboard mapping of programs, changes were made to the following files:

```
/etc/inputrc
/usr/X11R6/lib/X11/Xmodmap
/etc/skel/.Xmodmap
/etc/skel/.exrc
/etc/skel/.less
/etc/skel/.lesskey
/etc/csh.cshrc
/etc/termcap
/usr/lib/terminfo/x/xterm
/usr/X11R6/lib/X11/app-defaults/XTerm
/usr/share/emacs/⟨VERSION⟩/site-lisp/term/*.el
/usr/lib/joerc
```

These changes only affect applications that make use of `terminfo` entries or whose configuration files are changed directly (`vi`, `less`, etc.). Other non-SuSE applications should be adjusted to these defaults.

Under X, the compose key ("multikey") can be accessed using the key combination Ctrl + ⇑ Shift (right). Also see the corresponding entry in `/usr/X11R6/lib/X11/Xmodmap`.

Local Adjustments — I18N/L10N

SuSE Linux is, to a very large extent, internationalized and can be modified for local needs in a flexible manner. In other words, internationalization (“I18N”) allows specific localizations (“L10N”). The abbreviations I18N and L10N are derived from the first and last letters of the words and, in between, the number of letters omitted.

Settings are made via LC_* variables defined in the file `/etc/sysconfig/language`. This refers not only to “native language support”, but also to the categories *Messages* (Language), *Character Set*, *Sort Order*, *Time and Date*, *Numbers*, and *Money*. Each of these categories can be defined directly via its own variable or indirectly via a variable in the file `language` (see the man page for `locale` (`man 5 locale`)).

1. RC_LC_MESSAGES, RC_LC_CTYPE, RC_LC_COLLATE, RC_LC_TIME, RC_LC_NUMERIC, RC_LC_MONETARY: These variables are passed to the shell without the RC_ prefix and determine the above categories. The files concerned are listed below.

   The current setting can be shown with the command `locale`.

2. RC_LC_ALL: This variable (if set) overwrites the values of the variables mentioned in item 1.

3. RC_LANG: If none of the above variables are set, this is the “fallback”. By default, SuSE Linux only sets RC_LANG. This makes it easier for users to enter their own values.

4. ROOT_USES_LANG: A `yes` or `no` variable. If it is set to `no`, `root` always works in the POSIX environment.

The other variables can be set via the YaST sysconfig editor.

The value of such a variable contains the language code, country code, encoding, and modifier. The individual components are connected by special characters:

```
LANG=⟨language⟩[[_⟨COUNTRY⟩].Encoding[@Modifier]]
```

Some Examples

You should always set the language and country codes together. Language settings follow the standard ISO 639 (`http://www.evertype.com/standards/iso639/iso639-en.html` and `http://www.loc.gov/standards/iso639-2/`). Country codes are listed in ISO 3166, see (`http://www.din.de/gremien/nas/nabd/iso3166ma/codlstp1/en_listp1.html`). It only makes sense to set values for which usable description files can be found in `/usr/lib/locale`. Additional description files can be created from the files in `/usr/share/i18n` using the command `localedef`. A description file for `en_US.UTF-8` (for English and United States) can be created with:

```
earth:~ #  localedef -i en_US -f UTF-8 en_US.UTF-8
```

LANG=en_US.ISO-8859-1

This sets the variable to English language, country to United States, and the character set to `ISO-8859-1`. This character set does not support the Euro sign, but it will be useful sometimes for programs that have not been updated to support `ISO-8859-15`. The string defining the charset (`ISO-8859-1` in our case) will then be evaluated by programs like Emacs.

LANG=en_US.UTF-8

If you use a Unicode xterm, it is necessary to specify `UTF-8` as well. To achieve this, make a small shell script called `uxterm` to start `xterm` with UTF-8 loaded each time. See File 27.

```
#!/bin/bash
export LANG=en_US.UTF-8
xterm -fn \
'-Misc-Fixed-Medium-R-Normal--18-120-100-100-C-90-ISO10646-1' \
-T 'xterm UTF-8' $*
```

File 27: *uxterm to Start a Unicode xterm*

SuSEconfig reads the variables in `/etc/sysconfig/language` and writes the necessary changes to `/etc/SuSEconfig/profile` and `/etc/SuSEconfig/csh.cshrc`. `/etc/SuSEconfig/profile` is read or “sourced” by `/etc/profile`. `/etc/SuSEconfig/csh.cshrc` is sourced by `/etc/csh.cshrc`. This makes the settings available system-wide.

Settings for Language Support

Files in the category *Messages* are, as a rule, only stored in the language directory (e. g., `en`) to have a fallback. If you set LANG to `en,_US` and the "message" file in `/usr/share/locale/en_US/LC_MESSAGES` does not exist, it will fall back to `/usr/share/locale/en/LC_MESSAGES`.

A fallback chain can also be defined, for example, for Breton → French or for Galician → Spanish → Portuguese:

```
LANGUAGE="br_FR:fr_FR"
LANGUAGE="gl_ES:es_ES:pt_PT"
```

If desired, use the Norwegian variants "nynorsk" and "bokmål" instead (with additional fallback to `no`):

```
LANG="nn_NO"
LANGUAGE="nn_NO:nb_NO:no"
```

or

```
LANG="nb_NO"
LANGUAGE="nb_NO:nn_NO:no"
```

Note that in Norwegian, LC_TIME is also treated differently.

Possible Problems

- The thousand comma is not recognized. LANG is probably set to `en`, but the description the glibc uses is located in `/usr/share/locale/en_US/LC_NUMERIC`. LC_NUMERIC, for example, must be set to `en_US`.

For More Information

- *The GNU C Library Reference Manual*, Chap. "Locales and Internationalization"; included in package `glibc-info`.
- Markus Kuhn, *UTF-8 and Unicode FAQ for Unix/Linux*, currently at `http://www.cl.cam.ac.uk/~mgk25/unicode.html`.
- *Unicode-Howto*, by Bruno Haible `file:/usr/share/doc/howto/en/html/Unicode-HOWTO.html`.

The SuSE Linux Boot Concept

Booting and initializing a UNIX system can challenge even an experienced system administrator. This chapter gives a short overview of the SuSE Linux boot concept. The new implementation is compatible with the *System Initialization* section of the LSB specification (Version 1.3.x). Refer to *Linux Standard Base (LSB)* on page 252 for more information about LSB.

The init Program 280
Runlevels 280
Changing Runlevels 282
Init Scripts 283
The YaST Runlevel Editor 286
SuSEconfig and /etc/sysconfig 288
The YaST sysconfig Editor 289

The simple words "Uncompressing Linux..." signal that the kernel is taking control of your hardware. It checks and sets your console — more precisely: the BIOS registers of graphics cards and output format — to read BIOS settings and to initialize basic hardware interfaces. Next, your drivers “probe” existing hardware and initialize it accordingly. After checking the partitions and mounting the root file system, the kernel starts init, which “boots” (Unix jargon) the main system with all its programs and configurations. The kernel controls the entire system, including hardware access and the CPU time programs use.

The init Program

The program init is the process responsible for initializing the system itself in the required way. All other processes are considered child processes of init.

init takes a special role. It is started directly by the kernel and resists *signal 9*, which normally kills processes. All other programs are either started directly by init or by one of its “child” processes.

init is centrally configured via the `/etc/inittab` file. Here, the “runlevels” are defined (see *Runlevels* on this page). It also specifies which services and daemons are available in each of the levels.

Depending on the entries in `/etc/inittab`, several scripts are run by init. For reasons of clarity, these scripts all reside in the directory `/etc/init.d`.

The entire process of starting the system and shutting it down is maintained by init. From this point of view, the kernel can be considered a background process whose task it is to maintain all other processes and to adjust CPU time and hardware access according to requests from other programs.

Runlevels

In Linux, *runlevels* define how the system is started. After booting, the system starts as defined in `/etc/inittab` in the line `initdefault`. Usually this is `3` or `5` (see Table 12.1 on the next page). An alternative to this is assigning a special runlevel at boot time (e. g., at the boot prompt). The kernel passes any parameters it does not need directly to init.

To change runlevels while the system is running, enter init and the corresponding number as an argument. Only the system administrator is allowed to do this.

`init 1` (or `shutdown now`) causes the system to change to *single user mode*, which is used for system maintenance and administration. After finishing his work, the administrator can switch back to the normal runlevel by entering `init 3`, which starts all the essential programs and allows regular users to log in and to work with the system. On the other hand, `init 0` (or `shutdown -h now`) causes the system to halt. `init 6` (or `shutdown -r now`) causes it to shut down with a subsequent reboot.

Note

Runlevel 2 with a `/usr/` Partition Mounted via NFS

You should not use runlevel 2 if your system mounts the `/usr` partition via NFS. The `/usr` directory holds important programs essential for the proper functioning of the system. Because the NFS service is not made available by runlevel 2 (local multiuser mode without remote network), the system would be seriously restricted in many aspects.

Note

Runlevel	Description
0	System halt
S	Single user mode; from the boot prompt, only with US keyboard
1	Single user mode
2	Local multiuser mode without remote network (e.g., NFS)
3	Full multiuser mode with network
4	Not used
5	Full multiuser mode with network and X display manager — KDM (default), GDM, or XDM
6	System reboot

Table 12.1: *Available Runlevels*

Runlevel 5 is the default runlevel in all SuSE Linux standard installations. Users are prompted for login directly under a graphical interface.

If you have already installed and configured the X Window System properly as described in *The X Window System* on page 93) and want users to log in via a graphical user interface, change the runlevel to 5. Try it first by typing `init 5` to see whether the system works as expected. If it does, use YaST to set the default runlevel to 5.

Caution

Modifying `/etc/inittab`

If `/etc/inittab` is damaged, the system might not boot properly. Therefore, be extremely careful while editing `/etc/inittab` and always keep a backup of an intact version. To repair damage, try entering `init=/bin/sh` after the kernel name at the boot prompt to boot directly into a shell. After that, replace `/etc/inittab` with your backup version using the `cp` command.

Caution

Changing Runlevels

Generally, two things happen when you change runlevels. First, *stop scripts* of the current runlevel are launched, closing down some programs essential for the current runlevel. Then *start scripts* of the new runlevel are started. Here, in most cases, a number of programs will be started.

For example, the following occurs when changing from runlevel 3 to 5:

- The administrator (`root`) tells init to change to a different runlevel by entering `init 5`.
- init now consults its configuration file (`/etc/inittab`) and realizes it should start `/etc/init.d/rc` with the new runlevel as a parameter.
- Now rc calls all the stop scripts of the current runlevel, but only for those where there is no start script in the selected new runlevel. In our example, these are all the scripts that reside in `/etc/init.d/rc3.d` (old runlevel was 3) and start with a `'K'`. The number following `'K'` guarantees a certain order to start, as there are some dependencies to consider.

  Note

  The names of the stop scripts always begin with `'K'` for kill. Start scripts begin with `'S'` for start.

  Note

- The last things to start are the start scripts of the new runlevel. These are (in our example) in `/etc/init.d/rc5.d` and begin with an `'S'`. The same procedure regarding the order in which they are started is applied here.

When changing into the same runlevel as the current runlevel, init only checks `/etc/inittab` for changes and starts the appropriate steps (e. g., for starting a getty on another interface).

Init Scripts

Scripts in `/etc/init.d` are divided into two sections:

- scripts executed directly by init. This only applies while booting and shutting down the system immediately (power failure or a user pressing Ctrl + Alt + Del).
- scripts executed indirectly by init. These are run when changing the runlevel and always call the master script /etc/init.d/rc, which guarantees the correct order of the relevant scripts.

All scripts are located in `/etc/init.d`. Scripts for changing the runlevel are also found there, but are called via symbolic links from one of the subdirectories (`/etc/init.d/rc0.d` to `/etc/init.d/rc6.d`). This is just for clarity reasons and avoids duplicate scripts (e. g., if they are used in several runlevels). Because every script can be executed as both a start and a stop script, these scripts must understand the parameters "start" and "stop". The scripts understand, in addition, the "restart", "reload", "force-reload", and "status" options. These different options are explained in Table 12.2.

Option	Description
`start`	Start service.
`stop`	Stop service.
`restart`	If the service is running, stop it then restart it. If it is not running, start it.
`reload`	Reload the configuration without stopping and restarting the service.
`force-reload`	Reload the configuration if the service supports this. Otherwise, do the same as if `restart` had been given.
`status`	Show current status of service.

Table 12.2: *Possible init Script Options*

Links in each runlevel-specific subdirectory make it possible to associate scripts with different runlevels. When installing or uninstalling packages, such links are added and removed with the help of the program insserv (or using `/usr/lib/lsb/install_initd`, which is a script calling this program). See the man page for `insserv` (`man 8 insserv`) for details.

Below is a short introduction to the boot and stop scripts launched first (or last, respectively) as well as an explanation of the maintaining script.

`boot` Executed while starting the system directly using init. It is independent of the chosen runlevel and is only executed once. Here, the `proc` and `pts` file systems are mounted and the blogd (Boot Logging Daemon) is activated. If the system is booted for the first time after an update or an installation, the initial system configuration is started.

The blogd daemon is a service started by the boot *and* by the rc scripts before any other one. It is stopped after the actions triggered by the above scripts are completed (e.g., after running a number of subscripts). The blogd daemon writes any screen output to the log file `/var/log/boot.msg` — but only if and when `/var` is mounted read-write. Otherwise, blogd buffers all screen data until `/var` becomes available. Further information about blogd can be obtained with `man blogd`.

The script `boot` is also responsible for starting all the scripts in `/etc/init.d/boot.d` with a name that starts with `'S'`. There, the file systems are checked and loop devices are configured if needed. The system time is also set. If an error occurs while automatically checking and repairing the file system, the system administrator can intervene after first entering the root password. Last executed is the script boot.local.

`boot.local` Here, enter additional commands to execute at boot before changing into a runlevel. It can be compared to `AUTOEXEC.BAT` on DOS systems.

`boot.setup` This script is executed when changing from *single user mode* to any other runlevel and is responsible for a number of basic settings, namely for the keyboard layout and for initializing the virtual consoles.

`halt` This script is only executed while changing into runlevel 0 or 6. Here, it is executed either as `halt` or as `reboot`. Whether the system shuts down or reboots depends on how halt is called.

`rc` This script calls the appropriate stop scripts of the current runlevel and the start scripts of the newly selected runlevel.

Adding init Scripts

You can create your own scripts and easily integrate them into the scheme described above. For instructions about the formatting, naming, and organization of your custom scripts, refer to the specifications of the LSB and to the man pages of `init`, `init.d`, and `insserv`. Additionally consult the man pages of `startproc` and `killproc`.

Caution

Creating Your Own init Scripts

Faulty init scripts may freeze your machine. Edit such scripts with great care and, if possible, subject them to heavy testing in the multiuser environment. Some useful information about init scripts can be found in *Runlevels* on page 280.

Caution

- To create a custom init script for a given program or service, use the file `/etc/init.d/skeleton` as a template. Save a copy of this file under the new name and edit the relevant program and file names, paths, and other details as needed. You may also need to enhance the script with your own parts, so the correct actions are triggered by the init procedure.
- The `INIT INFO` block at the top is a required part of the script and should be edited:

```
### BEGIN INIT INFO
# Provides:          FOO
# Required-Start:    $syslog $remote_fs
# Required-Stop:     $syslog $remote_fs
# Default-Start:     3 5
# Default-Stop:      0 1 2 6
# Description:       Start FOO to allow XY and provide YZ
### END INIT INFO
```

Output 15: *A Minimal INIT INFO Block*

In the first line of the `INFO` block, after `Provides:`, specify the name of the program or service controlled by this init script. In the `Required-Start:` and `Required-Stop:` lines, specify all services that need to be started or stopped, respectively, before the service itself is started or stopped.

This information is used later to generate the numbering of script names, as found in the runlevel directories. Under `Default-Start:` and `Default-Stop:`, specify the runlevels in which the service should automatically be started or stopped. Finally, under `Description:`, provide a short description of the service in question.

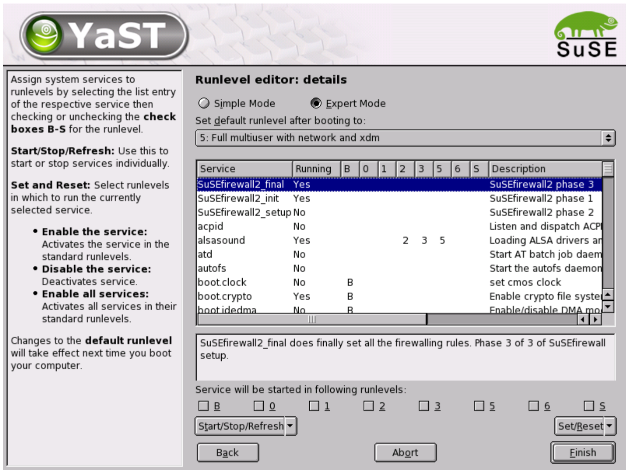
- To create the links from `/etc/init.d/` to the corresponding runlevel directories (`/etc/init.d/rc?.d/`), enter the command `insserv <new-script-name>`. The insserv program evaluates the `INIT INFO` header to create the necessary links for start and stop scripts in the runlevel directories (`/etc/init.d/rc?.d/`). The program also takes care of the correct start and stop order for each runlevel by including the necessary numbers in the names of these links. If you prefer a graphical tool to create such links, use the runlevel editor provided by YaST, as described in Section *The YaST Runlevel Editor* on the current page.

On the other hand, if a script already present in `/etc/init.d/` should be integrated into the existing runlevel scheme, create the links in the runlevel directories right away, either with insserv or by enabling the corresponding service in the runlevel editor of YaST. Your changes are applied during the next reboot — the new service will be started automatically.

The YaST Runlevel Editor

After starting this YaST module, it displays overview listing all the available services and the current status of each service — whether they are enabled or not. With the radio buttons, decide whether to use the module in 'Simple Mode' or in 'Expert Mode'. The default 'Simple Mode' should be sufficient for most purposes. The leftmost column shows the name of the service, the center column indicates its current status, and the right-hand column gives a short description. For the selected service, a more detailed description is provided in the lower part of the window. To enable a service, select it in the tabl then select 'Enable'. The same steps apply to disable a service.

For detailed control over the runlevels in which a service is started or stopped or to change the default runlevel, first select 'Expert Mode'. This mode displays the current default runlevel or "initdefault", which means the runlevel into which the system boots by default. Normally, the default runlevel of a SuSE Linux system is runlevel 5 (full multiuser mode with network and XDM). A suitable alternative might be runlevel 3 (full multiuser mode with network).


Assign system services to runlevels by selecting the list entry of the respective service then checking or unchecking the **check boxes B-S** for the runlevel.

Start/Stop/Refresh: Use this to start or stop services individually.

Set and Reset: Select runlevels in which to run the currently selected service.

- **Enable the service:** Activates the service in the standard runlevels.
- **Disable the service:** Deactivates service.
- **Enable all services:** Activates all services in their standard runlevels.

Changes to the **default runlevel** will take effect next time you boot your computer.

Runlevel editor: details

Simple Mode [✓ Expert Mode]

Set default runlevel after booting to: 5: Full multiuser with network and xdm

Service	Running	B	0	1	2	3	5	6	S	Description
SuSEfirewall2_final	Yes									SuSEfirewall2 phase 3
SuSEfirewall2_init	Yes									SuSEfirewall2 phase 1
SuSEfirewall2_setup	No									SuSEfirewall2 phase 2
acpid	No									Listen and dispatch ACPI
alsasound	Yes				2	3	5			Loading ALSA drivers ar
atd	No									Start AT batch job daem
autofs	No									Start the autofs daemon
boot.clock	No	B								set cmos clock
boot.crypto	Yes	B								Enable crypto file syste
boot.idedma	No	B								Enable/disable DMA mo

SuSEfirewall2_final does finally set all the firewalling rules. Phase 3 of 3 of SuSEfirewall setup.

Service will be started in following runlevels: ☐ B ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 5 ☐ 6 ☐ S

Figure 12.1: YaST: Runlevel Editor

This YaST dialog allows selection of one of the runlevels (as listed in Table 12.1 on page 281) as the new default. Additionally use the table in this window to enable or disable individual services and daemons. The table lists the services and daemons available, tells whether they are currently enabled on your system, and, if so, for which runlevels. After selecting one of the rows with the mouse, click the check boxes representing the runlevels ('B', '0', '1', '2', '3', '5', '6', and 'S') to define the runlevels where the selected service or daemon should be running. Runlevel 4 is always undefined to allow for the creation of a custom runlevel. Finally, a brief description of the currently selected service or daemon is provided just below the table overview.

With 'Start' and 'Stop', decide whether a server should be implemented. Check the current status is checked via 'Update', if this has not already been done automatically. 'Reset to Default Value' restores the settings to their default state. 'Activate Service' only appears if the service is currently disabled. 'Finish' saves the system configuration.

Caution

Changing Runlevel Settings

Faulty runlevel settings may render a system unusable. Before applying your changes, make absolutely sure you know about their consequences.

Caution

SuSEconfig and /etc/sysconfig

The main configuration of SuSE Linux can be done via the configuration files in `/etc/sysconfig`. Former versions of SuSE Linux relied on `/etc/rc.config` for system configuration, but it became obsolete in previous versions. `/etc/rc.config` will not be created at installation time, as all system configuration is controlled via `/etc/sysconfig`. However, if `/etc/rc.config` exists at the time of a system update, it will remain intact.

The individual files in `/etc/sysconfig` are only read by the scripts to which they are relevant. This ensures that network settings, for instance, need to be parsed only by network-related scripts. Apart from that, there are many other system configuration files that are generated according to the settings in `/etc/sysconfig`. This task is performed by SuSEconfig. For example, if you change the network configuration, SuSEconfig is likely to make changes to the file `/etc/host.conf` as well, as this is one of the files relevant for the network configuration.

If you change anything in these files manually, run `/sbin/SuSEconfig` afterwards to make sure all the necessary changes are made in all the relevant places. If you change the configuration using the YaST sysconfig editor, all changes are applied automatically — YaST automatically starts `SuSEconfig` to update the configuration files as needed.

This concept enables you to make basic changes to your configuration without needing to reboot the system. BEcause some changes are rather complex, some programs must be restarted for the changes to take effect. For instance, changes to the network configuration may require a restart of the network programs concerned. This can be achieved by entering the commands `rcnetwork stop` and `rcnetwork start`.

The recommended way to change the system configuration includes the following steps:

- Bring the system into *single user mode* (runlevel 1) with `init 1`.
- Change the configuration files as needed. This can be done using an editor of your choice, or with the sysconfig editor of YaST.

Note

Manual Changes to the System Configuration

If you do *not* use YaST to change the configuration files in `/etc/sysconfig`, make sure that empty variable values are represented by two quotation marks (e.g., ⟨*KEYTABLE=""*⟩) and that values with blanks in them are enclosed in quotation marks. Values consisting of one word only do not need to be quoted.

Note

- Execute `/sbin/SuSEconfig` to make sure that the changes take effect. If you have changed the configuration files with YaST, this is done automatically.
- Bring your system back to the previous runlevel with a command like `init 3` (replace `3` with the previous runlevel).

This procedure is mainly relevant if you have changed system-wide settings (such as network configuration). It is not necessary to go into *single user mode* for small changes, but it ensures all relevant programs are correctly restarted.

Tip

To disable the automatic configuration of SuSEconfig, set the variable ⟨*ENABLE_SUSECONFIG*⟩ in `/etc/sysconfig/suseconfig` to `no`. Do not disable SuSEconfig if you want to use the SuSE installation support. It is also possible to disable the autoconfiguration partially.

Tip

The YaST sysconfig Editor

The files where the most important SuSE Linux settings are stored are located in the `/etc/sysconfig` directory. The sysconfig editor presents the settings options in an easy-to-read manner. The values can be modified and subsequently added to the individual configuration files in this directory. In general, it is not necessary to edit them manually, however, because these files are automatically adjusted when installing a package or configuring a service.

Caution

Modifications of `/etc/sysconfig/` files

Do not modify the `/etc/sysconfig` files if you lack previous experience and knowledge. It could do considerable damage to your system. The files in `/etc/sysconfig` include a short comment for each variable to explain what effect they actually have.

Caution

The YaST sysconfig dialog is split into three parts. The left part of the dialog window shows a tree view of all configurable variables. As soon as you have selected a variable, the right part displays both the current selection and the current setting of this variable. Below, a third window displays a short description of the variable's purpose, possible values, the default value, and the actual configuration file from which this variable originates. The dialog also provides information about which configuration script is executed after changing the variable and which new service is started as a result of the change. YaST asks you to confirm your changes and informs you which scripts will be executed after leaving the dialog by selecting 'Finish'. Also select the services and scripts to skip for now, so they are started later.

Part IV

Network

Linux in the Network

Linux, really a child of the Internet, offers all the necessary networking tools and features for integration into all types of network structures. An introduction into the customary Linux protocol, TCP/IP, follows. The various services and special features of this protocol are discussed. Network access using a network card can be configured with YaST. The central configuration files are discussed and some of the most essential tools described. Only the fundamental mechanisms and the relevant network configuration files are discussed in this chapter. The configuration of Internet access with PPP via modem, ISDN, or other connection can be completed with YaST. It is described in the *User Guide*.

TCP/IP — The Protocol Used by Linux 294
IPv6 — The Next Generation's Internet 302
Network Integration 311
Manual Network Configuration 314
Routing in SuSE Linux 321
DNS — Domain Name System 323
LDAP — A Directory Service 334
NIS — Network Information Service 358
NFS — Shared File Systems 363
DHCP 367
Time Synchronization with xntp 372

TCP/IP — The Protocol Used by Linux

Linux and other Unix operating systems use the TCP/IP protocol. It is not a single network protocol, but a family of network protocols that offer various services. TCP/IP was developed based on an application used for military purposes and was defined in its present form in an RFC in 1981. RFC stands for "Request for Comments". They are documents that describe various Internet protocols and implementation procedures for the operating system and its applications. Since then, the TCP/IP protocol has been refined, but the basic protocol has remained virtually unchanged.

Tip

The RFC documents describe the setup of Internet protocols. To expand your knowledge about any of the protocols, refer to the appropriate RFC document. They are available online at `http://www.ietf.org/rfc.html`

Tip

The services listed in Table 13.1 are provided for the purpose of exchanging data between two Linux machines via TCP/IP. Networks combined by TCP/IP, comprising a world-wide network are also referred to, in their entirety, as "the Internet".

Protocol	Description
TCP	Transmission Control Protocol: A connection-oriented secure protocol. The data to transmit is first sent by the application as a stream of data then converted by the operating system to the appropriate format. The data arrives at the respective application on the destination host in the original data stream format in which it was initially sent. TCP determines whether any data has been lost during the transmission and that there is no mix-up. TCP is implemented wherever the data sequence matters.
UDP	User Datagram Protocol: A connectionless, insecure protocol. The data to transmit is sent in the form of packets already generated by the application. The order in which the data arrives at the recipient is not guaranteed and data loss is a possibility. UDP is suitable for record-oriented applications. It features a smaller latency period than TCP.

***Table 13.1:** continued overleaf. . .*

ICMP	Internet Control Message Protocol: Essentially, this is not a user-friendly protocol, but a special control protocol that issues error reports and can control the behavior of machines participating in TCP/IP data transfer. In addition, a special echo mode is provided by ICMP that can be viewed using the program ping.
IGMP	Internet Group Management Protocol: This protocol controls the machine behavior when implementing IP multicast. The following sections do not contain more infomation regarding IP multicasting, because of space limitations.

Table 13.1: *Several Protocols in the TCP/IP Protocol Family*

Almost all hardware protocols work on a packet-oriented basis. The data to transmit is packaged in "bundles", as it cannot be sent all at once. This is why TCP/IP only works with small data packets. The maximum size of a TCP/IP packet is approximately sixty-four kilobytes. The packets are normally quite a bit smaller, as the network software can be a limiting factor. The maximum size of a data packet on an ethernet is about fifteen hundred bytes. The size of a TCP/IP packet is limited to this amount when the data is sent over an ethernet. If more data is transferred, more data packets need to be sent by the operating system.

Layer Model

IP (Internet Protocol) is where the insecure data transfer takes place. TCP (Transmission Control Protocol), to a certain extent, is simply the upper layer for the IP platform serving to guarantee secure data transfer. The IP layer itself is, in turn, supported by the bottom layer, the hardware-dependent protocol, such as ethernet. Professionals refer to this structure as the "layer model". See Figure 13.1 on the next page.

The diagram provides one or two examples for each layer. As you can see, the layers are ordered according to "degrees of abstraction". The lowest layer is very close to the hardware. The uppermost layer, however, is almost a complete abstraction from the hardware. Every layer has its own special function.

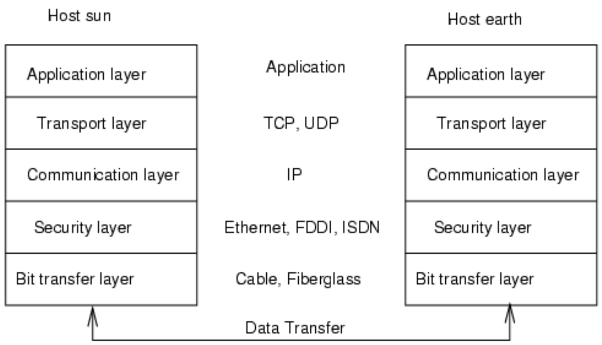


Figure 13.1: *Simplified Layer Model for TCP/IP*

The special functions of each layer are already implicit in their description. For example, the network used (e.g., ethernet) is depicted by the bit transfer and security layers.

- While layer 1 deals with cable types, signal forms, signal codes, and the like, layer 2 is responsible for accessing procedures (which host may send data?) and error correction. Layer 1 is called the *bit transfer layer*. Layer 2 is called the *security layer*.
- Layer 3 is the *communication layer* and is responsible for remote data transfer. The network layer ensures that the data arrives at the correct remote destination and can be delivered to it.
- Layer 4, the *transport layer*, is responsible for application data. It ensures that data arrives in the correct order and is not lost. While the security layer is only there to make sure that the data as transmitted is the correct one, the transport layer protects it from being lost.
- Finally, layer 5 is the layer where data is processed by the application itself.

For every layer to serve its designated function, additional information regarding each layer must be saved in the data packet. This takes place in the *header* of the packet. Every layer attaches a small block of data, called the protocol header, to the front of each emerging packet. A sample TCP/IP data packet traveling over an ethernet cable is illustrated in Figure 13.2 on the facing page.

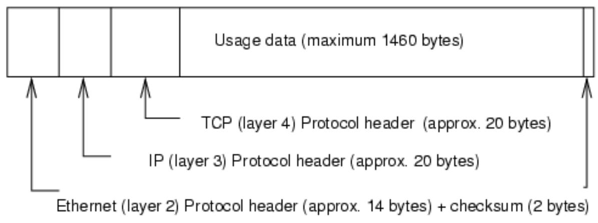

Usage data (maximum 1460 bytes)
TCP (layer 4) Protocol header (approx. 20 bytes)
IP (layer 3) Protocol header (approx. 20 bytes)
Ethernet (layer 2) Protocol header (approx. 14 bytes) + checksum (2 bytes)

***Figure 13.2:** TCP/IP Ethernet Packet*

The proof sum is located at the end of the packet, not at the beginning. This simplifies things for the network hardware. The largest amount of usage data possible in one packet is 1460 bytes in an ethernet network.

When an application sends data over the network, the data passes through each layer, all implemented in the Linux kernel except layer 1 (network card). Each layer is responsible for preparing the data so it can be passed to the next layer below. The lowest layer is ultimately responsible for sending the data.

The entire procedure is reversed when data is received. Like the layers of an onion, in each layer the protocol headers are removed from the usage data. Finally, layer 4 is responsible for making the data available for use by the applications at the destination.

In this manner, one layer only communicates with the layer directly above or below it. For applications, it is irrelevant whether data is transmitted via a 100 MBit/s FDDI network or via a 56-kbit/s modem line. Likewise, it is irrelevant for the data line which kind of data is being transmitted, as long as packets are in the correct format.

IP Addresses and Routing

Note

The discussion in the following sections is limited to IPv4 networks. For information about IPv6 protocol, the successor to IPv4, refer to Section *IPv6 — The Next Generation's Internet* on page 302.

Note

IP Address (binary):	11000000	10101000	00000000	00010100
IP Address (decimal):	192.	168.	0.	20

Table 13.2: *How an IP Address is Written*

IP Addresses

Every computer on the Internet has a unique 32-bit address. These 32 bits (or 4 bytes) are normally written as illustrated in the second row in Table 13.2. In decimal form, the four bytes are written in the decimal number system, separated by periods. The IP address is assigned to a host or a network interface. It cannot be used anywhere else in the world. There are certainly exceptions to this rule, but these play a minimal role in the following passages.

The ethernet card itself has its own unique address, the *MAC*, or media access control address. It is 48 bits long, internationally unique, and is programmed into the hardware by the network card vendor. There is, however, an unfortunate disadvantage of vendor-assigned addresses — MAC addresses do not make up a hierarchical system, but are instead more or less randomly distributed. Therefore, they cannot be used for addressing remote machines. The MAC address still plays an important role in communication between hosts in a local network and is the main component of the protocol header of layer 2.

The points in IP addresses indicate the hierarchical system. Until the 1990s, IP addresses were strictly categorized in classes. However, this system has proven too inflexible so was discontinued. Now, "classless routing" (or CIDR, Classless Inter Domain Routing) is used.

Netmasks and Routing

Netmasks were conceived for the purpose of informing the host with the IP address `192.168.0.20` of the location of the host with the IP address `192.168.0.1`. To put it simply, the netmask on a host with an IP address defines what is "internal" and what is "external". Hosts located "internally" (professionals say, "in the same subnetwork") respond directly. Hosts located "externally" ("not in the same subnetwork") only respond via a gateway or router. Because every network interface can receive its own IP address, it can get quite complicated.

Before a network packet is sent, the following runs on the computer: the IP address is linked to the netmask via a logical AND and the address of the sending host is likewise connected to the netmask via the logical AND. If there are several network interfaces available, normally all possible sender addresses are

	Binary Representation
IP address:192.168.0.20	11000000 10101000 00000000 00010100
Netmask: 255.255.255.0	11111111 11111111 11111111 00000000
Result of the link	11000000 10101000 00000000 00000000
In the decimal system	192. 168. 0. 0
IP address: 213.95.15.200	11010101 10111111 00001111 11001000
Netmask: 255.255.255.0	11111111 11111111 11111111 00000000
Result of the link	11010101 10111111 00001111 00000000
In the decimal system	213. 95. 15. 0

Table 13.3: *Linking IP Addresses to the Netmask*

verified. The results of the AND links will be compared. If there are no discrepancies in this comparison, the destination, or receiving host, is located in the same subnetwork. Otherwise, it must be accessed via a gateway. The more “1” bits are located in the netmask, the fewer hosts can be accessed directly and the more hosts can be reached via a gateway. Several examples are illustrated in Table 13.3.

The netmasks appear, like IP addresses, in decimal form divided by periods. Because the netmask is also a 32-bit value, four number values are written next to each other. Which hosts are gateways or which address domains are accessible over which network interfaces must be entered in the user configurations.

To give another example: all machines connected with the same ethernet cable are usually located in the *same subnetwork* and are directly accessible. When the ethernet is divided by switches or bridges, these hosts can still be reached.

However, the economical ethernet is not suitable for covering larger distances. You must transfer the IP packets to another hardware (e. g., FDDI or ISDN). Devices for this transfer are called routers or gateways. A Linux machine can carry out this task. The respective option is referred to as ip_forwarding.

If a gateway has been configured, the IP packet is sent to the appropriate gateway. This then attempts to forward the packet in the same manner — from host to host — until it reaches the destination host or the packet’s TTL (time to live) has expired.

Address Type	Description
Base network address	This is the netmask AND any address in the network, as shown in Table 13.3 on the preceding page under Result. This address cannot be assigned to any hosts.
Broadcast address	This basically says, "Access all hosts in this subnetwork." To generate this, the netmask is inverted in binary form and linked to the base network address with a logical OR. The above example therefore results in 192.168.0.255. This address cannot be assigned to any hosts.
Local host	The address `127.0.0.1` is strictly assigned to the "loopback device" on each host. A connection can be set up to your own machine with this address.

***Table 13.4:** Specific Addresses*

As IP addresses must be unique all over the world, you cannot just come up with your own random addresses. There are three address domains to use to set up a private IP-based network. With these, you cannot set up any connections to the rest of the Internet, unless you apply certain tricks, because these addresses cannot be transmitted over the Internet. These address domains are specified in RFC 1597 and listed in Table 13.5.

Network/Netmask	Domain
`10.0.0.0/255.0.0.0`	`10.x.x.x`
`172.16.0.0/255.240.0.0`	`172.16.x.x – 172.31.x.x`
`192.168.0.0/255.255.0.0`	`192.168.x.x`

***Table 13.5:** Private IP Address Domains*

Domain Name System

DNS

DNS serves to alleviate the burden of having to remember IP addresses: DNS assists in assigning an IP address to one or more names and assigning a name to an IP address. In Linux, this conversion is usually carried out by a special type of software known as bind. The machine that takes care of this conversion is called a *name server*.

The names make up a hierarchical system in which each name component is divided by dots. The name hierarchy is, however, independent of the IP address hierarchy described above.

Consider a complete name, such as `laurent.suse.de`, written in the format `hostname.domain`. A full name, referred to by experts as a "fully qualified domain name", or *FQDN* for short, consists of a host name and a domain name (`suse.de`). The latter also includes the *top level domain* or *TLD* (`de`).

TLD assignment has become, for historical reasons, quite confusing. Traditionally, three-letter domain names are used in the USA. In the rest of the world, the two-letter ISO national codes are the standard. In addition to that, in the year 2000 new multiletter TLDs have been introduced that represent certain spheres of activity (for example, `.info`, `.name`, `.museum`).

In the early days of the Internet (before 1990), the file `/etc/hosts` was used to store the names of all the machines represented over the Internet. This quickly proved to be impractical in the face of the rapidly growing number of computers connected to the Internet. For this reason, a decentralized database was developed to store the host names in a widely distributed manner. This database, similar to the name server, does not have the data pertaining to all hosts in the Internet readily available, but can dispatch requests to other name servers.

The top of the hierarchy is occupied by "root name servers". These root name servers manage the top level domains and are run by the Network Information Center, or *NIC*. Each root name server knows about the name servers responsible for a given top level domain. More information about top level domain NICs is available at `http://www.internic.net`.

DNS can do more than just resolve host names. The name server also knows which host is receiving e-mails for an entire domain — the *mail exchanger (MX)*.

For your machine to resolve an IP address, it must know about at least one name server and its IP address. Easily specify such a name server with the help of YaST. If you have a modem dial-up connection, you may not need to configure a name server manually at all. The dial-up protocol provides the name server address as the connection is made. The configuration of name server access with SuSE Linux is described in *DNS — Domain Name System* on page 323.

whois

The protocol whois is closely related to DNS. With this program, quickly find out who is responsible for any given domain.

IPv6 — The Next Generation's Internet

A New Internet Protocol

Due to the emergence of the WWW (World Wide Web), the Internet has experienced explosive growth with an increasing number of computers communicating via TCP/IP in the last ten years. Since Tim Berners-Lee at CERN (`http://public.web.cern.ch/`) invented the WWW in 1990, the number of Internet hosts has grown from a few thousand to about 100 million.

As mentioned, an IP address consists of "only" 32 bits. Also, quite a few IP addresses are lost — they cannot be used due to the way in which networks are organized. The number of addresses available in your subnet is the number of bits squared minus two. A subnetwork has, for example, two, six, or fourteen addresses available. To connect 128 hosts to the Internet, for instance, you need a subnetwork with 256 IP addresses, from which only 254 are usable, because two IP addresses are needed for the structure of the subnetwork itself: the broadcast and the base network address.

Under the current IPv4 protocol, DHCP or NAT (network address translation) are the typical mechanisms used to circumvent the potential address shortage. Combined with the convention to keep private and public address spaces separate, these methods can certainly mitigate the shortage. The problem with them lies in their configuration, which is quite a chore to set up and a burden to maintain. To set up a host in an IPv4 network, you need to find out about quite a number of address items, such as the host's own IP address, the subnetmask, the gateway address, and maybe a name server address. In fact, all these items need to be *known*, meaning they cannot be derived from somewhere else.

With IPv6, both the address shortage and the complicated configuration should be a thing of the past. The following sections tell more about the improvements and benefits brought by IPv6 and about the transition from the old protocol to the new one.

Advantages of IPv6

The most important and most visible improvement brought by the new protocol is the enormous expansion of the available address space. An IPv6 address is made up of 128 bit values instead of the traditional 32 bits. This provides for as many as several quadrillion IP addresses.

However, IPv6 addresses are not only different from their predecessors with regard to their length. They also have a different internal structure that may contain more specific information about the systems and the networks to which they belong. More details about this are found in Section *The IPv6 Address System* on the next page.

The following is a list of some other advantages of the new protocol:

Autoconfiguration IPv6 makes the network “plug and play” capable, which means that a newly set up system integrates into the (local) network without any manual configuration. The new host uses its autoconfig mechanism to derive its own address from the information made available by the neighboring routers, relying on a protocol called the *neighbor discovery* (ND) protocol. This method does not require any intervention on the administrator’s part and there is no need to maintain a central server for address allocation — an additional advantage over IPv4, where automatic address allocation requires a DHCP server.

Mobility IPv6 makes it possible to assign several addresses to one network interface at the same time. This allows users to access several networks easily, something that could be compared with the international roaming services offered by mobile phone companies: when you take your mobile phone abroad, the phone automatically logs in to a foreign service as soon as it enters the corresponding area, so you can be reached under the same number everywhere and are able to place an outgoing call just like in your home area.

Secure Communication With IPv4, network security is an add-on function. IPv6 includes IPSec as one of its core features, allowing systems to communicate over a secure tunnel to avoid eavesdropping by outsiders on the Internet.

Backward Compatibility Realistically, it will be impossible to switch the entire Internet from IPv4 to IPv6 in one fell swoop. Therefore, it is crucial that both protocols are able to coexist not only on the Internet, but also on system. This is ensured by compatible addresses on the one hand (IPv4 addresses can easily be translated into IPv6 addresses) and through the use of a number of tunnels on the other (see Section *IPv4 versus IPv6 — Moving between the Two Worlds* on page 308). Also, systems can rely on a *dual stack IP* technique to support both protocols at the same time, meaning that they have two network stacks that are completely separate, such that there is no interference between the two protocol versions.

Custom Tailored Services through Multicasting With IPv4, some services, such as SMB, need to broadcast their packets to all hosts in the local network. IPv6 allows a much more fine-grained approach by enabling servers to address hosts through *multicasting* — by addressing a number of hosts as parts of a group (which is different from addressing all hosts through *broadcasting* or each host individually through *unicasting*). Which hosts are addressed as a group may depend on the concrete application. There are some predefined groups to address all name servers (the *all nameservers multicast group*), for instance, or all routers (the *all routers multicast group*).

The IPv6 Address System

As mentioned, the current IP protocol is lacking in two important aspects: on the one hand, there is an increasing shortage of IP addresses; on the other hand, configuring the network and maintaining the routing tables is becoming a more and more complex and burdensome task. IPv6 solves the first problem by expanding the address space to 128 bits. The second one is countered by introducing a hierarchical address structure, combined with sophisticated techniques to allocate network addresses, as well as *multihoming* (the ability to allocate several addresses to one device, thus giving access to several networks).

When dealing with IPv6, it is useful to know about three different types of addresses:

Unicast Addresses of this type are associated with exactly one network interface. Packets with such an address are delivered to only one destination. Accordingly, unicast addresses are used to transfer packets to individual hosts on the local network or the Internet.

Multicast Addresses of this type relate to a group of network interfaces. Packets with such an address are delivered to all destinations that belong to the group. Multicast addresses are mainly used by certain network services to communicate with certain groups of hosts in a well-directed manner.

Anycast Addresses of this type are related to a group of interfaces. Packets with such an address are delivered to the member of the group that is closest to the sender, according to the principles of the underlying routing protocol. Anycast addresses are used to make it easier for hosts to find out about servers offering certain services in the given network area. All servers of the same type have the same anycast address. Whenever a host requests a service, it receives a reply from the server with the closest location, as determined by the routing protocol. If this server should fail for some reason, the protocol automatically selects the second closest server, then the third one, and so forth.

Structure of an IPv6 Address

An IPv6 address is made up of eight four-digit fields, each of them representing sixteen bits, written in hexadecimal notation. They are also separated by colons (`:`). Any leading zero bytes within a given field may be dropped, but zeros within the field or at its end may not. Another convention is that more than four consecutive zero bytes may be collapsed into a double colon. However, only one such `::` is allowed per address. This kind of shorthand notation is shown in Output 16, where all three lines represent the same address.

```
fe80 : 0000 : 0000 : 0000 : 0000 : 10 : 1000 : 1a4
fe80 :    0 :    0 :    0 :    0 : 10 : 1000 : 1a4
fe80 :                           : 10 : 1000 : 1a4
```

Output 16: *Sample IPv6 Address*

Each part of an IPv6 address has a defined function. The first bytes form the prefix and specify the type of address. The center part is the network portion of the address, but it may be unused. The end of the address forms the host part. With IPv6, the netmask is defined by indicating the length of the prefix after a slash at the end of the address. An address as shown in Output 17 contains the information that the first 64 bits form the network part of the address and the last 64 form its host part. In other words, the `64` means that the netmask is filled with 64 1-bit values from the left. Just like with IPv4, the IP address is ANDed with the values from the netmask to determine whether the host is located in the same subnetwork or in another one.

```
fe80::10:1000:1a4/64
```

Output 17: *IPv6 Address Specifying the Prefix Length*

IPv6 knows about several predefined types of prefixes, some of which are shown in Table 13.6 on the next page.

Prefix (hex)	Definition
`00`	IPv4 addresses and IPv4 over IPv6 compatibility addresses. These are used to maintain compatibility with IPv4. Their use still requires a router able to translate IPv6 packets into IPv4 packets. Several special addresses (such as that for the loopback device) have this prefix as well.
`2` or `3` as the first digit	Aggregatable global unicast addresses. As is the case with IPv4, an interface can be assigned to form part of a certain subnetwork. Currently, there are the following address spaces: `2001::/16` (production quality address space), `2002::/16` (6to4 address space), and `3ffe::/16` (6bone.net).
`fe80::/10`	Link-local addresses. Addresses with this prefix are not supposed to be routed and should therefore only be reachable from within the same subnetwork.
`fec0::/10`	Site-local addresses. These may be routed, but only within the network of the organization to which they belong. In effect, they are the IPv6 equivalent of the current private network address space (e.g., `10.x.x.x`).
`ff`	These are multicast addresses.

Table 13.6: *Various IPv6 Prefixes*

A unicast address consists of three basic components:

Public Topology The first part (which also contains one of the prefixes mentioned above) is used to route packets through the public Internet. It includes information about the company or institution that provides the Internet access.

Site Topology The second part contains routing information about the subnetwork to which the packet shall be delivered.

Interface ID The third part identifies the interface to which the packet shall be delivered. This also allows for the MAC to form part of the address. Given that the MAC is a globally unique, fixed identifier coded into the device by the hardware maker, the configuration procedure is substantially simplified. In fact, the first 64 address bits are consolidated to form the EUI-64 token, with the last 48 bits taken from the MAC, and the remaining 24 bits containing special information about the token type. This also makes it possible to assign an EUI-64 token to interfaces that do not have a MAC, such as those based on ppp or ISDN.

On top of this basic structure, IPv6 distinguishes between five different types of unicast addresses:

:: (unspecified) This address is used by the host as its source address when the interface is initialized for the first time — when the address cannot yet be determined by other means.

::1 (loopback) The address of the loopback device.

IPv4 compatible addresses The IPv6 address is formed by the IPv4 address and a prefix consisting of 96 zero bits. This type of compatibility address is used for tunneling (see Section 13 on the following page) to allow IPv4/IPv6 hosts to communicate with others operating in a pure IPv4 environment.

IPv4 addresses mapped to IPv6 This type of address specifies a pure IPv4 address in IPv6 notation.

Local addresses There are two address types for local use:

link-local This type of address can only be used in the local subnetwork. Packets with a source or target address of this type are not supposed to be routed to the Internet or other subnetworks. These addresses contain a special prefix (`fe80::/10`) and the interface ID of the network card, with the middle part consisting of null bytes. Addresses of this type are used during autoconfiguration to communicate with other hosts belonging to the same subnetwork.

site-local Packets with this type of address may be routed to other subnetworks, but not to the wider Internet — they must remain inside the organization's own network. Such addresses are used for intranets and are an equivalent of the private address space as defined by IPv4. They contain a special prefix (`fec0::/10`), the interface ID, and a sixteen bit field specifying the subnetwork ID. Again, the rest is filled with null bytes.

As a completely new feature introduced with IPv6, each network interface normally gets several IP addresses, with the advantage that several networks can be accessed through the same interface. One of these networks can be configured in completely automatic fashion, using the MAC and a known prefix, with the result that all hosts on the local network can be reached as soon as IPv6 is enabled (using the link-local address). With the MAC forming part of it, any IP address used in the world is unique. The only variable parts of the address are those specifying the site topology and the public topology, depending on the actual network where the host is currently operating.

For a host to go back and forth between different networks, it needs at least two addresses. One of them, the *home address*, not only contains the interface ID but also an identifier of the home network to which it normally belongs (and the corresponding prefix). The home address is a static address and, as such, it does not normally change. Still, all packets destined to the mobile host can be delivered to it, no matter whether it operates in the home network or somewhere outside. This is made possible by the completely new features introduced with IPv6, such as *stateless autoconfiguration* and *neighbor discovery*. In addition to its home address, a mobile host gets one or more further addresses that belong to the foreign networks where it is roaming. These are called *care-of* addresses. The home network has a facility that forwards any packets destined to the host when it is roaming outside. In an IPv6 environment, this task is performed by the *home agent*, which takes all packets destined to the home address and relays them through a tunnel. On the other hand, those packets destined to the care-of address are directly transferred to the mobile host without any special detours.

IPv4 versus IPv6 — Moving between the Two Worlds

It is unlikely that all hosts connected to the Internet will switch from IPv4 to IPv6 overnight. A rather more likely scenario is that both protocols will need to coexist for some time to come. The coexistence on one system is guaranteed where there is a dual stack implementation of both protocols. That still leaves the question how an IPv6 enabled host is supposed to communicate with an IPv4 host and how IPv6 packets should be transported by the current networks, which are predominantly IPv4 based.

The first problem can be solved with compatibility addresses (see Section *Structure of an IPv6 Address* on page 305), the second one by introducing a number of different tunneling techniques. IPv6 hosts that are more or less isolated in the (worldwide) IPv4 network can communicate through a specially wrapped channel — IPv6 packets are encapsulated as IPv4 packets to move them across an IPv4 network. Such a connection between two IPv4 hosts is called a *tunnel*. To achieve this, packets must include the IPv6 destination address (or the corresponding prefix) as well as the IPv4 address of the remote host at the receiving end of the tunnel. A basic tunnel can be configured *manually* according to an agreement between the hosts' administrators. This is also called *static tunneling*.

However, the configuration and maintenance of static tunnels is often too labor-intensive to use them for daily communication needs. Therefore, IPv6 provides for three different methods of *dynamic tunneling*:

6over4 IPv6 packets are automatically encapsulated as IPv4 packets and sent over an IPv4 network capable of multicasting. IPv6 is tricked into seeing the whole network (Internet) as a huge local area network (LAN). This makes it possible to determine the receiving end of the IPv4 tunnel automatically. However, this method does not scale very well and it is also hampered by the fact that IP multicasting is far from widespread on the Internet. Therefore, it only provides a solution for smaller corporate or institutional networks where multicasting can be enabled. The specifications for this method are laid down in RFC 2529.

6to4 With this method, IPv4 addresses are automatically generated from IPv6 addresses, enabling isolated IPv6 hosts to communicate over an IPv4 network. However, a number of problems have been reported as regards the communication between those isolated IPv6 hosts and the Internet. The method is described in RFC 3056.

IPv6 Tunnel Broker This method relies on special servers that provide dedicated tunnels for IPv6 hosts. It is described in RFC 3053.

Note

The 6bone initiative

In the heart of the "old-time" Internet, there is already a globally distributed network of IPv6 subnets that are connected through tunnels. This is the 6bone network (`www.6bone.net`), an IPv6 test environment that may be used by programmers and Internet providers who want to develop and offer IPv6 based services in order to gain the experience necessary to implement the new protocol. More information can be found on the project's Internet site.

Note

Further Reading and Links

The above overview does not cover the topic of IPv6 comprehensively. For a more in-depth look at the new protocol, refer to the following online documentation and books:

`http://www.ngnet.it/e/cosa-ipv6.php` An article series providing a well-written introduction to the basics of IPv6. A good primer on the topic.

`http://www.bieringer.de/linux/IPv6/` Here, find the Linux IPv6-HOWTO and many links related to the topic.

`http://www.6bone.net/` Visit this site if you want to join a tunneled IPv6 network.

`http://www.ipv6.org/` The starting point for everything about IPv6.

RFC 2640 The fundamental RFC about IPv6.

IPv6 Essentials A book describing all the important aspects of the topic. Silvia Hagen: *IPv6 Essentials*. O'Reilly & Associates, 2002 (ISBN 0-596-00125-8).

Network Integration

Currently TCP/IP is the standard network protocol. All modern operating systems can communicate via TCP/IP. Nevertheless, Linux also supports other network protocols, such as IPX (previously) implemented by Novell Netware or Appletalk used by Macintosh machines. Only the integration of a Linux machine into a TCP/IP network is discussed here. To integrate "exotic" arcnet, token rings, or FDDI network cards, refer to the kernel sources documentation at `/usr/src/linux/Documentation`. For information about network configuration changes made in SuSE Linux version 8.0, read the file `/usr/share/doc/packages/sysconfig/README`.

Preparing

The machine has to have a supported network card. Normally, the network card will already be recognized during installation and the appropriate driver loaded. See if your card has been integrated properly by entering the command `ifstatus eth0`. The output should show the status of the network device eth0.

If the kernel support for the network card is implemented as a module, as is usually the case with the SuSE kernel, the name of the module must be entered as an alias in `/etc/modules.conf`. For example, for the first ethernet card:

```
alias eth0 tulip
```

This will occur automatically if the driver support is started in the linuxrc during the first installation. Otherwise, start it via YaST at a later time.

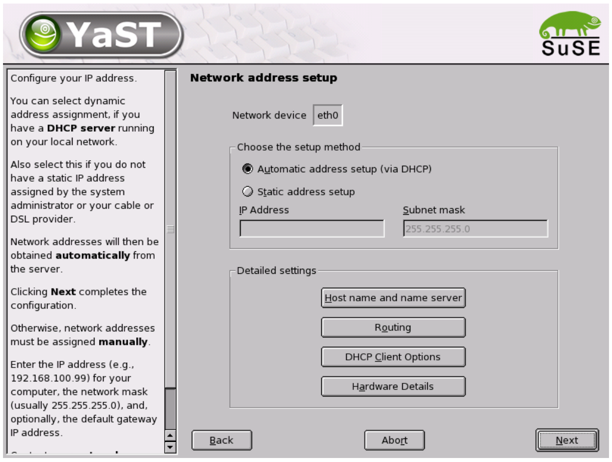
If you are using a hotplug network card (e. g., PCMCIA or USB), the drivers are autodetected when the card is plugged in. No configuration is necessary. Find more information in *Hotplugging Services* on page 193.

Configuration Assisted by YaST

To configure the network card with YaST, start the Control Center and select 'Network – Devices' → 'Network Card Configuration'. With 'Add', configure a new network card. With 'Delete', remove it from the configuration. With 'Edit', modify the network card configuration.

Activate the check box 'Hardware' to modify the hardware data for an already configured network card with 'Edit'. This opens the dialog for changing the settings of the network card, shown in Figure 13.3 on the next page.

Normally, the correct driver for your network card is configured during installation and is activated. Therefore, manual hardware parameter settings are only needed if multiple network cards are used or if the network hardware is not automatically recognized. In this case, select 'Add' to specify a new driver module.


Configure your IP address.

You can select dynamic address assignment, if you have a **DHCP server** running on your local network.

Also select this if you do not have a static IP address assigned by the system administrator or your cable or DSL provider.

Network addresses will then be obtained **automatically** from the server.

Clicking **Next** completes the configuration.

Otherwise, network addresses must be assigned **manually**.

Enter the IP address (e.g., 192.168.100.99) for your computer, the network mask (usually 255.255.255.0), and, optionally, the default gateway IP address.

Network address setup

Network device: eth0

Choose the setup method

● Automatic address setup (via DHCP)

○ Static address setup

IP Address:

Subnet mask: 255.255.255.0

Detailed settings

Figure 13.3: Configuring the Hardware Parameters

In this dialog, set the network card type and, for an ISA card, the interrupt to implement and the IO address. For some network drivers, also specify special parameters, such as the interface to use or whether it uses an RJ-45 or a BNC connection. For this, refer to the driver module documentation. To use PCMCIA or USB activate the respective check boxes.

After entering the hardware parameters, configure additional network interface data. Select 'Interface' in the dialog 'Network Base Configuration' to activate the network card and assign it an IP address. Select the card number then click 'Edit'. A new dialog will appear in which to specify the IP address and other IP network data. Find information about assigning addresses to your own network in *TCP/IP — The Protocol Used by Linux* on page 294 and Table 13.5 on page 300. Otherwise, enter the address assigned by your network administrator in the designated fields.

Configure a name server under 'Host Name and Name Server' so the name resolution functions as described in *DNS — Domain Name System* on page 323. Via 'Routing', set up the routing. Select 'Configuration for Experts' to make advanced settings.

If you are using wireless lan network cards, activate the check box 'Wireless

Device'. In the dialog window, set the most important options, like operation mode, network names, and the key for encrypted data transfer.

With that, the network configuration is complete. YaST starts SuSEconfig and transfers the settings to the corresponding files (see *Manual Network Configuration* on the next page). For the changes to take effect, the relevant programs must be reconfigured and the required daemons must be restarted. This is done by entering the command `rcnetwork restart`.

Hotplug and PCMCIA

Hotplug network cards, like PCMCIA or USB devices, are managed in a somewhat special way. Normal network cards are fixed components assigned a permanent device name, such as eth0. By contrast, PCMCIA cards are assigned a free device name dynamically on an as-needed basis. To avoid conflicts with fixed network cards, hotplug and PCMCIA services are loaded after the network has been started.

PCMCIA-related configuration and start scripts are located in the directory `/etc/sysconfig/pcmcia`. The scripts will be executed as soon as cardmgr, the PCMCIA Device Manager, detects a newly inserted PCMCIA card — which is why PCMCIA services do not need to be started before the network during boot.

Configuring IPv6

To configure IPv6, you will not normally need to make any changes on the individual workstations. However, the IPv6 support will have to be loaded. Do this most easily by entering the command `modprobe ipv6`.

Because of the autoconfiguration concept of IPv6, the network card is assigned an address in the "link-local" network. Normally, no routing table management takes place on a workstation. The network routers can be queried by the workstation, using the "router advertisement protocol", for what prefix and gateways should be implemented. The radvd program can be used to set up an IPv6 router. This program informs the workstations which prefix to use for the IPv6 addresses and which routers. Alternatively, use zebra for automatic configuration of both addresses and routing.

Consult the manual page of ifup (`man ifup`) to get information about how to set up various types of tunnels using the `/etc/sysconfig/network` files.

Manual Network Configuration

Manual configuration of the network software should always be the last alternative. We recommend using YaST.

All network interfaces are set up with the script `/sbin/ifup`. To halt the interface, use `ifdown`. To check its status, use `ifstatus`.

If you only have normal, built-in network cards, configure the interfaces by name. With the commands `ifup eth0`, `ifstatus eth0`, and `ifdown eth0`, start, check, or stop the interface `eth0`. The respective configuration files are stored in `/etc/sysconfig/network/ifcfg-eth0`. `eth0` is the name of the interface and the name of the configuration.

The network can alternatively be configured in relation to the hardware address (MAC address) of a network card. In this case, a configuration file `ifcfg-<hardwareaddresswithoutcolon>` is used. Use lowercase characters in the hardware address, as displayed by the command `ip link` (`ifconfig` shows uppercase letters). If `ifup` finds a configuration file matching the hardware address, a possibly existing file `ifcfg-eth0` will be ignored.

Things are a little more complicated with hotplug network cards. If you do not use one of those cards, skip the following sections and continue reading *Configuration Files* on the facing page.

Hotplug network cards are assigned the interface name arbitrarily, so the configuration for one of those cards cannot be stored under the name of the interface. Instead, a name is used that contains the kind of hardware and the connection point. In the following, this name is referred to as the hardware description. `ifup` has to be called with two arguments — the hardware description and the current interface name. `ifup` will then determine the configuration that best fits the hardware description.

For example, a laptop with two PCMCIA slots, a PCMCIA ethernet network card and a built-in network card configured as interface `eth0` is configured in the following way: The built-in network card is in slot `0` and its hardware description is `eth-pcmcia-0`. The program cardmgr or the hotplug network script runs the command `ifup eth-pcmcia-0 eth1` and `ifup` searches in `/etc/sysconfig/network/` for a file `ifcfg-eth-pcmcia-0`. If there is no such file, it looks for `ifcfg-eth-pcmcia`, `ifcfg-pcmcia-0`, `ifcfg-pcmcia`, `ifcfg-eth1` and `ifcfg-eth`. The first of these files found by `ifup` is used for the configuration. To generate a network configuration valid for all PCMCIA network cards in all slots, the configuration file must be named `ifcfg-pcmcia`.

This file would then be used for the ethernet card in slot 0 (`eth-pcmcia-0`) as well as for a token ring card in slot 1 (`tr-pcmcia-1`). A configuration depending on the hardware address is treated with higher priority.

YaST lists the configurations for hotplug cards and accordingly writes the settings to `ifcfg-eth-pcmcia-<number>`. To use such a configuration file for all slots, a link `ifcfg-eth-pcmcia` points to this file. Keep this in mind if you sometimes configure the network with and sometimes without YaST.

Configuration Files

This section provides an overview of the network configuration files and explains their purpose and the format used.

`/etc/sysconfig/network/ifcfg-*`

These files contain data specific to a network interface. They may be named after the network interface (`ifcfg-eth2`), the hardware address of a network card (`ifcfg-000086386be3`), or the hardware description (`ifcfg-usb`). If network aliases are used, the respective files are named `ifcfg-eth2:1` or `ifcfg-usb:1`. The script `ifup` gets the interface name and, if necessary, the hardware description as arguments then searches for the best matching configuration file.

The configuration files contain the IP address (BOOTPROTO="static", IPADDR="10.10.11.214") or the direction to use DHCP (BOOTPROTO="dhcp"). The IP address may also include the netmask (IPADDR="10.10.11.214/16") or the netmask can be specified separately (NETMASK="255.255.0.0"). Refer to the man page for `ifup` (`man ifup`) for the complete list of variables.

In addition, all the variables in the files `dhcp`, `wireless`, and `config` can be used in the `ifcfg-*` files, if a general setting is only to be used for one interface. By using the variables `POST_UP_SCRIPT` and `PRE_DOWN_SCRIPT`, individual scripts can be run after starting or before stopping the interface.

`/etc/sysconfig/network/config, dhcp, wireless`

The file `config` contains general settings for the behavior of `ifup`, `ifdown`, and `ifstatus`. `dhcp` contains settings for DHCP and `wireless` for wireless lan cards. The variables in all three configuration files are commented and can also be used in `ifcfg-*` files, where they are treated with higher priority.

`/etc/hosts`

In this file (see File 28), IP addresses are assigned to host names. If no name server is implemented, all hosts to which an IP connection will be set up must be listed here. For each host, a line consisting of the IP address, the fully qualified host name, and the host name (e. g., `earth`) is entered into the file. The IP address has to be at the beginning of the line, the entries divided by blanks and tabs. Comments are always preceeded by the `'#'` sign.

```
127.0.0.1 localhost
192.168.0.1 sun.cosmos.com sun
192.168.0.20 earth.cosmos.com earth
```

File 28: `/etc/hosts`

`/etc/networks`

Here, network names are converted to network addresses. The format is similar to that of the `hosts` file, except the network names preceed the addresses (see File 29).

```
loopback     127.0.0.0
localnet     192.168.0.0
```

File 29: `/etc/networks`

`/etc/host.conf`

Name resolution — the translation of host and network names via the *resolver* library — is controlled by this file. This file is only used for programs linked to the libc4 or the libc5. For current glibc programs, refer to the settings in `/etc/nsswitch.conf`. A parameter must always stand alone in its own line. Comments are preceeded by a `'#'` sign. Table 13.7 on the next page shows the parameters available.

order *hosts*, *bind*	Specifies in which order the services are accessed for the name resolution. Available arguments are (separated by blank spaces or commas): *hosts*: Searches the `/etc/hosts` file *bind*: Accesses a name server

Table 13.7: *continued overleaf. . .*

	nis: Via NIS
multi *on/off*	Defines if a host entered in `/etc/hosts` can have multiple IP addresses.
nospoof *on* alert *on/off*	These parameters influence the name server *spoofing*, but, apart from that, do not exert any influence on the network configuration.
trim ⟨*domainname*⟩	The specified domain name is separated from the host name after host name resolution (as long as the host name includes the domain name). This option is useful if only names from the local domain are in the `/etc/hosts` file, but should still be recognized with the attached domain names.

Table 13.7: *Parameters for /etc/host.conf*

An example for `/etc/host.conf` is shown in File 30.

```
# We have named running
order hosts bind
# Allow multiple addrs
multi on
```

File 30: *`/etc/host.conf`*

/etc/nsswitch.conf

With the GNU C Library 2.0, the "Name Service Switch" (NSS) became more important. See the man page for `nsswitch.conf` or, for more details, *The GNU C Library Reference Manual*, Chap. "System Databases and Name Service Switch". Refer to package `libcinfo`.

In the `/etc/nsswitch.conf` file, the order of certain data is defined. An example of `nsswitch.conf` is shown in File 31. Comments are preceeded by `'#'` signs. Here, for instance, the entry under "database" `hosts` means that a request is sent to `/etc/hosts` (`files`) via DNS (see *DNS — Domain Name System* on page 323).

```
passwd:     compat
group:      compat
```

```
hosts:       files dns
networks:    files dns

services:    db files
protocols:   db files

netgroup:    files
```

File 31: *`/etc/nsswitch.conf`*

The “databases” available over NSS are listed in Table 13.8. In addition, `automount`, `bootparams`, `netmasks`, and `publickey` are expected in the near future.

`aliases`	Mail aliases implemented by `sendmail`(8). See also the man page for `aliases`.
`ethers`	Ethernet addresses.
`group`	For user groups, used by `getgrent`(3). See also the man page for `group`.
`hosts`	For host names and IP addresses, used by `gethostbyname`(3) and similar functions.
`netgroup`	Valid host and user lists in the network for the purpose of controlling access permissions. See also the man page for `netgroup`.
`networks`	Network names and addresses, used by `getnetent`(3).
`passwd`	User passwords, used by `getpwent`(3). See also the man page for `passwd`.
`protocols`	Network protocols, used by `getprotoent`(3). See also the man page for `protocols`.
`rpc`	“Remote Procedure Call” names and addresses, used by `getrpcbyname`(3) and similar functions.
`services`	Network services, used by `getservent`(3).
`shadow`	“Shadow” user passwords, used by `getspnam`(3). See also the man page for `shadow`.

Table 13.8: *Available Databases via /etc/nsswitch.conf*

The configuration options for NSS databases are listed in Table 13.9 on the facing page.

`files`	directly access files, for example, to `/etc/aliases`.
`db`	access via a database.
`nis`	NIS, see also *NIS — Network Information Service* on page 358.
`nisplus`	
`dns`	Only usable by `hosts` and `networks` as an extension.
`compat`	Only usable by `passwd`, `shadow`, and `group` as an extension.
also	It is possible to trigger various reactions with certain lookup results. Details can be found in the man page for `nsswitch.conf`.

***Table 13.9:** Configuration Options for NSS "Databases"*

`/etc/nscd.conf`

The `nscd` (Name Service Cache Daemon) is configured in this file (see the man pages for `nscd` and `nscd.conf`). This effects the data resulting from `passwd`, `groups`, and `hosts`. The daemon must be restarted every time the name resolution (DNS) is changed by modifying the `/etc/resolv.conf` file. Use `rcnscd restart` to restart it.

Caution

If, for example, the caching for `passwd` is activated, it will usually take about fifteen seconds until a newly added user is recognized by the system. By restarting `nscd`, reduce this waiting period.

Caution

`/etc/resolv.conf`

As is already the case with the `/etc/host.conf` file, this file, by way of the *resolver* library, likewise plays a role in host name resolution. The domain to which the host belongs is specified in this file (keyword search). Also listed is the status of the name server address (keyword name server) to access. Multiple domain names can be specified. When resolving a name that is not fully qualified, an attempt is made to generate one by attaching the individual search entries. Multiple name servers can be made known by entering several lines, each beginning with name server. Comments are preceeded by `'#'` signs.

An example of `/etc/resolv.conf` is shown in File 32.

```
# Our domain
search cosmos.com

nameserver 192.168.0.1
```

File 32: `/etc/resolv.conf`

Some services, like pppd (wvdial), ipppd (isdn), dhcp (dhcpcd and dhclient), pcmcia, and hotplug, modify the file `/etc/resolv.conf`. To do so, they rely on the script `modify_resolvconf`.

If the file `/etc/resolv.conf` has been temporarily modified by this script, it will contain a predefined comment giving information about the service by which it has been modified, about the location where the original file has been backed up, and hints on how to turn off the automatic modification mechanism.

If `/etc/resolv.conf` is modified several times, the file will include modifications in a nested form. These can be reverted in a clean way even if this reversal takes place in an order different from the order in which modifications where introduced. Services that may need this flexibility include isdn, pcmcia, and hotplug.

If it happens that a service was not terminated in a normal, clean way, `modify_resolvconf` can be used to restore the original file. Also, on system boot, a check will be performed to see whether there is an uncleaned, modified `resolv.conf` (e. g., after a system crash), in which case the original (unmodified) `resolv.conf` will be restored.

YaST uses the command `modify_resolvconf check` to find out whether `resolv.conf` has been modified and will subsequently warn the user that changes will be lost after restoring the file.

Apart from this, YaST will not rely on `modify_resolvconf`, which means that the impact of changing `resolv.conf` through YaST is the same as that of any manual change. In both cases, changes are made on purpose and with a permanent effect, while modifications requested by the above-mentioned services are only temporary.

`/etc/HOSTNAME`

Here is the host name without the domain name attached. This file is read by several scripts while the machine is booting. It may only contain one line where the host name is mentioned.

Start-Up Scripts

Apart from the configuration files described above, there are also various scripts that load the network programs while the machine is being booted. This will be started as soon as the system is switched to one of the *multiuser runlevels* (see also Table 13.10).

`/etc/init.d/network`	This script takes over the configuration for the network hardware and software during the system's start-up phase.
`/etc/init.d/inetd`	Starts inetd. This is only necessary if you want to log in to this machine over the network.
`/etc/init.d/portmap`	Starts the portmapper needed for the RPC server, such as an NFS server.
`/etc/init.d/nfsserver`	Starts the NFS server.
`/etc/init.d/sendmail`	Controls the sendmail process.
`/etc/init.d/ypserv`	Starts the NIS server.
`/etc/init.d/ypbind`	Starts the NIS client.

Table 13.10: *Some Start-Up Scripts for Network Programs*

Routing in SuSE Linux

The routing table is set up in SuSE Linux via the configuration files `/etc/sysconfig/network/routes` and `/etc/sysconfig/network/ifroute-*`.

All the static routes required by the various system tasks can be entered in the `/etc/sysconfig/network/routes` file: routes to a host, routes to a host via a gateway, and routes to a network. For each interface that need individual routing, define an additional configuration file: `/etc/sysconfig/network/ifroute-*`. Replace `'*'` with the name of the interface. The entries in the routing configuration files look like this:

```
DESTINATION           GATEWAY NETMASK   INTERFACE [ TYPE ] [ OPTIONS ]
DESTINATION           GATEWAY PREFIXLEN INTERFACE [ TYPE ] [ OPTIONS ]
DESTINATION/PREFIXLEN GATEWAY -         INTERFACE [ TYPE ] [ OPTIONS ]
```

To omit GATEWAY, NETMASK, PREFIXLEN, or INTERFACE, write `'-'` instead. The entries TYPE and OPTIONS may just be omitted.

- The route's destination is in the first column. This column may contain the IP address of a network or host or, in the case of *reachable* name servers, the fully qualified network or host name.
- The second column contains the default gateway or a gateway through which a host or a network can be accessed.
- The third column contains the netmask for networks or hosts behind a gateway. The mask is `255.255.255.255`, for example, for a host behind a gateway.
- The last column is only relevant for networks connected to the local host such as loopback, ethernet, ISDN, PPP, and dummy device. The device name must be entered here.

The following scripts in the directory `/etc/sysconfig/network/scripts/` assist with the handling of routes:

ifup-route for setting up a route

ifdown-route for disabling a route

ifstatus-route for checking the status of the routes

DNS — Domain Name System

DNS (domain name system) is needed to resolve the domain and host names into IP addresses. In this way, the IP address `192.168.0.20` is assigned to the host name `earth`, for example. Before setting up your own name server, read the general information about DNS in *Domain Name System* on page 300. The configuration examples below are only valid for BIND 9, which is the new default DNS server coming with SuSE Linux.

Starting the Name Server BIND

On a SuSE Linux system, the name server BIND (short for *Berkeley Internet Name Domain*) comes preconfigured so that it can be started right after installation without any problem. If you already have a functioning Internet connection and have entered `127.0.0.1` as the name server address for `localhost` in `/etc/resolv.conf`, you normally already have a working name resolution without needing to know the DNS of the provider. BIND carries out the name resolution via the root name server, a notably slower process. Normally, the DNS of the provider should be entered with its IP address in the configuration file `/etc/named.conf` under forwarders to ensure effective and secure name resolution. If this works so far, the name server runs as a pure "caching-only" name server. Only when you configure its own zones will it become a proper DNS. A simple example of this is included in the documentation: `/usr/share/doc/packages/bind/sample-config`.

However, do not set up any official domains until assigned one by the responsible institution. Even if you have your own domain and it is managed by the provider, you are better off not to use it, as BIND would otherwise not forward any more requests for this domain. The provider's web server, for example, would not be accessible for this domain.

To start the name server, enter the command `rcnamed start` as `root`. If "done" appears to the right in green, `named`, as the name server process is called, has been started successfully. Test the name server immediately on the local system with the `host` or `dig` programs, which should return `localhost` as the default server with the address `127.0.0.1`. If this is not the case, `/etc/resolv.conf` probably contains an incorrect name server entry or the file does not exist at all. For the first test, enter `host 127.0.0.1`, which should always work. If you get an error message, use `rcnamed status` to see whether the server is actually running. If the name server does not start or behaves in an unexpected way, you can usually find the cause in the log file `/var/log/messages`.

To use the name server of the provider or one already running on your network as the “forwarder”, enter the corresponding IP address or addresses in the options section under forwarders. The addresses included in File 33 are just examples. Change these entries according to your own setup.

```
options {
         directory "/var/lib/named";
         forwarders { 10.11.12.13; 10.11.12.14; };
         listen-on { 127.0.0.1; 192.168.0.99; };
         allow-query { 127/8; 192.168.0/24; };
         notify no;
        };
```

File 33: *Forwarding Options in* `named.conf`

The options entry is followed by entries for the zone, for localhost, 0.0.127.in-addr.arpa, and the `type hint` entry under ".", which should always be present. The corresponding files do not need to be modified and should work as is. Also make sure that each entry is closed with a `';'` and that the curly braces are in the correct places. After changing the configuration file `/etc/named.conf` or the zone files, tell BIND to reread them with the command `rcnamed reload`. You can achieve the same by stopping and restarting the name server with the command `rcnamed restart`. The server can also be stopped at any time by entering the command `rcnamed stop`.

The Configuration File /etc/named.conf

All the settings for the BIND name server itself are stored in the file `/etc/named.conf`. However, the zone data for the domains to handle, consisting of the host names, IP addresses, and so on, are stored in separate files in the `/var/lib/named` directory. The details of this are described futher below.

The `/etc/named.conf` is roughly divided into two areas. One is the options section for general settings and the other consists of zone entries for the individual domains. A logging section as well as acl (access control list) entries are optional. Comment lines begin with a `'#'` sign or `'//'`. A minimalistic `/etc/named.conf` looks like File 34.

```
options {
        directory "/var/lib/named";
        forwarders { 10.0.0.1; };
        notify no;
};
```

```
zone "localhost" in {
        type master;
        file "localhost.zone";
};

zone "0.0.127.in-addr.arpa" in {
        type master;
        file "127.0.0.zone";
};

zone "." in {
        type hint;
        file "root.hint";
};
```

File 34: *A Basic* `/etc/named.conf`

Important Configuration Options

directory "/var/lib/named"; specifies the directory where BIND can find the files containing the zone data.

forwarders 10.0.0.1; ; is used to specify the name servers (mostly of the provider) to which DNS requests shall be forwarded if they cannot be resolved directly.

forward first; causes DNS requests to be forwarded before an attempt is made to resolve them via the root name servers. Instead of forward first, forward only can be written to have all requests forwarded and none sent to the root name servers. This makes sense for firewall configurations.

listen-on port 53 127.0.0.1; 192.168.0.1; ; tells BIND to which network interface and port to listen. The port 53 specification can be left out, as 53 is the default port. If this entry is completely omitted, BIND accepts requests on all interfaces.

listen-on-v6 port 53 { any; }; tells BIND on which port it should listen for IPv6 client requests. The only alternative to `any` is `none`. As far as IPv6 is concerned, the server only accepts a wild card address.

query-source address * port 53; This entry is necessary if a firewall is blocking outgoing DNS requests. This tells BIND to post requests externally from port 53 and not from any of the high ports above 1024.

query-source-v6 address * port 53; tells BIND which port to use for IPv6 queries.

allow-query 127.0.0.1; 192.168.1/24; ; defines the networks from which clients can post DNS requests. The /24 at the end is an abbreviated expression for the netmask, in this case, 255.255.255.0.

allow-transfer ! *; ; controls which hosts can request zone transfers. In the example, such requests are completely denied with ! *. Without this entry, zone transfers can be requested from anywhere without restrictions.

statistics-interval 0; In the absence of this entry, BIND generates several lines of statistical information per hour in `/var/log/messages`. Specify 0 to completely suppress such statistics or specify an interval in minutes.

cleaning-interval 720; This option defines at which time intervals BIND clears its cache. This triggers an entry in `/var/log/messages` each time it occurs. The time specification is in minutes. The default is 60 minutes.

interface-interval 0; BIND regularly searches the network interfaces for new or nonexisting interfaces. If this value is set to 0, this is not done and BIND only listens at the interfaces detected at start-up. Otherwise, the interval can be defined in minutes. The default is 60 minutes.

notify no; no prevents other name servers from being informed when changes are made to the zone data or when the name server is restarted.

The Configuration Section “Logging”

What, how, and where archiving takes place can be extensively configured in BIND. Normally, the default settings should be sufficient. File 35 represents the simplest form of such an entry and completely suppresses any logging.

```
logging {

        category default { null; };

};
```

File 35: *Entry to Disable Logging*

Zone Entry Structure

```
        zone "my-domain.de" in {
                type master;
                file "my-domain.zone";
                notify no;
        };
```

File 36: *Zone Entry for my-domain.de*

After zone, the name of the domain to administer is specified, `my-domain.de`, followed by in and a block of relevant options enclosed in curly braces, as shown in File 36. To define a "slave zone", the type is simply switched to `slave` and a name server is specified that administers this zone as `master` (which, in turn, may be a slave of another master), as shown in File 37.

```
        zone "other-domain.de" in {
                type slave;
                file "slave/other-domain.zone";
                masters { 10.0.0.1; };
        };
```

File 37: *Zone Entry for other-domain.de*

The zone options:

type master; By specifying `master`, tell BIND that the zone is handled by the local name server. This assumes that a zone file has been created in the correct format.

type slave; This zone is transferred from another name server. Must be used together with masters.

type hint; The zone `.` of the `hint` type is used for specification of the root name servers. This zone definition can be left as is.

file "my-domain.zone" or file "slave/other-domain.zone"; This entry specifies the file where zone data for the domain is located. This file is not required for a slave, where this data is fetched from another name server. To differentiate master and slave files, the directory `slave` is specified for the slave files.

masters { 10.0.0.1; }; This entry is only needed for slave zones. It specifies from which name server the zone file should be transferred.

allow-update { ! *; }; This option controls external write access, which would allow clients to make a DNS entry — something not normally desirable for security reasons. Without this entry, zone updates are not allowed at all. The above entry achieves the same because `! *` effectively bans any such activity.

Structure of Zone Files

Two types of zone files are needed. One serves to assign IP addresses to host names and the other does the reverse — supplies a host name for an IP address.

The `'.'` has an important meaning in the zone files. If host names are given without ending with a `'.'`, the zone is appended. Thus, complete host names specified with a complete domain must end with a `'.'` so the domain is not added to it again. A missing point or one in the wrong place is probably the most frequent cause of name server configuration errors.

The first case to consider is the zone file `world.zone`, responsible for the domain `world.cosmos`, shown in File 38.

```
1. $TTL 2D
2. world.cosmos.  IN SOA      gateway  root.world.cosmos. (
3.                   2003072441  ; serial
4.                1D          ; refresh
5.                2H          ; retry
6.                1W          ; expiry
7.                2D )        ; minimum
8.
9.                IN NS       gateway
10.               IN MX       10 sun
11.
12. gateway       IN A        192.168.0.1
13.               IN A        192.168.1.1
14. sun           IN A        192.168.0.2
15. moon          IN A        192.168.0.3
16. earth         IN A        192.168.1.2
17. mars          IN A        192.168.1.3
18. www                 IN CNAME    mond
```

File 38: *File* `/var/lib/named/world.zone`

Line 1: $TTL defines the default time to live that should apply to all the entries in this file. In this example, entries are valid for a period of 2 days (`2 D`).

Line 2: This is where the SOA control record begins:

- The name of the domain to administer is `world.cosmos` in the first position. This ends with a `'.'`, because otherwise the zone would be appended a second time. Alternatively, a `'@'` can be entered here, in which case the zone would be extracted from the corresponding entry in `/etc/named.conf`.
- After IN SOA is the name of the name server in charge as master for this zone. The name is expanded from `gateway` to `gateway.world.cosmos`, because it does not end with a `'.'`.
- An e-mail address of the person in charge of this name server will follow. Because the `'@'` sign already has a special meaning, `'.'` is entered here instead, so for root@world.cosmos the entry must read root.world.cosmos.. Again the `'.'` sign must be included at the end to prevent the zone from being added.
- The `'('` is used to include all lines up to `')'` into the SOA record.

Line 3: The serial number is an arbitrary number that is increased each time this file is changed. It is needed to inform the secondary name servers (slave servers) of changes. For this, a ten-digit number of the date and run number, written as YYYYMMDDNN, has become the customary format.

Line 4: The refresh rate specifies the time interval at which the secondary name servers verify the zone serial number. In this case, 1 day.

Line 5: The retry rate specifies the time interval at which a secondary name server, in case of error, attempts to contact the primary server again. Here, 2 hours.

Line 6: The expiration time specifies the time frame after which a secondary name server discards the cached data if it has not regained contact to the primary server. Here, it is a week.

Zeile 7: The last entry in the SOA record specifies the negative caching TTL — the time for which results of unresolved DNS queries from other servers may be cached.

Line 9: The IN NS specifies the name server responsible for this domain. The same is true here that gateway is extended to gateway.world.cosmos because it does not end with a `'.'`. There can be several lines like this — one for the primary and one for each secondary name server. If notify is not set to no in `/etc/named.conf`, all the name servers listed here will be informed of the changes made to the zone data.

Line 10: The MX record specifies the mail server that accepts, processes, and forwards e-mails for the domain world.cosmos. In this example, this is the host sun.world.cosmos. The number in front of the host name is the preference value. If there are multiple MX entries, the mail server with the smallest value is taken first and, if mail delivery to this server fails, an attempt will be made with the next higher value.

Lines 12–17: These are the actual address records where one or more IP addresses are assigned to host names. The names are listed here without a `'.'` because they do not include their domain, so world.cosmos is added to all of them. Two IP addresses are assigned to the host gateway, because it has two network cards. Wherever the host address is a traditional one (IPv4), the record is marked with an `A`. If the address is an IPv6 address, the entry is marked with `A6`. (The previous token for IPv6 addresses was `AAAA`, which is now obsolete.)

Line 18: The alias `www` can be used to address `mond` (CNAME = *canonical name*).

The pseudodomain `in-addr.arpa` is used for the reverse lookup of IP addresses into host names. It is appended to the network part of the address in reverse notation. So `192.168.1` is resolved into 1.168.192.in-addr.arpa. See File 39.

```
1. $TTL 2D
2. 1.168.192.in-addr.arpa. IN SOA  gateway.world.cosmos.
                                      root.world.cosmos. (
3.                         2003072441      ; serial
4.                         1D              ; refresh
5.                         2H              ; retry
6.                         1W              ; expiry
7.                         2D )            ; minimum
8.
9.                         IN NS           gateway.world.cosmos.
10.
11. 1                      IN PTR          gateway.world.cosmos.
12. 2                      IN PTR          earth.world.cosmos.
13. 3                      IN PTR          mars.world.cosmos.
```

***File 39:** Reverse Lookup*

Line 1: $TTL defines the standard TTL that applies to all entries here.

Line 2: The configuration file is supposed to activate reverse lookup for the network 192.168.1.0. Given that the zone is called 1.168.192.in-addr.arpa, we would not want to add this to the host names. Therefore, all host names are entered in their complete form — with their domain and with a `'.'` at the end. The remaining entries correspond to those described for the previous world.cosmos example.

Lines 3–7: See the previous example for world.cosmos.

Line 9: Again this line specifies the name server responsible for this zone. This time, however, the name is entered in its complete form with the domain and a `'.'` at the end.

Lines 11–13: These are the pointer records hinting at the IP addresses on the respective hosts. Only the last part of the IP address is entered at the beginning of the line, without the `'.'` at the end. Appending the zone to this (without the .in-addr.arpa) results in the complete IP address in reverse order.

Normally, zone transfers between different versions of BIND should be possible without any problem.

Secure Transactions

Secure transactions can be carried out with the help of transaction signatures (TSIGs) based on shared secret keys (also called TSIG keys). This section describes how to generate and use such keys.

Secure transactions are needed for the communication between different servers and for the dynamic update of zone data. Making the access control dependent on keys is much more secure than merely relying on IP addresses.

A TSIG key can be generated with the following command (for details see the man page for `dnssec-keygen` (`man dnssec-keygen`)):

```
dnssec-keygen -a hmac-md5 -b 128 -n HOST host1-host2
```

This creates two files with names similar to these:

```
Khost1-host2.+157+34265.private
Khost1-host2.+157+34265.key
```

The key itself (a string like ejIkuCyyGJwwuN3xAteKgg==) is found in both files. To use it for transactions, the second file (Khost1-host2.+157+34265.key) must be transferred to the remote host, preferably in a secure way (e.g., by using scp). On the remote server, the key must be included in the file /etc/named.conf to enable a secure communication between host1 and host2:

```
key host1-host2. {
  algorithm hmac-md5;
  secret "ejIkuCyyGJwwuN3xAteKgg==";
};
```

Caution

Make sure the permissions of /etc/named.conf are properly restricted. The default for this file is 0640, with the owner being root and the group named. As an alternative, move the keys to an extra file with specially limited permissions, which is then included from /etc/named.conf.

Caution

To enable the server host1 to use the key for host2 (which has the address 192.168.2.3 in our example), the server's /etc/named.conf must include the following rule:

```
server 192.168.2.3 {
  keys { host1-host2. ;};
};
```

Analogous entries must be included in the configuration files of host2.

In addition to any ACLs that are defined for IP addresses and address ranges, add TSIG keys for these to enable transaction security. The corresponding entry could look like this:

```
allow-update { key host1-host2. ;};
```

This topic is discussed in more detail in the *BIND Administrator Reference Manual* under update-policy.

Dynamic Update of Zone Data

The term "dynamic update" refers to operations by which entries in the zone files of a master server are added, changed, or deleted. This mechanism is described in RFC 2136. Dynamic update is configured individually for each zone entry by adding an optional allow-update or update-policy rule. Zones to update dynamically should not be edited by hand.

Transmit the entries to update to the server with the command `nsupdate`. For the exact syntax of this command, check the the man page for `nsupdate` (`man 8 nsupdate`). For security reasons, any such update should be performed using TSIG keys, as described in Section 13 on page 331.

DNSSEC

DNSSEC, or DNS security, is described in RFC 2535. The tools available for DNSSEC are discussed in the BIND Manual.

A zone considered secure must have one or several zone keys associated with it. These are generated with `dnssec-keygen`, just like the host keys. Currently the DSA encryption algorithm is used to generate these keys. The public keys generated should be included in the corresponding zone file with an $INCLUDE rule.

All keys generated are packaged into one set, using the command `dnssec-makekeyset`, which must then be transferred to the parent zone in a secure manner. On the parent, the set is signed with `dnssec-signkey`. The files generated by this command are then used to sign the zones with `dnssec-signzone`, which in turn generates the files to be included for each zone in `/etc/named.conf`.

Further Reading

For additional information, refer to the *BIND Administrator Reference Manual*, which is installed under `/usr/share/doc/packages/bind/`. Consider additionally consulting the RFCs referenced by the manual and the manual pages included with BIND.

LDAP — A Directory Service

It is crucial within a networked environment to keep important information structured and quickly available. Data chaos does not only loom when using the Internet. The search for important data in the company network can just as quickly grow disproportionately. What is the extension number of colleague XY? What is his e-mail address? This problem is solved by a directory service that, like the common yellow pages, keeps information available in a well-structured, quickly searchable form.

In the ideal case, a central server keeps the data in a directory and distributes it to all clients using a certain protocol. The data is structured in a way that a wide range of applications can access them. That way, it is not necessary for every single calendar tool and e-mail client to keep its own database — a central repository can be accessed instead. This notably reduces the administration effort for the concerned information. The use of an open and standardized protocol like LDAP ensures that as many different client applications as possible can access such information.

A directory in this context is a type of database optimized for quick and effective reading and searching:

- To make numerous (concurrent) reading accesses possible, the writing access is limited to a small number of updates by the administrator. Conventional databases are optimized for accepting the largest possible data volume in a short time.
- Because writing accesses can only be executed in a restricted fashion, a directory service is employed for administering mostly unchanging, static information. Data in a conventional database typically changes very often (*dynamic* data). Phone numbers in a company directory do not change nearly as often as, for instance, the figures administered in accounting.
- When static data is administered, updates of the existing data sets are very rare. When working with dynamic data, especially when data sets like bank accounts or accounting are concerned, the consistency of the data is of primary importance. If an amount is should be subtracted from one place to be added to another, both operations must happen concurrently, within a "transaction", to ensure the balance over the whole data stock. Databases support such transactions. Directories do not. Short-term inconsistencies of the data are quite acceptable in directories.

The design of a directory service like LDAP is not laid out to support complex update or query mechanisms. All applications accessing this service should gain access quickly and easily.

Many directory services have previously existed and still exist both in Unix and outside it. Novell NDS, Microsoft ADS, Banyan's Street Talk, and the OSI standard X.500 are just a few examples. LDAP was originally planned as a lean flavor of the DAP, the Directory Access Protocol, which was developed for accessing X.500. The X.500 standard regulates the hierarchical organization of directory entries.

LDAP is relieved of a few functions of the DAP and can be employed, above all, while saving resources without having to miss the entry hierarchies defined in X.500. The use of TCP/IP makes it substantially easier to establish interfaces between a docking application and the LDAP service.

LDAP, meanwhile, has evolved and is increasingly employed as a stand-alone solution without X.500 support. LDAP supports *referrals* with LDAPv3 (the protocol version in package openldap2), making it possible to realize distributed databases. The usage of SASL (Simple Authentication and Security Layer) is also new.

LDAP is not limited to querying data from X.500 servers, as it was originally planned. There is an open source server slapd, which can store object information in a local database. There is also an extension called slurpd, which is responsible for replicating multiple LDAP servers.

The openldap2 package consists of:

slapd A stand-alone LDAPv3 server wthat administers object information in a BerkeleyDB-based database.

slurpd This program enables the replication of modifications to data on the local LDAP server to other LDAP servers installed on the network.

additional tools for system maintenance `slapcat`, `slapadd`, `slapindex`

LDAP versus NIS

The Unix system administrator traditionally uses the NIS service for name resolution and data distribution in a network. The configuration data contained in the files in `/etc` and the directories `group`, `hosts`, `mail`, `netgroup`, `networks`, `passwd`, `printcap`, `protocols`, `rpc`, and `services` are distributed by clients all over the network. These files can be maintain without major effort because they are simple text files. The handling of larger amounts of data, however, becomes increasingly difficult due to nonexistent structuring. NIS is only designed for Unix platforms, which makes its employment as a central data administrator in a heterogenous network impossible.

Unlike NIS, the LDAP service is not restricted to pure Unix networks as opposed. Windows servers (from 2000) support LDAP as a directory service. Novell also offers an LDAP service. Application tasks mentioned above are additionally supported in non-Unix systems.

The LDAP principle can be applied to any data structure that should be centrally administered. A few application examples are:

- Employment as a replacement for the NIS service.
- Mail routing (postfix, sendmail).
- Address books for mail clients like Mozilla, Evolution, and Outlook.
- Administration of zone descriptions for a BIND9 name server.

This list can be extended because LDAP is extensible as opposed to NIS. The clearly-defined hierarchical structure of the data greatly helps the administration of very large amounts of data, because it can be searched better.

Structure of an LDAP Directory Tree

An LDAP directory has a tree structure. All entries (called objects) of the directory have a defined position within this hierarchy. This hierarchy is called the *directory information tree* or, for short, DIT. The complete path to the desired entry, which unambigously identifies it, is called *distinguished name* or DN. The single nodes along the path to this entry are called *relative distinguished name* or RDN. Objects can generally be assigned to one of two possible types:

container These objects can themselves contain other objects. Such object classes are `root` (the root element of the directory tree, which does not really exist), `c` (country), `ou` (organizational unit), and `dc` (domain component). This model is comparable to the directories (folders) in a file system.

leaf These objects sit at the end of a branch and have no subordinate objects. Examples are `person`, `InetOrgPerson`, or `groupofNames`.

The top of the directory hierarchy has a root element `root`. This can contain `c` (country), `dc` (domain component), or `o` (organization) as subordinate elements. The relations within an LDAP directory tree become more evident in the following example, shown in Figure 13.4 on the next page.

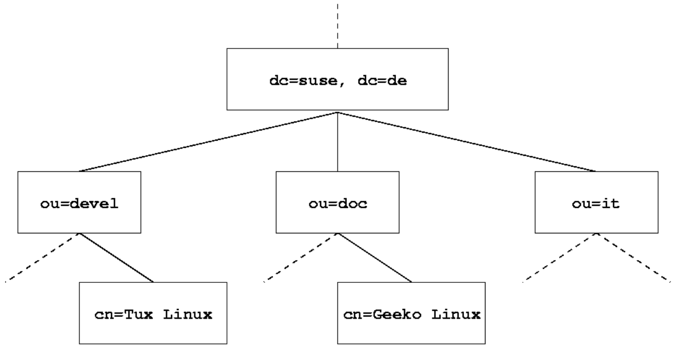


Figure 13.4: *Structure of an LDAP Directory*

The complete diagram comprises a fictional directory information tree. The entries on three levels are depicted. Each entry corresponds to one box in the picture. The complete, valid *distinguished name* for the fictional SuSE employee `Geeko Linux`, in this case, is `cn=Geeko Linux,ou=doc,dc=suse,dc=de`. It is composed by adding the RDN `cn=Geeko Linux` to the DN of the preceding entry `ou=doc,dc=suse,dc=de`.

The global determination of which types of objects should be stored in the DIT is done following a *scheme*. The type of an object is determined by the *object class*. The object class determines what attributes the concerned object *must* or *can* be assigned. A scheme, therefore, must contain definitions of all object classes and attributes used in the desired application scenario. There are a few common schemes (see RFC 2252 and 2256). It is, however, possible to create custom schemes or to use multiple schemes complementing each other if this is required by the environment in which the LDAP server should operate.

Table 13.11 on the following page offers a small overview of the object classes from `core.schema` and `inetorgperson.schema` used in the example, including compulsory attributes and valid attribute values.

Object Class	Meaning	Example Entry	Compulsory Attributes
dcObject	*domainComponent* (name components of the domain)	suse	dc
organizationalUnit	*organizationalUnit* (organizational unit)	doc	ou
inetOrgPerson	*inetOrgPerson* (person-related data for the intranet or Internet)	Geeko Linux	sn and cn

Table 13.11: *Commonly Used Object Classes and Attributes*

Output 18 shows an excerpt from a scheme directive with explanations offering some understanding of the new schemes.

```
...
#1 attributetype ( 2.5.4.11 NAME ( ’ou’ ’organizationalUnitName’ )
#2        DESC ’RFC2256: organizational unit this object belongs to’
#3        SUP name )

...
#4 objectclass ( 2.5.6.5 NAME ’organizationalUnit’
#5        DESC ’RFC2256: an organizational unit’
#6        SUP top STRUCTURAL
#7        MUST ou
#8        MAY ( userPassword $ searchGuide $ seeAlso $ businessCategory $
              x121Address $ registeredAddress $ destinationIndicator $
              preferredDeliveryMethod $ telexNumber $
              teletexTerminalIdentifier $ telephoneNumber $
              internationaliSDNNumber $ facsimileTelephoneNumber $
              street $ postOfficeBox $ postalCode $ postalAddress
              $ physicalDeliveryOfficeName $ st $ l $ description) )
...
```

Output 18: *Excerpt from schema.core*
(line numbering for explanatory reasons)

The attribute type `organizationalUnitName` and the corresponding object class `organizationalUnit` serve as an example here. Line 1 features the name of the attribute, its unique OID (*object identifier*) (numerical), and the abbreviation of the attribute.

Line 2 gives brief description of the attribute with DESC. The corresponding RFC on which the definition is based is also mentioned here. SUP in line 3 indicates a superordinate attribute type to which this attribute belongs.

The definition of the object class organizationalUnit begins in line 4, like in the definition of the attribute, with an OID and the name of the object class. Line 5 features a brief description of the object class. Line 6 with its entry SUP top indicates that this object class is not subordinate to another object class. Line 7, starting with MUST, lists all attribute types that *must* be used in conjunction with an object of the type organizationalUnit. Line 8 starting with MAY lists all attribute types that are allowed to be used in conjunction with this object class.

A very good introduction in the use of schemes can be found in the documentation to OpenLDAP. When installed, find it in /usr/share/doc/packages/openldap2/admin-guide/index.html.

Server Configuration with slapd.conf

Your installed system contains a complete configuration file for your LDAP server at /etc/openldap/slapd.conf. The single entries are briefly described here and necessary adjustments are explained. Entries prefixed with a hash prefix (#) are inactive. This comment character must be removed to activate them.

Global Directives in slapd.conf

```
include /etc/openldap/schema/core.schema include
/etc/openldap/schema/inetorgperson.schema
```

Output 19: *slapd.conf: Include Directive for Schemes*

This first directive in slapd.conf, shown in Output 19, specifies the scheme by which the LDAP directory is organized. The entry core.schema is compulsory. Additionally required schemes are appended to this directive (inetorgperson.schema has been added here as an example). More available schemes can be found in the directory /etc/openldap/schema. For replacing NIS by an analogous LDAP service, include the two schemes rfc2307.schema and cosine.schema. Information can be found in the included OpenLDAP documentation.

```
  pidfile /var/run/slapd.pid
  argsfile /var/run/slapd.args
```

Output 20: *slapd.conf: pidfile and argsfile*

These two files contain the PID (process ID) and some of the arguments with which the slapd process is started. There is no need for modifications here.

```
%
%

#
# Sample Access Control
#       Allow read access of root DSE
#       Allow self write access
#       Allow authenticated users read access
#       Allow anonymous users to authenticate
#
access to dn="" by * read
access to *
       by self write
       by users read
       by anonymous auth
#
# if no access controls are present, the default is:
#       Allow read by all
#
# rootdn can always write!
```

Output 21: *slapd.conf: Access Control*

Output 21 is the excerpt from `slapd.conf` that regulates the access permissions for the LDAP directory on the server. The settings made here in the global section of `slapd.conf` are valid as long as no custom access rules are declared in the database-specific section. These would overwrite the global declarations. As presented here, all users have read access to the directory, but only the administrator (`rootdn`) can write into this directory. Access control regulation in LDAP is a highly complex process. The following tips can help:

- Every access rule has the following structure:

```
access to <what> by <who> <access>
```

- ⟨*what*⟩ is a placeholder for the object or attribute to which access is granted. Individual directory branches can explicitly be protected with separate rules. It is also possible to process whole regions of the directory tree with one rule by using regular expressions. slapd evaluates all rules in the order in which they are listed in the configuration file. More general rules should be listed after more specific ones — the first rule slapd regards as valid is evaluated and all following entries are ignored.
- ⟨*who*⟩ determines who should be granted access to the areas determined with ⟨*what*⟩. Regular expressions may be used. slapd again aborts the evaluation of ⟨*who*⟩ after the first match so more specific rules should be listed before the more general ones. The following entries are possible (see table 13.12):

Tag	Scope
`*`	all users without exception
`anonymous`	not authenticated ("anonymous") users
`users`	authenticated users
`self`	users connected with the target object
`dn=<regex>`	all users matching the regular expression

***Table 13.12:** User Groups and Their Access Grants*

- ⟨*access*⟩ specifies the type of access. It is distinguished from the options listed below in Table 13.13.

Tag	Access Type
`none`	no access
`auth`	for contacting the server
`compare`	to objects for comparison access
`search`	for the employment of search filters
`read`	read access
`write`	write access

***Table 13.13:** Types of Access*

slapd compares the access right requested by the client with those granted in `slapd.conf`. The client is granted access if the rules allow a higher or equal right than the requested one. If the client requests higher rights than those declared in the rules, it is denied access.

Output 22 shows a simple example for a simple access control that can be arbitrarily developed using regular expressions.

```
access to dn.regex="ou=([^,]+),dc=suse,dc=de"
      by cn=administrator,ou=$1,dc=suse,dc=de write
      by user read
      by * none
```

Output 22: *slapd.conf: Example for Access Control*

This rule declares that only its respective administrator has write access to an individual `ou` entry. All other authenticated users have read access and the rest of the world has no access.

Tip

Establishing Access Rules

If there is no `access to` rule or no matching `by` ⟨*who*⟩ directive, access is denied. Only explicitly declared access rights are granted. If no rules are declared at all, the default principle is write access for the administrator and read access for the rest of the world.

Tip

Find detailed information and an example configuration for LDAP access rights can be found in the online documentation of the installed openldap2 package.

Apart from the possibility to administer access permissions with the central server configuration file (`slapd.conf`), there is ACI, Access Control Information. ACI allows storage of the access information for individual objects within the LDAP tree. This type of access control is not yet common and is still considered experimental by the developers. Refer to `http://www.openldap.org/faq/data/cache/758.html` for information.

Database-Specific Directives in slapd.conf

```
database        ldbm
suffix          "dc=suse,dc=de"
rootdn          "cn=admin,dc=suse,dc=de"
# Clear text passwords, especially for the rootdn, should
# be avoided.  See slappasswd(8) and slapd.conf(5) for details.
# Use of strong authentication encouraged.
rootpw          secret
# The database directory MUST exist prior to running slapd AND
# should only be accessible by the slapd/tools. Mode 700 recommended.
directory       /var/lib/ldap
# Indices to maintain
index   objectClass     eq
```

Output 23: *slapd.conf: Database-Specific Directives*

The type of database, LDBM in this case, is determined in the first line of this section (see Output 23). The second line determines, with `suffix`, for which portion of the LDAP tree this server shoud be responsible. The following `rootdn` determines who owns administrator rights to this server. The user declared here does not have to have an LDAP entry or exist as regular user. The administrator password is set with `rootpw`. Instead of using `secret` here, it is possible to enter the hash of the administrator password created by slappasswd. The `directory` directive indicates the directory (in the file system) where the database directories are stored on the server. The last directive, `index objectClass eq`, results in the maintenance of an index over all object classes. Attributes searched for most often can be added here according to experience. Custom `Access` rules defined here for the database are used instead of the global `Access` rules.

Starting and Stopping the Servers

Once the LDAP server is fully configured and all desired entries have been made according to the pattern described below in Section *Data Handling in the LDAP Directory* on the following page, start the LDAP server as the `root` user by entering `rcldap start`.

To stop the server manually, enter the command `rcldap stop`. Request the status of the running LDAP server with `rcldap status`.

The YaST runlevel editor, described in Section *The YaST Runlevel Editor* on page 286, can be used to have the server started and stopped automatically on boot and halt of the system. It is also possible to create the corresponding links to the starting and stopping scripts with the `insserv` command from a command prompt as described in Section *Adding init Scripts* on page 285.

Data Handling in the LDAP Directory

OpenLDAP offers a series of tools for the administration of data in the LDAP directory. The four most important tools for adding to, deleting from, searching through, and modifying the data stock are briefly explained below.

Inserting Data into an LDAP Directory

Once the configuration of your LDAP server in `/etc/openldap/lsapd.conf` is correct and ready to go, meaning that it features appropriate entries for `suffix`, `directory`, `rootdn`, `rootpw`, and `index`, proceed to entering records. OpenLDAP offers the `ldapadd` command for this task. If possible, add the objects to the database in bundles for practical reasons. LDAP is able to process the LDIF format (LDAP Data Interchange Format) to accomplish this. An LDIF file is a simple text file that can contain an arbitrary number of pairs of attribute and value. Refer to the schema files declared in `slapd.conf` for the available object classes and attributes. The LDIF file for creating a rough framework for the example in Figure 13.4 on page 337 would look like that in File 40.

```
# The SuSE Organization
dn: dc=suse,dc=de
objectClass: dcObject
objectClass: organization
o: SuSE AG
dc: suse

# The organizational unit development (devel)
dn: ou=devel,dc=suse,dc=de
objectClass: organizationalUnit
ou: devel

# The organizational unit documentation (doc)
dn: ou=doc,dc=suse,dc=de
objectClass: organizationalUnit
ou: doc

# The organizational unit internal IT (it)
dn: ou=it,dc=suse,dc=de
objectClass: organizationalUnit
ou: it
```

File 40: *Example for an LDIF File*

Note

Encoding of LDIF Files

LDAP works with UTF-8 (Unicode). Umlauts therefore must be encoded correctly. Use an editor that supports UTF-8 (such as Kate or recent versions of Emacs). Otherwise, it would be necessary to either renounce on umlauts and other special characters or to use recode to recode the input to UTF-8.

Note

The file is saved with the `.ldif` suffix and is passed to the server with the following command:

```
ldapadd -x -D <dn of the administrator> -W -f <file>.ldif
```

The first option `-x` switches off the authentication with SASL in this case. The `-D` switch declares the user that calls the operation. The valid DN of the administrator is entered here just like it has been configured in `slapd.conf`. In the current example, this would be `cn=admin,dc=suse,dc=de`. The switch `-W` circumvents entering the password on the command line (in clear text) and activates a separate password requesting prompt. This password was previously determined in `slapd.conf` with `rootpw`. The `-f` switch passes the file name. See the details of running `ldapadd` in Output 24.

```
ldapadd -x -D cn=admin,dc=suse,dc=de -W -f example.ldif
Enter LDAP password:
adding new entry "dc=suse,dc=de"
adding new entry "ou=devel,dc=suse,dc=de"
adding new entry "ou=doc,dc=suse,dc=de"
adding new entry "ou=it,dc=suse,dc=de"
```

***Output 24:** ldapadd with example.ldif*

The user data of the individual colleagues can be prepared in separate LDIF files. The following example, shown in Output 25, adds the colleague `Tux` to the new LDAP directory.

```
# The colleague Tux
dn: cn=Tux Linux,ou=devel,dc=suse,dc=de
objectClass: inetOrgPerson
cn: Tux Linux
```

```
givenName: Tux
mail: tux@suse.de
uid: tux
telephoneNumber: +49 1234 567-8
```

Output 25: *LDIF Data for Tux*

An LDIF file can contain an arbitrary number of objects. It is possible to pass entire directory branches to the server at once or only parts of it as shown in the example of individual objects. If it is necessary to modify some data relatively often, a fine subdivision of single objects is recommended.

Modifying Data in the LDAP Directory

The tool `ldapmodify` is provided for modifying the data stock. The easiest way to do this is to modify the corresponding LDIF file then pass this modified file to the LDAP server. To change the telephone number of colleague Tux from `+49 1234 567-8` to `+49 1234 567-10`, the LDIF file must be edited like in Output 26.

```
# The Colleague Tux
dn: cn=Tux Linux,ou=devel,dc=suse,dc=de
changetype: modify
replace: telephoneNumber
telephoneNumber: +49 1234 567-10
```

Output 26: *Modified LDIF File tux.ldif*

Import the modified file into the LDAP directory with the following command:

```
ldapmodify -x -D cn=admin,dc=suse,dc=de -W -f tux.ldif
```

Alternatively, pass the attributes to change directly to `ldapmodify`. The procedure for this is described below:

- Call `ldapmodify` and enter your password:

  ```
  ldapmodify -x -D cn=admin,dc=suse,dc=de -W
  Enter LDAP password:
  ```

- Enter the changes while carefully complying to the syntax in the order it is presented below:

```
    dn: cn=Tux Linux,ou=devel,dc=suse,dc=de
    changetype: modify
    replace: telephoneNumber
    telephoneNumber: +49 1234 567-10
```

Read detailed information about `ldapmodify` and its syntax in its corresponding man page.

Searching or Reading Data from an LDAP Directory

OpenLDAP provides, with `ldapsearch`, a command line tool for searching data within an LDAP directory and reading data from it. A simple query would have the following syntax:

```
ldapsearch -x -b "dc=suse,dc=de" "(objectClass=*)"
```

The option `-b` determines the search base — the section of the tree within which the search should be performed. In the current case, this is `dc=suse,dc=de`. To perform a more finely-grained search in specific subsections of the LDAP directory (for instance, only within the `devel` department), pass this section to ldapsearch with `-b`. The `-x` switch requests the activation of simple authentication. `(objectClass=*)` declares that all objects contained in the directory should be read. This command option can be used after the creation of a new directory tree to verify that all entires have been recorded correctly and the server responds as desired. More information about the use of `ldapsearch` can be found in the corresponding man page (`man ldapsearch`).

Deleting Data from an LDAP Directory

Delete unwanted entries with `ldapdelete`. The syntax is similar to that of the commands described above. To delete, for example, the complete entry for `Tux Linux`, the following command is issued:

```
ldapdelete -x -D "cn=admin,dc=suse,dc=de" -W cn=Tux \
Linux,ou=devel,dc=suse,dc=de
```

LDAP Configuration with YaST

Note

Configuration of the LDAP Server

YaST assists in the organization of directory entries, but not in the actual configuration of the LDAP server. The LDAP server must be set up properly (bound schemas, appropriate ACLs, start-up behavior) before it is possible to work with YaST's LDAP client module. The list of schemas must be extended by with `yast2userconfig.schema` in addition to the typical NIS schemas (`rfc2307bis.schema` and `cosine.schema`). Add a base entry for the LDAP tree under which all other objects are located. This entry is created in the same way as described above for ldapadd from an `.ldif` file.

Note

In SuSE Linux, it is possible to employ LDAP instead of NIS for the administration of group and user data. YaST offers a module for user authentication in a network in 'Network Services' → 'LDAP Client'. This menu offers the activation of LDAP for the administration of user information and accepts standard entries that will queried by the YaST modules when new users or groups are created.

Standard Procedure

The processes acting in the background of a client machine must be known to understand the workings of the YaST LDAP module. If LDAP is activated for network authentication or the YaST module is called, the packages `pam_ldap` and `nss_ldap` are installed and the two corresponding configuration files are adapted.

`pam_ldap` is the PAM module responsible for negotiation between login processes and the LDAP directory as the source of authentication data. The dedicated module `pam_ldap.so` is installed and the PAM configuration is adapted (see Output 27).

```
auth:       use_ldap nullok
account:    use_ldap
password:   use_ldap nullok
session:    none
```

Output 27: *pam_unix2.conf Adapted to LDAP*

When manually configuring additional services to use LDAP, include the PAM LDAP module in the PAM configuration file corresponding to the service in `/etc/pam.d`. Configuration files already adapted to individual services can be found in `/usr/share/doc/packages/pam_ldap/pam.d/`. Copy appropriate files to `/etc/pam.d`.

The name resolution of `glibc` through the `nsswitch` mechanism is adapted to the employment of LDAP with `nss_ldap`. A new, adapted file `nsswitch.conf` is created in `/etc/` with the installation of this package. More about the workings of `nsswitch.conf` can be found in Section *Configuration Files* on page 315. The following lines must be present in `nsswitch.conf` for user administration and authentication with LDAP (compare with Output 28):

```
passwd: files ldap
group:  files ldap
```

Output 28: *Adaptations in nsswitch.conf*

These lines order the resolver library of `glibc` first to evaluate the corresponding files in `/etc` and additionally access the LDAP server as sources for authentication and user data. Test this mechanism, for example, by reading the content of the user database with the command `getent passwd`. The returned set should contain a survey of the local users of your system as well as all users stored on the LDAP server.

Modules and Templates — Configuration with YaST

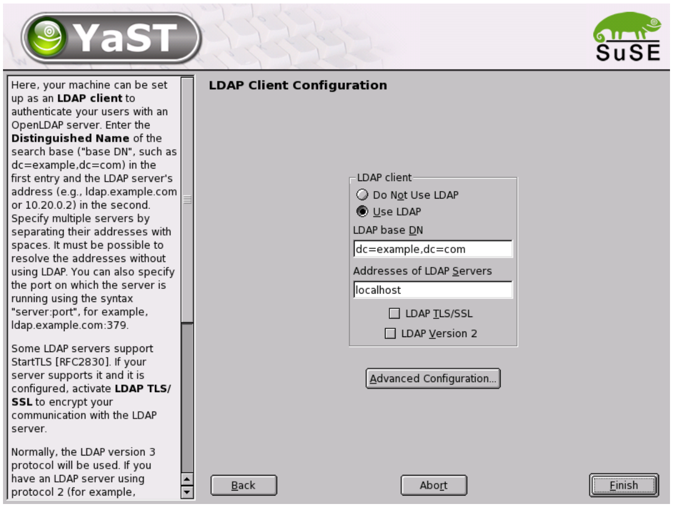
After `nss_ldap` and `pam_ldap` have been adapted correctly by YaST, the actual configuration work can begin on the first YaST input form (see Figure 13.5).

Note

Employing the YaST Client

Use the YaST LDAP client to adapt the YaST modules for user and group administration and to extend them as needed. It is furthermore possible to define templates with default values for the individual attributes to simplify the actual registration of the data. The presets created here are stored themselves as LDAP objects in the LDAP directory. The registration of user data is still done with the regular YaST module input forms. The registered information is stored as objects in the LDAP directory.

Note



Here, your machine can be set up as an **LDAP client** to authenticate your users with an OpenLDAP server. Enter the **Distinguished Name** of the search base ("base DN", such as dc=example,dc=com) in the first entry and the LDAP server's address (e.g., ldap.example.com or 10.20.0.2) in the second. Specify multiple servers by separating their addresses with spaces. It must be possible to resolve the addresses without using LDAP. You can also specify the port on which the server is running using the syntax "server:port", for example, ldap.example.com:379.

Some LDAP servers support StartTLS [RFC2830]. If your server supports it and it is configured, activate **LDAP TLS/SSL** to encrypt your communication with the LDAP server.

Normally, the LDAP version 3 protocol will be used. If you have an LDAP server using protocol 2 (for example,

LDAP Client Configuration

LDAP client

Do Not Use LDAP [✓ Use LDAP]

LDAP base DN: dc=example,dc=com

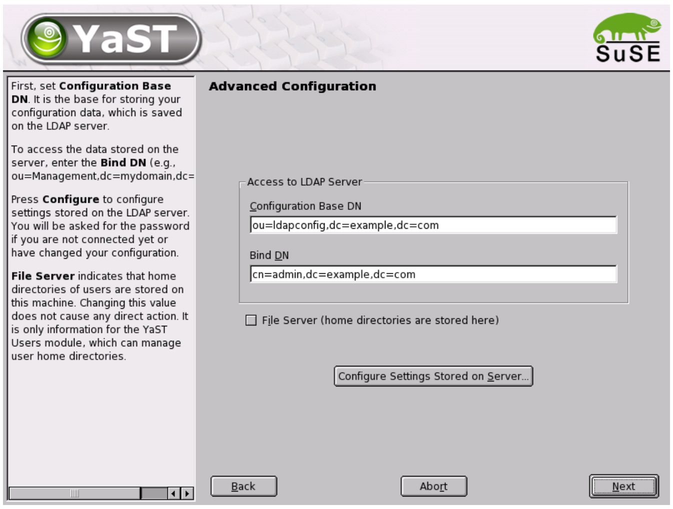
Addresses of LDAP Servers: localhost

☐ LDAP TLS/SSL

☐ LDAP Version 2

Figure 13.5: YaST: Configuration of the LDAP Client

Activate the use of LDAP for user authentication via radio button in the first dialog. Enter the search base on the server below which all data is stored on the LDAP server in 'LDAP base DN'. Enter the address at which the LDAP server can be reached in 'Adresses of LDAP Servers'. If the server supports StartTLS, check 'LDAP TLS/SSL' to activate encrypted communication between the client and the server. To modify data on the server as administrator, click 'Advanced Configuration' (see Figure 13.6 on the facing page).



First, set **Configuration Base DN**. It is the base for storing your configuration data, which is saved on the LDAP server.

To access the data stored on the server, enter the **Bind DN** (e.g., ou=Management,dc=mydomain,dc=

Press **Configure** to configure settings stored on the LDAP server. You will be asked for the password if you are not connected yet or have changed your configuration.

File Server indicates that home directories of users are stored on this machine. Changing this value does not cause any direct action. It is only information for the YaST Users module, which can manage user home directories.

Advanced Configuration

Access to LDAP Server

Configuration Base DN: ou=ldapconfig,dc=example,dc=com

Bind DN: cn=admin,dc=example,dc=com

☐ File Server (home directories are stored here)

Figure 13.6: *YaST: Advanced Configuration*

Enter the required access data for modifying configurations on the LDAP server here. These are 'Configuration Base DN' below which all configuration objects are stored and 'Bind DN'. The Bind DN is, in this case, your user DN. Check 'File Server' if the computer on which this YaST module is executed is the network file server.

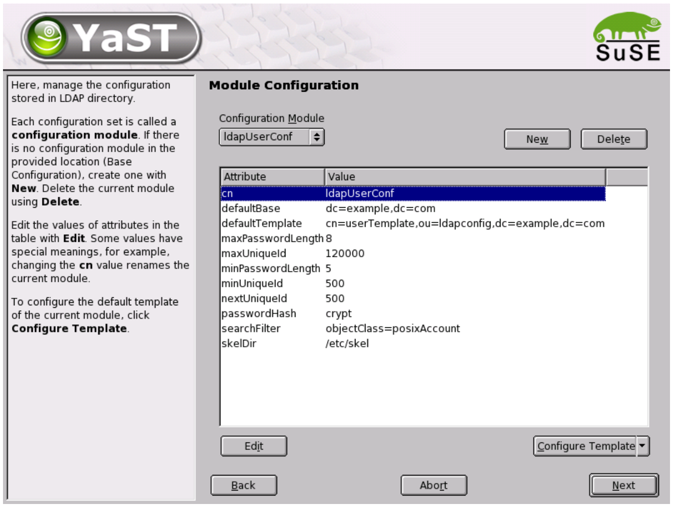
Click 'Configure Settings Stored on Server' to edit entries on the LDAP server. In the pop-up that appears, enter your LDAP password for authentication with the server. Access to the configuration modules on the server is then granted according to the ACLs and ACIs stored on the server.

Tip

YaST currently only supports modules for group and user administration.

Tip

The dialog for module configuration (Figure 13.7 on the next page) allows selection and modification existing configuration modules, creation of new modules, and design and modification of templates for such modules. To modify a value in a configuration module or rename a module, select the module type in the combobox above the content view of the current module. The content view then features a table listing all attributes allowed in this module with their assigned values. Apart from all set attributes, the list also contains all other attributes allowed by the current schema but currently not used.


Here, manage the configuration stored in LDAP directory.

Each configuration set is called a **configuration module**. If there is no configuration module in the provided location (Base Configuration), create one with **New**. Delete the current module using **Delete**.

Edit the values of attributes in the table with **Edit**. Some values have special meanings, for example, changing the **cn** value renames the current module.

To configure the default template of the current module, click **Configure Template**.

Module Configuration

Configuration Module: ldapUserConf

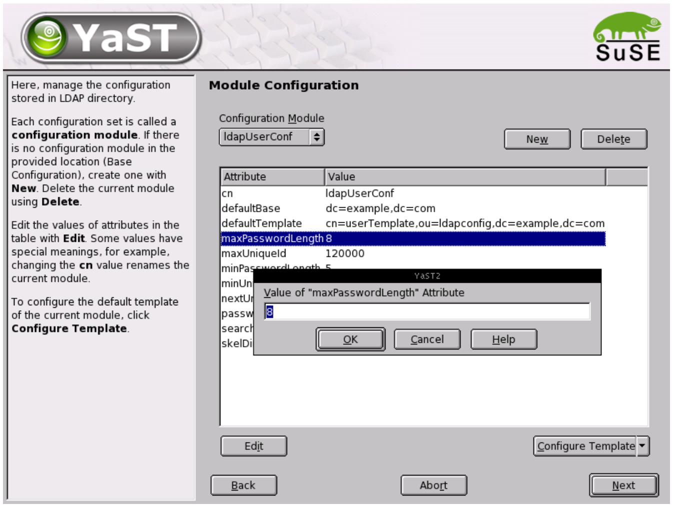
Attribute	Value
cn	ldapUserConf
defaultBase	dc=example,dc=com
defaultTemplate	cn=userTemplate,ou=ldapconfig,dc=example,dc=com
maxPasswordLength	8
maxUniqueId	120000
minPasswordLength	5
minUniqueId	500
nextUniqueId	500
passwordHash	crypt
searchFilter	objectClass=posixAccount
skelDir	/etc/skel

***Figure 13.7:** YaST: Module Configuration*

To copy a module, it is only necessary to change `cn`. To modify individual attribute values, select them from the content list then click 'Edit'. A dialog window opens in which to change all settings belonging to the attribute. The changes are accepted with 'OK'.

If a new module should be added to the existing modules, click 'New', located above the content overview. Enter the name and the object class of the new module in the dialog that appears (either `userConfiguration` or `groupConfiguration`). When the dialog is closed with 'OK', the new module is added to the selection list of the existing modules and can then be selected or deselected in the combobox. Clicking 'Delete' deletes the currently selected module.

The YaST modules for group and user administration embed templates with sensible standard values, if these were previously defined with the YaST LDAP clients. To edit a template as desired, click 'Configure Template'. The drop-down menu either contains already existing, modifiable templates or an empty entry. Select one and configure the properties of this template in the 'Object Template Configuration' form (see Figure 13.10 on page 355). This form is subdivided into two overview windows in table form. The upper window lists all general template attributes. Determine the values according to your mission scenario or leave some of them empty. Empty attributes are deleted on the LDAP server.



Here, manage the configuration stored in LDAP directory.

Each configuration set is called a **configuration module**. If there is no configuration module in the provided location (Base Configuration), create one with **New**. Delete the current module using **Delete**.

Edit the values of attributes in the table with **Edit**. Some values have special meanings, for example, changing the **cn** value renames the current module.

To configure the default template of the current module, click **Configure Template**.

Module Configuration

Configuration Module: ldapUserConf

Attribute	Value
cn	ldapUserConf
defaultBase	dc=example,dc=com
defaultTemplate	cn=userTemplate,ou=ldapconfig,dc=example,dc=com
maxPasswordLength	8
maxUniqueId	120000
minPasswordLength	5
minUn	
nextUr	
passw	
search	
skelDi	

Value of "maxPasswordLength" Attribute: 8

Figure 13.8: YaST: Changing Attributes in the Module Configuration

The second view ('Default Values for New Objects') lists all attributes of the corresponding LDAP object (in this case group or user configuration) for which a standard value is defined. Additional attributes and their standard values can be added, existing attribute-value pairs can be edited, and entire attributes can be deleted. Copy a template by changing the `cn` entry. Connect the template to its module, as already described, by setting the `defaultTemplate` attribute value of the module to the DN of the adapted template.

Tip

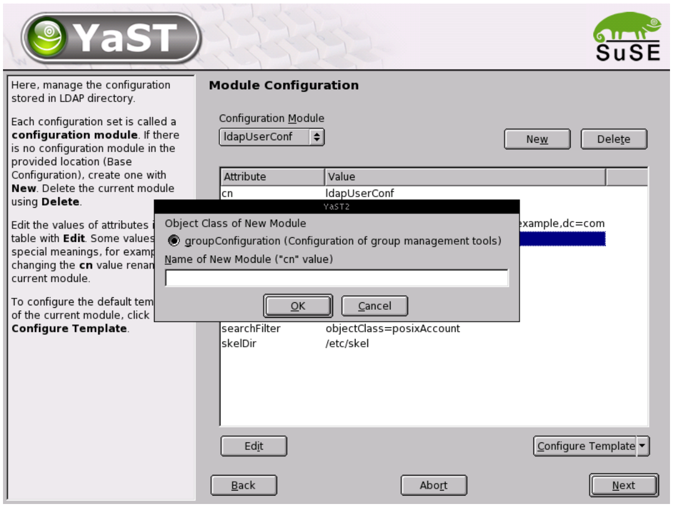
The default values for an attribute can be created from other attributes by using a variable style instead of an absolute value. For example, when creating a new user, `cn=%sn %givenName` is created automatically from the attribute values for `sn` and `givenName`.

Tip

Once all modules and templates are configured correctly and ready to run, new groups and users can be registered in the usual way with YaST.

Users and Groups — Configuration with YaST

The actual registration of user and group data differs only slightly from the procedure when not using LDAP. The following brief instructions relate to the administration of users. The procedure for administering groups is analogous.



Here, manage the configuration stored in LDAP directory.

Each configuration set is called a **configuration module**. If there is no configuration module in the provided location (Base Configuration), create one with **New**. Delete the current module using **Delete**.

Edit the values of attributes i table with **Edit**. Some values special meanings, for examp changing the **cn** value renan current module.

To configure the default tem of the current module, click **Configure Template**.

Module Configuration

Configuration Module: ldapUserConf

Attribute	Value
cn	ldapUserConf
	xample,dc=com
searchFilter	objectClass=posixAccount
skelDir	/etc/skel

YaST2

Object Class of New Module

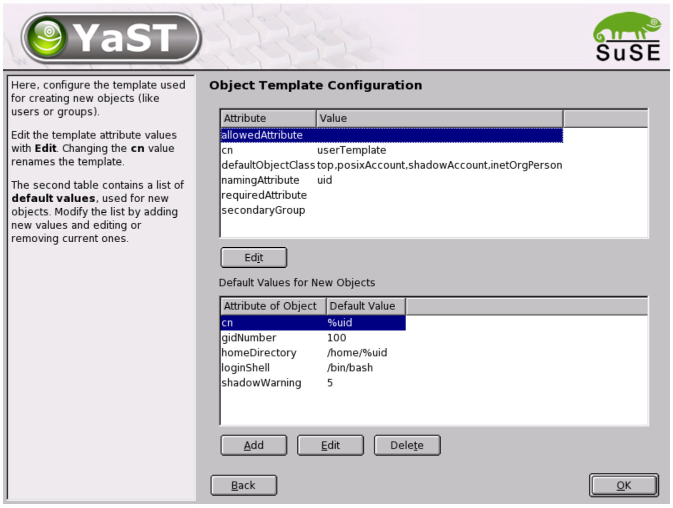
● groupConfiguration (Configuration of group management tools)

Name of New Module ("cn" value)

Figure 13.9: *YaST: Creating a New Module*

Access the YaST user administration with 'Security & Users' → 'User Administration'. An input form is displayed for the registration of the most important user data, like name, login, and password. 'Details' accesses a form for the configuration of group membership, login shell, and the home directory. The default values for the input fields have previously been defined with the procedure described in Section *Modules and Templates — Configuration with YaST* on page 350. When LDAP is used, this form leads to another form for the registration of LDAP-specific attributes. It is shown in Figure 13.12 on page 357. Select all attributes for which to change the value then click 'Edit'. Closing the form that opens with with 'Continue' returns to the initial input form for user administration.

The initial input form of user administration, shown in Figure 13.11 on page 356, offers 'Expert Options'. This gives the possibility to apply LDAP search filters to the set of available users or to configure the YaST LDAP client with 'Configure LDAP Client'.



Here, configure the template used for creating new objects (like users or groups).

Edit the template attribute values with **Edit**. Changing the **cn** value renames the template.

The second table contains a list of **default values**, used for new objects. Modify the list by adding new values and editing or removing current ones.

Object Template Configuration

Attribute	Value
allowedAttribute	
cn	userTemplate
defaultObjectClass	top,posixAccount,shadowAccount,inetOrgPerson
namingAttribute	uid
requiredAttribute	
secondaryGroup	

Edit

Default Values for New Objects

Attribute of Object	Default Value
cn	%uid
gidNumber	100
homeDirectory	/home/%uid
loginShell	/bin/bash
shadowWarning	5

Add Edit Delete

Back OK

Figure 13.10: *YaST: Configuration of an Object Template*

For More Information

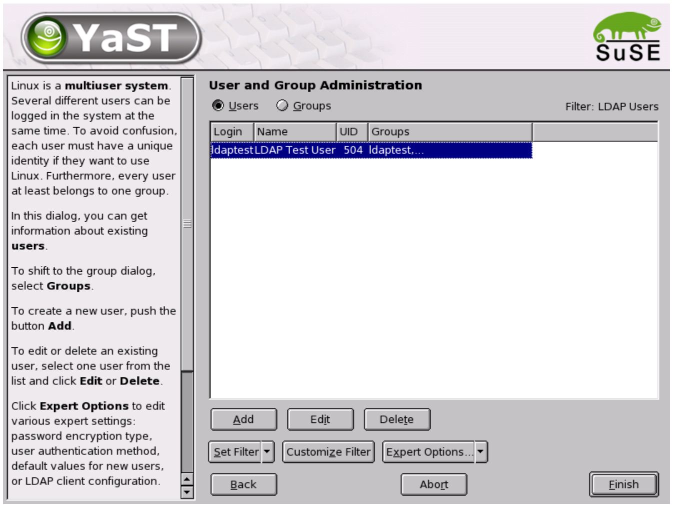
More complex subjects, like SASL configuration or the establishment of a replicating LDAP server that distributes the workload among multiple "slaves", were intentionally not included in this chapter. Detailed informationabout both subjects can be found in the *OpenLDAP 2.1 Administrator's Guide* (see below for references).

The web site of the OpenLDAP project offers exhaustive documentation for beginning and advanced LDAP users:

OpenLDAP Faq-O-Matic A very rich question and answer collection concerning installation, configuration, and employment of OpenLDAP. `http://www.openldap.org/faq/data/cache/1.html`.

Quick Start Guide Brief step-by-step instructions for installing your first LDAP server. `http://www.openldap.org/doc/admin21/quickstart.html` or on an installed system in `/usr/share/doc/packages/openldap2/admin-guide/quickstart.html`

OpenLDAP 2.1 Administrator's Guide A detailed introduction to all important aspects of LDAP configuration, including access controls and encryption.



Linux is a **multiuser system**. Several different users can be logged in the system at the same time. To avoid confusion, each user must have a unique identity if they want to use Linux. Furthermore, every user at least belongs to one group.

In this dialog, you can get information about existing **users**.

To shift to the group dialog, select **Groups**.

To create a new user, push the button **Add**.

To edit or delete an existing user, select one user from the list and click **Edit** or **Delete**.

Click **Expert Options** to edit various expert settings: password encryption type, user authentication method, default values for new users, or LDAP client configuration.

User and Group Administration

Login	Name	UID	Groups
ldaptest	LDAP Test User	504	ldaptest,...

Figure 13.11: *YaST: User Administration*

`http://www.openldap.org/doc/admin21/` or on an installed system in `/usr/share/doc/packages/openldap2/admin-guide/index.html`

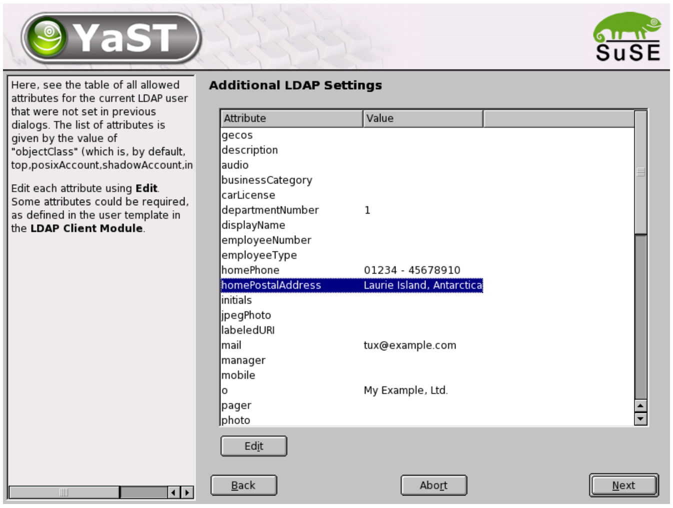
The following redbooks from IBM exist regarding the subject of LDAP:

Understanding LDAP A detailed general introduction to the basic principles of LDAP.
`http://www.redbooks.ibm.com/redbooks/pdfs/sg244986.pdf`

LDAP Implementation Cookbook The target audience consists of administrators of *IBM SecureWay Directory*. However, important general information about LDAP is also contained here.
`http://www.redbooks.ibm.com/redbooks/pdfs/sg245110.pdf`

Printed literature about LDAP:

- Howes, Smith, and Good: *Understanding and Deploying LDAP Directory Services*. Addison-Wesley, 2. Aufl., 2003. - (ISBN 0-672-32316-8)
- Hodges: *LDAP System Administration*. O'Reilly & Associates, 2003. - (ISBN 1-56592-491-6)


Here, see the table of all allowed attributes for the current LDAP user that were not set in previous dialogs. The list of attributes is given by the value of "objectClass" (which is, by default, top,posixAccount,shadowAccount,in

Edit each attribute using **Edit**. Some attributes could be required, as defined in the user template in the **LDAP Client Module**.

Additional LDAP Settings

Attribute	Value
gecos	
description	
audio	
businessCategory	
carLicense	
departmentNumber	1
displayName	
employeeNumber	
employeeType	
homePhone	01234 - 45678910
homePostalAddress	Laurie Island, Antarctica
initials	
jpegPhoto	
labeledURI	
mail	tux@example.com
manager	
mobile	
o	My Example, Ltd.
pager	
photo	

Figure 13.12: *YaST: Additional LDAP Settings*

The ultimate reference material for the subject of LDAP is the corresponding RFCs (request for comments), 2251 to 2256.

NIS — Network Information Service

As soon as multiple UNIX systems in a network want to access common resources, it becomes important that all user and group identities are the same for all machines in that network. The network should be transparent to the user: whatever machine a user uses, he will always find himself in exactly the same environment. This is made possible by means of NIS and NFS services. NFS distributes file systems over a network and is discussed in *NFS — Shared File Systems* on page 363.

NIS (Network Information Service) is a database service that enables access to `/etc/passwd`, `/etc/shadow`, and `/etc/group` across a network. NIS can be used for other, more specialized tasks (such as for `/etc/hosts` or `/etc/services`). NIS is commonly referred to as YP. This comes from "yellow pages", the "yellow pages" on the net.

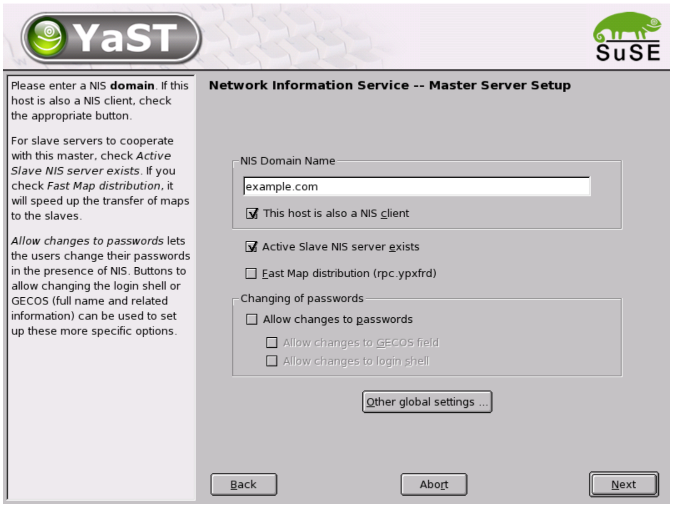
NIS Master and Slave Server

For the configuration, select 'NIS Server' from the YaST module 'Network — Services'. If no NIS server existed so far in your network, activate 'Create NIS Master Server' in the next screen. If you already have an NIS server (a "master"), you can add a NIS slave server (for example, if you want to configure a new subnetwork). First, the configuration of the master server is described.

If some needed packages are missing, insert the respective CD or DVD as requested to install the packages automatically. Enter the domain name at the top of the configuration dialog, which is shown in Figure 13.13 on the next page. In the check box below, define whether the host should also be an NIS client, enabling users to log in and access data from the NIS server.

If you want to configure additional NIS servers (*slave servers*) in your network afterwards, activate 'Active NIS Slave Server Exists' now. Select 'Fast Map Distribution' to set fast transfer of the database entries from the master to the slave server.

To allow users in your network to change their passwords on the NIS server (with the command `yppasswd`), activate this option. This will activate the check boxes 'Allow Changes of GECOS Field' and 'Allow Changes of Login Shell'. "GECOS" means that the users can also change their names and address settings with the command `ypchfn`. "SHELL" allows users to modify their default shell with the command `ypchsh`.



Please enter a NIS **domain**. If this host is also a NIS client, check the appropriate button.

For slave servers to cooperate with this master, check *Active Slave NIS server exists*. If you check *Fast Map distribution*, it will speed up the transfer of maps to the slaves.

Allow changes to passwords lets the users change their passwords in the presence of NIS. Buttons to allow changing the login shell or GECOS (full name and related information) can be used to set up these more specific options.

Network Information Service -- Master Server Setup

NIS Domain Name: example.com

[✓] This host is also a NIS client

[✓] Active Slave NIS server exists

[ ] Fast Map distribution (rpc.ypxfrd)

Changing of passwords

[ ] Allow changes to passwords

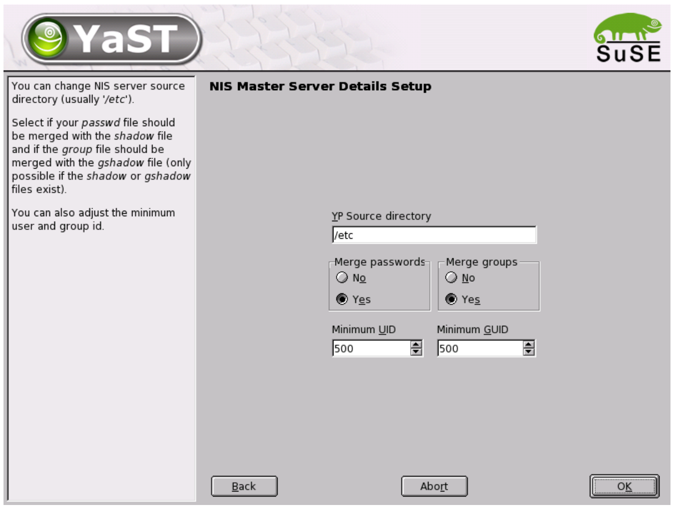
[ ] Allow changes to GECOS field

[ ] Allow changes to login shell

Figure 13.13: *YaST: NIS Server Configuration Tool*

By clicking 'Other Global Settings...', access a screen, shown in Figure 13.14 on the following page, in which to change the source directory of the NIS server (`/etc` by default). In addition, passwords and groups can be linked here. The setting should be left at 'Yes' so the files (`/etc/passwd` and `/etc/shadow` as well as `/etc/group` and `/etc/gshadow`) can be synchronized. Also determine the smallest user and group ID. Press 'OK' to confirm your settings and return to the previous screen. Click 'Next'.

If you previously enabled 'Active NIS Slave Server Exists', enter the host names used as slaves and click 'Next'. If you do not use slave servers, the slave configuration is skipped and you continue directly to the dialog for the database configuration. Here, specify the *maps*, the partial databases to be transferred from the NIS server to the respective client. The default settings are usually adequate. You should know exactly what you are doing if you modify the settings.



You can change NIS server source directory (usually '/etc').

Select if your *passwd* file should be merged with the *shadow* file and if the *group* file should be merged with the *gshadow* file (only possible if the *shadow* or *gshadow* files exist).

You can also adjust the minimum user and group id.

NIS Master Server Details Setup

YP Source directory: /etc

Merge passwords: No [✓ Yes]

Merge groups: No [✓ Yes]

Minimum UID: 500

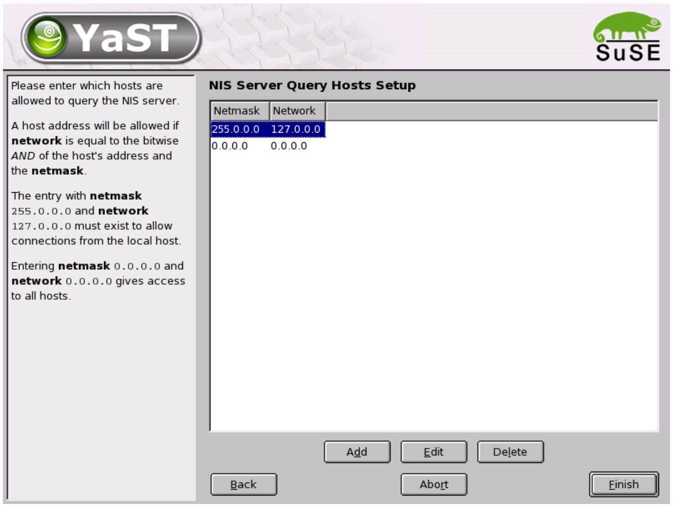
Minimum GUID: 500

Figure 13.14: YaST: Changing the Directory and Synchronizing Files for a NIS Server

'Next' continues to the last dialog, shown in Figure 13.15 on the next page. Specify from which networks requests can be sent to the NIS server. Normally, this is your internal network. In this case, there should be the following two entries:

```
255.0.0.0 127.0.0.0
0.0.0.0 0.0.0.0
```

The first one enables connections from your own host, which is the NIS server. The second one allows all hosts with access to the same network to send requests to the server.


Please enter which hosts are allowed to query the NIS server.

A host address will be allowed if **network** is equal to the bitwise *AND* of the host's address and the **netmask**.

The entry with **netmask** `255.0.0.0` and **network** `127.0.0.0` must exist to allow connections from the local host.

Entering **netmask** `0.0.0.0` and **network** `0.0.0.0` gives access to all hosts.

NIS Server Query Hosts Setup

Netmask	Network
255.0.0.0	127.0.0.0
0.0.0.0	0.0.0.0

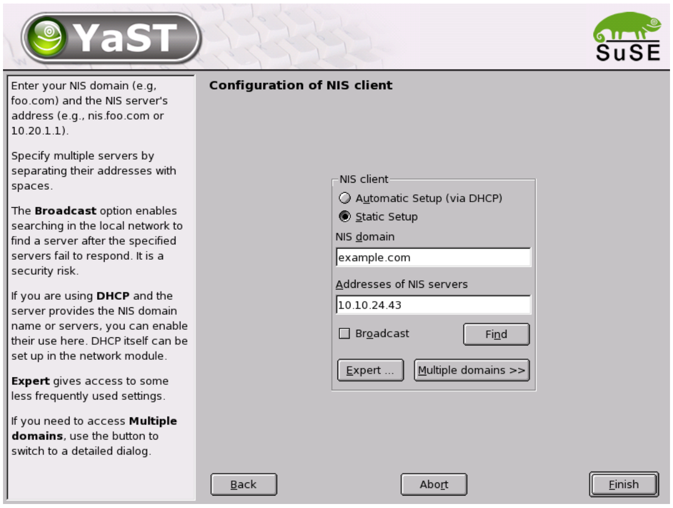
Figure 13.15: *YaST: Setting Request Permissions for a NIS Server*

The NIS Client Module of YaST

This module facilitates the configuration of the NIS client. After having chosen to use NIS and, depending on the circumstances, of the automounter, you are being led to the following menu. Then, select whether the host has a fixed IP address or receives one issued by DHCP. DHCP also provides the NIS domain and the NIS server. For further information about DHCP, see *DHCP* on page 367. If a static IP address is used, specify the NIS domain and the NIS server manually.

The button 'Search' makes YaST search for an active NIS server in your network.

In addition, you also have the possibility to specify multiple domains with one default domain. Use 'Add' to specify multiple servers including the broadcast function for the individual domains.



Enter your NIS domain (e.g, foo.com) and the NIS server's address (e.g., nis.foo.com or 10.20.1.1).

Specify multiple servers by separating their addresses with spaces.

The **Broadcast** option enables searching in the local network to find a server after the specified servers fail to respond. It is a security risk.

If you are using **DHCP** and the server provides the NIS domain name or servers, you can enable their use here. DHCP itself can be set up in the network module.

Expert gives access to some less frequently used settings.

If you need to access **Multiple domains**, use the button to switch to a detailed dialog.

Configuration of NIS client

NIS client

- ○ Automatic Setup (via DHCP)
- ● Static Setup

NIS domain: example.com

Addresses of NIS servers: 10.10.24.43

☐ Broadcast

Figure 13.16: *Setting Domain and Address of NIS Server*

In the expert settings, check 'Answer to the Local Host Only', if you do not want other hosts to be able to query which server your client is using. By checking 'Broken Server', no answers from servers on unprivileged ports are accepted. This is recommended for security reasons. For further information, see `man ypbind`.

NFS — Shared File Systems

As mentioned in *NIS — Network Information Service* on page 358, NFS (together with NIS) makes a network transparent to the user. With NFS, it is possible to distribute file systems over the network. It does not matter at which terminal a user is logged in. He will always find himself in the same environment.

As with NIS, NFS is an asymmetric service. There are NFS servers and NFS clients. A machine can be both — it can supply file systems over the network (export) and mount file systems from other hosts (import). Generally, these are servers with a very large hard disk capacity, whose file systems are mounted by other clients.

Importing File Systems with YaST

Any user authorized to do so can mount NFS directories from an NFS server into his own file tree. This can be achieved most easily using the YaST module 'NFS Client'. Just enter the host name of the NFS server, the directory to import, and the mount point at which to mount this directory locally. All this is done after clicking 'Add' in the first dialog (Figure 13.17).

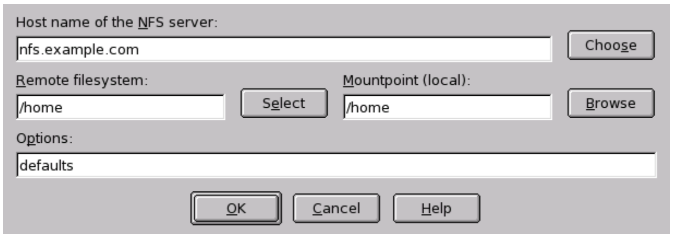

Host name of the NFS server: nfs.example.com
Remote filesystem: /home
Mountpoint (local): /home
Options: defaults

Figure 13.17: *NFS Client Configuration with YaST*

Importing File Systems Manually

File systems can easily be imported manually from an NFS server. The only prerequisite is a running RPC port mapper, which can be started by entering the command `rcportmap start` as `root`. Once this prerequisite is met, remote file systems exported on the respective machines can be mounted in the file system just like local hard disks by using the command `mount` with the following syntax:

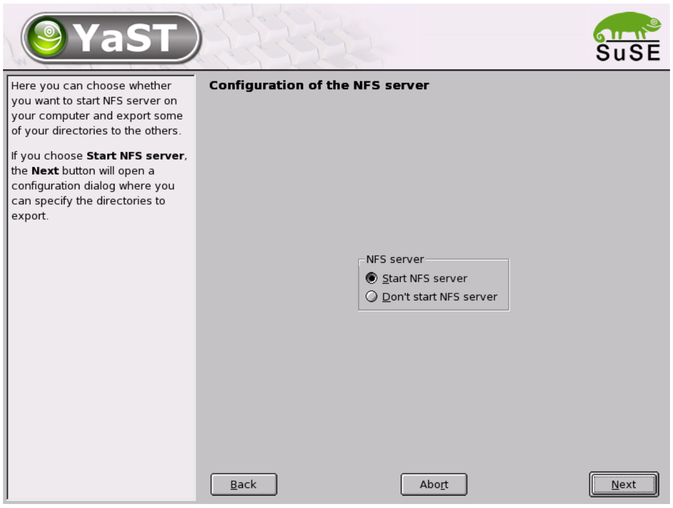
```
mount ⟨host⟩:⟨remote-path⟩ ⟨local-path⟩
```

If user directories from the machine `sun`, for example, should be imported, the following command can be used:

```
mount sun:/home /home
```

Exporting File Systems with YaST

YaST enables you to quickly turn any host in your network into an NFS server. In YaST select 'Network — Services' → 'NFS Server'. See Figure 13.18.



Here you can choose whether you want to start NFS server on your computer and export some of your directories to the others.

If you choose **Start NFS server**, the **Next** button will open a configuration dialog where you can specify the directories to export.

Configuration of the NFS server

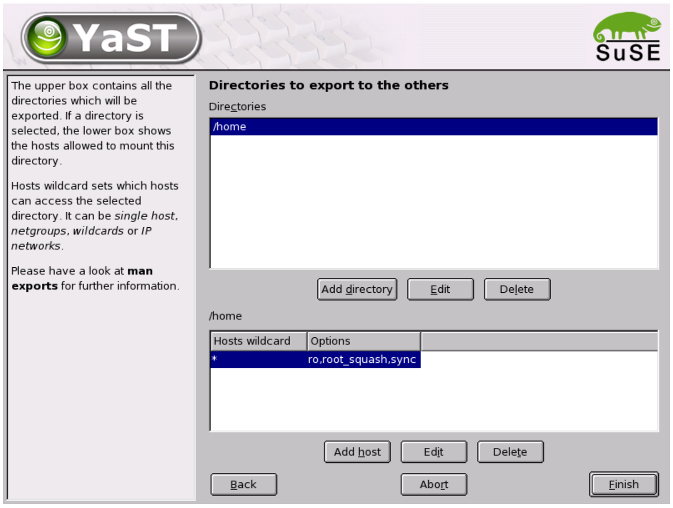
NFS server
● Start NFS server
○ Don't start NFS server

Figure 13.18: *YaST: NFS Server Configuration Tool*

Next, activate 'Start NFS Server' and click 'Next'. In the upper text field, enter the directories to export. Below, enter the hosts that should have access to them. This dialog is shown in Figure 13.19 on the facing page. There are four options that can be set for each host: ⟨*single host*⟩, ⟨*net groups*⟩, ⟨*wild cards*⟩, and ⟨*IP networks*⟩. A more thorough explanation of these options is provided by the man page for `exports` (`man exports`). 'Exit' completes the configuration.

Exporting File Systems Manually

If you do not want to use YaST, make sure the following systems run on the NFS server:



The upper box contains all the directories which will be exported. If a directory is selected, the lower box shows the hosts allowed to mount this directory.

Hosts wildcard sets which hosts can access the selected directory. It can be *single host, netgroups, wildcards* or *IP networks*.

Please have a look at **man exports** for further information.

Directories to export to the others

Directories

Directories
/home

/home

Hosts wildcard	Options
*	ro,root_squash,sync

Figure 13.19: *Configuring an NFS Server with YaST*

- RPC portmapper (*rpc.portmap*)
- RPC mount daemon (*rpc.mountd*)
- RPC NFS daemon (*rpc.nfsd*)

For these services to be started by the scripts /etc/init.d/portmap and /etc/init.d/nfsserver when the system is booted, enter the commands `insserv /etc/init.d/nfsserver` and `insserv /etc/init.d/portmap`. After these daemons have been started, the configuration file `/etc/exports` decides which directories should be exported to which machines.

For each directory to export, one line is needed to specify which machines may access that directory with what permissions. All subdirectories of this directory will automatically be exported as well. Authorized machines are usually denoted with their full names (including domain name), but it is possible to use wild cards like `'*'` or `'?'`. If no machine is specified here, any machine is allowed to import this file system with the given permissions.

Permissions of the file system to export are specified in brackets after the machine name. The most important options are:

ro	File system is exported with read-only permission (default).
rw	File system is exported with read-write permission.
root_squash	This makes sure the user `root` of the given machine does not have `root` specific permissions on this file system. This is achieved by assigning user ID `65534` to users with user ID `0` (root). This user ID should be set to `nobody`
no_root_squash	Does not assign user ID `0` to user ID `65534` (default).
link_relative	Converts absolute links (those beginning with `'/'`) to a sequence of `'../'`. This is only useful if the entire file system of a machine is mounted (default).
link_absolute	Symbolic links remain untouched.
map_identity	User IDs are exactly the same on both client and server (default).
map-daemon	Client and server do not have matching user IDs. This tells nfsd to create a conversion table for user IDs. **ugidd** is required for this to work.

Table 13.14: *Permissions for Exported File Systems*

Your `exports` file might look like File 41.

```
#
# /etc/exports
#
/home             sun(rw)   venus(rw)
/usr/X11          sun(ro)   venus(ro)
/usr/lib/texmf    sun(ro)   venus(rw)
/                 earth(ro,root_squash)
/home/ftp         (ro)
# End of exports
```

File 41: *`/etc/exports`*

File `/etc/exports` is read by mountd. If you change anything in this file, restart mountd and nfsd for your changes to take effect. This can easily be done with `rcnfsserver restart`.

DHCP

The DHCP Protocol

The purpose of the "Dynamic Host Configuration Protocol" is to assign network settings centrally from a server rather than configuring them locally on each and every workstation. A client configured to use DHCP does not have control over its own static address. It is enabled to fully autoconfigure itself according to directions from the server.

One way to use DHCP is to identify each client using the hardware address of its network card (which is fixed in most cases) then supply that client with identical settings each time it connects to the server. DHCP can also be configured so the server assigns addresses to each "interested" host *dynamically* from an address pool set up for that purpose. In the latter case, the DHCP server will try to assign the same address to the client each time it receives a request from it (even over longer periods). This, of course, will not work if there are more client hosts in the network than network addresses available.

With these possibilities, DHCP can make life easier for system administrators in two ways. Any changes (even bigger ones) related to addresses and the network configuration in general can be implemented centrally by editing the server's configuration file. This is much more convenient than reconfiguring lots of client machines. Also it is much easier to integrate machines, particularly new machines, into the network, as they can be given an IP address from the pool. Retrieving the appropriate network settings from a DHCP server can be especially useful in the case of laptops regularly used in different networks.

A DHCP server not only supplies the IP address and the netmask, but also the host name, domain name, gateway, and name server addresses to be used by the client. In addition to that, DHCP allows for a number of other parameters to be configured in a centralized way, for example, a time server from which clients may poll the current time or even a print server.

The following section, gives an overview of DHCP without describing the service in every detail. In particular, we want to show how to use the DHCP server dhcpd in your own network to easily manage its entire setup from one central point.

DHCP Software Packages

Both a DHCP server and DHCP clients are available for SuSE Linux. The DHCP server available is dhcpd (published by the Internet Software Consortium). On the client side, you can choose between two different DHCP client programs:

dhclient (also from ISC) and the “DHCP client daemon” in the dhcpcd package.

SuSE Linux installs dhcpcd by default. The program is very easy to handle and will be launched automatically on each system boot to watch for a DHCP server. It does not need a configuration file to do its job and should work out of the box in most standard setups. For more complex situations, use the ISC dhclient, which is controlled by means of the configuration file /etc/dhclient.conf.

The DHCP Server dhcpd

The core of any DHCP system is the *dynamic host configuration protocol daemon*. This server “leases” addresses and watches how they are used, according to the settings as defined in the configuration file /etc/dhcpd.conf. By changing the parameters and values in this file, a system administrator can influence the program’s behavior in numerous ways.

Look at a basic sample /etc/dhcpd.conf file:

```
default-lease-time 600;         # 10 minutes
max-lease-time 7200;            # 2  hours

option domain-name "kosmos.all";
option domain-name-servers 192.168.1.1, 192.168.1.2;
option broadcast-address 192.168.1.255;
option routers 192.168.1.254;
option subnet-mask 255.255.255.0;

subnet 192.168.1.0 netmask 255.255.255.0
 {
  range 192.168.1.10 192.168.1.20;
  range 192.168.1.100 192.168.1.200;
 }
```

File 42: *The Configuration File /etc/dhcpd.conf*

This simple configuration file should be sufficient to get the DHCP server to assign IP addresses in the network. Make sure a semicolon is inserted at the end of each line, because otherwise dhcpd will not be started.

As you can see, the above sample file can be divided into three sections. The first one defines how many seconds an IP address is “leased” to a requesting host by default (default-lease-time) before it should apply for renewal. The section also includes a statement on the maximum period for which a machine may keep an IP address assigned by the DHCP server without applying for renewal (max-lease-time).

In the second part, some basic network parameters are defined on a global level:

- The line `option domain-name` defines the default domain of your network.
- With the entry `option domain-name-servers`, specify up to three values for the DNS servers used to resolve IP addresses into host names (and vice versa). Ideally, configure a name server on your machine or somewhere else in your network before setting up DHCP. That name server should also define a host name for each dynamic address and vice versa. To learn how to configure your own name server, read *DNS — Domain Name System* on page 323.
- The line `option broadcast-address` defines the broadcast address to be used by the requesting host.
- With `option routers`, tell the server where to send data packets that cannot be delivered to a host on the local network (according to the source and target host address and the subnet mask provided). In most cases, especially in smaller networks, this router will be identical with the Internet gateway.
- With `option subnet-mask`, specify the netmask assigned to clients.

The last section of the file is there to define a network, including a subnet mask. To finish, specify the address range that the DHCP daemon should use to assign IP addresses to interested clients. In our example, clients may be given any address between `192.168.1.10` and `192.168.1.20` as well as `192.168.1.100` and `192.168.1.200`.

After editing these few lines, you should be able to activate the DHCP daemon with the command `rcdhcpd start`. It will be ready for use immediately. You can also use the command `rcdhcpd check-syntax` to perform a brief syntax check. If you encounter any unexpected problems with your configuration — the server aborts with an error or does not return "done" on start — you should be able to find out what has gone wrong by looking for information either in the main system log `/var/log/messages` or on console 10 (Ctrl + Alt + F10).

On a default SuSE Linux system, the DHCP daemon is started in a chroot environment for security reasons. The configuration files must be copied to the chroot environment so the daemon can find them. Normally, there is no need to worry about this because the command `rcdhcpd start` automatically copies the files.

Hosts with Fixed IP Addresses

As mentioned above, DHCP can also be used to assign a predefined, static address to a specific host for each request. As might be expected, addresses assigned explicitly will always take priority over addresses from the pool of dynamic addresses. Furthermore, a static address will never expire in the way a dynamic address would, for example, if there were not enough addresses available so the server needed to redistribute them among hosts.

To identify a host configured with a *static* address, dhcpd uses the hardware address, which is a globally unique, fixed numerical code consisting of six octet pairs for the identification of all network devices (e.g., `00:00:45:12:EE:F4`).

If the respective lines, like the ones in 43, are added to the configuration file 42 on page 368, the DHCP daemon will assign the same set of data to the corresponding host under all circumstances.

```
host earth {
 hardware ethernet 00:00:45:12:EE:F4;
 fixed-address 192.168.1.21;
}
```

***File 43:** Additions to the Configuration File*

The structure of this entry is almost self-explanatory: The name of the respective host (host *host name*) is entered in the first line and the MAC address in the second line. On Linux hosts, this address can be determined with the command `ifstatus` followed by the network device (e.g., eth0). If necessary, activate the network card first: `ifup eth0`. The output should contain something like *link/ether 00:00:45:12:EE:F4*.

In the above example, a host with a network card having the MAC address *00:00:45:12:EE:F4* is assigned the IP address `192.168.1.21` and the host name `earth` automatically. The type of hardware to enter is `ethernet` in nearly all cases, although `token-ring`, which is often found on IBM systems, is also supported.

For More Information

As stated at the beginning of this chapter, these pages are only intended to provide a brief survey of what you can do with DHCP. For more information, the page of the *Internet Software Consortium* on the subject (`http://`

`www.isc.org/products/DHCP/`) will prove a good source to read about the details of DHCP, including about version 3 of the protocol, currently in beta testing. Apart from that, you can always rely on the man pages for further help. Try `man dhcpd`, `man dhcpd.conf`, `man dhcpd.leases`, and `man dhcp-options`. Also, several books about *Dynamic Host Configuration Protocol* have been published over the years that take an in-depth look at the topic.

With `dhcpd`, it is even possible to offer a file to a requesting host, as defined with the parameter *filename*, and that this file may contain a bootable Linux kernel. This allows you to build client hosts which do not need a hard disk — they are enabled to load both their operating system and their network data over the network (*diskless clients*), which could be an interesting option for both cost and security reasons.

Time Synchronization with xntp

Keeping track of the exact current time is an important aspect in many processes in a computer system. Computers have a built-in clock for this. Unfortunately, this clock often does not meet the requirements of some applications, like databases. This problem is usually solved by repeatedly correcting the time of the local computer by hand or over a network. A computer clock should, at best, never be set back and the amount it gets set forward should not exceed a certain time interval. It is relatively simple to occasionally correct the time kept by the computer clock with ntpdate. This, however, results in a sudden jump in time that may not be tolerated by all applications.

An interesting approach to solving this problem is offered by xntp. For one, xntp continuously corrects the local computer clock by following statistically gathered correction data. It also constantly corrects the local time by querying time servers in the network. The third correction method offers accessing local time normals, like radio-controlled clocks.

Configuration in a Network

The default setting of xntp in SuSE Linux is that of only respecting the local computer clock as a time reference. The most simple possibility to access a time server in the network is the declaration of "server" parameters. For example, if a time server be available with the name `ntp.example.com`, add this server to the file `/etc/ntp.conf` in the following way:

```
server ntp.example.com
```

Enter additional time servers by inserting additional lines with the keyword "server". After xntpd has been started with the command `rcxntpd start`, the application waits for one hour until the time has stabilized before creating the "drift file" for the correction of the local computer clock. The "drift file" offers the long-term advantage of predicting, right after booting the computer, by how much the hardware clock will be off over time. The correction becomes immediately effective, which ensures a high stability of the computer time.

The name of the time server in your network does not need to be known if it is also available by broadcast. This can be reflected in the configuration file `/etc/ntp.conf` with the parameter `broadcastclient`. However, some authentication mechanisms should be activated in this case to prevent a faulty time server in the network from changing the time on your computer.

Any xntpd in the network can also commonly be accessed as a time server. To run xntpd with broadcasts, activate the broadcast option:

```
broadcast 192.168.0.255
```

Adjust the broadcast address to your specific case. It should, however, be ensured that the time server really serves the correct time. Time normals are well-suited for this.

Establishing a Local Time Normal

The program package xntp also contains drivers that allow connection to local time normals. A list of supported clocks is provided in the package xntp-doc in the file `file:/usr/share/doc/packages/xntp-doc/html/refclock.htm`. Each driver has been assigned a number. The actual configuration in xntp is done over pseudo-IPs. The clocks are registered in the file `/etc/ntp.conf` as if they were time servers available over the network.

These clocks are assigned special IP addresses that follow the pattern `127.127.t.u`. The value `t` is assigned from the previously mentioned file with the reference clocks. The value `u` is the device number that only then deviates from 0 if more than one clock of the same type is connected to the computer. For example, a `Type 8 Generic Reference Driver (PARSE)` clock has the pseudo-IP address `127.127.8.0`.

The various drivers usually have special parameters that describe the configuration in more detail. The file `file:/usr/share/doc/packages/xntp-doc/html/refclock.htm` provides links to the corresponding driver page describing these parameters. It is, for instance, necessary to provide an additional mode that specifies the clock more accurately. The module `Conrad DCF77 receiver module`, for example, has mode 5. The keyword `prefer` must be specified to make xntp accept this clock as a reference. The complete `server` entry for a “Conrad DCF77 receiver module” therefore is:

```
server 127.127.8.0 mode 5 prefer
```

Other clocks follow the same pattern. Find xntp documentation in the directory `/usr/share/doc/packages/xntp-doc/html` after the installation of the package package `xntp-doc`.

The Apache Web Server

Basics

Web Server

A web server issues `HTML` pages requested by a client. These pages can be stored in a directory (passive or static pages) or be generated in response to a query (active contents).

HTTP

The clients are usually web browsers, like Konqueror or Mozilla. Communication between the browser and the web server takes place by way of the *H*yper*T*ext *T*ransfer *P*rotocol (HTTP). The current version HTTP 1.1 is documented in RFC 2068 and in the update RFC 2616. These RFCs are available at `http://www.w3.org`.

URLs

Clients use URLs to request pages from the server. For example, `http://www.suse.com/index_us.html`. A URL consists of:

- A protocol. Frequently-used protocols:
  - ▷ `http://` HTTP protocol
  - ▷ `https://` Secure, encrypted version of HTTP
  - ▷ `ftp://` *F*ile *T*ransfer *P*rotocol for uploading and downloading files

- A domain, in this example, `www.suse.com`. The domain can be subdivided in two parts. The first part (`www`) points to a computer. The second part (`suse.com`) is the actual domain. Together, they are referred to as FQDN (Fully Qualified Domain Name).
- A resource, in this example, `index_us.html`. This part specifies the full path to the resource. The resource can be a file, as in this example. However, it can also be a CGI script, a Java server page, or some other resource.

Various Internet mechanisms (such as the Domain Name System, DNS) convey the query to the domain, directing the access to one or several responsible computers. Apache delivers the actual resource (in this example, the page `index_us.html`) from its file directory. In this case, the file is located in the top level of the directory. However, resources can also be located in subdirectories as in the following:

`http://www.suse.com/us/business/services/support/index.html`

The file path is relative to the `DocumentRoot`, which can be changed in the configuration file. *DocumentRoot* on page 384 describes how this is done.

Automatic Output of a Default Page

If no page is specified, Apache automatically appends one of the common names for such pages to the URL. The most frequently-used name for such pages is `index.html`. The activation of this functionality and the page names taken into consideration can be configured as described in *DirectoryIndex* on page 385. In this example, `http://www.suse.com` is sufficient to prompt the server to display the page `http://www.suse.com/index_us.html`.

What Is Apache?

The Most Popular Web Server

With a share of more than sixty percent (source: `http://www.netcraft.com`), Apache is the world's most widely-used web server. For web applications, Apache is often combined with Linux, the database MySQL, and the programming languages PHP and Perl. This combination is commonly referred to as "LAMP".

Some of the strengths of Apache are as follows:

Expandability

By means of modules, Apache can be expanded with a wide range of functions. For example, Apache can execute CGI scripts in diverse programming languages by means of modules.

Apart from Perl and PHP, additional scripting languages, such as Python or Ruby, are also available. Furthermore, there are modules for secure data transmission (Secure Sockets Layer, SSL), user authentication, expanded logging, and other functions.

Customizability

By means of custom modules, Apache can be adapted to all kinds of requirements and preferences. Of course, this requires a certain amount of know-how.

Stability

As Apache is Open Source software. Its code has been screened for bugs and optimized by a large number of programmers. This approach ensures that Apache is largely free from errors (as far as this is possible for software). Nevertheless, the possibility that new security bugs may be detected in the future can never be fully excluded. *Security* on page 398 shows where to find information about security issues and how these can be eliminated.

Features

Apache supports a number of useful features, some of which are described below.

Virtual Hosts

Support for virtual hosts means that a single instance of Apache and a single machine can be used for several web sites. For the users, the web server appears as several independent web servers. The virtual hosts can be configured on different IP addresses or on the basis of names. Thus, you can save the acquisition costs and administration workload for additional machines.

Flexible URL Rewriting

Apache offers a number of possibilities for manipulating and rewriting URLs. Check the Apache documentation for details.

Content Negotiation

Apache can deliver a page that is adapted to the capabilities of the client (browser). For example, simple versions without frames can be delivered for older browsers or browsers that only operate in text mode (such as Lynx). In this way, the notorious JavaScript incompatibility of various browsers can be circumvented by delivering a special page version for every browser (provided you are prepared to adapt the JavaScript code for each individual browser).

Flexible Error Handling

You can react in a flexible way and provide a suitable response in the event of an error (such as nonexistent pages). The response can even be generated actively, for example, with CGI.

Basics

When Apache processes a query, several "handlers" can be specified for handling the query (by means of directives in the configuration file). These handlers can be part of Apache or a module invoked for processing the query. Thus, this procedure can be arranged in a very flexible way. Furthermore, special modules can be coupled with Apache for the purpose of processing requests.

The modularization has reached an advanced level especially in Apache 2, where almost everything except some minor tasks is handled by means of modules. In Apache 2, even HTTP is processed by way of modules. Accordingly, Apache 2 does not necessarily have to be a web server. It can also be used for completely different purposes with other modules. For example, there is a proof-of-concept mail server (POP3) module based on Apache.

Differences between Apache 1.3 and Apache 2

Overview

The main differences between Apache 1.3 and Apache 2 are as follows:

- The way in which multiple queries are processed concurrently. In Apache 2, you can choose between threads and processes. The process management has been relocated to a separate module called the multiprocessing module (MPM). Depending on the MPM, Apache 2 responds to queries in different ways, with different effects on the performance and the use of modules. Details are provided below.

- The innards of Apache have been thoroughly revised. Apache now uses a new, special base library (Apache Portable Runtime, APR) as the interface to system functions and for the memory management. Moreover, important and widespread modules such as mod_gzip (successor: mod_deflate) and mod_ssl, which have a profound impact on the processing of requests, are now integrated more fully in Apache.
- Apache 2 now supports the Internet protocol of the future IPv6.
- A new mechanism now enables manufacturers of modules to specify the desired loading sequence for modules. Thus, users no longer have to do this themselves. The order in which modules are executed is often significant. Previous, it was determined by means of the loading sequence. For example, a module that only gives authenticated users access to certain resources must be run first to prevent the pages from being displayed to users who do not have any access permissions.
- Queries to and replies from Apache can be processed with filters.
- Support for files that are larger than 2 GB (large file support, LFS) on 32-bit systems.
- Some of the newer modules are only available for Apache 2.
- Multilanguage error responses.

See also `http://httpd.apache.org/docs-2.0/en/`.

What is a Thread?

A thread is a "light process." The advantage of a thread over a process is its lower resource consumption. Therefore, the use of threads instead of processes increases the performance. The disadvantage is that applications executed in a thread environment must be thread-safe. This means that:

- Functions (or the methods in object-oriented applications) must be reentrant — a function with the same input always delivers the same result, even if other threads concurrently execute the same function. Accordingly, functions must be programmed in such a way that they can be executed simultaneously by severals threads.

- The access to resources (usually variables) must be arranged in such a way that concurrent threads do not conflict.

Threads and Processes

In contrast to Apache 1.3, which starts a separate process for every query, Apache 2 can handle queries as separate processes or in a mixed mode combining processes and threads. The MPM "prefork" is responsible for the execution as process. The MPM "worker" prompts the execution as thread. Select the MPM to use during the installation (see *Installation* on this page). The third mode — "perchild" — is not yet fully mature and is therefore not available for installation in SuSE Linux.

The difficulty with Apache 2 is that not all modules have been revised to be thread-safe. If you need a module that has not yet been adapted to threads, continue with Apache 1.3 or use Apache 2 with the MPM "prefork".

Conclusion

If you are satisfied with Apache 1.3 and the permanent availability of the web pages is vital, you can postpone the migration. Likewise, if you need modules that have not yet been adapted to Apache 2, you should also postpone the migration.

If increased performance is important or if you need one of the new features (such as filtering), you should consider a migration to Apache 2. Another argument in favor of Apache 2 is the availability of a YaST module that facilitates the configuration.

Whatever your decision may be, you should test your web site with Apache 2 in a test installation prior to the final launch.

Installation

Package Selection in YaST

For simple requirements, all you need is the Apache package. You can install the package `apache` (Apache 1.3) or the package `apache2` (Apache 2). The pros and cons of these versions are covered in *Differences between Apache 1.3 and Apache 2* on page 378.

If you do not want or need the new features of Apache 2, it is recommended to install Apache 1.3 (package `apache`).

If you decide to install the package `apache2`, you need one of the MPM (multiprocessing module) packages, such as the package `apache2-prefork` or the package `apache2-worker`. When selecting an MPM, remember that the thread-based worker MPM cannot be used with the package `mod_php4`, as some of the libraries of the package `mod_php4` are not yet thread-safe.

Activating Apache

Even if Apache is installed, it will not be started automatically. To start Apache, activate it in the runlevel editor. To start it permanently when the system is booted, check the runlevels 3 and 5 in the runlevel editor. To check if Apache is active, enter `http://localhost/` in a browser. If Apache is active, you will see an example page, provided the package `apache-example-pages` or the package `apache2-example-pages` is installed.

Modules for Active Contents

To use active contents with the help of modules, install the modules for the respective programming languages. These are the package `mod_perl` for Perl, the package `mod_php4` for PHP, and the package `mod_python` for Python or the corresponding modules for Apache 2. The use of these modules is covered in *Generating Active Contents with Modules* on page 391.

Other Recommended Packages

Additionally, you should install the extensive documentation provided in the package `apache-doc` or the package `apache2-doc`. An alias (*Configuration* on the next page explains what an alias is) is available for the documentation, enabling you to access it with the URL `http://localhost/manual` following the installation.

To develop modules for Apache or compile third-party modules, install the package `apache-devel` or the package `apache2-devel` and the needed development tools. These include the `apxs` tools, which are described in *Installation of Modules with apxs* on the following page.

Installation of Modules with apxs

apxs (or its Apache 2 equivalent apxs2) is an important tool for module developers. This program enables the compilation and installation of modules in source code with a single command (including the required changes to the configuration files). Furthermore, you can also install modules available as object files (extension .o) or static libraries (extension .a). From the sources, apxs creates a Dynamic Shared Object (DSO), which is directly used by Apache as module.

The installation of a module from source code can be performed with a command such as the following:

```
apxs -c -i -a mod_foo.c
```

Other options of apxs are described in the man page.

Installation on page 380 describes which packages must be installed to install the different versions of apxs.

apxs2 is available in several versions: apxs2, apxs2-prefork, and apxs2-worker. apxs2 installs modules in such a way that they can be used for all MPMs. The other two programs install modules in a way that they can only be used for the respective MPMs ("prefork" or "worker"). Thus, apxs2 installs modules in /usr/lib/apache2, and apxs2-prefork installs modules in /usr/lib/apache2-prefork.

The option -a should not be used with Apache 2, as this would cause the changes to be written directly to /etc/httpd/httpd.conf. Rather, modules should be activated by means of the entry APACHE_MODULES in /etc/sysconfig/apache2 as described in *Configuration with SuSEconfig* on the facing page.

Configuration

Following the installation of Apache, additional changes are only necessary if you have special needs or preferences. In many cases, Apache can be used as it is.

Apache can be configured with SuSEconfig or by directly editing the file /etc/httpd/httpd.conf. If you want to edit /etc/httpd/httpd.conf directly, set the entry

```
ENABLE_SUSECONFIG_APACHE="yes"
```

in /etc/sysconfig/apache2 to no to prevent SuSEconfig from overwriting your changes in /etc/httpd/httpd.conf.

Configuration with SuSEconfig

The settings made in `/etc/sysconfig/apache` (and `/etc/sysconfig/apache2`) are applied to the Apache configuration files with SuSEconfig. The offered configuration options should be sufficient for most scenarios. The file provides explanatory comments for all variables.

Custom Configuration Files

Instead of performing changes directly in the configuration file `/etc/httpd/httpd.conf`, you can designate your own configuration file (such as `httpd.conf.local`) with the help of the variable `APACHE_CONF_INCLUDE_FILES`. Consequently, the file will be interpreted by the main configuration file. In this way, changes to the configuration will be retained even if the file `/etc/httpd/httpd.conf` is overwritten during a new installation.

Modules

Modules installed with YaST can be activated by setting the respective variable in `/etc/sysconfig/apache` to “yes” (Apache 1.3) or by including the name of module in the list specified for the variable `APACHE_MODULES` (Apache 2). This variable is located in the file `/etc/sysconfig/apache2`.

Flags

`APACHE_SERVER_FLAGS` can be used to specify flags that activate or deactivate certain sections of the configuration file. Thus, if a section in the configuration file is embraced with

```
<IfDefine someflag>
.
.
.
</IfDefine>
```

it will only be activated if the respective flag is set in `ACTIVE_SERVER_FLAGS`:

```
ACTIVE_SERVER_FLAGS = ... someflag ...
```

In this way, extensive sections of the configuration file can easily be activated or deactivated for test purposes.

Manual Configuration

The Configuration File

The configuration file `/etc/httpd/httpd.conf` (or `/etc/apache2/httpd.conf`) enables changes that are not possible by editing `/etc/sysconfig/apache` or `/etc/sysconfig/apache2`. The following sections describe some of the parameters that can be set in this file. The parameters are listed in the order in which they appear in this file.

DocumentRoot

One basic setting is the `DocumentRoot`, the directory under which Apache looks for web pages to be delivered by the server. For the default virtual host, it is set to `/srv/www/htdocs`. Normally, this setting does not need to be changed.

Timeout

Specifies the waiting period after which the server reports a time-out for a request.

MaxClients

The maximum number of clients Apache can handle concurrently. The default setting is `150`, but this value may be too small for a heavily frequented web site. In Apache 1, this value is modified by SuSEconfig depending on the setting of the variable `HTTPD_PERFORMANCE`.

LoadModule

The `LoadModule` directives specify the modules to load. In Apache 1.3, the modules are loaded in the order specified in the `LoadModule` directives. In Apache 2, the loading sequence is determined by the modules themselves (see *Differences between Apache 1.3 and Apache 2* on page 378). These directives also specify the file containing the module.

Port

Specifies the port on which Apache waits for queries. Usually, this is port 80, the default port for HTTP. Normally, this setting should not be changed.

One reason for letting Apache listen to another port may be the test of a new version of a web site. In this way, the operational version of the web site continues to be accessible via default port 80.

Another reason may be that you merely want to make pages available on the intranet, as they contain information that are not intended for the public. For this purpose, you can set the port to a value like `8080` and block external access to this port by means of the firewall. In this way, the server can be protected against external access.

Directory

This directive can be used to set the access permissions and other permissions for a directory. A directive of this kind also exists for the `DocumentRoot`. The directory name specified here must be changed whenever the `DocumentRoot` is changed.

DirectoryIndex

Here, determine for which files Apache should search to complete a URL lacking a file specification. The default setting is `index.html`. For example, if the client requests the URL `http://www.xyz.com/foo/bar` and the directory `foo/bar` containing a file called `index.html` exists under the `DocumentRoot`, Apache returns this page to the client.

AllowOverride

Every directory from which Apache delivers documents can contain a file that can override the global access permissions and other settings for this directory. These settings apply recursively to the current directory and its subdirectories, until they are overridden by another such file in a subdirectory. Accordingly, settings specified in a file in the `DocumentRoot` are applied globally. Normally, these files are called `.htaccess`. However, this can be changed (see *AccessFileName* on the following page).

Use `AllowOverride` to determine if the settings specified in the local files are allowed to override the global settings. Possible values are `None`, `All`, and any combination of `Options`, `FileInfo`, `AuthConfig`, and `Limit`. The meanings of these values are described in detail in the Apache documentation. The (safe) default setting is `None`.

Order

This option influences the sequence for the application of the settings for the access permissions `Allow` and `Deny`. The default setting is:

```
Order allow,deny
```

Accordingly, the access permissions for allowed accesses are applied first, followed by the access permissions for denied accesses.

The underlying approach is based on one of the following:

- "allow all" (allow every access) with exceptions
- "deny all" (deny every access) with exceptions

Example for the latter:

```
Order deny,allow
Deny from all
Allow from example.com
Allow from 10.1.0.0/255.255.0.0
```

AccessFileName

Here, set the name for the files that can override the global access permissions and other settings for directories delivered by Apache (see *AllowOverride* on the page before). The default setting is `.htaccess`.

ErrorLog

Specifies the name of the file in which Apache logs error messages. The default setting is `/var/log/httpd/errorlog`. Error messages for virtual hosts (see *Virtual Hosts* on page 395) are also logged in this file, unless a special log file was specified in the `VirtualHost` section of the configuration file.

LogLevel

Error messages are classified in various severity levels. This setting specifies the severity level from which error messages are logged. The specification of a level causes error messages of this and higher severity levels to be logged. The default setting is `warn`.

Alias

Using an alias, you can specify a shortcut for a directory that enables direct access to this directory. For example, the alias `/manual/` enables access to the directory `/srv/www/htdocs/manual` even if the DocumentRoot is set to a directory other than `/srv/www/htdocs` (it does not make any difference if the DocumentRoot has this value). With this alias, `http://localhost/manual` enables direct access to the respective directory.

You may need to specify a `Directory` directive (see *Directory* on the page before) determining the permissions for for the target directory specified in an `Alias` instruction.

ScriptAlias

This directive is similar to `Alias`. In addition, it indicates that the files in the target directory should be treated as CGI scripts.

Server-Side Includes

Server-side includes can be activated by searching all executable files for SSIs. This can be done with the following instruction:

```
<IfModule mod_include.c>
XBitHack on
</IfModule>
```

To search a file for SSIs, use the following command to make the file executable:

```
chmod +x <filename>
```

Alternatively, explicitly specify the file type to search for SSIs. This can be done with the following instruction:

```
AddType text/html .shtml
AddHandler server-parsed .shtml
```

It is *not* advisable to simply state `.html`, as this will cause Apache to search all pages for SSIs (even those that definitely do not contain any), which greatly impedes the performance.

In SuSE Linux, these two directives are already included in the configuration files, so normally no changes are necessary.

UserDir

With the help of the module `mod_userdir` and the directive `UserDir`, you can specify a directory in the home directory of the user in which the user can publish his files by way of Apache. This can be configured in SuSEconfig by means of the variable `HTTPD_SEC_PUBLIC_HTML`. To enable the publishing of files, this variable must be set to `yes`. This results in the following entry in the file `/etc/httpd/suse_public_html.conf` (which is interpreted by `/etc/httpd/httpd.conf`).

```
<IfModule mod_userdir.c>
    UserDir public_html
</IfModule>
```

Using Apache

Where Can I Place My Pages and Scripts?

To display your (static) web pages with Apache, simply place your files in the correct directory. In SuSE Linux, the correct directory is `/srv/www/htdocs`. A few small example pages may already be installed there. By means of these pages, check if Apache was installed correctly and is currently active. Subsequently, you can simply overwrite or uninstall these pages. Custom CGI scripts are installed in `/srv/www/cgi-bin`.

Apache Operating Status

During operation, Apache writes log messages to the file `/var/log/httpd/access_log` or `/var/log/apache2/access_log`. These messages show which resources were requested and delivered at what time and with which method (`GET`, `POST`...). Error messages are logged to the file `/var/log/httpd/error_log` (or to `/var/log/apache2` in Apache 2).

Active Contents

Overview

Apache provides several possibilities for delivering active contents to clients. Active contents are HTML pages that are generated on the basis of variable input data of the client, such as search engines that respond to the input of one or several search strings (possibly interlinked with logical operators like "and" or "or") by returning a list of pages containing these search strings.

Apache offers three ways of generating active contents:

- Server Side Includes (SSI). These are directives that are embedded in an HTML page by means of special comments. Apache interprets the content of the comments and delivers the result as part of the HTML page.
- Common Gateway Interface (CGI). These are programs that are located in certain directories. Apache forwards the parameters transmitted by the client to these programs and returns the output of the programs. This kind of programming is quite easy, especially since existing command-line programs can be designed in such a way that they accept input from Apache and return their output to Apache.

- Modules. Apache offers interfaces for executing any modules within the scope of the request processing. Apache gives these programs access to important information such as the request or the HTTP headers. Thus, programs can be integrated for the generation of active contents as well as for other functions (such as authentication).

  The progamming of such modules requires some expertise. The advantages of this approach are high performance and possibilities by far exceeding those of SSI and CGI.

Script Interpreter as Module versus CGI

Normally, CGI scripts are executed directly by Apache (similar to a command on the command line). In contrast, modules are controlled by a persistent interpreter that is embedded in Apache.

In this way, separate processes do not have to be started and terminated for every request (this would result in a considerable overhead for the process management, memory management, and so on). Rather, the script is handled by the running interpreter.

However, this approach has a catch. Compared to modules, CGI scripts are relatively tolerant towards careless programming. With CGI scripts, errors such as a failure to release resources and memory do not have a lasting effect, since the programs are terminated after the request has been processed. This results in the clearance of memory that was not released by the program due to a programming error.

With modules, the effects of programming errors accumulate, as the interpreter is persistent. If the server is not restarted and the interpreter runs for several months, the failure to release resources, such as database connections, can be quite disturbing.

SSI

Server-side includes are directives that are embedded in special comments and executed by Apache. The result is embedded in the output. For example, the current date can be printed with

```
<!--#echo var="DATE_LOCAL" -->
```

# at the end of the opening comment mark `<!--` shows Apache that this is an SSI directive and not a simple comment.

SSIs can be activated in several ways. The easiest approach is to search all executable files for SSIs. Another approach is to specify certain file types to be searched for SSIs. Both settings are explained in *Server-Side Includes* on page 387.

CGI

What Is CGI?

CGI is the abbreviation for “Common Gateway Interface”. With CGI, the server does not simply deliver a static HTML page, but executes a program that generates the page. This enables the generation of pages representing the result of a calculation, such as the result of the search in a database. By means of arguments passed to the executed program, the program can return an individual response page for every request.

Advantages of CGI

The main advantage of CGI is that this technology is quite simple. The program merely has to exist in a specific directory and is executed by the web server just like a command-line program. The server sends the program output on the standard output channel (`stdout`) to the client.

GET and POST

Input parameters can be passed to the server with `GET` or `POST`. Depending on which method is used, the server passes the parameters to the script in various ways. With `POST`, the server passes the parameters to the program on the standard input channel (`stdin`). (The program would receive its input in the same way when started from a console.)

With `GET`, the server uses the environment variable `QUERY_STRING` to pass the parameters to the program. An environment variable is a variable globally made available by the system (such as the variable `PATH`, which contains a list of paths the system searches for executable commands when the user enters a command).

Languages for CGI

Theoretically, CGI programs can be written in any programming language. Usually, scripting languages (interpreted languages), such as Perl or PHP, are used for this purpose. If speed is critical, C or C++ may be more suitable.

Where Are the Scripts Placed?

In the simplest case, Apache looks for these programs in a specific directory (`cgi-bin`). This directory can be set in the configuration file (see *Configuration* on page 382). If necessary, additional directories can be specified. In this case, Apache will search these directories for executable programs. However, this represents a security risk, as any user will be able to let Apache execute programs (some of which may be malicious). If executable programs are restricted to `cgi-bin`, the administrator can easily see who places which scripts and programs in this directory and check them for any malicious intent.

Generating Active Contents with Modules

Modules for Scripting Languages

A variety of modules is available for use with Apache.

Note

Modules

The term “module” is used in two different senses.

First, there are modules that can be integrated in Apache for the purpose of handling specific functions, such as modules for embedding programming languages. These modules are introduced below.

Second, in connection with programming languages, modules refer to an independent group of functions, classes, and variables. These modules are integrated in a program to provide a certain functionality, such as the CGI modules available for all scripting languages. These modules facilitate the programming of CGI applications by providing various functions, such as methods for reading the request parameters and for the HTML output.

Note

The following modules are available as packages in SuSE Linux.

mod_perl

General Information about Perl

Perl is a popular, proven scripting language. There are numerous modules and libraries for Perl, including a library for expanding the Apache configuration file. The home page for Perl is `http://www.perl.com/`. A range of libraries for Perl is available in the Comprehensive Perl Archive Network (CPAN) at `http://www.cpan.org/`.

Setting up mod_perl

To set up `mod_perl` in SuSE Linux, simply install the respective package (see *Installation* on page 380). Following the installation, the needed entries will exist in the Apache configuration file (see `/usr/include/apache/modules/perl/startup.perl` for Apache 1 or `/etc/apache2/mod\_perl-startup.pl` for Apache 2). Information about `mod_perl` is available at `http://perl.apache.org/`.

mod_perl versus CGI

In the simplest case, you can run a previous CGI script as a `mod_perl` script by requesting it with a different URL. The configuration file contains aliases that point to the same directory and execute any scripts it contains either via CGI or via `mod_perl`. All these entries already exist in the configuration file.

The alias entry for CGI is as follows:

```
ScriptAlias /cgi-bin/ "/srv/www/cgi-bin/"
```

The entries for `mod_perl` are as follows:

```
<IfModule mod_perl.c>
    # Provide two aliases to the same cgi-bin directory,
    # to see the effects of the 2 different mod_perl modes.
    # for Apache::Registry Mode
    ScriptAlias /perl/          "/srv/www/cgi-bin/"
    # for Apache::Perlrun Mode
    ScriptAlias /cgi-perl/      "/srv/www/cgi-bin/"
</IfModule>
```

The following entries are also needed for `mod_perl`. These entries already exist in the configuration file.

```
#
# If mod_perl is activated, load configuration information
#
<IfModule mod_perl.c>
Perlrequire /usr/include/apache/modules/perl/startup.perl
PerlModule Apache::Registry

#
# set Apache::Registry Mode for /perl Alias
#
<Location /perl>
SetHandler  perl-script
PerlHandler Apache::Registry
Options ExecCGI
PerlSendHeader On
</Location>

#
# set Apache::PerlRun Mode for /cgi-perl Alias
#
<Location /cgi-perl>
SetHandler  perl-script
PerlHandler Apache::PerlRun
Options ExecCGI
PerlSendHeader On
</Location>

</IfModule>
```

These entries create aliases for the `Apache::Registry` and `Apache::PerlRun` modes. The difference between these two modes is as follows:

- With `Apache::Registry`, all scripts are compiled and kept in a cache. Every script is applied as the content of a subroutine.

  Although this is good for the performance, there is a disadvantage: the scripts must be programmed extremely carefully, as the variables and subroutines persist between the requests.

This means that you have to reset the variables to enable their use for the next request. If, for example, the credit card number of a customer is stored in a variable in an online banking script, this number could appear again when the next customer uses the application and requests the same script.

- `Apache::PerlRun` is more like CGI. The scripts are recompiled for every request. Thus, variables and subroutines disappear from the namespace between the requests. (The namespace is the entirety of all variable names and routine names that are defined at a given time during the existence of a script.)

  Therefore, `Apache::PerlRun` does not necessitate painstaking programming, as all variables are reinitialized when the script is started and no values are kept from previous requests.

  For this reason, `Apache::PerlRun` is slower than `Apache::Registry` but is still a lot faster than CGI, as no separate process is started for the interpreter.

mod_php4

PHP is a programming language that was especially developed for use with web servers. In contrast to other languages whose commands are stored in separate files (scripts), the PHP commands are embedded in an HTML page (similar to SSI). The PHP interpreter processes the PHP commands and embeds the processing result in the HTML page.

The home page for PHP is `http://www.php.net/`.

Packages: The package `mod_php4-core` must be installed. Additionally, the package `mod_php4` is required for Apache 1 and the package `apache2-mod_php4` for Apache 2.

mod_python

Python is an object-oriented programming language with a very clear and legible syntax. An unusual but convenient feature is that the program structure depends on the indention. Blocks are not defined with braces (as in C and Perl) or other demarcation elements (such as `begin` and `end`), but by their level of indention.

More information about this language is available at `http://www.python.org/`. For more information about `mod_python`, visit the URL `http://www.modpython.org/`.

The package to install is package `mod_python` or package `apache2-mod_python`.

mod_ruby

Ruby

Ruby is a relatively new, object-oriented high-level programming language that resembles certain aspects of Perl and Python and is ideal for scripts. Like Python, it has a clean, transparent syntax. On the other hand, Python has adopted abbreviations such as `$.r` for the number of the last line read in the input file — a feature that is welcomed by some programmers and abhorred by others. The basic concept of Ruby closely resembles Smalltalk.

The home page of Ruby is `http://www.ruby-lang.org/`.

An Apache module is available for Ruby. The home page is `http://www.modruby.net/`.

Virtual Hosts

Overview: Virtual Hosts

Using virtual hosts, you can host several domains with a single web server. In this way, you can save the costs and administration workload for separate servers for each domain. Being one of the first web servers that offered this feature, Apache offers several possibilities for virtual hosts:

- Name-based virtual hosts
- IP-based virtual hosts
- Operation of multiple instances of Apache on one machine

All three alternatives are introduced in the following paragraphs.

Name-Based Virtual Hosts

With name-based virtual hosts, one instance of Apache hosts several domains. You do not need to set up multiple IPs for a machine. This is the easiest, preferred alternative. Reasons against the use of name-based virtual hosts are covered in the Apache documentation.

The configuration takes place directly by way of the configuration file (/etc/httpd/httpd.conf). To activate name-based virtual hosts, a suitable directive must be specified:

```
NameVirtualHost *
```

The specification of * is sufficient to prompt Apache to accept all incoming requests.

Subsequently, the individual hosts must be configured:

```
<VirtualHost *>
    ServerName www.mycompany.com
    DocumentRoot /srv/www/htdocs/mycompany.com
    ServerAdmin webmaster@mycompany.com
    ErrorLog /var/log/httpd/www.my.company.com-error_log
    CustomLog /var/log/httpd/www.mycompany.com-access_log common
</VirtualHost>

<VirtualHost *>
    ServerName www.myothercompany.com
    DocumentRoot /srv/www/htdocs/myothercompany.com
    ServerAdmin webmaster@myothercompany.com
    ErrorLog /var/log/httpd/www.myothercompany.com-error_log
    CustomLog /var/log/httpd/www.myothercompany.com-access_log common
</VirtualHost>
```

In the following paragraphs, the path to the log files of Apache 2 should be changed from /var/log/httpd to /var/log/apache2.

A VirtualHost entry also must be configured for the domain the server originally hosted (www.mycompany.com). In this example, the original domain and one additional domain (www.myothercompany.com) are hosted on the same server.

Just as in NameVirtualHost, a * is also specified in the VirtualHost directives. Apache uses the host field in the HTTP header to connect the request with the virtual host. The request is forwarded to the virtual host whose ServerName matches the host name specified in this field.

For the directives ErrorLog and CustomLog, the log files do not have to contain the domain name. Here, you can use a name of your choice.

Serveradmin designates the e-mail address of the responsible person that can be contacted if problems arise. In the event of errors, Apache will state this address in the error messages it sends to the client.

IP-Based Virtual Hosts

Overview

This alternative requires the setup of multiple IPs for a machine. In this case, one instance of Apache hosts several domains, each of them assigned a different IP. The following example shows how Apache can be configured to host the original IP (`192.168.1.10`) plus two additional domains on additional IPs (`192.168.1.20` and `192.168.1.21`).

Of course, this particular example will only work on an intranet, as IPs ranging from `192.168.0.0` to `192.168.255.0` are not routed on the Internet.

Configuring IP Aliasing

For Apache to host multiple IPs, the underlying machine must accept requests for multiple IPs. This is called multi-IP hosting. For this purpose, IP aliasing must be activated in the kernel. This is the default setting in SuSE Linux.

Once the kernel has been configured for IP aliasing, the commands `ifconfig` and `route` can be used to set up additional IPs on the host. These commands must be executed as `root`. For the following example, we assume that the host already has its own IP (such as `192.168.1.10`), which is assigned to the network device `eth0`.

Enter the command `ifconfig` to find out the IP of the host. Further IPs can be added with commands such as the following:

```
/sbin/ifconfig eth0:0 192.168.1.20
/sbin/ifconfig eth0:1 192.168.1.21
```

All these IPs will be assigned to the same physical network device (`eth0`).

Virtual Hosts with IPs

Once IP aliasing has been set up on the system or the host has been configured with several network cards, Apache can be configured. Specify a separate `VirtualHost` block for every virtual server:

```
<VirtualHost 192.168.1.20>
    ServerName www.myothercompany.com
    DocumentRoot /srv/www/htdocs/myothercompany.com
    ServerAdmin webmaster@myothercompany.com
    ErrorLog /var/log/httpd/www.myothercompany.com-error_log
    CustomLog /var/log/httpd/www.myothercompany.com-access_log common
</VirtualHost>
```

```
<VirtualHost 192.168.1.21>
    ServerName www.anothercompany.com
    DocumentRoot /srv/www/htdocs/anothercompany.com
    ServerAdmin webmaster@anothercompany.com
    ErrorLog /var/log/httpd/www.anothercompany.com-error_log
    CustomLog /var/log/httpd/www.anothercompany.com-access_log common
</VirtualHost>
```

`VirtualHost` directives are only specified for the additional domains. The original domain (`www.mycompany.com`) is configured with the respective settings (`DocumentRoot`, etc.) outside the `VirtualHost` blocks.

Multiple Instances of Apache

With the said methods for virtual hosts, the administrators of a domain can read the data of the other domains. To segregate the individual domains, start several instances of Apache that use separate settings for `User`, `Group`, and other variables in the configuration file.

In the configuration file, use the `Listen` directive to specify the IP handled by the respective Apache instance. For the above example, the directive for the first Apache instance would be as follows:

```
Listen 192.168.1.10:80
```

For the other two instances:

```
Listen 192.168.1.20:80
```

and

```
Listen 192.168.1.21:80
```

Security

Minimizing the Risk

If you do not need a web server on a machine, you should deactivate Apache in the runlevel editor, uninstall it, or refrain from installing it in the first place. To minimize the risk, deactivate all servers you do not need.

This especially applies to hosts used as firewalls. If possible, do not run any servers on these hosts.

Access Permissions

DocumentRoot Should Belong to root

By default, the DocumentRoot directory (/srv/www/htdocs) and the CGI directory belong to the user root. You should not change this setting. If the directories are writable for all, any user can place files into these directories. These files will be executed by Apache as the user wwwrun. Apache should not have any write permissions for the data and scripts it delivers. Therefore, these should not belong to the user wwwrun, but to another user (such as root).

To enable users to place files in the document directory of Apache, you should not make it writable for all, but rather create a subdirectory that is writable for all (such as /srv/www/htdocs/miscellaneous).

Publishing Documents from Home Directories

Another possibility to make sure that users can publish their files in the network is to specify a subdirectory of the user's home directory in the configuration file. The user can place his files for web presentation in this directory (e.g., ~/public_html). By default, this is activated in SuSE Linux. See *UserDir* on page 387 for details.

These web pages can be accessed by specifying the user in the URL. The URL contains the element *ũsername* as a shortcut for the respective directory in the user's home directory. Example: Enter http://localhost/~tux in a browser to list the files in the directory public_html in the home directory of the user newbie.

Stay Updated

If you operate a web server and especially if this web server is publicly accessible, you should always be informed about bugs and potential vulnerable spots. Sources for exploits and fixes are listed in *Security* on page 401.

Troubleshooting

What if Apache does not display a page correctly or not at all?

- First, take a look at the error log and check if the messages it contains reveal the error. The general error log is located in /var/log/httpd/error_log or /var/log/apache2/error_log.

A proven approach is to track the log files in a console to see how the server reacts to an access. This can be done by entering the following in a root console:

```
tail -f /var/log/apache2/*_log
```

This can also be quite informative and helpful when starting the server.

- Check the online bug database at http://bugs.apache.org/.
- Read the relevant mailing lists and newsgroups. The mailing list for users is available at http://httpd.apache.org/userslist.html.

  Recommended newsgroups: comp.infosystems.www.servers.unix and related groups.
- If none of the said possibilities provide any solution and you are sure that you have detected a bug in Apache, report it at http://www.suse.de/feedback/.

Further Documentation

Apache

Apache is shipped with detailed documentation. The installation of this documentation is described in *Installation* on page 380. Following the installation, you can access the documentation at http://localhost/manual.

The latest documentation is available at the Apache home page at http://httpd.apache.org.

CGI

More information about CGI is available at the following pages:

- http://apache.perl.org/
- http://perl.apache.org/
- http://www.modperl.com/
- http://www.modpercookbook.org/
- http://www.fastcgi.com/
- http://www.boutell.com/cgic/

Security

The latest patches for the SuSE packages are made available at `http://www.suse.com/us/security/`. Visit this URL at regular intervals. Here, you can also sign up for the SuSE mailing list for security announcements.

The Apache team promotes an open information policy with regard to bugs in Apache. The latest bug reports and possible vulnerable spots are published at `http://httpd.apache.org/security_report.html`.

If you detect a security bug (check the said pages to make sure it has not already been discovered), report it to the following e-mail address:

`security@suse.de`

Other sources for information about security issues of Apache (and other Internet programs):

- `http://www.cert.org/`
- `http://www.vnunet.com/`
- `http://www.securityfocus.com/`

Additional Sources

If you experience difficulties, take a look at the SUSE Support Database at `http://sdb.suse.de/en/`. An online newspaper focusing on Apache is available at `http://www.apacheweek.com/`.

The history of Apache is recounted at `http://httpd.apache.org/ABOUT_APACHE.html`. This page also explains why the server is called “Apache”.

File Synchronization

Today, many people use several computers — one computer at home, one or several computers at the workplace, and possibly a laptop or PDA on the road. Many files are needed on all these computers. You may want to be able work with all computers and modify the files and subsequently have the latest version of the data available on all computers.

Data Synchronization Software 404
Determining Factors for Selecting a Program 405
Introduction to InterMezzo 409
Introduction to Unison 412
Introduction to CVS 414
Introduction to mailsync 416

Data Synchronization Software

Data synchronization is no problem for computers that are permanently linked by means of a fast network. In this case, use a network file system like NFS and store the files on a server, enabling all hosts to access the same data via the network. This approach is impossible if the network connection is poor or not permanent. When you are on the road with a laptop, you need to keep copies of all needed files on the local hard disk. However, it will then be necessary to synchronize modified files. When you modify a file on one computer, you have to make sure that a copy of the file is updated on all other computers. For occasional copies, this can be done manually with scp or rsync. However, if many files are involved, the procedure can be complicated and requires great care to avoid errors, such as overwriting a new file with an old file.

Caution

Risk of data loss

Before you start managing your data with a synchronization system, you should be well acquainted with the program used and test its functionality. A backup is indispensable for important files.

Caution

The time-consuming and error-prone task of manually synchronizing data can be avoided by using one of the programs that employ various methods to automate this job. The following summaries are merely intended to convey a general understanding of how these programs work and how they can be used. If you plan to use them, read the program documentation.

InterMezzo

The idea of InterMezzo is the implementation of a file system that exchanges files via the network like NFS, but stores local copies on the individual computers, thus ensuring that the files are available even when the network connection is down. The local copies can be edited. All changes are noted in a special log file. When the connection is restored, these changes are automatically forwarded and the files are synchronized. More information about InterMezzo is available in `/usr/share/doc/packages/InterMezzo/InterMezzo-HOWTO.html`, if the package is installed.

Unison

Unison is not a network file system. Rather, the files are simply saved and edited locally. The program Unison can be executed manually to synchronize files. When the synchronization is performed for the first time, a database is created on the two hosts, containing check sums, time stamps, and permissions of the selected files. The next time it is executed, Unison can recognize which files were changed and propose the transmission from or to the other host. Usually all suggestions can be accepted.

CVS

CVS, which is mostly used for managing program source versions, offers the possibility to keep copies of the files on multiple computers. Accordingly, it is also suitable for our purpose.

CVS maintains a central repository on the server, in which not only the files but also changes to files are saved. Changes that are performed locally are committed to the repository and can be retrieved from other computers by means of an update. Both procedures must be initiated by the user.

CVS is very resilient to errors in the event that changes occur on several computers. The changes are merged and, if changes took place in the same lines, a conflict will be reported. When a conflict occurs, the database remains in a consistent state. The conflict is only visible for resolution on the client host.

mailsync

In contrast to the synchronization tools covered in the previous sections, mailsync merely serves the purpose of synchronizing e-mails between mailboxes. The procedure can be applied to local mailbox files as well as to mailboxes on an IMAP server.

Based on the message ID contained in the e-mail header, the individual messages are either synchronized or deleted. Synchronization is possible between individual mailboxes and between mailbox hierarchies.

Determining Factors for Selecting a Program

Client-Server vs. Peer-to-Peer

Two different models are commonly used for distributing data. In the first model, all clients synchronize their files with a central server.

The server must be accessible by all clients at least from time to time. This model is used by CVS and InterMezzo.

The other possibility is to let equal hosts synchronize their data among each other. This is the approach Unison uses.

Portability

InterMezzo is a solution that only supports Linux systems at present. In the past, the support was limited to 32-bit little endian architectures (ix86). Due to the migration from the perl-based lento to InterSync, this limitation no longer applies. Nevertheless, caution is needed when synchronizing between different architectures, as this feature has not yet been tested thoroughly. CVS and Unison are also available for many other operating systems, including various Unix and Windows systems.

Interactive vs. Automatic

In InterMezzo, the data synchronization normally occurs automatically in the background as soon as a network connection can be established with the server. Manual intervention is only required when conflicts arise.

In CVS and Unison, the data synchronization is started manually be the user. This enables more control over the data to synchronize and easier conflict handling. On the other hand, if the synchronization intervals are too long, conflicts are more likely to occur.

Speed

Due to their interactive character, Unison and CVS appear to be slower than InterMezzo, which operates in the background. Usually CVS is somewhat faster than Unison.

Conflicts: Incidence and Solution

Conflicts do not occur often in CVS, even if several people work on one large program project. This is because the documents are merged on the basis of individual lines. When a conflict occurs, only one client is affected. Usually conflicts can easily be resolved in CVS.

Unison reports conflicts, allowing the affected files to be excluded from the synchronization. However, changes cannot be merged as easy as in CVS.

Due to the noninteractive character of InterMezzo, conflicts cannot simply be resolved interactively. When conflicts occur, InterSync terminates with an alert message. In this case, the system administrator must intervene and possibly transfer files manually (using rsync or scp) to restore a consistent state.

Selecting and Adding Files

InterMezzo synchronizes the entire file system. Newly added files in the file system automatically appear on the other computers.

Configured in the simplest way possible, Unison synchronizes an entire directory tree. New files appearing in the tree are automatically included in the synchronization.

In CVS, new directories and files must be added explicitly using the command `cvs add`. Thus, the user has more control over the files to synchronize. On the other hand, new files are often overlooked, especially if the question marks in the output of `cvs update` are ignored because of the number of files.

History

An additional feature of CVS is that old file versions can be reconstructed. A brief editing remark can be inserted for each change and the development of the files can easily be traced later based on the content and the remarks. This is a valuable aid for theses and program texts.

Data Volume and Hard Disk Requirements

An adequate amount of free space for all distributed data is required on the hard disks of all involved hosts. CVS requires additional space for the repository on the server. The file history is also stored on the server, requiring even more space. When files in text format are changed, only the modified lines need to be saved. Binary files require additional space amounting to the size of the file every time the file is changed.

GUI

Unison offers a graphical user interface that displays the synchronization procedures Unison wants to perform. Accept the proposal or exclude individual files from the synchronization. In text mode, you can interactively confirm the individual procedures.

Experienced users normally control CVS from the command line. However, graphical user interfaces are available for Linux, such as cervisia, as well as for other operating systems, like wincvs. Many development tools (such as kdevelop) and text editors (such as emacs) provide CVS support. The resolution of conflicts is often much easier with these front-ends.

InterMezzo does not offer that much comfort. On the other hand, normally it does not require any interaction and should simply do its job in the background once it is configured.

User Friendliness

The configuration of InterMezzo is relatively difficult and should only be performed by a system administrator who has some experience with Linux. `root` privileges are required for the configuration. Unison is easy to use and is also suitable for newcomers.

CVS is more difficult to use. Users should understand the interaction between the repository and local data. Changes to the data should first be merged locally with the repository. This is done with the command `cvs update`. Then the data must be sent back to the repository with the command `cvs commit`. If this procedure has been grasped, newcomers will also be able to use CVS with ease.

Security Against Attacks

During transmission, the data should be protected against interception and manipulation. Both Unison and CVS can easily be used via ssh (Secure Shell), providing security against attacks of this kind. Use of CVS or Unison via rsh (Remote Shell) should be avoided and access by way of the CVS "pserver" mechanism in insecure networks is not advisable either.

In InterMezzo, the data synchronization is performed via http. This protocol can easily be intercepted or altered. To increase the level of security, SSL can be used, but this makes the configuration a little bit more difficult. InterMezzo should only be used without SSL in secure, trustworthy networks.

Protection Against Data Loss

CVS looks back on a long record of deployment by developers for the management of program projects and is extremely stable. As the development history is saved, CVS even provides protection against certain user errors, such as the unintentional deletion of a file.

	InterMezzo	Unison	CVS	mailsync
C-S/equal	C-S	P2P	C-S	P2P
Portability	Linux(i386)	Lin,Un*x,Win	Lin,Un*x,Win	Lin,Un*x
Interactive	-	x	x	-
Speed	++	-	o	+
Conflicts	-	o	++	+
File selection	File system	Directory	Selection	Mailbox
History	-	-	x	-
Hard disk space	o	o	--	+
GUI	-	+	o	-
Difficulty	-	+	o	o
Attacks	-	+(ssh)	+(ssh)	+(SSL)
Data loss	o	+	++	+

***Table 15.1:** Features of the File Synchronization Tools -- = very poor, - = poor or not available, o = medium, + = good, ++ = excellent, x = available*

Unison is still relatively new, but boasts a high level of stability. However, it is more sensitive to user errors. Once the synchronization of the deletion of a file has been confirmed, there is no way to restore the file.

Currently, InterMezzo is still in alpha stage. As the files are stored in a separate file system, the probability of a major data loss is relatively low. However, something could go wrong with the file synchronization itself, leaving behind wrecked files. The resilience to user errors is also limited: when a file is deleted locally, the same step is performed on all synchronized hosts. For this reason, backups are strongly recommended.

Introduction to InterMezzo

Architecture

InterMezzo uses a special file system type. The files are stored locally on the hard disks of the individual hosts. One of the file systems available in Linux is used for this purpose, preferably `ext3` or one of the other journaling file systems. Following the preparation of the partition, the file system is mounted with the type `intermezzo`. The kernel loads a module with InterMezzo support and all changes performed in this file system are written to a log file.

Following these preliminary steps, InterSync can be started. This program starts a web server, such as apache, other hosts can access to exchange data. When configuring a client, the name of the server must be specified in InterSync. This server will be contacted. A freely selectable designation for the file system — the "fileset" — is used to identify the file system.

InterSync is the next generation of the older InterMezzo system, which used a perl daemon called lento for the file synchronization. The documentation of InterSync still refers to this older system occasionally. However, this system has been replaced by InterSync. Unfortunately, the module included in standard kernels still supports lento and does not work with InterSync. A newer module is available in the SuSE kernel. For self-compiled kernels, the kernel module should be built with the package `km_intersync`.

The configuration of InterMezzo requires system administrator permissions. As indicated above, the configuration of InterMezzo is relatively difficult and should therefore be performed by an experienced system administrator. The configuration described below does not provide any protective mechanisms. Thus, others can easily intercept and manipulate the data synchronized with InterMezzo. For this reason, the configuration should only take place in a trust-worthy environment, such as a wired private network protected by a firewall.

Configuring an InterMezzo Server

One of the hosts, preferably one having a good network connection, is assigned the role of the server. The entire data synchronization traffic traverses this server.

A separate file system must be set up for the data storage. If you do not have a spare partition and do not use LVM, the easiest way is to set up the file system in the form of a "loop device", which enables the use of a file in the local file system as a separate file system.

In the following example, an InterMezzo/ext3 file system with a size of 256 MB is set up in the root directory. The fileset is assigned the designation `fset0`.

```
dd if=/dev/zero of=/izo0 bs=1024 count=262144
mkizofs -r fset0 /izo0 # The warning can be ignored
```

This file system is mounted to `/var/cache/intermezzo`.

```
mount -t intermezzo -ofileset=fset0,loop /izo /var/cache/intermezzo
```

To do this automatically when the system is booted, an entry must be made in the file `/etc/fstab`. Now InterSync can be configured by customizing `/etc/sysconfig/intersync`. The following is entered in this file:

```
INTERSYNC_CLIENT_OPTS="--fset=fset0"
INTERSYNC_CACHE=/var/cache/intermezzo
INTERSYNC_PROXY=""
```

Now InterSync can be started with the following command:

```
/etc/init.d/intersync start
```

To do this automatically when the system is booted, the service can be entered in the list of services to start with `insserv intersync`.

Configuring InterMezzo Clients

The configuration of the clients (one server can serve multiple clients) is virtually the same as that of the server. The only difference is that the name of the server has to be specified in the variable INTERSYNC_CLIENT_OPTS when configuring `/etc/sysconfig/intersync`:

```
INTERSYNC_CLIENT_OPTS="-fset=fset0 -server=sun.cosmos.com"
```

`sun.cosmos.com`must be replaced with the network name of the server. If possible, the file systems on all computers should have the same size.

Troubleshooting

As soon as a client is started, changes to files located in the directory `/var/cache/intermezzo/` should also be visible on the server and all other clients. If this is not the case, this is usually because no connection can be established to the server or due to a configuration error such as a wrong "fileset" designation. To find the error, analyze the log messages in the system log `/var/log/messages`. The web server started logs its data to `/var/intermezzo-X/`. The log file of the kernel, which records changes to the file system, is located in `/var/cache/intermezzo/.intermezzo/fset0/kml` and can be viewed with `kmlprint`.

When a conflict occurs, normally one of the `InterSync` processes is aborted. If the file synchronization is no longer performed, look for indications in the log file and use `/etc/init.d/intersync status` to check if the synchronization service is still active.

If necessary, refer to the package documentation:

```
/usr/share/doc/packages/intersync/
http://www.inter-mezzo.org/
```

Introduction to Unison

Uses

Unison is an excellent solution for synchronizing and transferring entire directory trees. The synchronization is performed in both directions and can be controlled by means of an intuitive graphical front-end. A console version can also be used. The synchronization can be automated so interaction with the user is not required, but experience is necessary.

Requirements

Unison must be installed on the client as well as on the server. In this context, the term *server* refers to a second, remote host (unlike CVS, explained in *CVS* on page 405).

In the following section, Unison is used together with ssh. An ssh client must be installed on the client and an ssh server must be installed on the server.

Using Unison

The approach used by Unison is the association of two directories ("roots") with each other. This association is symbolic — it is not an online connection. In our example, the directory layout is as follows:

Client:	Server:
`/home/tux/dir1`	`/home/geeko/dir2`

You want to synchronize these two directories. The user is known as `newbie`on the client and as `geeko` on the server. The first thing to do is to test if the client-server communication works:

```
unison -testserver /home/tux/dir1 ssh://geeko@server//homes/geeko/dir2
```

The most frequently encountered problems are:

- The Unison versions used on the client and server are not compatible
- The server does not allow SSH connections
- None of the two specified paths exists

If everything works, omit the option `-testserver`.

During the first synchronization, Unison does not yet know the relationship between the two directories and submits suggestions for the transfer direction of the individual files and directories. The arrows in the 'Action' column indicate the transfer direction. A question mark means that Unison is not able to make a suggestion regarding the transfer direction, as both versions were either changed or are new.

The arrow keys can be used to set the transfer direction for the individual entries. If the transfer directions are correct for all displayed entries, simply click "Go".

The characteristics of Unison (e.g., whether to perform the synchronization automatically in clear cases) can be controlled by means of command-line parameters specified when the program is started. The complete list of all parameters can be viewed with `unison --help`.

For each pair, a synchronization log is maintained in the user directory `~/.unison`. Configuration sets such as `~/.unison/example.prefs` can also be stored in this directory:

```
root=/home/foobar/dir1
root=ssh://fbar@server//homes/fbar/dir2
batch=true
```

File 44: *The file* `~/.unison/example.prefs`

To start the synchronization, specify this file as the command-line parameter as in `unison example.prefs`.

More Information

The official documentation of Unison is extremely useful. For this reason, this section merely provides a brief introduction. The complete manual is available at `http://www.cis.upenn.edu/~bcpierce/unison/` and in the SuSE package `unison`.

Introduction to CVS

Uses

CVS is suitable for synchronization purposes if individual files are edited frequently and are stored in a loose file format, such as ASCII text or program source text. The use of CVS for synchronizing data in other formats, such as JPEG files, is possible, but leads to large amounts of data, as all variants of a file are stored permanently on the CVS server. Furthermore, in such cases most of the capabilities of CVS cannot be used.

The use of CVS for synchronizing files is only possible if all workstations can access the same server. In contrast, with the program Unison the data can be passed by host A through the hosts B and C to the server S.

Configuring a CVS Server

The "server" is the place where all valid files are located, including the latest versions of all files. Any stationary workstation can be used as a server. If possible, the data of the CVS should be included in regular backups.

When configuring a CVS server, it might be a good idea to grant the user access to the server via ssh. If the user is known to the server as `newbie`and the CVS software is installed on the server as well as on the client (e.g., notebook), the following environment variables must be set on the client side:

```
CVS_RSH=ssh CVS_ROOT=newbie@server:/serverdir
```

The command `cvs init` can be used to initialize the CVS server from the client side. This needs to be done only once.

Finally, the synchronization must be assigned a name. Select or create a directory on the client that will exclusively contain files to manage with CVS (the directory can also be empty). The name of the directory will also be the name of the synchronization. In our example, we use a directory called `synchome`. Change to this directory and enter the following command to set the synchronization name to `synchome`:

```
cvs import synchome newbie newbie_0
```

Many CVS commands require a comment. For this purpose, CVS starts an editor (the editor defined in the environment variable `$EDITOR` or vi if no editor was defined). The editor call can be circumvented by entering the comment in advance on the command line, such as in the following example:

```
cvs import -m 'this is a test' synchome newbie newbie_0
```

Using CVS

From now on, the synchronization repository can be "checked out" from all hosts:

```
cvs co synchome
```

This creates a new subdirectory `synchome` on the client. To commit your changes to the server, change to the directory `synchome` (or one of its subdirectories) and enter `cvs commit`.

By default, all files (including subdirectories) are committed to the server. To commit only individual files or directories, specify them as in `cvs commit file1 directory1`. New files and directories must be added to the repository before they are committed to the server with a command like `cvs add file1 directory1`. Subsequently, the newly added files and directories can be committed: `cvs commit file1 directory1`.

If you change to another workstation, "check out" the synchronization repository, provided this has not been done during an earlier session at the same workstation (see above).

The synchronization with the server is started with the command `cvs update`. You can also update individual files or directories as in `cvs update file1 directory1`. If you first want to see the difference from the versions stored on the server, use the command `cvs diff`or `cvs diff file1 directory1`. Use `cvs -nq update` to see which files would be affected by an update.

Here are some of the status symbols displayed during an update:

U The local version was updated.

M The local version was modified. If there were changes on the server, it was possible to merge the differences in the local copy.

P The local version was patched with the version on the server.

C The local file conflicts with current version in the repository.

? This file does not exist in the CVS.

The status `M` indicates a locally modified file. Either commit the local copy to the server or remove the local file and run the update again. In this case, the missing file will be retrieved from the server. If you commit a locally modified file and the file was changed and commited before in the same line, you might get a conflict indicated with `C`.

In this case look at conflict marks (»> and «<) in the file and decide between the two versions. As this can be a rather unpleasant job, you might decide to abandon your changes, delete the local file, and enter `cvs up` to retrieve the current version from the server.

More Information

This section merely offers a brief introduction to the many possibilities of CVS. Extensive documentation is available at the following URLs:

```
        http://www.cvshome.org/
        http://www.gnu.org/manual/
```

Introduction to mailsync

Uses

mailsync is mainly suitable for the following three tasks:

- Synchronization of locally stored e-mails with e-mails stored on a server
- Migration of mailboxes to a different format or to a different server
- Integrity check of a mailbox or search for duplicates

Configuration and Use

mailsync distinguishes between the mailbox itself (the "store") and the connection between two mailboxes (the "channel". The definitions of the stores and channels are stored in `~/.mailsync`. The following paragraphs explain a number of store examples.

A simple definition might appear as follows:

```
store saved-messages {
        pat     Mail/saved-messages
        prefix  Mail/
}
```

`Mail/` is a subdirectory of the user's home directory that contains e-mail folders, including the folder `saved-messages`. If mailsync is started with

```
mailsync -m saved-messages
```

an index of all messages will be listed in `saved-messages`. If the following definition is made

```
store localdir {
          pat     Mail/*
          prefix  Mail/
}
```

the command `mailsync -m localdir` will cause all messages stored under `Mail/` to be listed. In contrast, the command `mailsync localdir` lists the folder names. The specifications of a store on an IMAP server appear as follows:

```
store imapinbox {
  server  {mail.edu.harvard.com/user=gulliver}
  ref     {mail.edu.harvard.com}
  pat     INBOX
}
```

The above example merely addresses the main folder on the IMAP server. A store for the subfolders would appear as follows:

```
store imapdir {
  server  {mail.edu.harvard.com/user=gulliver}
  ref     {mail.edu.harvard.com}
  pat     INBOX.*
  prefix  INBOX.
}
```

If the IMAP server supports encrypted connections, the server specification should be changed to

```
server  {mail.edu.harvard.com/ssl/user=gulliver}
```

or, if the server certificate is not known, to

```
server {mail.edu.harvard.com/ssl/novalidate-cert/user=gulliver}
```

The prefix will be explained later.

Now the folders under `Mail/` should be connected to the subdirectories on the IMAP server:

```
channel folder localdir imapdir {
        msinfo .mailsync.info
}
```

mailsync uses the `msinfo` file to keep track of the messages that have already been synchronized.

The command `mailsync folder` does the following:

- The mailbox pattern is expanded on both sides
- The prefix is removed from the resulting folder names
- The folders are synchronized in pairs (or created if they do not exist)

Accordingly, the folder `INBOX.sent-mail` on the IMAP server will be synchronized with the local folder `Mail/sent-mail` (provided the definitions explained above exist). The synchronization between the individual folder is performed as follows:

- If a message already exists on both sides, nothing happens
- If the message is missing on one side and is new (not listed in the `msinfo` file), it will be transmitted there
- If the message merely exists on one side and is old (already listed in the `msinfo` file), it will be deleted there (because the message that had obviously existed on the other side was deleted)

To know in advance which messages will be transmitted and which will be deleted during a synchronization, start mailsync with a channel *and* a store:

```
mailsync folder localdir
```

This command produces a list of all messages that are new on the local host as well as a list of all messages that would be deleted on the IMAP side during a synchronization. Similarly, the command

```
mailsync folder imapdir
```

produces a list of all messages that are new on the IMAP side and a list of all messages that would be deleted on the local host during a synchronization.

Possible Problems

In the event of a data loss, the safest method is to delete the relevant channel log file `msinfo`. Accordingly, all messages that only exist on one side will be viewed as new and therefore will be transmitted during the next synchronization.

Only messages with a message ID are included in the synchronization. Messages lacking a message ID are simply ignored, which means they are neither transmitted nor deleted. A missing message ID is usually caused by faulty programs when sending or writing a message.

On certain IMAP servers, the main folder is addressed with `INBOX` and subfolders are addressed with a randomly selected name (in contrast to INBOX and INBOX.name). Therefore, for such IMAP servers, it is not possible to specify a pattern exclusively for the subfolders.

After the successful transmission of messages to an IMAP server, the mailbox drivers (c-client) used by mailsync set a special status flag. For this reason, some e-mail programs, like mutt, are not able to recognize these messages as new. The setting of this special status flag can be disabled with the option `-n`.

More Information

The `README` in `/usr/share/doc/packages/mailsync/`, which is included in the package `mailsync`, provides additional information. In this connection, RFC 2076 "Common Internet Message Headers" is of special interest.

Heterogenous Networks

In addition to connecting to other Linux systems, Linux is also able to connect to Windows and Macintosh computers and communicate over Novell networks. This chapter shows the requirements for and configuration of heterogenous networks.

Samba 422
Netatalk 430
Netware Emulation with MARSNWE 437

Samba

With the program Samba, convert a UNIX machine into a file and print server for DOS, Windows, and OS/2 machines. The Samba Project is run by the Samba Team and was originally developed by the Australian Andrew Tridgell.

Samba has now become a fully-fledged and rather complex product. This section presents an overview of its basic functionality. Samba offers plenty of online documentation. Enter `apropos samba` at the command line to display some manual pages or just browse the `/usr/share/doc/packages/samba` directory if Samba is installed for more online documentation and examples. A commented example configuration (`smb.conf.SuSE`) can be found in the `examples` subdirectory.

Samba uses the SMB protocol (Server Message Block) that is based on the NetBIOS services. Due to pressure from IBM, Microsoft released the protocol so other software manufacturers could establish connections to a Microsoft domain network. Samba sets the SMB protocol on top of the TCP/IP protocol, so the TCP/IP protocol must also be installed on all clients.

NetBIOS

NetBIOS is a software interface (API) designed for communication between machines. Here, a name service is provided. It enables machines connected to the net to reserve names for themselves. After reservation, these machines can be addressed by name. There is no central process that checks names. Any machine on the network can reserve as many names as it wants, if the names are not already in use. The NetBIOS interface can now be implemented for different network architectures. An implementation that works relatively closely with network hardware is called NetBEUI, but this is often referred to as NetBIOS. Network protocols implemented with NetBIOS are IPX from Novell (NetBIOS via TCP/IP) and TCP/IP.

The NetBIOS names sent via TCP/IP have nothing in common with the names used in `/etc/hosts` or those defined by DNS. NetBIOS uses its own, completely independent naming convention. However, it is recommended to use names that correspond to DNS host names to make administration easier. This is the default used by Samba.

Clients

All common operating systems, such as Mac OS X, Windows, and OS/2, support the SMB protocol. The TCP/IP protocol must be installed on all computers. Samba provides a client for the UNIX versions.

For Linux, there is a file-system kernel module for SMB that allows the integration of SMB resources on the Linux system level.

SMB servers provide hardware space to their clients by means of shares. A share includes a directory and its subdirectories on the server. It is exported by means of a name and can be accessed by its name. The share name can be set to any name — it does not have to be the name of the export directory. A printer is also assigned a name. Clients can access the printer by its name.

Installing and Configuring the Server

If you intent to use Samba as server, install the package `samba`. The services required for Samba can be started with `rcnmb start && rcsmb start` and stopped with `rcsmb stop && rcnmb stop`.

The main configuration file of Samba is `/etc/samba/smb.conf`. This file can be divided into two logical parts. The `[global]` section contains the central and global settings. The `[share]` sections contain the individual file and printer shares. By means of this approach, details regarding the shares can be set differently or globally in the `[global]` section, which enhances the structural transparency of the configuration file.

The global Section

The following parameters of the `[global]` section need some adjustment to match the requirements of your network setup so other machines can access your Samba server via SMB in a Windows environment.

workgroup = TUX-NET This line assigns the Samba server to a work group. Replace `TUX-NET` with an appropriate work group of your networking environment. Your Samba server will appear under its DNS name unless this name has been assigned to any other machine in the net.

If the DNS name is not available, set the server name using `netbiosname=MYNAME`. See `man smb.conf` for more details about this parameter.

os level = 2 This parameter triggers whether your Samba server tries to become LMB "Local Master Browser" for its work group. Choose a very low value to spare the existing Windows net from any disturbances caused by a misconfigured Samba server. More information about this important topic can be found in the files `BROWSING.txt` and `BROWSING-Config.txt` under the `textdocs` subdirectory of the package documentation.

As long as there is no other SMB server present in your network, such as a Windows NT or 2000 server, and the Samba server should keep a list of all systems present in the local environment, set the `os level` to a higher value (for example, `65`). Your Samba server will thus be chosen as LMB for your local network.

When changing this setting, consider carefully how this could affect an existing Windows network environment. A misconfigured Samba server can cause serious problems when trying to become LMB for its work group. Contact your administrator and subject your configuration to some heavy testing either in an isolated network or at a noncritical time of day.

wins support and wins server If your Samba server should integrate into an existing Windows network with a running WINS server, remove the leading semicolon in front of the `wins server` parameter and adjust the IP address to the requirements of your network. If your Windows machines run in separate subnets, they should "see" each other, your Windows network does not have a WINS server running, and your Samba server should become the WINS server, uncomment the line holding the `wins support = yes` parameter. Make sure you activate this setting solely on a Samba server. `wins server` may not be used in this constellation.

Shares

The following examples illustrate how a CD-ROM drive and the user directories (`homes`) are made available to the SMB clients.

`[cdrom]`

```
;[cdrom]
;       comment = Linux CD-ROM
;       path = /media/cdrom
;       locking = No
```

***File 45:** A CD-ROM Share*

To avoid having the CD-ROM drive accidentally made available, these lines are deactivated with comment marks (semicolons in this case). Remove the semicolons in the first column to share the CD-ROM drive via Samba.

`[cdrom]` and `comment` The entry `[cdrom]` is the name of the share that can be seen by all SMB clients on the net. An additional `comment` can be added to further describe the share.

path = /media/cdrom `path` exports the directory `/media/cdrom`.

By means of a very restrictive default configuration, this kind of share is only made available to the users present on this system. If this share should be made available to everybody, add a line `guest ok = yes` to the configuration. This setting gives read permissions to anyone on the network. It is recommended to handle this parameter with great care. This applies even more to the use of this parameter in the `[global]` section.

`[homes]`
The `[home]` share is of special importance here. If the user has a valid account and password for the Linux file server and his own home directory, he can be connected to it.

```
[homes]
        comment = Home Directories
        valid users = %S
        browseable = No
        read only = No
        create mask = 0640
        directory mask = 0750
```

***File 46:** homes Share*

`[homes]` As long as there is no other share using the share name of the user connecting to the SMB server, a share is dynamically generated using the `[homes]` share directives. The resulting name of the share is identical to the user name.

`valid users=%S` `%S` is replaced by the concrete name of the share as soon as a connection has been successfully established. For a `[homes]` share, this is always identical to the user's name. As a consequence, access rights to a user's share are restricted exclusively to the user.

`browseable = No` This setting enables the share to be invisible in the network environment.

`read only = No` By default, Samba prohibits write access to any exported share by means of the `read only = Yes` parameter. To make a share writeable, set the value `read only = No`, which is synonymous with `writeable = Yes`.

`create mask = 0640` Systems that are not based on MS Windows NT do not understand the concept of UNIX permissions, so they cannot assign permissions when creating a file.

The parameter `create mask` defines the access permissions assigned to newly created files. This only applies to writeable shares. In effect, this setting means the owner has read and write permissions and the members of the owner's primary group have read permissions. `valid users = %S` prevents read access even if the group has read permissions. Therefore, if you want the group to have read or write access, the line `valid users = %S` must be deactivated.

Security Levels

The SMB protocol comes from the DOS and Windows world and directly takes into consideration the problem of security. Each share access can be protected with a password. SMB has three possible ways of checking the permissions:

- **Share Level Security:** A password is firmly assigned to a share. Everyone who knows this password has access to that share.
- **User Level Security:** This variation introduces the concept of the user to SMB. Each user must register with the server with his own password. After registering, the server can grant access to individual exported shares dependent on user names.
- **Server Level Security:** To its clients, Samba pretends to be working in User Level Mode. However, it passes all password queries to another User Level Mode Server, which takes care of authentication. This setting expects an additional parameter (`password server =`).

The distinction between share, user, and server level security applies to the entire server. It is not possible to offer individual shares of a server configuration with Share Level Security and others with User Level Security. However, you can run a separate Samba server for each configured IP address on a system.

More information on this subject can be found in the file `textdocs/security_level.txt`. For multiple servers on one system, pay attention to the parameters `interfaces` and `bind interfaces only`.

Tip

For simple administration tasks with the Samba server, there is also the program swat. It provides a simple web interface with which to configure the Samba server conveniently. In a web browser, open `http://localhost:901` and log in as user `root`. swat is also activated in the files `/etc/xinetd.d/samba` and `/etc/services`. To do this, enter the line `diable = no`. More information about swat is provided in the man page.

Tip

Samba as Login Server

In networks where predominantly Windows clients are found, it is often preferable that users may only register with a valid account and password. This can be brought about with the help of a Samba server. In a Windows-based network, this task is handled by a Windows NT server configured as a Primary Domain Controller (PDC). The entries that must be made in the `[global]` section of `smb.conf` are shown in File 47.

```
[global]
 workgroup = TUX-NET
 domain logons = Yes
 domain master = Yes
```

***File 47:** Global Section in smb.conf*

If encrypted passwords are used for verification purposes — this is the default setting in maintained MS Windows 9x versions, MS Windows NT 4.0 from service pack 3, and all later products — the Samba server must be able to handle these. The entry `encrypt passwords = yes` in the `[global]` section enables this functionality. In addition, it is necessary to prepare user accounts and passwords in an encryption format that conforms with Windows. This is done with the command `smbpasswd -a name`. Create the domain account for the computers, required by the Windows NT domain concept, with the following commands:

```
useradd machinename\$
smbpasswd -a -m machinename
```

***File 48:** Setting up a Machine Account*

With the `useradd` command, a dollar sign is added. The command `smbpasswd` inserts this automatically when the parameter -m is used. The commented configuration example (`/usr/share/doc/packages/Samba/examples/smb.conf.SuSE`) contains settings that automate this task.

```
add user script = /usr/sbin/useradd -g machines \
                  -c "NT Machine Account" -d \
                  /dev/null -s /bin/false %m\$
```

***File 49:** Automated Setup of a Machine Account*

For the authentication method selected in this example, all user data is stored in `/etc/samba/smbpasswd`. To store your user data on an LDAP server, go to 'YaST' → 'System' → '/etc/sysconfig Editor' → 'Network Services' → 'Samba' then modify the parameter `SAMBA_SAM` to `ldap`. Finally, execute `SuSEconfig -module samba`.

Installing Clients

Clients can only access the Samba server via TCP/IP. NetBEUI and NetBIOS via IPX cannot be used with Samba.

Windows 9x and ME

Windows 9x and ME already have built-in support for TCP/IP. However, this is not installed as the default. To add TCP/IP, go to 'Control Panel' → 'System' and choose 'Add' → 'Protocols' → 'TCP/IP from Microsoft'. After rebooting your Windows machine, find the Samba server by double-clicking the desktop icon for the network environment.

Tip

To use a printer on the Samba server, install the standard or Apple-PostScript printer driver from the corresponding Windows version. It is best to link this to the Linux printer queue, which accepts Postscript as input format.

Tip

Optimization

`socket options` is one possible optimization provided with the sample configuration that ships with your Samba version. Its default configuration refers to a local ethernet network. For additional information about `socket options`, refer to the section "socket options" in the man page for `smb.conf` (`man smb.conf`) and to the man page for `socket` (`man 7 socket`). Additional information is provided in `textdocs/Speed.txt` and `textdocs/Speed2.txt`.

The standard configuration in `/etc/samba/smb.conf` is designed to provide useful settings based on the default settings of the Samba team. However, a ready-to-use configuration is not possible, especially in view of the network configuration and the work group name. The commented sample configuration `examples/smb.conf.SuSE` contains information that will be helpful for the adaption to local requirements.

Tip

The Samba team offers `textdocs/DIAGNOSIS.txt`, which is a step-by-step guide to check your configuration.

Tip

Netatalk

With the package `netatalk`, obtain a high-performance file and print server for MacOS clients. With it, access data on a Linux machine from a Macintosh or print to a connected printer. Netatalk is a suite of Unix programs that run on kernel-based DDP (Datagram Delivery Protocol) and implement the AppleTalk protocol family (ADSP, ATP, ASP, RTMP, NBP, ZIP, AEP, and PAP).

AppleTalk is, in effect, an equivalent to the more familiar TCP (Transmission Control Protocol). It has counterparts to many TCP/IP-based services, including services for resolving host names and time synchronization. For example, the command `aecho` (AEP, AppleTalk Echo Protocol) is used instead of `ping` (ICMP ECHO_REQUEST, Internet Control Message Protocol).

The three daemons described below are normally started on the server:

- atalkd ("AppleTalk Network Manager") that somewhat correlates with the programs ifconfig and routed
- afpd (AppleTalk Filing Protocol daemon), which provides an interface for Macintosh clients to Unix file systems
- papd (Printer Access Protocol daemon), which makes printers available in the (AppleTalk) network.

Of course, you can export server directories not only via Netatalk, but also, at the same time, via Samba for Windows clients (see *Clients* on page 422) and via NFS (see *NFS — Shared File Systems* on page 363), which is very useful in heterogeneous network environments. This centralizes the management of data backup and user permissions on the Linux server.

There are some important details to consider when using Netatalk:

- Due to Macintosh client restrictions, the user passwords on the server cannot be longer than eight characters.
- Macintosh clients cannot access Unix files with names longer than 31 characters.
- File names may not contain colons (`':'`) because they serve as path name separators in MacOS.

Configuring the File Server

In the default configuration, Netatalk is already fully functional as a file server for home directories of the Linux system. To use the extended features, define some settings in the configuration files. These are located in the `/etc/netatalk` directory.

All configuration files are pure text files. Text that follows a hash mark `'#'` (comments) and empty lines can be disregarded. The various services (printing, Appletalk broadcast, Appletalk via TCP/IP, time server) can be activated through the file `/etc/netatalk/netatalk.conf`:

```
ATALKD_RUN=yes
PAPD_RUN=yes
AFPD_RUN=yes
TIMELORD_RUN=no
```

Configuring the Network — `atalkd.conf`

Define, in `/etc/netatalk/netatalkd.conf`, over which interfaces services are provided. This is usually `eth0`, which means it suffices if the only value entered here is `eth0`. In the example file that comes with Netatalk, this is the case. Enter additional interfaces to use several network cards at the same time. When the server is started, it searches the network for existing zones and servers and modifies the corresponding lines by entering the set AppleTalk network addresses. You will then find a line such as

```
eth0 -phase 2 -net 0-65534 -addr 65280.57
```

at the end of the file. For more complex configurations, refer to examples in the configuration file. Find documentation about additional options in the manual page of afpd.

Defining File Servers — `afpd.conf`

The `afpd.conf` file contains definitions for how your file server appears on MacOS machines as an item under the 'Chooser' dialog. As is the case with the other configuration files, these also contain detailed comments explaining the wide variety of options.

If you do not change anything here, the default server will simply be started and displayed with the host name in the 'Chooser'. Therefore, you do not necessarily need to enter anything. However, you can give additional file servers a variety of names and options here, for instance, to provide a specific "guest server" where everybody can save files as "guest".

```
"Guest server" -uamlist uams_guest.so
```

Define a server that denies guests access, but which is only accessible for users who already exist in the Linux system with:

```
"Font server" -uamlist uams_clrtxt.so,uams_dhx.so
```

This behavior is controlled by the option `uamlist`, followed by a list of authentication modules to use, separated by commas. If you do not provide this option, all procedures are active by default.

An AppleShare server not only provides its services by default via AppleTalk, but also ("encapsulated") via TCP/IP. The default port is 548. Assign dedicated ports to additional AppleShare servers (on the same machine) if these should also run via TCP. The availability of the service via TCP/IP enables access to the server even over non-AppleTalk networks, such as the Internet.

In this case, the syntax would read:

```
"Font server" -uamlist uams_clrtxt.so,uams_dhx.so -port 12000
```

The AppleShare server, set to the port 12000, then appears in the network with the name "Font server" and will not allow guest access. In this way, it is also accessible via TCP/IP routers.

The file `AppleVolumes.default` (described in detail below) defines which directories located on the server are made available by each AppleShare server as network *volumes*. Define other files containing unique descriptions for each AppleShare server using the option `-defaultvol`, such as with (in one line):

```
"Guest server" -uamlist uams_guest.so -defaultvol
/etc/netatalk/AppleVolumes.guest
```

Further options are explained in the `afpd.conf` file itself.

Directories and Access Permissions — `AppleVolumes.default`

Here, define directories to export. The access permissions are defined via the customary Unix user and group permissions. This is configured in the `AppleVolumes.default` file. Along with `AppleVolumes.default`, additional files can be created, such as `AppleVolumes.guest`, used by some servers (by giving the option `-defaultvol` in the `afpd.conf` file — see previous section).

Note

Here, the syntax has partially changed. Take this into consideration if you are updating this version from a previous one. For example, it is now `allow:` instead of `access=` (a typical symptom would be if, instead of the drive descriptions, you were to see a display of the drive options on the Mac clients in the 'Chooser'.) Because the new files are created with the `.rpmnew` endings during an update, it is possible that your previous settings may no longer function as a result of the modified syntax. Create backups of your configuration files, copy your old configurations from them into your new files, then rename these files to the proper names. This way, you will benefit from the current comments contained in the configuration files, which provide a detailed explanation of the diverse options.

Note

The syntax

```
/usr/local/psfonts "PostScript Fonts"
```

indicates that the Linux directory `/usr/local/psfonts` located in the root directory is available as an AppleShare volume with the name "PostScript Fonts".

Options are separated by a space and attached to the end of a line. A very useful option is the access restriction:

```
/usr/local/psfonts "PostScript Fonts" allow:User1,@group0
```

which restricts access to the volume "PostScript Fonts" to the user "User1" and all members of the group "group0". The users and groups entered here must be known to the Linux system. Likewise, explicitly deny users access with `deny:User2`.

These restrictions only apply to access via AppleTalk and not to the normal access rights users have if they can log in to the server itself.

Netatalk maps the customary Resource Fork of MacOS files to `.AppleDouble` directories in the Linux file system. Using the `noadouble` option, set these directories to be created only when they are actually needed. Syntax:

```
/usr/local/guests "Guests" options:noadouble
```

Additional options and features can be found in the explanations included in the file itself.

The tilde (`'~'`) in this configuration file stands for the home directory for each and every user on the server. This way, every user can easily access his home directory without each one being defined explicitly here. The example file installed already includes a tilde, which is why Netatalk makes the home directory available by default as long as you do not modify anything in this file.

afpd also searches for a file `Applevolumes` or `.Applevolumes` in the home directory of a user logged on to the system. Entries in this file supplement the entries in the server files `AppleVolumes.system` and `AppleVolumes.default` to enable individual type and creator file specifications and to access specific directories. These entries are extensions and do not allow access for the user for whom access permission is denied from the server side.

The `netatalk.pamd` file is used, via PAM (pluggable authentication modules), for authentication purposes. Using PAM is, however, irrelevant in this context.

File Specifications — `AppleVolumes.system`

In the `AppleVolumes.System` file, define which customary MacOS type and creator specifications are assigned to certain file endings. An entire series of default values are already predefined. If a file is displayed by a generic white icon, there is not yet an entry for it in this file. If you encounter a problem with a text file belonging to another system, which cannot be opened properly in MacOS or vice versa, check the entries there.

Configuring the Print Server

A laserwriter service is made available by configuring the `papd.conf` file. The printer must be already functioning locally via lpd, so configure a printer as described in Chapter *Printer Operation* on page 117. If you can print a text file locally using the command `lpr file.txt`, the first step has been successfully completed.

You do not necessarily need to enter anything in `papd.conf` if a local printer is configured in Linux, because print jobs can simply be forwarded to the print daemon `lpd` without additional specifications. The printer registers itself in the AppleTalk network as Laserwriter. You can, however, extend your printer entries by referring to File 50 on the next page.

```
Printer_Reception:pr=lp:pd=/etc/netatalk/kyocera.ppd
```

File 50: `papd.conf`

This causes the printer named Printer_Reception to appear as a 'Chooser' item. The corresponding printer description file is usually provided by the vendor. Otherwise, refer to the file `Laserwriter` located in the 'System Extensions' folder. However, when using this file you often cannot use all of the printer's features.

Starting the Server

The server can be started at system boot time via its "init script" or manually with `rcatalk start`. The init script is located at `/etc/init.d/netatalk`.

The actual starting of the server takes place in the background. It takes about a minute until the AppleTalk interfaces are set up and responsive. Check for the status as shown in the following (all servers are running if `OK` is reported three times):

```
earth:~ #  rcatalk status
Checking for service atalk:OKOKOK
```

From a Mac running MacOS, check for AppleTalk activation, choose 'Filesharing', then double-click 'AppleShare'. The names of the servers should then appear in the window. Double-click a server and log in. It should then be possible to access a shared volume.

The procedure is a bit different for AppleShare servers configured to use TCP only (and no DDP). To connect, press the 'Server IP address' button and enter the respective IP address. If necessary, append the port number, separated by a colon (`':'`).

Additional Information

To take full advantage of all the options netatalk offers, read the corresponding manual pages. Find them by entering the command `rpm -qd netatalk`. The `/etc/netatalk/netatalk.conf` file is not used in our netatalk version, so disregard it.

Helpful URLs:

- http://netatalk.sourceforge.net/
- http://www.umich.edu/~rsug/netatalk/
- http://thehamptons.com/anders/netatalk/
- http://cgi.zettabyte.net/fom-serve/netatalk/cache/1.html

We do not currently recommend trying to access an AppleShare file system hosted on a Macintosh from a Linux machine. Software is available, but it is in early development stages. For more information, refer to http://www.panix.com/~dfoster/afpfs/.

Netware Emulation with MARSNWE

The Netware emulator MARSNWE can easily replace the file and print services of a Novell Netware 2.2 or 3.11 server. It can also be used in this manner as an IPX router. However, it does not offer the features of newer Netware versions, such as NDS (Netware Directory Services). Workstations running DOS or Windows already configured to access a Netware 2.2, 3.11, or 3.12 server can use the Linux server with the Netware emulator MARSNWE as a server without having to change the configuration much. Administration is best taken care of in Linux, because Novell system administration applications can only be utilized under certain conditions and have licensing issues as well.

Starting the Netware Emulator MARSNWE

MARSNWE in SuSE Linux can be started immediately after installation, because it is already preconfigured for initial testing. The required IPX support on the part of the kernel is available as a loadable kernel module and is automatically loaded by the start script. The IPX interface is automatically set up by MARSNWE. At this point, the network number and the protocol to use will both be read from the extensively commented configuration file `/etc/nwserv.conf`. MARSNWE is started via the command `rcnwe start`. The `done` message to the right of the screen in green indicates that MARSNWE has been successfully started. Use `rcnwe status` to check whether the Netware emulator is running. Halt it with `rcnwe stop`.

The Configuration File /etc/nwserv.conf

The configuration options are summarized in enumerated sections. Every configuration line starts with the number of the corresponding section. Only sections 1 to 22 are relevant here. Not all numbers are used, however. Most of the time, the following sections are enough for the configuration:

1 Netware Volumes

2 Server Name

4 IPX Network

13 User Names

21 Printers

After modifying the configuration, MARSNWE must be restarted with the command `rcnwe restart`.

The configuration options in detail:

Volumes (Section 1):

```
1    SYS     /usr/local/nwe/SYS/     kt      711 600
```

Here, the volumes to export are defined. Every line begins with the section number (here 1), followed by the volume name and the server directory path. In addition, various options can be specified represented by specific letters and a UMASK for the generation of both directories and files. If a UMASK is not specified, the default value from Section 9 is used. The volume for SYS is already entered. To avoid problems with uppercase and lowercase letters in the file names, it is recommended to use the k option, so all the file names will be converted to lowercase letters.

Server Name (Section 2):

```
2    MARS
```

This specification is optional. The host name will be used by default.

Internal Network Number (Section 3):

```
3    auto
```

The internal network number is generated from the network card's MAC address if auto is specified here. This setting is usually retained.

IPX Configuration (Section 4):

```
4    0x0     *       AUTO            1
4    0x22    eth0    ethernet_ii     1
```

Here, the Netware network number is specified as well as to which network interface using which protocol the bind should be made. The first example sets up everything automatically, while the second binds the network number 0x22 to the network card eth0 with the frame type Ethernet-II. If you have several network cards and enter all these with different network numbers, IPX will be routed between them.

Create Mode (Section 9):

```
9    0751    0640
```

Enters the default permission with which directories and files are created.

GID and GID with minimal permissions (Section 10, 11):

```
10   65534
11   65534
```

Group ID and user ID for users not logged in. Here nogroup and nobody.

Supervisor Login (Section 12):

```
12   SUPERVISOR      root
```

The supervisor is mapped to user `root`.

User Logins (Section 13):

```
13   LINUX           linux
```

Netware users are assigned to Linux users. A static password can optionally be entered here.

Automatic User Mapping (Section 15):

```
15   0       top-secret
```

If `1` is specified here instead of `0`, Linux logins will automatically be made available as Netware logins. In this case, the password is "top-secret".

Printer Queues (Section 21):

```
21   LP      -       lpr -
```

The first parameter LP is the name of the Netware printer. Second, the name of the spool directory can be given. The print command is listed last.

Print Server (Section 22):

```
22   PS_NWE  LP_PS   1
```

Printers can be defined here that are accessed over the pserver by the package `ncpfs`.

Access to Netware Servers and Their Administration

The package `ncpfs` is a collection of small programs that can be used to administer a Netware 2.2 or 3.11 server from Linux, mount Netware volumes, or manage printers. To access Netware servers newer than version 4, the bindery emulation and IPX must be enabled on them.

The following programs are available. Refer to the man pages for their functions:

nwmsg	ncopy	ncpmount	ncpumount
nprint	nsend	nwauth	nwbocreate
nwbols	nwboprops	nwborm	nwbpadd
nwbpcreate	nwbprm	nwbpset	nwbpvalues
nwdir	nwdpvalues	nwfsctrl	nwfsinfo
nwfstime	nwgrant	nwpasswd	nwpurge
nwrevoke	nwrights	nwsfind	nwtrustee
nwtrustee2	nwuserlist	nwvolinfo	pqlist
pqrm	pqstat	pserver	slist

`ncpmount`, for example, is an essential program used to mount volumes from a Netware server in Linux. In turn, `ncpumount` is used to unmount them. package `ncpfs` contains tools for configuring the IPX protocol and IPX routing:

```
ipx_cmd
ipx_configure
ipx_interface
ipx_internal_net
ipx_route
```

With `ipx_configure` and `ipx_interface`, configure the the network card's IPX. If you already have MARSNWE running, however, it will take care of this configuration automatically.

IPX Router with ipxrip

Another package for converting Linux into an IPX router is package `ipxrip`. Usually, it is not needed, because an IPX router can be configured with MARSNWE or the tools from package `ncpfs`.

Internet

A lot could be written about the Internet, but most applications just work "out of the box" after configuring Internet access with YaST. Therefore, this chapter only focuses on more interesting aspects: the configuration of the smpppd (SuSE Meta PPP-Daemon), the manual configuration of ADSL access in case problems arise with the YaST2 configuration, and the configuration of the Squid proxy.

The smpppd as Dial-up Assistant 442
Configuring an ADSL or T-DSL Connection 444
Proxy Server: Squid 445

The smpppd as Dial-up Assistant

Program Components for the Internet Dial-Up

Most home users do not have a dedicated line connecting them to the Internet. Rather, they use dial-up connections. Depending on the dial-up method (ISDN or DSL), the connection is controlled by the ipppd or the pppd. Basically, all that needs to be done to go online is to start these programs correctly.

If you have a flat-rate connection that does not generate any additional costs for the dial-up connection, simply start the respective daemon. Control the dial-up connection with a KDE applet or a command-line interface. If the Internet gateway is not the host you are using, you might want to control the dial-up connection by way of a network host.

This is where smpppd is involved. It provides a uniform interface for auxiliary programs and acts in two directions: first, it programs the required pppd or ipppd and controls its dial-up properties. Second, it makes various providers available to the user programs and transmits information about the current status of the connection. As smpppd can also be controlled by way of the network, it is suitable for controlling dial-up connections to the Internet from a workstation in a private subnetwork.

Configuring the smpppd

The connections provided by smpppd are automatically configured by YaST. The actual dial-up programs kinternet and cinternet are also preconfigured. Manual settings are only required to configure additional features of the smpppd, such as remote control.

The configuration file of smpppd is `/etc/smpppd.conf`. By default, it does not enable remote control. The most important options of this configuration file are as follows:

open-inet-socket = `<yes|no>` To control smpppd via the network, this option must be set to `yes`. The port on which the smpppd will listen is `3185`. If this parameter is set to `yes`, the parameters `bind-address`, `host-range`, and `password` should also be set accordingly.

bind-address = `<ip>` If a host has several IP addresses, this parameter can be used to determine by which IP address smpppd should accept connections.

host-range = `<min ip> <max ip>` The parameter `host-range` can be used to define a network range. Hosts whose IP addresses are within this range are granted access to smpppd. All hosts not within this range are denied access.

password = `<password>` By assigning a password, limit the clients to authorized hosts. As this is a plain-text password, you should not overrate the security it provides. If no password is assigned, all clients are entitled to access smpppd.

More information about smpppd is available in the man page for `smpppd` (`man 8 smpppd`) and the man page for `smpppd.conf` (`man 5 smpppd.conf`).

Configuring kinternet and cinternet for Remote Use

The programs kinternet and cinternet can be used locally as well as for controlling a remote smpppd. cinternet is the the command-line counterpart of the graphical kinternet. To prepare these utilities for use with a remote smpppd, edit the configuration file `/etc/smpppd-c.conf` manually or using kinternet. This file only uses three options:

server = `<server>` Here, specify the host on which the smpppd runs. If this host is the same as the default gateway of the host, it is sufficient to set the `gateway-fallback` to `yes`.

gateway-fallback = `<yes|no>` If no server was specified and there is no local smpppd, this option, which is enabled by default, causes a search for an smpppd on the default gateway.

password = `<password>` Insert the password selected for smpppd.

If the smpppd is active, you can now try to access it. This can be done with the command `cinternet --verbose --interface-list`. If you experience difficulties at this point, refer to the man page for `smpppd-c.conf` (`man 5 smpppd-c.conf`) and the man page for `cinternet` (`man 8 cinternet`).

Configuring an ADSL or T-DSL Connection

Default Configuration

Currently, SuSE Linux supports DSL connections that work with the point-to-point over ethernet protocol (PPPoE) used by most major providers. If you are not sure what protocol is used for your DSL connections, ask your provider. If you have a single-user workstation with a graphical interface, the DSL connection should be set up with the YaST modules ADSL or T-DSL.

1. The `ppp` and `smpppd` packages must be installed. It is best to use YaST for this purpose.
2. Configure your network card with YaST. Do not activate dhcp, but set a fixed IP address instead, such as `192.168.2.22`.
3. The parameters set with the DSL module of YaST will be saved in the file `/etc/sysconfig/network/providers/provider0`. In addition, there are configuration files for the smpppd (SuSE meta ppp daemon) and its front-ends kinternet and cinternet. For information, refer to `man smpppd`.
4. If necessary, start the network with the command `rcnetwork start` and the smpppd with the command `rcsmpppd start`.
5. On a system without a graphical user interface, use the commands `cinternet -start` and `cinternet -stop` to establish or terminate a connection. On a graphical user interface, this can be done with kinternet. This program is started automatically in KDE if you used YaST to set up DSL. Click the gear icon in the control panel. Select 'Communication/Internet' → 'Internet Tools' → 'kinternet'. A plug icon will appear in the control panel. You can now start the connection with a simple click on the icon, and terminate the connection later on with another click.

DSL Connection by Dial-on-Demand

Dial-on-demand means that the connection will automatically be set up when the user goes online, for example, when visiting a web site in a browser or when sending an e-mail. After a certain amount of idle time when no data is sent or received, the connection will automatically be dropped. Because the dial-up connection via PPPoE, the protocol for ADSL, is very fast, it seems as if it were a dedicated line to the Internet.

Using dial-on-demand, however, really only makes sense if you have a flat-rate connection. If you use it but are charged for time online, make sure tthere are no interval processes, such as a cronjob, periodically establishing a connection. This could get quite expensive.

Although a permanent online connection would also be possible using a DSL flat-rate connection, there are certain advantages to having a connection that only exists for a short amount of time when needed:

- Most providers drop the connection after a certain period of time.
- A permanent connection can be considered as a drain on resources (e. g., IP addresses).
- Being online permanently is a security risk, because hackers may be able to comb the system systematically for vulnerable areas. A system that is only accessible over the Internet when necessary and is always changing IP addresses is significantly more difficult to attack.

Dial-on-demand can be enabled using YaST (also refer to the *User Guide*). Alternatively, set it up manually:

Set the parameter DEMAND="yes" in the `/etc/sysconfig/network/providers/provider0` file then define an idle time via the variable IDLETIME="60". This way, an unused connection will be dropped after sixty seconds.

Proxy Server: Squid

The following chapter describes how caching web sites assisted by a proxy server works and what the advantages of using proxy servers are. A widely popular proxy cache for Linux and UNIX platforms is Squid. The chapter discusses its configuration, the specifications required to get it running, how to configure the system to do transparent proxying, how to gather statistics about the cache's use with the help of programs like Calamaris and cachemgr, and how to filter web contents with squidGuard.

About Proxy Caches

Squid acts as a proxy cache. It behaves like an agent that receives requests from clients, in this case web browsers, and passes them to the specified server. When the requested objects arrive at the agent, it stores a copy in a disk cache.

Benefits arise when different clients request the same objects: these will be served directly from the disk cache, much faster than obtaining them from the Internet and, at the same time, saving overall bandwidth for the system.

Tip

Squid covers a wide range of features, including intercommunicating hierarchies of proxy servers to divide the load, defining strict access control lists to all clients accessing the proxy, and, with the help of other applications, allowing or denying access to specific web pages. It also can obtain statistics about the most visited web sites, user usage of the Internet, and others.

Tip

Squid is not a generic proxy. It proxies normally only between HTTP connections. It does also support the protocols FTP, Gopher, SSL, and WAIS, but it does not support other Internet protocols, such as Real Audio, news, or videoconferencing. Because Squid only supports the UDP protocol to provide communication between different caches, many other multimedia programs will not be supported.

Some Facts About Cache Proxying

Squid and Security

It is also possible to use Squid together with a firewall to secure internal networks from the outside using a proxy cache. The firewall denies all clients access to external services except Squid. All web connections must be established by way of the proxy.

If the firewall configuration includes a DMZ, set the proxy there. In this case, it is important that all computers in the DMZ send their log files to hosts inside the secure network. The possibility of implementing a "transparent" proxy is covered in *Transparent Proxy Configuration* on page 455.

Multiple Caches

Several proxies can be configured in such a way that objects can be exchanged between them, thus reducing the total system load and increasing the chances of finding an object already existing in the local network. It enables the configuration of cache hierarchies so a cache is able to forward object requests to sibling caches or to a parent cache. It can get objects from another cache in the local network or directly from the source.

Choosing the appropriate topology for the cache hierarchy is very important, because we do not want to increase the overall traffic on the network. For example, in a very large network, it is possible to configure a proxy server for every subnetwork and connect it to a parent proxy, connected in its turn to the proxy cache from the ISP. All this communication is handled by ICP (Internet Cache Protocol) running on top of the UDP protocol. Data transfers between caches are handled using HTTP (Hyper Text Transmission Protocol) based on TCP.

To find the most appropriate server from which to get the objects, one cache sends an ICP request to all sibling proxies. These will answer the requests via ICP responses with a HIT code if the object was detected or a MISS if it was not. If multiple HIT responses were found, the proxy server will decide which server to download depending on factors such as which cache sent the fastest answer or which one is closer. If no satisfactory responses have been sent, the request will be sent to the parent cache.

Tip

To avoid duplication of objects in different caches in our network, other ICP protocols are used, such as CARP (Cache Array Routing Protocol) or HTCP (HyperText Cache Protocol). The more objects maintained in the network, the greater the possibility of finding the desired one.

Tip

Caching Internet Objects

Not all objects available in the network are static. There are a lot of dynamically generated CGI pages, visitor counters, and encrypted SSL content documents. Objects like this are not cached because they will have changed each time they are accessed.

The question remains as to how long all the other objects stored in the cache should stay there. To determine this, all objects in the cache are assigned one of various possible states.

Web and proxy servers find out the status of an object by adding headers to these objects, such as "Last modified" or "Expires" and the corresponding date. Other headers specifying that objects must not be cached are used as well.

Objects in the cache are normally replaced, due to a lack of free hard disk space, using algorithms such as LRU (Last Recently Used). It consists of first replacing the less requested objects.

System Requirements

The most important thing is to determine the maximum load the system will have to bear. It is, therefore, important to pay more attention to the load picks, because these might be more than four times the day's average. When in doubt, it would be better to overestimate the system's requirements, because having Squid working close to the limit of its capabilities could lead to a severe loss in the quality of the service. The following sections point to the system factors in order of significance.

Hard Disks

Speed plays an important role in the caching process, so this factor deserves special attention. In hard disks, this parameter is described as "random seek time", measured in milliseconds. As a rule of thumb, the lower this value, the better.

One possibility to speed up the system is to concurrently use a number of disks or to employ striping RAID arrays.

Size of the Disk Cache

It depends on a few factors. In a small cache, the probability of a HIT (finding the requested object already located there) will be small, because the cache is easily filled so the less requested objects will be replaced by newer ones. On the other hand, if for example `1 GB` is available for the cache and the users only surf `10 MB` a day, it will take more than one hundred days to fill the cache.

The probably easiest way to determine the needed cache size is to consider the maximum transfer rate of our connection. With a `1 Mbit/s` connection, the maximum transfer rate will be `125 KB/s`. If all this traffic ends up in the cache, in one hour it will add up to `450 MB` and, assuming that all this traffic is generated in only 8 working hours, it will reach `3.6 GB` in one day. Since the connection is normally not used to its upper volume limit, it can be assumed that the total data volume handled by the cache is approximately `2 GB`. This is why in the example `2 GB` of disk space is required for Squid to keep one day's worth of browsed data cached.

Since Squid prominently reads or writes smaller blocks of data from the hard disk, the access time of a hard disk is more important than its data throughput speed. It is especially in these cases that hard disks with high rotation speeds are of great advantage by allowing a faster positioning of the heads.

RAM

The amount of memory required by Squid directly correlates to the number of objects in the cache. Squid also stores cache object references and frequently requested objects in the main memory to speed up retrieval of this data. Random access memory is much faster than a hard disk.

It is very important to have more than enough memory for the Squid process, because system performance will be dramatically reduced if it must be swapped to disk. The cachemgr.cgi tool can be used for the cache memory management. This tool is introduced in *cachemgr.cgi* on page 458.

CPU

Squid is not a program that requires intensive CPU usage. The load of the processor is only increased while the contents of the cache are being loaded or checked. Using a multiprocessor machine does not increase the performance of the system. To increase efficiency, it is better to buy faster disks or add more memory.

Some examples of configured systems running Squid are available at `http://wwwcache.ja.net/servers/squids.html`.

Starting Squid

Squid is already preconfigured in SuSE Linux, so you can start it easily right after installation. A prerequisite for a smooth start is an already configured network, at least one name server and, of course, Internet access. Problems can arise if a dial-up connection is used with dynamic DNS configuration. In cases such as this, at least the name server should be clearly entered, because Squid will not start if it does not detect a DNS server in the `/etc/resolv.conf`.

To start Squid, enter `rcsquid start` at the command line as `root`. For the initial start-up, the directory structure must first be defined in `/var/squid/cache`. This is done by the start script `/etc/init.d/squid` automatically and can take a few seconds or even minutes. If `done` appears to the right in green, Squid has been successfully loaded. Test Squid's functionality on the local system by entering `localhost` and `Port 3128` as proxy in the browser. To allow all users to access Squid and thus the Internet, change the entry in the configuration file `/etc/squid/squid.conf` from `http_access deny all` to `http_access allow all`. However, in doing so, consider that Squid is made completely accessible to anyone by this action. Therefore, define ACLs that control access to the proxy. More on this is available in *Options for Access Controls* on page 453.

If you have made changes in the configuration file /etc/squid/squid.conf, instruct Squid to load the changed file. Do this by entering rcsquid reload or restart Squid with rcsquid restart. With rcsquid status, determine whether the proxy is running. Use rcsquid stop to halt Squid. The latter can take a while, because Squid waits up to half a minute (shutdown_lifetime option in /etc/squid/squid.conf) before dropping the connections to the clients then will still need to write its data to the disk. Terminating Squid with kill or killall can lead to the destruction of the cache, which will then have to be fully removed to restart Squid.

If Squid dies after a short period of time, although it has seemingly been started successfully, it can be the result of a faulty name server entry or a missing /etc/resolv.conf file. The cause of the start failure would then be logged by Squid in the /var/squid/logs/cache.log file.

If Squid should be loaded automatically when the system boots, reset the entry START_SQUID=no to START_SQUID=yes in the /etc/sysconfig/squid file.

An uninstall of Squid will remove neither the cache or the log files. Manually delete the /var/cache/squid directory.

Local DNS Server

Setting up a local DNS server, such as BIND9, makes absolute sense even if the server does not manage its own domain. It will then simply act as a "caching-only DNS" and will also be able to resolve DNS requests via the root name server without requiring any special configuration. If you enter this in the /etc/resolv.conf with the IP address 127.0.0.1 for localhost, Squid will detect a valid name server when it starts up. Configuring a name server is discussed in *DNS — Domain Name System* on page 323. It is sufficient, however, to install the package and to boot it. The name server of the provider should be entered in the configuration file /etc/named.conf under forwarders along with its IP address. If you have a firewall running make sure the DNS requests will be sent.

The Configuration File /etc/squid/squid.conf

All Squid proxy server settings are made in the /etc/squid/squid.conf file. To start Squid for the first time, no changes will be necessary in this file, but external clients will initially be denied access. The proxy needs to be made available for the localhost, usually with 3128 as port. The options are extensive and therefore provided with ample documentation and examples in the preinstalled /etc/squid/squid.conf file. Nearly all entries begin with a # sign (the lines are commented out) and the relevant specifications can be found at the end of the line. The given values almost always correlate with the default values, so removing the comment signs without changing any of the parameters actually has little effect in most cases. It is better to leave the sample as it is and reinsert the options along with the modified parameters in the line below. In this way, easily interpret the default values and the changes.

Note

Update from Version 2.4 to Version 2.5

Following an update of Squid from version 2.4 to version 2.5, the cache of Squid must be deleted, as the directory structure was changed.

Note

If you have updated from an earlier Squid version, it is recommended to edit the new `/etc/squid/squid.conf` and only apply the changes made in the previous file. If you try to implement the old `squid.conf` again, run a risk that the configuration will no longer function, because options are sometimes modified and new changes added.

General Configuration Options (Selection)

http_port 3128 This is the port where Squid listens for client requests. The default port is `3128`, but `8080` is also common. If desired, specify several port numbers separated by blank spaces.

cache_peer <hostname> <type> <proxy-port> <icp-port> Here, enter a parent proxy as "parent", for example, or use that of the provider. As `<hostname>`, the name and IP address of the proxy to use are entered and, as `<type>`, `parent`. For `<proxy-port>`, enter the port number that is also specified by the operator of the parent for use in the browser, usually `8080`. Set the `<icp-port>` to `7` or `0` if the ICP port of the parent is not known and its use is irrelevant to the provider. In addition, `default` and `no-query` should be specified after the port numbers to strictly prohibit the use of the ICP protocol. Squid will then behave like a normal browser as far as the provider's proxy is concerned.

cache_mem 8 MB This entry defines the amount of memory Squid can use for the caches. The default is `8 MB`.

cache_dir ufs /var/cache/squid/ 100 16 256 The entry `cache_dir` defines the directory where all the objects are stored on disk. The numbers at the end indicate the maximum disk space in `MB` to use and the number of directories in the first and second level. The `ufs` parameter should be left alone.

The default is `100 MB` occupied disk space in the `/var/cache/squid` directory and creation of 16 subdirectories inside it, each containing 256 more subdirectories. When specifying the disk space to use, leave sufficient reserve disk space. Values from a minimum of fifty to a maximum of eighty percent of the available disk space make the most sense here. The last two numbers for the directories should only be increased with caution, because too many directories can also lead to performance problems. If you have several disks that share the cache, enter several `cache_dir` lines.

cache_access_log /var/log/squid/access.log path for log messages

cache_log /var/log/squid/cache.log path for log messages

cache_store_log /var/log/squid/store.log path for log messages

These three entries specify the paths where Squid logs all its actions. Normally, nothing is changed here. If Squid is experiencing a heavy usage burden, it might make sense to distribute the cache and the log files over several disks.

emulate_httpd_log off If the entry is set to `on`, obtain readable log files. Some evaluation programs cannot interpret this, however.

client_netmask 255.255.255.255 With this entry, mask the logged IP addresses in the log files to hide the clients' identity. The last digit of the IP address will be set to zero if you enter `255.255.255.0` here.

ftp_user Squid@ With this, set the password Squid should use for the anonymous FTP login. It can make sense, however, to specify a valid e-mail address here, because some FTP servers can check these for validity.

cache_mgr webmaster An e-mail address to which Squid sends a message if it unexpectedly crashes. The default is `webmaster`.

logfile_rotate 0 If you run `squid -k rotate`, Squid can rotate secured log files. The files will be enumerated in this process and after reaching the specified value, the oldest file at that point will be overwritten. This value here normally stands for `0` because archiving and deleting log files in SuSE Linux is carried out by a cronjob found in the configuration file `/etc/logrotate/squid`.

append_domain <domain> With `append_domain`, specify which domain to append automatically when none is given. Usually, your own domain is entered here, so entering `www` in the browser accesses your own web server.

forwarded_for on If you set the entry to `off`, Squid will remove the IP address and the system name of the client from the HTTP requests.

negative_ttl 5 minutes; negative_dns_ttl 5 minutes Normally, you do not need to change these values. If you have a dial-up connection, however, the Internet may, at times, not be accessible. Squid will make a note of the failed requests then refuse to issue new ones, although the Internet connection has been reestablished. In a case such as this, change the `minutes` to `seconds` then, after clicking `Reload` in the browser, the dial-up process should be reengaged after a few seconds.

never_direct allow <acl_name> To prevent Squid from taking requests directly from the Internet, use the above command to force connection to another proxy. This must have previously been entered in `cache_peer`. If `all` is specified as the `<acl_name>`, force all requests to be forwarded directly to the `parent`. This might be necessary, for example, if you are using a provider that strictly stipulates the use of its proxies or denies its firewall direct Internet access.

Options for Access Controls

Squid provides an intelligent system that controls access to the proxy. By implementing ACLs, it can be configured easily and comprehensively. This involves lists with rules that are processed sequentially. ACLs must be defined before they can be used. Some default ACLs, such as `all` and `localhost`, already exist. After defining an ACL, implement it, for example, in conjunction with `http_access`.

acl <acl_name> <type> <data> An ACL requires at least three specifications to define it. The name `<acl_name>` can be chosen arbitrarily. For `<type>`, select from a variety of different options which can be found in the `ACCESS CONTROLS` section in the `/etc/squid/squid.conf` file. The specification for `<data>` depends on the individual ACL type and can also be read from a file, for example, via host names, IP addresses, or URLs. The following are some simple examples:

```
acl mysurfers srcdomain .my-domain.com
acl teachers src 192.168.1.0/255.255.255.0
acl students src 192.168.7.0-192.168.9.0/255.255.255.0
acl lunch time MTWHF 12:00-15:00
```

http_access allow <acl_name> `http_access` defines who is allowed to use the proxy and who can access what on the Internet. For this, ACLs must be given. `localhost` and `all` have already been defined above, which can deny or allow access via `deny` or `allow`. A list containing any number of `http_access` entries can be created, processed from top to bottom, and, depending on which occurs first, access will be allowed or denied to the respective URL. The last entry should always be `http_access deny all`. In the following example, the `localhost` has free access to everything while all other hosts are denied access completely.

```
http_access allow localhost
http_access deny all
```

Another example, where the previously-defined ACLs are used. The group `teachers` always has access to the Internet. The group `students` only gets access Monday to Friday during lunch time.

```
http_access deny localhost
http_access allow teachers
http_access allow students lunch time
http_access deny all
```

The list with the `http_access` entries should only be entered, for the sake of readability, at the designated position in the `/etc/squid/squid.conf` file. That is, between the text

```
# INSERT YOUR OWN RULE(S) HERE TO ALLOW ACCESS FROM YOUR
# CLIENTS
```

and the last

```
http_access deny all
```

redirect_program /usr/bin/squidGuard With this option, a redirector, such as squidGuard, which is able to block unwanted URLs, can be specified. Internet access can be individually controlled for various user groups with the help of proxy authentication and the appropriate ACLs. squidGuard is a package in and of itself that can be separately installed and configured.

authenticate_program /usr/sbin/pam_auth If users must be authenticated on the proxy, a corresponding program, such as pam_auth, can be specified here. When accessing pam_auth for the first time, the user will see a login window where the user name and password must be entered. In addition, an ACL is still required so only clients with a valid login can use the Internet:

```
acl password proxy_auth REQUIRED

http_access allow password
http_access deny all
```

The REQUIRED after proxy_auth can be replaced with a list of permitted user names or with the path to such a list.

ident_lookup_access allow <acl_name> With this, have an ident request run for all ACL-defined clients to find each user's identity. If you apply all to the <acl_name>, this will be valid for all clients. Also, an ident daemon must be running on all clients. For Linux, install the pidentd package for this purpose. For Windows, there is free software available to download from the Internet. To ensure that only clients with a successful ident lookup are permitted, a corresponding ACL also needs to be defined here:

```
acl identhosts ident REQUIRED

http_access allow identhosts
http_access deny all
```

Here, too, replace the REQUIRED with a list of permitted user names. Using ident can slow down the access time quite a bit, because ident lookups will be repeated for each request.

Transparent Proxy Configuration

The usual way of working with proxy servers is the following: the web browser sends requests to a certain port in the proxy server and the proxy provides these required objects, whether they are in its cache or not. When working in a real network, several situations may arise:

- For security reasons, it is recommended that all clients use a proxy to surf the Internet.

- All clients must use a proxy whether they are aware of it or not.
- The proxy in a network is moved, but the existing clients should retain their old configuration.

In all these cases, a transparent proxy may be used. The principle is very easy: the proxy intercepts and answers the requests of the web browser, so the web browser receives the requested pages without knowing from where they are coming. This entire process is done transparently, hence the name.

Kernel Configuration

First, make sure the proxy server's kernel has support for transparent proxying. Kernel modules change sometimes from version to version. Check the current state in the Transparent Proxy mini-howto installed in your SuSE Linux system at `/usr/share/doc/howto/en/html/mini/TransparentProxy-3.html` or online at the Linux Documentation Project web page (`http://www.tldp.org/HOWTO/mini/TransparentProxy-3.html`).

Configuration Options in /etc/squid/squid.conf

The options to activate in the `/etc/squid/squid.conf` file to get the transparent proxy up and running are:

- httpd_accel_host virtual
- httpd_accel_port 80 # the port number where the actual HTTP server is located
- httpd_accel_with_proxy on
- httpd_accel_uses_host_header on

Firewall Configuration with SuSEfirewall2

Now redirect all incoming requests via the firewall with help of a port forwarding rule to the Squid port.

To do this, use the SuSE-provided tool SuSEfirewall2. Its configuration file can be found in `/etc/sysconfig/SuSEfirewall2`. Again, the configuration file consists of well-documented entries. Even to set only a transparent proxy, you must configure some firewall options. In our example:

- Device pointing to the Internet: FW_DEV_EXT="eth1"

- Device pointing to the network: FW_DEV_INT="eth0"

Set ports and services (see `/etc/exports`) on the firewall being accessed from untrusted networks such as the Internet. In this example, only web services are offered to the outside:

FW_SERVICES_EXT_TCP="www"

Define ports or services (see `/etc/exports`) on the firewall to be accessed from the secure network, both TCP and UDP services:

FW_SERVICES_INT_TCP="domain www 3128"

FW_SERVICES_INT_UDP="domain"

This allows accessing web services and Squid (whose default port is 3128).

The service "domain" specified before stands for DNS. This service is commonly used. Otherwise, simply take it out of the above entries and set the following option to no:

FW_SERVICE_DNS="yes"

The most important option is number 15:

```
#
# 15.)
# Which accesses to services should be redirected to a localport
# on the firewall machine?
#
# This can be used to force all internal users to surf via your
# squid proxy, or transparently redirect incoming webtraffic to
# a secure webserver.
#
# Choice: leave empty or use the following explained syntax of
# redirecting rules, separated by a space.
# A redirecting rule consists of 1) source IP/net,
# 2) destination IP/net, 3) original destination port and
# 4) local port to redirect the traffic to, separated by a colon,
# e.g. "10.0.0.0/8,0/0,80,3128 0/0,172.20.1.1,80,8080"
#
```

File 51: *Firewall Configuration: Option 15*

The comments above show the syntax to follow. First, the IP address and the netmask of the "internal networks" accessing the proxy firewall. Second, the IP address and the netmask to which these clients "send" their requests. In the case of web browsers, specify the networks 0/0, a wild card that means “to everywhere”. After that, enter the “original” port to which these requests are sent and, finally, the port to which all these requests are “redirected”. As Squid supports more protocols than HTTP, redirect requests from other ports to our proxy, such as FTP (port 21), HTTPS, or SSL (port 443). The example uses the default port 3128. If there are more networks or services to add, they only need to be separated by a single blank character in the corresponding entry.

FW_REDIRECT_TCP="192.168.0.0/16,0/0,80,3128 192.168.0.0/16,0/0,21,3128"

FW_REDIRECT_UDP="192.168.0.0/16,0/0,80,3128 192.168.0.0/16,0/0,21,3128"

To start the firewall and the new configuration with it, change an entry in the `/etc/sysconfig/SuSEfirewall2` file. The entry START_FW must be set to "yes".

Start Squid as shown in *Starting Squid* on page 449. To check if everything is working properly, check the Squid logs in `/var/log/squid/access.log`.

To verify that all ports are correctly configured, perform a port scan on the machine from any computer outside your network. Only the web services port (80) should be open. To scan the ports with `nmap`, the command syntax is `nmap -O IP_address`.

Squid and Other Programs

In the following, see how other applications interact with Squid. `cachemgr.cgi` enables the system administrator to check the amount of memory needed for caching objects. squidGuard filters web pages. Calamaris is a report generator for Squid.

cachemgr.cgi

The cache manager (cachemgr.cgi) is a CGI utility for displaying statistics about the memory usage of a running Squid process. It is also a more convenient way to manage the cache and view statistics without logging the server.

Setup

First, a running web server on your system is required. To check if Apache is already running, type, as `root`, `rcapache status`.

If a message like this appears:

```
Checking for service httpd: OK
Server uptime: 1 day 18 hours 29 minutes 39 seconds
```

Apache is running on your machine. Otherwise, type `rcapache start` to start Apache with the SuSE Linux default settings.

The last step to set it up is to copy the file `cachemgr.cgi` to the Apache directory `cgi-bin`:

```
cp /usr/share/doc/packages/squid/scripts/cachemgr.cgi
/srv/www/cgi-bin/
```

Cache Manager ACLs in /etc/squid/squid.conf

There are some default settings in the original file required for the cache manager:

```
acl manager proto cache_object
acl localhost src 127.0.0.1/255.255.255.255
```

With the following rules:

```
http_access allow manager localhost
http_access deny manager
```

the first ACL is the most important, as the cache manager tries to communicate with Squid over the cache_object protocol.

The following rules assume that the web server and Squid are running on the same machine. If the communication between the cache manager and Squid originates at the web server on another computer, include an extra ACL as in File 52.

```
acl manager proto cache_object
acl localhost src 127.0.0.1/255.255.255.255
acl webserver src 192.168.1.7/255.255.255.255 # webserver IP
```

***File 52:** Access Rules*

Then add the rules as in File 53.

```
http_access allow manager localhost
http_access allow manager webserver
http_access deny manager
```

***File 53:** Access Rules*

Configure a password for the manager for access to more options, like closing the cache remotely or viewing more information about the cache. For this, configure the entry cachemgr_passwd with a password for the manager and the list of options to view. This list appears as a part of the entry comments in `/etc/squid/squid.conf`.

Restart Squid every time the configuration file is changed. This can easily be done with `rcsquid reload`.

Viewing the Statistics

Go to the corresponding web site:
`http://webserver.example.org/cgi-bin/cachemgr.cgi`

Press 'continue' and browse through the different statistics. More details for each entry shown by the cache manager is in the Squid FAQ at `http://www.squid-cache.org/Doc/FAQ/FAQ-9.html`

squidGuard

This section is not intended to go through an extensive configuration of squidGuard, only to introduce it and give some advice for using it. For more in-depth configuration issues, refer to the squidGuard web site at `http://www.squidguard.org`.

squidGuard is a free (GPL), flexible, and fast filter, redirector, and access controller plug-in for Squid. It lets you define multiple access rules with different restrictions for different user groups on a Squid cache. squidGuard uses Squid's standard redirector interface.

squidGuard can be used for the following:

- limit the web access for some users to a list of accepted or well-known web servers or URLs
- block access to some listed or blacklisted web servers or URLs for some users
- block access to URLs matching a list of regular expressions or words for some users
- redirect blocked URLs to an "intelligent" CGI-based info page
- redirect unregistered users to a registration form
- redirect banners to an empty GIF

- have different access rules based on time of day, day of the week, date, etc.
- have different rules for different user groups
- and much more

Neither squidGuard or Squid can be used to:

- Edit, filter, or censor text inside documents
- Edit, filter, or censor HTML-embedded script languages, such as JavaScript or VBscript

Using squidGuard

Install the package `squidGuard`. Edit a minimal configuration file `/etc/squidguard.conf`. There are plenty of configuration examples in `http://www.squidguard.org/config/`. Experiment later with more complicated configuration settings.

The following step is to create a dummy "access denied" page or a more or less intelligent CGI page to redirect Squid if the client requests a blacklisted web site. Using Apache is strongly recommended.

Now, tell Squid to use squidGuard. Use the following entry in the `/etc/squid.conf` file:

redirect_program /usr/bin/squidGuard

There is another option called redirect_children configuring how many different "redirect" (in this case squidGuard) processes are running on the machine. squidGuard is fast enough to cope with lots of requests (squidGuard is quite fast: 100,000 requests within 10 seconds on a 500MHz Pentium with 5900 domains, 7880 URLs, total 13780).

Therefore, it is not recommended to set more than 4 processes, because this may lead to an unnecessary increase of memory for the allocation of these processes.

redirect_children 4

Last, have Squid read its new configuration by running `rcsquid reload`. Now, test your settings with a browser.

Cache Report Generation with Calamaris

Calamaris is a Perl script used to generate reports of cache activity in ASCII or HTML format. It works with native Squid access log files. The Calamaris home page is located at `http://Calamaris.Cord.de/`

The use of the program is quite easy. Log in as `root`, then enter:

```
cat access.log.files | calamaris [options] > reportfile
```

It is important when piping more than one log file that the log files are chronologically ordered with older files first.

The various options are:

-a normally used for the output of available reports

-w an HTML report

-l a message or logo in the header of the report

More information about the various options can be found with
`man calamaris`.

A typical example is:

```
cat access.log.2 access.log.1 access.log | calamaris -a -w \
 >/usr/local/httpd/htdocs/Squid/squidreport.html
```

This puts the report in the directory of the web server. Apache is required to view the reports.

Another powerful cache report generator tool is SARG (Squid Analysis Report Generator). More information about this can be found in the relevant Internet pages at `http://web.onda.com.br/orso/` .

More Information about Squid

Visit the home page of Squid at `http://www.squid-cache.org/`. Here, find the Squid User Guide and a very extensive collection of FAQs on Squid.

There is a Mini-Howto regarding transparent proxies in the package `howtoen` under `/usr/share/doc/howto/en/mini/TransparentProxy.gz` .

In addition, mailing lists are available for Squid at `squid-users@squid-cache.org`. The archive for this is located at: `http://www.squid-cache.org/mail-archive/squid-users/`

Security in the Network

Masquerading, firewall, and Kerberos constitute the basis for a secure network, enabling control of the data traffic. The Secure Shell (SSH) allows users to log in to remote hosts by way of an encrypted connection. The information in this chapter provides a basis for securing a network and working securely in the network with these tools.

Masquerading and Firewalls 464
SSH — Secure Shell, the Safe Alternative 470
Network Authentication — Kerberos 475
Installing and Administering Kerberos 481
Security and Confidentiality 496

Masquerading and Firewalls

Because of its outstanding network capabilities, Linux is frequently used as a router operating system for dial-up or dedicated lines. *Router*, in this case, refers to a host with multiple network interfaces that transmits any packets not destined for one of its own network interfaces to another host communicating with it. This router is often called a gateway. The packet filtering mechanism provided by the Linux kernel allows precise control over which packets of the overall traffic are transferred.

In general, defining the exact rules for a packet filter requires at least some experience on the part of the administrator. For the less experienced user, SuSE Linux includes a separate package, package `SuSEfirewall2`, intended to make it easier to set up these rules. SuSEfirewall2 is highly configurable, making it a good choice for a more complex packet filtering setup.

With this packet filter solution, a Linux machine can be used as a router with masquerading to link a local network through a dial-up or dedicated connection where only one IP address is visible to the outside world. Masquerading is accomplished by implementing rules for packet filtering.

Caution

This chapter only describes standard procedures that should work well in most situations. Although every effort has been made to provide accurate and complete information, no guarantee is included. SuSE cannot be responsible for the success or failure of your security measures. We do appreciate your criticism and comments. Although you might not receive a direct answer from us, rest assured that suggestions for improvement will be taken seriously.

Caution

Masquerading Basics

Masquerading is the Linux-specific form of NAT (Network Address Translation). The basic principle is not very complicated: Your router has more than one network interface, typically a network card and a separate interface to the Internet (e.g., an ISDN interface). While this interfaces links with the outside world, the remaining ones are used to connect this router with the other hosts in your network. For example, the dial-up is conducted via ISDN and the network interface is `ippp0`. Several hosts in your local network are connected to the network card of your Linux router, in this example, `eth0`. Hosts in the network should be configured to send packets destined outside the local network to this gateway.

Note

Make sure both the broadcast addresses and the network masks are the same for all the hosts when configuring your network.

Note

When one of the hosts sends a packet destined for an Internet address, this packet is sent to the network's default router. The router needs to be configured to actually forward such packets. SuSE Linux does not enable this with a default installation for security reasons. Set the variable `IP_FORWARD`, defined in the file `/etc/sysconfig/sysctl`, to `IP_FORWARD=yes`. The forwarding mechanism is enabled after rebooting or issuing the command `echo 1 > /proc/sys/net/ipv4/ip_forward`.

The router has only one IP address visible from the outside, such as the IP address of the connected ISDN interface. The source address of transmitted packets must be replaced with the router's address to enable reply. The target host only knows your router, not hosts in your internal network. Your internal host disguises itself behind the router, which is why the technique is called "masquerading."

The router, as the destination of any reply packets, must identify the incoming packets, change the target address to the intended recipient, and forward it to that host in the local network. The identification of packets belonging to a connection handled by a masquerading router is done with the help of a table kept in the kernel of your router while connected. By using the `ipchains` and the `iptables` commands, the superuser (`root`) can view these tables. Read the man pages for these commands for detailed instructions. For the identification of single masqueraded connections, the source and target addresses, the port numbers, and the protocols involved are relevant. A router is capable of hiding many thousand connections per internal host simultaneously.

With the routing of inbound traffic depending on the masquerading table, there is no way to open a connection to an internal host from the outside. For such a connection, there would be no entry in the table because it is only created if an internal host opens a connection with the outside. In addition, any established connection is assigned a status entry in the table and this entry cannot be used by another connection. A second connection would require another status record. As a consequence of all this, you might experience some problems with a number of applications, such as ICQ, cucme, IRC (DCC, CTCP), Quake, and FTP (in PORT mode). Netscape, as well as the standard FTP program and many others, uses the PASV mode. This passive mode is much less problematic as far as packet filtering and masquerading is concerned.

Firewalling Basics

"Firewall" is probably the most widely used term to describe a mechanism to control the data traffic between two networks and to provide and manage the link between networks. There are various types of firewalls, which mostly differ in regard to the abstract level on which traffic is analyzed and controlled. Strictly speaking, the mechanism described in this section is called a "packet filter." Like any other type of firewall, a packet filter alone does not guarantee full protection from all security risks. A packet filter implements a set of rules related to protocols, ports, and IP addresses to decide whether data may pass. This blocks any packets that, according to the address or destination, are not supposed to reach your network. Packets sent to the telnet service of your hosts on port 23, for example, should be blocked, while you might want people to have access to your web server and therefore enable the corresponding port. A packet filter will not scan the contents of any packets as long as they have legitimate addresses (e. g., directed to your web server). Thus, packets could attack your CGI server, but the packet filter would let them through.

A more effective, but more complex mechanism is the combination of several types of systems, such as a packet filter interacting with an application gateway or proxy. In this case, the packet filter rejects any packets destined to disabled ports. Only packets directed to the application gateway are accepted. This gateway or proxy pretends to be the actual client of the server. In a sense, such a proxy could be considered a masquerading host on the protocol level used by the application. One example for such a proxy is Squid, an HTTP proxy server. To use Squid, the browser must be configured to communicate via the proxy, so any HTTP pages requested would be served from the proxy cache rather than directly from the Internet. As another example, the SuSE proxy suite (package `proxy-suite`) includes a proxy for the FTP protocol.

The following section focuses on the packet filter that comes with SuSE Linux. For more information and links, read the Firewall HOWTO included in package `howtoen`. If this package is installed, read the HOWTO with `less /usr/share/doc/howto/en/Firewall-HOWTO.gz`.

SuSEfirewall2

The configuration of SuSEfirewall2 requires a certain degree of experience and understanding. The documentation of SuSEfirewall2 is available in `/usr/share/doc/packages/SuSEfirewall2`.

The configuration can be performed with YaST (see *Configuration with YaST* on page 469) or manually in the file `/etc/sysconfig/SuSEfirewall2`, which is well commented.

Manual Configuration

The following paragraphs provide step-by-step instructions for a successful configuration. For each configuration item, find a note specifying whether it is relevant for firewalling or for masquerading. Aspects related to the DMZ (or "demilitarized zone") are not covered here.

If your requirements are strictly limited to masquerading, only fill out items marked *masquerading*.

- First, use the YaST runlevel editor to enable SuSEfirewall2 in your runlevel (3 or 5 most likely). It sets the symlinks for the SuSEfirewall2_* scripts in the `/etc/init.d/rc?.d/` directories.
- FW_DEV_WORLD (firewall, masquerading): The device linked to the Internet, such as `eth0` or `ippp0`.
- FW_DEV_INT (firewall, masquerading): The device linked to the internal, "private" network. Leave this blank if there is no internal network and the firewall is supposed to protect only the one host.
- FW_ROUTE (firewall, masquerading): If you need the masquerading function, enter `yes` here. Your internal hosts will not be visible to the outside, because their private network addresses (e. g., `192.168.x.x`) are ignored by Internet routers.

  For a firewall without masquerading, only set this to `yes` to allow access to the internal network. Your internal hosts need to use officially registered IPs in this case. Normally, however, you should *not* allow access to your internal network from the outside.
- FW_MASQUERADE (masquerading): Set this to `yes` if you need the masquerading function. It is more secure to have a proxy server between the hosts of the internal network and the Internet.
- FW_MASQ_NETS (masquerading): Specify the hosts or networks to masquerade, leaving a space between the individual entries. For example, FW_MASQ_NETS="192.168.0.0/24 192.168.10.1".
- FW_PROTECT_FROM_INTERNAL (firewall): Set this to `yes` to protect your firewall host from attacks originating in your internal network. Services will only be available to the internal network if explicitly enabled. See also FW_SERVICES_INTERNAL_TCP and FW_SERVICES_INTERNAL_UDP.
- FW_AUTOPROTECT_GLOBAL_SERVICES (firewall): This should normally be `yes`.

- FW_SERVICES_EXTERNAL_TCP (firewall): Enter the services that should be available, for example, `"www smtp ftp domain 443"` . Leave this blank for a workstation at home that is not intended to offer any services.
- FW_SERVICES_EXTERNAL_UDP (firewall): Leave this blank if you do not run a name service that should be made available to the outside. Otherwise, enter the ports to use.
- FW_SERVICES_INTERNAL_TCP (firewall): This defines the services available to the internal network. The notation is the same as for external TCP services, but, in this case, refers to the *internal* network.
- FW_SERVICES_INTERNAL_UDP (firewall): See above.
- FW_TRUSTED_NETS (firewall): Specify the hosts you *really* trust ("trusted hosts"). Note, however, that these also need to be protected from attacks.

  `"172.20.0.0/16 172.30.4.2"` means that all hosts with an IP address beginning with `172.20.x.x` and the host with the IP address `172.30.4.2` are allowed to pass information through the firewall.
- FW_SERVICES_TRUSTED_TCP (firewall): Here, specify the port addresses that may be used by the trusted hosts. For example, to grant them access to all services, enter `1:65535`. Usually, it is sufficient to enter `ssh` as the only service.
- FW_SERVICES_TRUSTED_UDP (firewall): Just like above, but for UDP ports.
- FW_ALLOW_INCOMING_HIGHPORTS_TCP (firewall): Set this to `ftp-data` if you intend to use normal (active) FTP services.
- FW_ALLOW_INCOMING_HIGHPORTS_UDP (firewall): Set this to `dns` to use the name servers registered in `/etc/resolv.conf`. If you enter `yes` here, all high ports will be enabled.
- FW_SERVICE_DNS (firewall): Enter `yes` if you run a name server that should be available to external hosts. At the same time, enable port 53 under FW_TCP_SERVICES_*.
- FW_SERVICE_DHCLIENT (firewall): Enter `yes` here if you use dhclient to assign your IP address.
- FW_LOG_* (firewall): Specify the firewall's logging activity. For normal operation, it is sufficient to set FW_LOG_DENY_CRIT to `yes`.

- FW_STOP_KEEP_ROUTING_STATE (firewall): Insert `yes` if you have configured your dial-up procedure to work automatically via diald or ISDN (dial-on-demand).

Now that you have configured SuSEfirewall2, do not forget to test your setup (for example, with `telnet` from an external host). Have a look at `/var/log/messages`, where you should see something like:

```
Feb  7 01:54:14 www kernel: Packet log: input DENY eth0
PROTO=6 129.27.43.9:1427 195.58.178.210:23 L=60 S=0x00
I=36981 F=0x4000 T=59 SYN (#119)
```

Configuration with YaST

The YaST menus for the graphical configuration can be accessed from the YaST Control Center. Select 'System and Users' → 'Firewall'. The configuration is divided in four sections:

Basic Settings Specify the interfaces to protect. To protect an individual host to which no internal network is connected, just specify the interface facing the Internet. If an internal network is connected to your system, the interface facing the network must also be specified. Exit this dialog with 'Next'.

Services You only need this option to use your system to offer services accessible from the Internet (web server, mail server, etc.). Activate the respective check boxes or use the 'Expert...' button to enable services by way of their port numbers (listed in `/etc/services`). If you are not going to use your host as a server, press 'Next' to exit this dialog without making any changes.

Features Here you can select the main features of your firewall:

- 'Allow traceroute' assists you in checking the routing to your firewall.
- 'Forward Traffic and Do Masquerading' protects hosts in the internal network against the Internet — all Internet services seem to be used by your firewall, while the internal hosts remain invisible.
- 'Protect All Running Services' indicates that network access to TCP and UDP services of the firewall is denied entirely. This does not affect the services explicitly made available in the preceding step.

- 'Protect from Internal Network' Only the released firewall services are available for *internal* hosts. As it is not possible to make services available here, deactivate this option to grant access from the internal network.

Upon completion of the feature configuration, exit this dialog with 'Next'.

Logging Determine the scope of logging for your firewall. Before you activate the 'Logging options', consider that these log files produce a great amount of output. The configuration of the logging function is the final step of the firewall configuration. Exit the dialog with 'Next' and confirm the following message to activate the firewall.

SSH — Secure Shell, the Safe Alternative

With more and more computers installed in networked environments, it becomes often necessary to access hosts from a remote location. This normally means that a user sends login and password strings for authentication purposes. But as long as these strings are transmitted as plain text, they could be intercepted and misused to gain access to that user account, without the authorized user even knowing about it. Apart from the fact that this would open all the user's files to an attacker, the illegal account could be used to obtain administrator or `root` access, or to penetrate other systems. In the past, remote connections were established with Telnet, which offers no guards against eavesdropping in the form of encryption or other security mechanisms. There are other unprotected communication channels, like the traditional FTP protocol and some remote copying programs.

The SSH suite provides the necessary protection, by encrypting the authentication strings (usually a login name and a password) and all the other data exchanged between the hosts. With SSH, the data flow could still be recorded by a third party – only that the contents are encrypted and cannot be reverted to plain text unless the encryption key is known. So SSH enables secure communications over insecure networks such as the Internet. The SSH flavor that comes with SuSE Linux is OpenSSH.

The OpenSSH Package

SuSE Linux installs the package OpenSSH by default. The programs ssh, scp, and sftp are then available as alternatives to telnet, rlogin, rsh, rcp, and ftp.

The ssh Program

Using the ssh program, it is possible to log in to remote systems and work interactively. It replaces both telnet and rlogin. The slogin program is just a symbolic link pointing to ssh, with the name indicating that it is akin to rlogin. As an example, you can log in to the host `sun` with the command `ssh sun`. The host then prompts for the password on `sun`.

After successful authentication, you can work on the remote command line or use interactive applications, such as YaST. If the local user name is different from the remote user name, you can log in using a different login name with `ssh -l augustine sun` or `ssh augustine@sun`.

Furthermore, ssh offers the possibility to run commands on remote systems, as known from rsh. In the following example, we will run the command `uptime` on the host `sun` and create a directory with the name `tmp`. The program output will be displayed on the local terminal of the host `earth`.

```
ssh otherplanet "uptime; mkdir tmp"
tux@otherplanet's password:
1:21pm up 2:17, 9 users, load average: 0.15, 0.04, 0.02
```

Quotation marks are necessary here to send both instructions with one command. It is only by doing this that the second command is likewise executed on `sun`.

scp — Secure Copy

scp copies files to a remote machine. It is a secure and encrypted substitute for rcp. For example, `scp MyLetter.tex sun:` copies the file `MyLetter.tex` from the host `earth` to the host `sun`. To give a different user name, use the `username@host` format. Note that there is no `-l` option for this command.

After the correct password is entered, scp starts the data transfer and shows a growing row of asterisks to simulate a progress bar. In addition, the program displays the estimated time of arrival to the right of the progress bar. All output can be suppressed by giving the option `-q`.

scp also provides a recursive copying feature for entire directories. The command `scp -r src/ sun:backup/` copies the entire contents of the directory `src/` including all subdirectories to the host `sun` in the subdirectory `backup/`. If this subdirectory does not exist yet, it will be created automatically.

The option `-p` tells scp to leave the time stamp of files unchanged. `-C` compresses the data transfer. This minimizes the data volume to be transferred, but creates a heavier burden on the processor.

sftp — Secure File Transfer

The sftp program can be used instead of scp for secure file transfer. During an sftp session, you can use many of the familiar commands as known from ftp. The sftp program may be a better choice than scp, especially when transferring data for which the file names are unknown beforehand.

The SSH Daemon (sshd) — Server-Side

To work with the SSH client programs ssh and scp, a server, the SSH daemon, has to be running in the background, listening for connections on TCP/IP port 22.

The daemon generates three key pairs when starting for the first time. Each key pair consist of a private and a public key. Therefore, this procedure is referred to as public key-based. To guarantee the security of the communication via SSH, access to the private key files must be restricted to the system administrator. The file permissions are set accordingly by the default installation. The private keys are only required locally by the SSH daemon and must not be given to anyone else. The public key components (recognizable by the name extension `.pub`) are sent to the client requesting the connection; they are readable for all users.

A connection is initiated by the SSH client. The waiting SSH daemon and the requesting SSH client exchange identification data to compare the protocol and software versions, and to prevent connections through the wrong port. Since a child process of the original SSH daemon replies to the request, several SSH connections can be made simultaneously.

For the communication between SSH server and SSH client, OpenSSH supports versions 1 and 2 of the SSH protocol. A newly installed SuSE Linux system will default to version 2. If you want to keep using version 1 after an update, follow the instructions in `/usr/share/doc/packages/openssh/README.SuSE`. This document also describes how an SSH 1 environment can be transformed into a working SSH 2 environment with just a few steps.

When using version 1 of SSH, the server sends its public host key, as well as a server key, which is regenerated by the SSH daemon every hour. Both allow the SSH client to encrypt a freely chosen session key, which is sent over to the SSH server. The SSH client also tells the server which encryption method (cipher) to use.

Version 2 of the SSH protocol does not require a server key. Both sides use an algorithm according to Diffie-Helman instead to exchange their keys.

The private host and server keys are absolutely required to decrypt the session key and cannot be derived from the public parts. Only the SSH daemon contacted can decrypt the session key using its private keys (see `man /usr/share/doc/packages/openssh/RFC.nroff`). This initial connection phase can be watched closely by turning on the verbose debugging option `-v` of the SSH client. Version 2 of the SSH protocol is used by default, which however can be overridden to use version 1 of the protocol with the `-1` switch. The client stores all public host keys in `~/.ssh/known_hosts` after its first contact with a remote host. This prevents any "man-in-the-middle" attacks, i. e.attempts by foreign SSH servers to use spoofed names and IP addresses are clearly exposed. Such attacks will be detected either by a host key which is not included in `~/.ssh/known_hosts`, or by the server's inability to decrypt the session key in the absence of an appropriate private counterpart.

It is recommended to backup the private and public keys stored in `/etc/ssh/` in a secure, external location. In this way, key modifications can be detected and the old ones can be used again after a reinstallation. This spares users any unsettling warnings. If it is verified that, despite the warning, it is indeed the correct SSH server, the existing entry regarding this system will have to be removed from `~/.ssh/known_hosts`.

SSH Authentication Mechanisms

Now the actual authentication will take place, which, in its simplest form, consists of entering a password as mentioned above. The goal of SSH was to introduce a secure software that is also easy to use. As it is meant to replace rsh and rlogin, SSH must also be able to provide an authentication method appropriate for daily use. SSH accomplishes this by way of another key pair, which is generated by the user. The SSH package provides a helper program for this, which is ssh-keygen. After entering `ssh-keygen -t rsa` or `ssh-keygen -t dsa`, the key pair will be generated and you will be prompted for the base file name in which to store the keys:

```
Enter file in which to save the key (/home/newbie/.ssh/id_rsa):
```

Confirm the default setting and answer the request for a passphrase. Even if the software suggests an empty passphrase, a text from ten to thirty characters is recommended for the procedure described here. Do not use short and simple words or phrases. Confirm by repeating the passphrase. Subsequently, you will see where the private and public keys are stored, in our example, the files `id_rsa` and `id_rsa.pub`.

```
Enter same passphrase again: Your identification has been
saved in /home/newbie/.ssh/id_rsa Your public key has been
saved in /home/newbie/.ssh/id_rsa.pub. The key fingerprint is:
79:c1:79:b2:e1:c8:20:c1:89:0f:99:94:a8:4e:da:e8 newbie@sun
```

Use `ssh-keygen -p -t rsa` or `ssh-keygen -p -t dsa` to change your old passphrase.

Copy the public key component (`id_rsa.pub` in our example) to the remote machine and save it there at the location `~/.ssh/authorized_keys`. You will be asked to authenticate yourself with your passphrase the next time you establish a connection. If this does not occur, verify the location and contents of these files.

In the long run, this procedure is more troublesome than giving your password each time. Therefore, the SSH package provides another tool, the ssh-agent, which retains the private keys for the duration of an X session. The entire X session will be started as a child process of ssh-agent. The easiest way to do this is to set the variable `usessh` at the beginning of the `.xsession` file to `yes` and log in via a display manager such as KDM or XDM. Alternatively, enter ssh-agent startx.

Now you can use `ssh` or `scp` as usual. If you have distributed your private key as described above, you are no longer prompted for your password. Take care of terminating your X session or locking it with a password-protection, for instance xlock.

All the relevant changes which resulted from the introduction of version 2 of the SSH protocol are also documented in the file `/usr/share/doc/packages/openssh/README.SuSE`.

X, Authentication, and Other Forwarding Mechanisms

Beyond the previously described security-related improvements, ssh also simplifies the use of remote X applications. If you run `ssh` with the option `-X`, the DISPLAY variable will automatically be set on the remote machine and all X output will be exported to the remote machine over the existing ssh connection. At the same time, X applications started remotely and locally viewed with this method cannot be intercepted by unauthorized persons.

By adding the option `-A`, the ssh-agent authentication mechanism will be carried over to the next machine. This way, you can work from different machines without having to enter a password, but only if you have distributed your public key to the destination hosts and properly saved it there.

Both mechanisms are deactivated in the default settings, but can be permanently activated at any time in the system-wide configuration file `/etc/ssh/sshd_config` or the user's `~/.ssh/config`.

ssh can also be used to redirect TCP/IP connections. In the examples below, SSH is told to redirect the SMTP and the POP3 port, respectively:

```
ssh -L 25:sun:25 earth
```

Here, each connection directed to "`earth` port 25", SMTP is redirected to the SMTP port on `sun` via an encrypted channel. This is especially useful for those using SMTP servers without SMTP-AUTH or POP-before-SMTP features. From any arbitrary location connected to a network, e-mail can be transferred to the "home" mail server for delivery. Similarly, all POP3 requests (port 110) on `earth` can be forwarded to the POP3 port of `sun`with this command:

```
ssh -L 110:sun:110 earth
```

Both commands must be executed as `root`, because the connection is made to privileged local ports. E-mail is sent and retrieved by normal users in an existing SSH connection. The SMTP and POP3 host must be set to `localhost` for this.

Additional information can be found in the manual pages for each of the programs described above and also in the files under `/usr/share/doc/packages/openssh`.

Network Authentication — Kerberos

An open network provides no means to ensure that a workstation can identify its users properly except the usual password mechanisms. In common installations, the user must enter the password each time a service inside the network is accessed. Kerberos provides an authentication method with which a user must register once and is then trusted in the complete network for the rest of the session. To have a secure network, the following requirements must be met:

- Have all users prove their identity for each desired service and make sure no one can take the identity of someone else.
- Make sure each network server also proves its identity. If you do not, an attacker might be able to impersonate the server and obtain sensitive information transmitted to the server. This concept is called "mutual authentication", because the client authenticates to the server and vice versa.

Kerberos helps you meet the above requirements by providing strongly encrypted authentication. The following shows how this is achieved. Only the basic principles of Kerberos are discussed here. For detailed technical instruction, refer to the documentation provided with your implementation of Kerberos.

Note

The original Kerberos was designed at the MIT. Besides the MIT Kerberos, there exist several other implementations of Kerberos. SuSE Linux ships with a free implementation of Kerberos 5, the Heimdal Kerberos 5 from KTH. Because the following text covers features common to all versions, the program itself is referred to as Kerberos as long as no Heimdal-specific information is presented.

Note

Kerberos Terminology

The following glossary will help you cope with Kerberos terminology.

credential Users or clients need to present some kind of credentials that authorize them to request services. Kerberos knows two kinds of credentials — tickets and authenticators.

ticket A ticket is a per-server credential used by a client to authenticate at a server from which it is requesting a service. It contains the name of the server, the client's name, the client's Internet address, a time stamp, a lifetime, and a random session key. All this data is encrypted using the server's key.

authenticator Combined with the ticket, an authenticator is used to prove that the client presenting a ticket is really the one it claims to be. An authenticator is built of the client's name, the workstation's IP address, and the current workstation's time all encrypted with the session key only known to the client and the server from which it is requesting a service. An authenticator can only be used once, unlike a ticket. A client can build an authenticator itself.

principal A Kerberos principal is unique entity (a user or service) to which it can assign a ticket. A principal consists of the following components:

- **primary** — the first part of a the principal, which can be the same as your user name in the case of a user.
- **instance** — some optional information characterizing the primary. This string is separated from the primary by a `'/'`.
- **realm** — this specifies your Kerberos realm. Normally, your realm is your domain name in uppercase letters.

mutual authentication Kerberos ensures that both client and server can be sure of each others identity. They will share a (session) key, which they can use to communicate securely.

session key Session keys are temporary private keys generated by Kerberos. They are known to the client and used to encrypt the communication between the client and the server for which it requested and received a ticket.

replay Almost all messages passed on in a network can be eavesdropped, stolen, and resent. In Kerberos context, this would be most dangerous if an attacker manages to obtain your request for a service containing your ticket and authenticator. He could then try to resend it ("replay") and to impersonate you. However, Kerberos implements several mechanisms to deal with that problem.

server or service "Service" is used when we talk of a specific action to perform. The process behind this action is referred to as a "server".

How Kerberos Works

Kerberos is often called a third party trusted authentication service, which means all its clients trust Kerberos's judgment of another client's identity. Kerberos keeps a database of all its users and their private keys.

To ensure Kerberos is worth all the trust put in it, run both the authentication and ticket-granting server on a dedicated machine. Make sure only the administrator can access this machine physically and over the network. Reduce the (networking) services run on it to the absolute minimum — do not even run sshd.

First contact Your first contact with Kerberos is quite similar to any login procedure at a normal networking system. Enter your user name. This piece of information and the name of the ticket-granting service are sent to the authentication server (Kerberos). If the authentication server knows about your existence, it will generate a (random) session key for further use between your client and the ticket-granting server. Now the authentication server will prepare a ticket for the ticket-granting server. The ticket contains the following information — all encrypted with a session key only the authentication server and the ticket-granting server know:

- the names both of the client and the ticket-granting server
- the current time

- a lifetime assigned to this ticket
- the client's IP address
- the newly-generated session key

This ticket is then sent back to the client together with the session key, again in encrypted form, but this time the private key of the client is used. This private key is only known to Kerberos and the client, because it is derived from your user password. Now that the client has received this response, you are prompted for your password. This password is converted into the key that can decrypt the package sent by the authentication server. The package is "unwrapped" and password and key are erased from the workstation's memory. As long as the lifetime given to the ticket used to obtain other tickets does not expire, your workstation can prove your identity.

Requesting a service To request a service from any server in the network, the client application needs to prove its identity to the server. Therefore, the application generates an authenticator. An authenticator consists of the following components:

- the client's principal
- the client's IP address
- the current time
- a checksum (chosen by the client)

All this information is encrypted using the session key that the client has already received for this special server. The authenticator and the ticket for the server are sent to the server. The server uses its copy of the session key to decrypt the authenticator, which gives him all information needed about the client requesting its service to compare it to that contained in the ticket. The server checks if the ticket and the authenticator originate from the same client.

Without any security measures implemented on the server side, this stage of the process would be an ideal target for replay attacks. Someone could try to resend a request stolen off the net some time before. To prevent this, the server will not accept any request with a time stamp and ticket received previously. In addition to that, a request with a time stamp differing too much from the time the request is received can be ignored.

Mutual authentication Kerberos authentication can be used in both directions. It is not only a question of the client being the one it claims to be. The server should also be able to authenticate itself to the client requesting its service. Therefore, it sends some kind of authenticator itself. It adds one to the checksum it received in the client's authenticator and encrypts it with the session key, which is shared between it and the client. The client takes this response as a proof of the server's authenticity and they both start cooperating.

Ticket-granting — getting into contact with all servers Tickets are designed to be used for one server at a time. This implies that you have to get a new ticket each time you request another service. Kerberos implements a mechanism to obtain tickets for individual servers. This service is called the "ticket-granting service". The ticket-granting service is a service just like any other service mentioned before, so uses the same access protocols that have already been outlined. Any time an application needs a ticket that has not already been requested, it contacts the ticket-granting server. This request consists of the following components:

- the requested principal
- the ticket-granting ticket
- an authenticator

Like any other server, the ticket-granting server now checks the ticket-granting ticket and the authenticator. If they are considered valid, the ticket-granting server builds a new session key to be used between the original client and the new server. Then the ticket for the new server is built, containing the following information:

- the client's principal
- the server's principal
- the current time
- the client's IP address
- the newly-generated session key

The new ticket is assigned a lifetime, which is the lesser of the remaining lifetime of the ticket-granting ticket and the default for the service. The client receives this ticket and the session key, which are sent by the ticket-granting service, but this time the answer is encrypted with the session key that came with the original ticket-granting ticket. The client can decrypt the response without requiring the user's password when a new service is contacted. Kerberos can thus acquire ticket after ticket for the client without bothering the user more than once at login time.

Compatibility to Windows 2000 Windows 2000 contains a Microsoft implementation of Kerberos 5. As SuSE Linux makes use of the Heimdal implementation of Kerberos 5, find useful information and guidance in the Heimdal documentation. See *For More Information* on the facing page.

Users' View of Kerberos

Ideally, a user's one and only contact with Kerberos happens during login at his workstation. The login process includes obtaining a ticket-granting ticket. At logout, a user's Kerberos tickets are automatically destroyed, which hinders anyone else from impersonating this user when not logged in. The automatic destruction of tickets can lead to a somewhat awkward situation when a user's login session lasts longer than the maximum lifespan given to the ticket-granting ticket (a reasonable setting is ten hours). However, the user can get a new ticket-granting ticket by running kinit. Enter the password password again and Kerberos obtains access to desired services without additional authentication. Those interested in a list of all the tickets silently acquired for them by Kerberos should run klist.

Here is a short list of some applications that use Kerberos authentication. These applications can be found under `/usr/lib/heimdal/bin`. They all have the full functionality of their common UNIX and Linux brothers plus the additional bonus of transparent authentication managed by Kerberos:

- telnet, telnetd
- rlogin
- rsh, rcp, rshd
- popper, push
- ftp, ftpd
- su
- imapd
- pine

You no longer have to type your password for using these applications because Kerberos has already proven your identity. ssh — if compiled with Kerberos support — can even forward all the tickets acquired for one workstation to another one. If you use ssh to log in to another workstation, ssh makes sure the encrypted contents of the tickets are adjusted to the new situation. Simply copying tickets between workstations is not sufficient as the ticket contains workstation specific information (the IP address). XDM and KDM offer Kerberos support, too. Read more about the Kerberos network applications in the *Kerberos V5 UNIX User's Guide* at `http://web.mit.edu/kerberos/www/krb5-1.3/krb5-1.3/doc/krb5-user.html`.

For More Information

SuSE Linux contains a free implementation of Kerberos called Heimdal. Its documentation is installed along with the package `heimdal` under `/usr/share/doc/packages/heimdal/doc/heimdal.info`. It is also available at the project's home page at `http://www.pdc.kth.se/heimdal/`

This is the official site of the MIT Kerberos is `http://web.mit.edu/kerberos/www/`. There, find links to any other relevant resource concerning Kerberos.

A "classical" dialog pointing out the principles of Kerberos is available at `http://web.mit.edu/kerberos/www/dialogue.html`. It is a less technical but still comprehensive read.

The paper at :
`ftp://athena-dist.mit.edu/pub/kerberos/doc/usenix.PS` gives quite an extensive insight to the basic principles of Kerberos without being too difficult to read. It also provides a lot of opportunities for further investigation and reading about Kerberos.

These links provide a short introduction to Kerberos and answer many questions regarding Kerberos installation, configuration, and administration:
`http://web.mit.edu/kerberos/www/krb5-1.3/krb5-1.3/doc/krb5-user.html`
`http://web.mit.edu/kerberos/www/krb5-1.3/krb5-1.3/doc/krb5-install.html`
`http://web.mit.edu/kerberos/www/krb5-1.3/krb5-1.3/doc/krb5-admin.html`
The official Kerberos FAQ is available at `http://www.nrl.navy.mil/CCS/people/kenh/kerberos-faq.html`.

The book *Kerberos — A Network Authentication System* by Brian Tung (ISBN 0-201-37924-4) offers extensive information.

Installing and Administering Kerberos

This section covers the installation of the Heimdal Kerberos implementation as well as some aspects of administration. This section does, however, assume that you are familiar with the basic concepts of Kerberos (see also *Network Authentication — Kerberos* on page 475).

Choosing the Kerberos Realms

The “domain” of a Kerberos installation is called a realm and is identified by a name, such as `FOOBAR.COM` or simply `ACCOUNTING`. Kerberos is case-sensitive, so `foobar.com` is actually a different realm than `FOOBAR.COM`. Use the case you prefer. It is common practice, however, to use uppercase realm names.

It is also a good idea to use your DNS domain name (or a subdomain, such as `ACCOUNTING.FOOBAR.COM`). As shown below, your life as an administrator can be much easier if you configure your Kerberos clients to locate the KDC and other Kerberos services via DNS. To do so, it is helpful if your realm name is a subdomain of your DNS domain name.

Unlike the DNS name space, Kerberos is not hierarchical. You cannot set up a realm named `FOOBAR.COM`, have two “subrealms” named `DEVELOPMENT` and `ACCOUNTING` underneath it, and expect the two subordinate realms to somehow inherit principals from `FOOBAR.COM`. Instead, you would have three separate realms for which you would have to configure “crossrealm” authentication for users from one realm to interact with servers or other users from another realm.

For the sake of simplicity, assume you are setting up just one realm for your entire organization. Setting up crossrealm authentication is described in **?**, for instance. For the remainder of this section, the realm name `SAMPLE.COM` is used in all examples.

Setting up the KDC Hardware

The first thing required to use Kerberos is a machine that will act as the Key Distribution Center, or KDC for short. This machine holds the entire Kerberos user database with passwords and all information.

The KDC is the most important part of your security infrastructure — if someone breaks into it, all user accounts and all of your infrastructure protected by Kerberos is compromised. An attacker with access to the Kerberos database can impersonate any principal in the database. Tighten security for this machine as much as possible:

- Put the server machine into a physically secured location, such as a locked server room to which only a very few people have access.
- Do not run any network applications on it except the KDC. This includes servers and clients — for instance, the KDC should not import any file systems via NFS or use DHCP to retrieve its network configuration.

It is probably a good approach to install a minimal system first, then check the list of installed packages and remove any unneeded packages. This includes servers, such as inetd, portmap, and cups, as well as anything X11-based. Even installing an SSH server should be considered a potential security risk.

No graphical login is provided on this machine as an X server is a potential security risk. Kerberos provides its own administration interface.

- Configure `/etc/nsswitch.conf` to use only local files for user and group lookup. Change the lines for `passwd` and `group` to look like this:

```
passwd:         files
group:          files
```

  Edit the `passwd`, `group`, `shadow`, and `gshadow` files in `/etc` and remove the lines that start with a `+` character (these are for NIS lookups).

  Also consider disabling DNS lookups, because there is a potential risk involved. If there is a security bug in the DNS resolver library, an attacker might be able to trick the KDC into performing a DNS query that triggers this bug. To disable DNS lookups, simply remove `/etc/resolv.conf`.

- Disable all user accounts except root's account by editing `/etc/shadow` and replacing the hashed passwords with `*` or `!` characters.

Clock Synchronization

To use Kerberos successfully, make sure all system clocks within your organization are synchronized within a certain range. This is important because Kerberos protects against "replayed" credentials. An attacker might be able to observe Kerberos credentials on the network and reuse them to attack the server. Kerberos employs several defenses to prevent this. One of them is that it puts time stamps into its tickets. A server receiving a ticket with a time stamp that is not the current time rejects the ticket.

Of course, Kerberos will allow a certain leeway when comparing time stamps. However, computer clocks can be very inaccurate in keeping time — it is not unheard of for PC clocks to lose or gain half an hour over the course of a week. For this reason, configure all hosts on the network to synchronize their clocks with a central time source.

A simple way to do so is by installing an NTP time server on one machine and have all clients synchronize their clocks with this server. Do this either by running an NTP daemon in client mode on all these machines or by running `ntpdate` once a day from all clients (this solution will probably work for a small number of clients only). The KDC itself needs to be synchronized to the common time source as well. Because running an NTP daemon on this machine would be a security risk, it is probably a good idea to do this by running ntpdate via a cron entry. NTP configuration itself is beyond the scope of this section. For more information, refer to the NTP documentation included in your installed system under `/usr/share/doc/packages/xntp-doc`.

It is also possible to adjust the maximum deviation Kerberos allows when checking time stamps. This value (called "clock skew") can be set via the `krb5.conf` file as described in *Adjusting the Clock Skew* on page 489.

Log Configuration

By default, the Kerberos daemons running on the KDC host log information to the syslog daemon. To keep an eye on what your KDC is doing, process these log files regularly, scanning for unusual events or potential problems. Either do this by running a log scanner script on the KDC host itself or by copying these files from the KDC to another host with `rsync`. Forwarding all log output via syslogd's log forwarding mechanisms is not recommended, because information traverses the network unencrypted.

Installing the KDC

This section covers the initial installation of the KDC, including creation of an administrative principal.

Installing the RPMs

Before you can start, install the Kerberos software. On the KDC, install the packages `heimdal`, `heimdal-lib`, and `heimdal-tools`:

```
rpm -ivh heimdal-*.rpm heimdal-lib-*.rpm heimdal-tools*.rpm
```

Setting the Master Key

Your next step is to initialize the database where Kerberos keeps all information on principals. First, set the database master key, which is used to protect the database from accidental disclosure, in particular when it is backed up to a tape. The master key is derived from a pass phrase and is stored in a file called the stash file. This is so you do not need to type in the password every time the KDC is restarted. Make sure you choose a good pass phrase, such as a sentence from a book opened at a random page.

When you make tape backups of the Kerberos database (`/var/heimdal/heimdal.db`), do not back up the stash file (which is in `/var/heimdal/m-key`). Otherwise, everyone able to read the tape could also decrypt the database. Therefore, it is also a good idea to keep a copy of the pass phrase in a safe or some other secure location, because you will need it when restoring your database from backup tape after a crash.

To set the master key, run kstash without arguments and enter the pass phrase twice:

```
kstash

Master key:<enter pass phrase>
Verifying password - Master key:<enter pass phrase again>
```

Creating the Realm

Finally, create entries for your realm in the Kerberos database. Run kadmin utility with the -l option as shown. This option tells kadmin to access the database locally. By default, it will try to contact the Kerberos admin service over the network. At this stage, this will not work because it is not running yet.

Now, tell kadmin to initialize your realm. It will ask you a number of questions in return. It is best to accept the default settings offered by kadmin initially:

```
kadmin -l

kadmin> init SAMPLE.COM
Realm max ticket life [unlimited]: <press return>
Realm max renewable ticket life [unlimited]: <press return>
```

To verify that it did anything, use the list command:

```
kadmin> list *
default@SAMPLE.COM
kadmin/admin@SAMPLE.COM
kadmin/hprop@SAMPLE.COM
kadmin/changepw@SAMPLE.COM
krbtgt/SAMPLE.COM@SAMPLE.COM
changepw/kerberos@SAMPLE.COM
```

This shows that there are now a number of principals in the database. All of these are for internal use by Kerberos.

Creating a Principal

Next, create two Kerberos principals for yourself: one "normal" principal for your everyday work and one for administrative tasks relating to Kerberos. Assuming your login name is `newbie`, proceed as follows:

```
kadmin -l


kadmin> add newbie
Max ticket life [1 day]: <press return>
Max renewable life [1 week]: <press return>
Principal expiration time [never]: <press return>
Password expiration time [never]: <press return>
Attributes []: <press return>
newbie@SAMPLE.COM's Password: <type password here>
Verifying password: <re-type password here>
```

Accepting the defaults by pressing Enter is okay. Choose a good password, however.

Next, create another principal named `newbie/admin` by typing `add newbie/admin` at the `kadmin` prompt. The `admin` suffixed to your user name is a "role". Later, use this role when administering the Kerberos database. A user can have several roles for different purposes. Roles are basically completely different accounts with similar names.

Starting the KDC

Start the KDC daemons. This includes kdc itself (the daemon handling user authentication and ticket requests), kadmind (the server performing remote administration), and kpasswddd (handling user's password change requests). To start the daemon manually, enter:

```
rckdc start


Starting kdc                done
```

Also make sure KDC is started by default when the server machine is rebooted. This is done with the command `insserv kdc`.

Configuring Kerberos Clients

When configuring Kerberos, there are basically two approaches you can take — static configuration via the `/etc/krb5.conf` file or dynamic configuration via DNS. With DNS configuration, Kerberos applications try to locate the KDC services via DNS records. With static configuration, add the host names of your KDC server to `krb5.conf` (and update the file whenever you move the KDC or reconfigure your realm in other ways).

DNS-based configuration is generally a lot more flexible and the amount of configuration work per machine is a lot less. However, it requires that your realm name is either the same as your DNS domain or a subdomain of it.

Configuring Kerberos via DNS also creates a minor security issue — an attacker can seriously disrupt your infrastructure through your DNS (by shooting down the name server, by spoofing DNS records, etc). However, this amounts to a denial of service at most. A similar scenario applies to the static configuration case unless you enter IP addresses in `krb5.conf` instead of host names.

Static Configuration

One way to configure Kerberos is to edit the configuration file `/etc/krb5.conf`. The file installed by default contains various sample entries. Erase all of these entries before starting. `krb5.conf` is made up of several sections, each introduced by the section name included in brackets like `[this]`.

To configure your Kerberos clients, add the following stanza to `krb5.conf` (where `kdc.sample.com` is the host name of the KDC):

```
[libdefaults]
        default_realm = SAMPLE.COM

[realms]
        SAMPLE.COM = {
                kdc = kdc.sample.com
                kpasswd_server = kdc.sample.com
                admin_server = kdc.sample.com
        }
```

The `default_realm` line sets the default realm for Kerberos applications. If you have several realms, just add another statement to the `[realms]` section.

Also add a statement to this file that tells applications how to map host names to a realm. For instance, when connecting to a remote host, the Kerberos library needs to know in which realm this host is located. This must be configured in the `[domain_realms]` section:

```
[domain_realm]
        .sample.com = SAMPLE.COM
        www.foobar.com = SAMPLE.COM
```

This tells the library that all hosts in the `sample.com` DNS domains are in the `SAMPLE.COM` Kerberos realm. In addition, one external host named `www.foobar.com` should also be considered a member of the `SAMPLE.COM` realm.

DNS-Based Configuration

DNS-based Kerberos configuration makes heavy use of SRV records (see *(RFC2052) A DNS RR for specifying the location of services* at `http://www.ietf.org`). These records are not supported in earlier implementations of the BIND name server. At least BIND version 8 is required for this.

The name of a SRV record, as far as Kerberos is concerned, is always in the format `_service._proto.realm`, where realm is the Kerberos realm. Domain names in DNS are case insensitive, so case-sensitive Kerberos realms would break when using this configuration method. `_service` is a service name (different names are used when trying to contact the KDC or the password service, for example). `_proto` can be either `_udp` or `_tcp`, but not all services support both protocols.

The data portion of SRV resource records consists of a priority value, a weight, a port number, and a host name. The priority defines the order in which hosts should be tried (lower values indicate a higher priority). The weight is there to support some sort of load balancing among servers of equal priority. You will probably never need any of this, so it is okay to set these to zero.

Heimdal Kerberos currently looks up the following names when looking for services:

`_kerberos` This defines the location of the KDC daemon (the authentication and ticket granting server). Typical records look like this:

```
_kerberos._udp.SAMPLE.COM.  IN  SRV   0 0 88 kdc.sample.com.
_kerberos._tcp.SAMPLE.COM.  IN  SRV   0 0 88 kdc.sample.com.
```

`_kpasswd` This describes the location of the password changing server. Typical records look like this:

```
_kpasswd._udp.SAMPLE.COM.   IN  SRV   0 0 464 kdc.sample.com.
```

Because kpasswdd does not support TCP, there should be no `_tcp` record.

`_kerberos-adm` This describes the location of the remote administration service. Typical records look like this:

```
_kerberos-adm._tcp.SAMPLE.COM. IN  SRV   0 0 749 kdc.sample.com.
```

Because kadmind does not support UDP, there should be no _udp record.

As with the static configuration file, there is a mechanism to inform clients that a specific host is in the SAMPLE.COM realm, even if it is not part of the sample.com DNS domain. This can be done by attaching a TXT record to _keberos.hostname, as shown here:

```
_keberos.www.foobar.com.  IN TXT "SAMPLE.COM"
```

Adjusting the Clock Skew

The “clock skew” is the tolerance for accepting tickets with time stamps that do not exactly match the host’s system clock. Usually, the clock skew is set to 300 seconds, or 5 minutes. This means a ticket can have a time stamp somewhere between 5 minutes ago and 5 minutes in the future from the server’s point of view.

When using NTP to synchronize all hosts, you can reduce this value to about one minute. The clock skew value can be set in /etc/krb5.conf like this:

```
[libdefaults]
        clockskew = 120
```

Remote Kerberos Administration

To be able to add and remove principals from the Kerberos database without accessing the KDC’s console directly, tell the Kerberos administration server which principals are allowed to do what. Do this by editing the file /var/heimdal/kadmind.acl (ACL is an abbreviation for Access Control List). The ACL file allows you to specify privileges with a fine degree of control. For details, refer to the manual page with man 8 kadmind.

Right now, just grant yourself the privilege to do anything you want with the database by putting the following line into the file:

```
newbie/admin              all
```

Replace the user name newbie with your own. You then have to restart the KDC for the change to take effect.

Using kadmin for Remote Administration

You should now be able to perform Kerberos administration tasks remotely using the kadmin tool. First, obtain a ticket for your admin role and use that ticket when connecting to the kadmin server:

```
kinit newbie/admin
newbie/admin@SAMPLE.COM's Password: <enter password>
/usr/sbin/kadmin
kadmin> privs
change-password, list, delete, modify, add, get
```

Using the privs command, verify which privileges you have. The list shown above is the full set of privileges.

As an example, modify the principal `newbie`:

```
kadmin> mod newbie
Max ticket life [1 day]:2 days
Max renewable life [1 week]:
Principal expiration time [never]:2003-01-01
Password expiration time [never]:
Attributes []:
```

This changes the maximum ticket life time to two days and sets the expiration date for the account to January 1, 2003.

Basic kadmin Commands

Here is a brief list of kadmin commands. For more information, refer to the man page for `kadmin` (`man 8 kadmin`).

add ⟨***principal***⟩ add a new principal

modify ⟨***principal***⟩ edit various attributes of a principal, such as maximum ticket life time and account expiration date

delete ⟨***principal***⟩ remove a principal from the database

rename ⟨***principal***⟩ ⟨***newname***⟩ renames a principal to ⟨*newname*⟩

list ⟨***pattern***⟩ list all principals matching the given pattern. Patterns work much like the shell globbing patterns: `list newbie*` would list `newbie` and `newbie/admin` in our example.

get ⟨*principal*⟩ display detailed information about the principal

passwd ⟨*principal*⟩ changes a principal's password

At all stages, help is available by typing ? and Enter. This even works in prompt environments generated by `modify` and `add`.

The `init` command used when initially creating the realm (as well as a few others) is not available in remote mode. To create a new realm, go to the KDC's console and use kadmin in local mode (using the `-l` command line option). The same is true for dumping and restoring the KDC database using the `dump`, `load`, and `merge` commands.

Creating Kerberos Host Principals

In addition to making sure every machine on your network knows which Kerberos realm it is in and what KDC to contact, create a "host principal" for it. So far, only user credentials have been discussed. However, Keberized services usually need to authenticate themselves to the client user, too. Therefore, special "host principals" must be present in the Kerberos database for each host in the realm.

The naming convention for host principals is `host/`⟨*hostname*⟩`@`⟨*REALM*⟩, where ⟨*hostname*⟩ is the host's fully qualified host name. Host principals are almost like user principals, but not quite. The main difference between a user principal and a host principal is that the key of the former is protected by a password — when a user obtains a ticket-granting ticket from the KDC, he needs to type his password so Kerberos can decrypt the ticket. Obviously, it would be quite inconvenient for the system administrator if he had to obtain new tickets for the SSH daemon every eight hours or so.

Instead, the key required to decrypt the initial ticket for the host principal is extracted by the administrator from the KDC once and stored in a local file called the "keytab". Services such a the SSH daemon read this key and use it to obtain new tickets automatically when needed. The default keytab file resides in `/etc/krb5.keytab`.

To create a host principal for `machine.sample.com`, enter the following commands during your kadmin session:

```
kinit newbie/admin
newbie/admin@SAMPLE.COM's Password: <type password>
kadmin add -r host/machine.sample.com
Max ticket life [1 day]:
```

```
Max renewable life [1 week]:
Principal expiration time [never]:
Password expiration time [never]:
Attributes []:
```

Instead of setting a password for the new principal, the -r flag tells kadmin to generate a random key. We can do this here because we do not want any user interaction for this principal. It is a server account for the machine.

Finally, extract the key and store it in the local keytab file /etc/krb5.keytab. This file is owned by the superuser, so you must be root to execute the next command:

```
ktutil get host/machine.sample.com
```

When completed, make sure you destroy the admin ticket obtained via kinit above with kdestroy.

Enabling PAM Support for Kerberos

SuSE Linux comes with a PAM module named pam_krb5, which supports Kerberos login and password update. This module can be used by applications, such as console login, su, and graphical login applications like KDM, where the user presents a password and would like the authenticating application to obtain an initial Kerberos ticket on his behalf.

Beginning with this version of SuSE Linux, the pam_unix module, too, supports Kerberos authentication and password updating. To enable Kerberos support in pam_unix, edit the file /etc/security/pam_unix2.conf so it contains the following lines:

```
auth:       use_krb5 nullok
account:    use_krb5
password:   use_krb5 nullok
session:    none
```

After that, all programs evaluating the entries in this file use Kerberos for user authentication. For a user that does not have a Kerberos principal, pam_unix falls back on the normal password authentication mechanism. For those users who have a principal, it should now be possible to change their Kerberos passwords transparently using the passwd command.

To make fine adjustments to the way in which pam_krb5 is used, edit the file /etc/krb5.conf and add default applications to pam. For details refer to the manual page with man 5 pam_krb5.

The `pam_krb5` module was specifically **not** designed for network services that accept Kerberos tickets as part of user authentication. This is an entirely different matter, which is discussed below.

Configuring SSH for Kerberos Authentication

OpenSSH supports Kerberos authentication in both protocol version 1 and 2. In version 1, there are special protocol messages to transmit Kerberos tickets. Version 2 does not use Kerberos directly anymore, but relies on "GSSAPI", the General Security Services API. This is a programming interface that is not specific to Kerberos — it was designed to hide the peculiarities of the underlying authentication system, be it Kerberos, a public-key authentication system like SPKM, or others. The GSSAPI library included in SuSE Linux supports only Kerberos, however.

To use sshd with Kerberos authentication, edit `/etc/ssh/sshd_config` and set the following options:

```
# These are for protocol version 1
KerberosAuthentication yes
KerberosTgtPassing yes
# These are for version 2
GSSAPIAuthentication yes
GSSAPIKeyExchange yes
```

Then restart your SSH daemon using `rcsshd restart`.

To use Kerberos authentication with protocol version 2, enable it on the client-side as well. Do this either in the system-wide configuration file `/etc/ssh/ssh_config` or on a per-user level by editing `~/.ssh/config`. In both cases, add the option `GSSAPIAuthentication yes`.

You should now be able to connect using Kerberos authentication. Use `klist` to verify you have a valid ticket, then connect to the SSH server. To force SSH protocol version 1, specify option `-1` on the command line.

```
ssh earth.sample.com
```

```
Last login: Fri Aug  9 14:12:50 2002 from zamboni.sample.com
Have a lot of fun...
```

Using LDAP and Kerberos

When using Kerberos, one way to distribute the user information (such as user ID, groups, home directory, etc.) in your local network is to use LDAP. This requires a strong authentication mechanism that prevents packet spoofing and other attacks. One solution is to use Kerberos for LDAP communication, too.

OpenLDAP implements most authentication flavors through SASL, the Simple Authentication Session Layer. SASL is basically a network protocol designed for authentication. The SASL implementation used in SuSE Linux is cyrus-sasl, which supports a number of different authentication flavors. Kerberos authentication is performed through GSSAPI (General Security Services API). By default, the SASL plug-in for GSSAPI is not installed. Install it manually with `rpm -ivh cyrus-sasl-gssapi-*.rpm`.

To enable Kerberos binding to the OpenLDAP server, create a principal `ldap/earth.sample.com` and add that to the keytab:

```
kadmin add -r ldap/earth.sample.com
ktutil get ldap/earth.sample.com
```

By default, the LDAP server slapd will run as user and group `ldap`, while the keytab file is readable by `root` only. Therefore, either change the LDAP configuration so the server runs as `root` or make the keytab file readable by group `ldap`.

To run slapd as root, edit `/etc/sysconfig/openldap`. Disable the `OPENLDAP_USER` and `OPENLDAP_GROUP` variables by putting a comment character in front of them.

To make the keytab file readable by group LDAP, execute

```
chgrp ldap /etc/krb5.keytab
chmod 640 /etc/krb5.keytab
```

Neither solution is perfect. However, at the moment it is not possible to configure OpenLDAP to make it use a separate keytab file.

Finally, restart the LDAP server using `rcldap restart`.

Using Kerberos Authentication with LDAP

You should now be able to use tools, such as ldapsearch, with Kerberos authentication automatically.

```
ldapsearch -b ou=People,dc=suse,dc=de '(uid=newbie)'
```

```
SASL/GSSAPI authentication started
SASL SSF: 56
SASL installing layers
[...]

# newbie, People, suse.de
dn: uid=newbie,ou=People,dc=suse,dc=de
uid: newbie
cn: Olaf Kirch
[...]
```

As you can see, ldapsearch prints a message that it started GSSAPI authentication. The next message is admittedly very cryptic, but it shows that the "Security Strength Factor" (SSF for short) is 56. (The value 56 is somewhat arbitrary. Most likely it was chosen because this is the number of bits in a DES encryption key.) What this tells you is that GSSAPI authentication was successful and that encryption is being used to provide integrity protection and confidentiality of the LDAP connection. If there are several SASL mechanisms that could be used, you can force `ldapsearch` to use GSSAPI by adding `-Y GSSAPI` to the command line options.

In Kerberos, authentication is always mutual. This means that not only have you authenticated yourself to the LDAP server, but also the LDAP server authenticated itself to you. In particular, this means communication is with the desired LDAP server, rather than some bogus service set up by an attacker.

Kerberos Authentication and LDAP Access Control

Now, allow each user to modify the login shell attribute of their LDAP user record. Assuming you have a schema where the LDAP entry of user `joe` is located at `uid=joe,ou=people,dc=suse,dc=de`, set up the following access controls in `/etc/openldap/slapd.conf`:

```
# This is required for things to work _at all_
access to dn.base="" by * read
# Let each user change their login shell
access to dn="*,ou=people,dc=suse,dc=de" attrs=loginShell
       by self write
# Every user can read everything
access to *
       by users read
```

The second statement gives authenticated users write access to the `loginShell` attribute of their own LDAP entry. The third statement gives all authenticated users read access to the entire LDAP directory.

There is one minor piece of the puzzle missing, which is how the LDAP server can find out that the Kerberos user `joe@SAMPLE.COM` corresponds to the LDAP distinguished name `uid=joe,ou=people,dc=suse,dc=de`. This sort of mapping must be configured manually using the `saslExpr` directive. In our example, add the following to `slapd.conf`:

```
saslRegexp
        uid=(.*),cn=GSSAPI,cn=auth
        uid=$1,ou=people,dc=example,dc=com
```

To understand how this works, you need to know that when SASL authenticates a user, OpenLDAP will form a distinguished name from the name given to it by SASL (such as `joe`) and the name of the SASL flavor (`GSSAPI`). The result would be `uid=joe,cn=GSSAPI,cn=auth`.

If a `saslRegexp` has been configured, it will check the DN formed from the SASL information using the first argument as a regular expression. If this regular expression matches, the name will be replaced with the second argument of the `saslRegexp` statement. The placeholders `$1` will be replaced with the substring matched by the `(.*)` expression.

More complicated match expressions are possible. If you have a more complicated directory structure or a schema where the user name is not part of the DN, you can even use search expressions to map the SASL DN to the user DN.

Security and Confidentiality

Basic Considerations

One of the main characteristics of a Linux or UNIX system is its ability to handle several users at the same time (multiuser) and to allow these users to perform several tasks (multitasking) on the same computer simultaneously. Moreover, the operating system is network transparent. The users often do not know whether the data and applications they are using are provided locally from their machine or made available over the network.

With the multiuser capability the respective data of different users must be stored separately. Security and privacy need to be guaranteed. "Data security" was already an important issue, even before computers could be linked through networks. Just like today, the most important concern was the ability to keep data available in spite of a lost or otherwise damaged data medium, a hard disk in most cases.

This chapter is primarily focused on confidentiality issues and on ways to protect the privacy of users, but it cannot be stressed enough that a comprehensive security concept should always include procedures to have a regularly updated, workable, and tested backup in place. Without this, you could have a very hard time getting your data back — not only in the case of some hardware defect, but also if the suspicion arises that someone has gained unauthorized access and tampered with files.

Local Security and Network Security

There are several ways of accessing data:

- Personal communication with people who have the desired information or access to the data on a computer
- directly from the console of a computer (physical access)
- over a serial line
- using a network link

In all these cases, a user should be authenticated before accessing the resources or data in question. A web server might be less restrictive in this respect, but you still would not want it to disclose all your personal data to any surfer out there.

In the list above, the first case is the one where the highest amount of human interaction is involved, such as when you are contacting a bank employee and are required to prove that you are the person owning that bank account. Then you will be asked to provide a signature, a PIN, or a password to prove that you are the person you claim to be. In some cases, it might be possible to elicit some intelligence from an informed person just by mentioning known bits and pieces here and there to win the confidence of that person by using clever rhethoric. The victim could be led to gradually reveal more information, maybe without even becoming aware of it. Among hackers, this is called "social engineering". You can only guard against this by educating people and by dealing with language and information in a conscious way. Before breaking into computer systems, attackers often try to target receptionists, service people working with the company, or even family members. In many cases, such an attack based on social engineering will only be discovered at a much later time.

A person wanting to obtain unauthorized access to your data could also use the traditional way and try to get at your hardware directly. Therefore, the machine should be protected against any tampering so that no one can remove, replace, or cripple its components. This also applies to backups and even any network cable or the power cord. Likewise, secure the boot procedure, as there are some well-known key combinations which invoke special reactions during booting. Protect yourself against this by setting passwords for the BIOS and the boot-loader.

Serial terminals connected to serial ports are still used in many places. Unlike network interfaces, they do not rely on a network protocol to communicate with the host. A simple cable or an infrared port is used to send plain characters back and forth between the devices. The cable itself is the weakest point of such a system: with an older printer connected to it, it is easy to record anything that runs over the wires. What can be achieved with a printer can also be accomplished in other ways, depending on the effort that goes into the attack.

Reading a file locally on a host requires other access rules than opening a network connection with a server on a different host. There is a distinction between local security and network security. The line is drawn where data has to be put into packets to be sent somewhere else.

Local Security

Local security starts with the physical environment in the location where the computer is running. Set up your machine in a place where security is in line with your expectations and needs.

The main goal of "local security" is to keep users separate from each other, so that no user can assume the permissions or the identity of another. This is a general rule to be observed, but it is especially true for the user `root` who holds the supreme power on the system. User `root` can take on the identity of any other local user without being prompted for the password and read any locally stored file.

Passwords

On a Linux system, passwords are, of course, *not* stored as plain text and the text string entered is not simply matched with the saved pattern. If this were the case, all accounts on your system would be compromised as soon as someone got access to the corresponding file. Instead, the stored password is encrypted and, each time it is entered, is encrypted again and the two encrypted strings are compared. Naturally, this will only work if the encrypted password cannot be reverse-computed into the original text string.

This is actually achieved by a special kind of algorithm, also called "trapdoor algorithm," because it only works in one direction. An attacker who has obtained the encrypted string will not be able to get your password by simply applying the same algorithm again. Instead, it would be necessary to test all the possible character combinations until a combination is found which looks like your password when encrypted. As you can imagine, with passwords eight characters long, there are quite a number of possible combinations to calculate.

In the seventies, it was argued that this method would be more secure than others due to the relative slowness of the algorithm used, which took a few seconds to encrypt just one password. In the meantime, however, PCs have become powerful enough to do several hundred thousand or even millions of encryptions per second. Because of this, encrypted passwords should not be visible to regular users (`/etc/shadow` cannot be read by normal users). It is even more important that passwords are not easy to guess, in case the password file becomes visible due to some error. Consequently, it is not really useful to "translate" a password like "tantalise" into "t@nt@1ls3".

Replacing some letters of a word with similar looking numbers is not safe enough. Password cracking programs which use dictionaries to guess words also play with substitutions like that. A better way is to make up a word with no common meaning, something which only makes sense to you personally, like the first letters of the words of a sentence or the title of a book, such as "The Name of the Rose" by Umberto Eco. This would give the following safe password: "TNotRbUE9". By contrast, passwords like "beerbuddy" or "jasmine76" are easily guessed even by someone who has only some casual knowledge about you.

The Boot Procedure

Configure your system so it cannot be booted from a floppy or from CD, either by removing the drives entirely or by setting a BIOS password and configuring the BIOS to allow booting from a hard disk only. Normally, a Linux system will be started by a boot loader, allowing you to pass additional options to the booted kernel. This is crucial to your system's security. Not only does the kernel itself run with root permissions, but it is also the first authority to grant root permissions at system start-up. Prevent others from using such parameters during boot by setting an additional password in `/etc/lilo.conf` (see *Booting and Boot Managers* on page 69).

File Permissions

As a general rule, always work with the most restrictive privileges possible for a given task. For example, it is definitely not necessary to be `root` to read or write e-mail. If the mail program has a bug, this bug could be exploited for an attack which will act with exactly the permissions of the program when it was started. By following the above rule, minimize the possible damage.

The permissions of the more than 200,000 files included in a SuSE distribution are carefully chosen. A system administrator who installs additional software or other files should take great care when doing so, especially when setting the permission bits. Experienced and security-conscious system administrators always use the `-l` option with the command `ls` to get an extensive file list, which allows them to detect any wrong file permissions immediately. An incorrect file attribute does not only mean that files could be changed or deleted. These modified files could be executed by `root` or, in the case of configuration files, that programs could use such files with the permissions of `root`. This significantly increases the possibilities of an attacker. Attacks like this are called cuckoo eggs, because the program (the egg) is executed (hatched) by a different user (bird), just like a cuckoo tricks other birds into hatching its eggs.

A SuSE Linux system includes the files `permissions`, `permissions.easy`, `permissions.secure`, and `permissions.paranoid`, all in the directory `/etc`. The purpose of these files is to define special permissions, such as world-writable directories or, for files, the setuser ID bits, which means the corresponding program will not run with the permissions of the user that has launched it, but with the permissions of the file owner, `root` in most cases. An administrator may use the file `/etc/permissions.local` to add his own settings. To define which of the above files is used by SuSE's configuration programs to set permissions accordingly use the submenu 'Security' in YaST2. To learn more about the topic, read the comments in `/etc/permissions` or consult the manual page of `chmod` (`man chmod`).

Buffer Overflows and Format String Bugs

Special care must be taken whenever a program is supposed to process data that can or could be changed by a user, but this is more of an issue for the programmer of an application than for regular users. The programmer has to make sure that his application will interpret data in the correct way, without writing them into memory areas that are too small to hold them. Also, the program should hand over data in a consistent manner, using the interfaces defined for that purpose.

A "buffer overflow" can happen if the actual size of a memory buffer is not taken into account when writing to that buffer. There are cases where this data (as generated by the user) uses up some more space than what is available in the buffer. As a result, data is written beyond the end of that buffer area, which, under certain circumstances, makes it possible that a program will execute program sequences influenced by the user (and not by the programmer), rather than just processing user data. A bug of this kind may have serious consequences, in particular if the program is being executed with special privileges (see Section *File Permissions* on the facing page).

"Format string bugs" work in a slightly different way, but again it is the user input which could lead the program astray. In most cases, these programming errors are exploited with programs executed with special permissions — setuid and setgid programs — which also means that you can protect your data and your system from such bugs by removing the corresponding execution privileges from programs. Again, the best way is to apply a policy of using the lowest possible privileges (see Section *File Permissions* on the preceding page).

Given that buffer overflows and format string bugs are bugs related to the handling of user data, they are not only exploitable if access has been given to a local account. Many of the bugs that have been reported can also be exploited over a network link. Accordingly, buffer overflows and format string bugs should be classified as being relevant for both local and network security.

Viruses

Contrary to what some people will tell you, there *are* viruses that run on Linux. However, the viruses that are known were released by their authors as "proof of concept" to prove that the technique works as intended. None of these viruses have been spotted "in the wild" so far.

Viruses would not be able to survive and spread without a host on which they could live. In our case, the host would be a program or an important storage area of the system, such as the master boot record, which needs to be writable for the program code of the virus. Owing to its multiuser capability, Linux can restrict write access to certain files, especially important with system files. Therefore, if you did your normal work with `root` permissions, you would increase the chance of the system being infected by a virus. By contrast, if you follow the principle of using the lowest possible privileges as mentioned above, chances of getting a virus are slim.

Apart from that, you should never rush into executing a program from some Internet site that you do not really know. SuSE's RPM packages carry a cryptographic signature as a digital label that the necessary care was taken to build them. Viruses are a typical sign that the administrator or the user lacks the required security awareness, putting at risk even a system that should be highly secure by its very design.

Viruses should not be confused with worms which belong to the world of networks entirely. Worms do not need a host to spread.

Network Security

Network security is important for protecting from an attack originating in the network. The typical login procedure requiring a user name and a password for user authentication is a local security issue. However, in the particular case of logging in over a network, we need to differentiate between both security aspects. What happens until the actual authentication is network security and anything that happens afterwards is local security.

X Window System and X11 Authentication

As mentioned at the beginning, network transparency is one of the central characteristics of a UNIX system. X11, the windowing system of UNIX operating systems, can make use of this feature in an impressive way. With X11, it is basically no problem to log in at a remote host and start a graphical program that will then be sent over the network to be displayed on your computer.

For an X client to be displayed remotely using our X server, the latter is supposed to protect the resource managed by it (i. e. the display) from unauthorized access. In more concrete terms, certain permissions must be given to the client program. With the X Window System, there are two ways to do this, called host-based access control and cookie-based access control. The former relies on the IP address of the host where the client is supposed to run. The program to control this is `xhost`. `xhost` enters the IP address of a legitimate client into a tiny database belonging to the X server. However, relying on IP addresses for authentication is not very secure. For example, if there were a second user working on the host sending the client program, that user would have access to the X server as well — just like someone stealing the IP address. Because of these shortcomings, we will not describe this authentication method in more detail here, but you can learn about it from `man xhost`.

In the case of cookie-based access control, a character string is generated which is only known to the X server and to the legitimate user, just like an ID card of some kind. This cookie (the word goes back not to ordinary cookies, but to Chinese fortune cookies which contain an epigram) is stored on login in the file `.Xauthority` in the user's home directory and is available to any X Window client wanting to use the X server to display a window. The file `.Xauthority` can be examined by the user with the tool `xauth`. If you were to rename `.Xauthority` or if you deleted the file from your home directory by accident, you would not be able to open any new windows or X clients. Read more about X Window security mechanisms in the man page of `Xsecurity` (`man Xsecurity`).

`ssh` (secure shell) can be used to completely encrypt a network connection and forward it to an X server transparently without the encryption mechanism being perceived by the user. This is also called X forwarding. X forwarding is achieved by simulating an X server on the server side and setting a DISPLAY variable for the shell on the remote host. Further details about `ssh` can be found in Section *SSH — Secure Shell, the Safe Alternative* on page 470.

Caution

If you do not consider the host where you log in to be a secure host, do not use X forwarding. With X forwarding enabled, an attacker could authenticate via your ssh connection to intrude on your X server and sniff your keyboard input, for instance.

Caution

Buffer Overflows and Format String Bugs

As discussed on on page 500, buffer overflows and format string bugs should be classified as issues concerning both local and network security. As with the local variants of such bugs, buffer overflows in network programs, when successfully exploited, are mostly used to obtain `root` permissions. Even if that is not the case, an attacker could use the bug to gain access to an unprivileged local account to exploit any other vulnerabilities which might exist on the system.

Buffer overflows and format string bugs exploitable over a network link are certainly the most frequent form of remote attacks in general. Exploits for these — programs to exploit these newly-found security holes — are often posted on the security mailing lists. They can be used to target the vulnerability without knowing the details of the code. Over the years, experience has shown that the availability of exploit codes has contributed to more secure operating systems, obviously due to the fact that operating system makers were forced to fix the problems in their software. With free software, anyone has access to the source code (SuSE Linux comes with all available source codes) and anyone who finds a vulnerability and its exploit code can submit a patch to fix the corresponding bug.

DoS — Denial of Service

The purpose of this kind of attack is to force down a server program or even an entire system, something which could be achieved by various means: overloading the server, keeping it busy with garbage packets, or exploiting a remote buffer overflow.

Often a DoS attack is done with the sole purpose of making the service disappear. However, once a given service has become unavailable, communications could become vulnerable to so-called "man-in-the-middle attacks" (sniffing, TCP connection hijacking, spoofing) and DNS poisoning.

Man in the Middle: Sniffing, Hijacking, Spoofing

In general, any remote attack performed by an attacker who puts himself between the communicating hosts is called a "man-in-the-middle attack". What almost all types of man-in-the-middle attacks have in common is that the victim is usually not aware that there is something happening. There are many possible variants, for example, the attacker could pick up a connection request and forward that to the target machine himself. Now the victim has unwittingly established a connection with the wrong host, because the other end is posing as the legitimate destination machine.

The simplest form of a man-in-the-middle attack is called "sniffer" — the attacker is "just" listening to the network traffic passing by. As a more complex attack, the "man in the middle" could try to take over an already established connection (hijacking). To do so, the attacker would have to analyze the packets for some time to be able to predict the TCP sequence numbers belonging to the connection. When the attacker finally seizes the role of the target host, the victims will notice this, because they get an error message saying the connection was terminated due to a failure. The fact that there are protocols not secured against hijacking through encryption, which only perform a simple authentication procedure upon establishing the connection, makes it easier for attackers.

"Spoofing" is an attack where packets are modified to contain counterfeit source data, mostly the IP address. Most active forms of attack rely on sending out such fake packets — something that, on a Linux machine, can only be done by the superuser (`root`).

Many of the attacks mentioned are carried out in combination with a DoS. If an attacker sees an opportunity to abruptly bring down a certain host, even if only for a short time, it will make it easier for him to push the active attack, because the host will not be able to interfere with the attack for some time.

DNS poisoning

DNS poisoning means that the attacker corrupts the cache of a DNS server by replying to it with spoofed DNS reply packets, trying to get the server to send certain data to a victim who is requesting information from that server. Many servers maintain a trust relationship with other hosts, based on IP addresses or host names. The attacker will need a good understanding of the actual structure of the trust relationships between hosts to dusguise itself as one of the trusted hosts. Usually, the attacker analyzes some packets received from the server to get the necessary information. The attacker often needs to target a well-timed DoS attack at the name server as well. Protect yourself by using encrypted connections that are able to verify the identity of the hosts to which to connect.

Worms

Worms are often confused with viruses, but there is a clear difference between the two. Unlike viruses, worms do not need to infect a host program to live. Rather, they are specialized to spread as quickly as possible on network structures. The worms that appeared in the past, such as Ramen, Lion, or Adore, make use of well-known security holes in server programs like `bind8` or `lprNG`. Protection against worms is relatively easy. Given that some time will elapse between the discovery of a security hole and the moment the worm hits your server, there is a good chance that an updated version of the affected program will be available on time. Of course, that is only useful if the administrator actually installs the security updates on the systems in question.

Some General Security Tips and Tricks

Information: To handle security competently, it is important to keep up with new developments and to stay informed about the latest security issues. One very good way to protect your systems against problems of all kinds is to get and install the updated packages recommended by security announcements as quickly as possible. SuSE security announcements are published on a mailing list to which you can subscribe by following the link `http://www.suse.de/security`. The list `suse-security-announce@suse.de` is a first-hand source of information regarding updated packages and includes members of SuSE's security team among its active contributors.

The mailing list `suse-security@suse.de` is a good place to discuss any security issues of interest. Subscribe to it under the URL as given above for `suse-security-announce@suse.de`.

`bugtraq@securityfocus.com` is one of the best-known security mailing lists worldwide. We recommend reading this list, which receives between 15 and 20 postings per day. More information can be found at `http://www.securityfocus.com`.

The following is a list of rules which you may find useful in dealing with basic security concerns:

- According to the rule of using the most restricive set of permissions possible for every job, avoid doing your regular jobs as `root`. This reduces the risk of getting a cuckoo egg or a virus and protects you from your own mistakes.
- If possible, always try to use encrypted connections to work on a remote machine. Use ssh (secure shell) to replace `telnet`, `ftp`, `rsh`, and `rlogin`.
- Avoid using authentication methods based on IP addresses alone.
- Try to keep the most important network-related packages up-to-date and subscribe to the corresponding mailing lists to receive announcements on new versions of such programs (`bind`, `sendmail`, `ssh`, etc.). The same should apply to software relevant to local security.
- Change the `/etc/permissions` file to optimize the permissions of files crucial to your system's security. If you remove the setuid bit from a program, it might well be that it cannot do its job anymore in the way it is supposed to. On the other hand, consider that, in most cases, the program will also have ceased to be a potential security risk. You might take a similar approach with world-writable directories and files.
- Disable any network services you do not absolutely require for your server to work properly. This will make your system safer. Open ports, with the socket state LISTEN, can be found with the program `netstat`. As for the options, we suggest that you use `netstat -ap` or `netstat -anp`. The `-p` option allows you to see which process is occupying a port under which name.

  Compare the `netstat` results with those of a thorough port scan done from outside your host. An excellent program for this job is `nmap`, which not only checks out the ports of your machine, but also draws some conclusions as to which services are waiting behind them. However, port scanning may be interpreted as an aggressive act, so do not do this on a host without the explicit approval of the administrator. Finally, remember that it is important not only to scan TCP ports, but also UDP ports (options `-sS` and `-sU`).
- To monitor the integrity of the files of your system in a reliable way, use the program `tripwire`, available on the SuSE Linux distribution. Encrypt the database created by `tripwire` to prevent someone from tampering with it. Furthermore, keep a backup of this database available outside your machine, stored on an external data medium not connected to it by a network link.

- Take proper care when installing any third-party software. There have been cases where a hacker had built a trojan horse into the tar archive of a security software package, which was fortunately discovered very quickly. If you install a binary package, have no doubts about the site from which you downloaded it.

  Note that SuSE's RPM packages are gpg-signed. The key used by SuSE for signing reads as follows:

  ID:9C800ACA 2000-10-19 SuSE Package Signing Key <build@suse.de>

  Key fingerprint = 79C1 79B2 E1C8 20C1 890F 9994 A84E DAE8 9C80 0ACA

  The command `rpm --checksig package.rpm` shows whether the checksum and the signature of an uninstalled package are correct. Find the key on the first CD of the distribution and on most key servers worldwide.

- Check your backups of user and system files regularly. Consider that if you do not test whether the backup will work, it might actually be worthless.

- Check your log files. Whenever possible, write a small script to search for suspicious entries. Admittedly, this is not exactly a trivial task. In the end, only you can know which entries are unusual and which are not.

- Use `tcp_wrapper` to restrict access to the individual services running on your machine, so you have explicit control over which IP addresses can connect to a service. For further information regarding `tcp\_wrappers`, consult the manual page of `tcpd` and `hosts\_access` (`man 8 tcpd`, `man hosts_access`).

- Use SuSEfirewall to enhance the security provided by `tcpd` (tcp_wrapper).

- Design your security measures to be redundant: a message seen twice is much better than no message at all.

Using the Central Security Reporting Address

If you discover a security-related problem (please check the available update packages first), write an e-mail to `security@suse.de`. Please include a detailed description of the problem and the version number of the package concerned. SuSE will try to send a reply as soon as possible. You are encouraged to pgp encrypt your e-mail messages. SuSE's pgp key is as follows:

ID:3D25D3D9 1999-03-06 SuSE Security Team <security@suse.de>

Key fingerprint = 73 5F 2E 99 DF DB 94 C4 8F 5A A3 AE AF 22 F2 D5

This key is also available for download from: `http://www.suse.de/security`

Part V

Appendixes

File Systems in Linux

Linux supports a number of different file systems. This chapter presents a brief overview of the most popular Linux file systems, elaborating on their design concept, advantages, and fields of application. Some additional information about LFS (“Large File Support”) in Linux is also provided.

Glossary 512
Major File Systems in Linux 512
Some Other Supported File Systems 518
Large File Support in Linux 519
For More Information 520

Glossary

metadata A file system internal data structure that assures all the data on disk is properly organized and accessible. Essentially, it is "data about the data." Almost every file system has its own structure of metadata, which is partly why the file systems show different performance characteristics. It is of major importance to maintain metadata intact, because otherwise the whole data on the file system could become inaccessible.

inode Inodes contain various information about a file, including size, number of links, date, and time of creation, modification, and access, as well as pointers to the disk blocks where the file contents are actually stored.

journal In the context of a file system, a journal is an on-disk structure containing a kind of log where the file system stores what it is about to change in the file system's metadata. "Journaling" greatly reduces the recovery time of a Linux system because it obsoletes the lengthy search process that checks the whole file system at system start-up. Instead, only the journal is replayed.

Major File Systems in Linux

Unlike two or three years ago, choosing a file system for a Linux system is no longer a matter of a few seconds ("Ext2 or ReiserFS?"). Kernels starting from 2.4 offer a variety of file systems from which to choose. The following is an overview of how those file systems basically work and which advantages they offer.

It is very important to bear in mind that there may be no file system that best suits all kinds of applications. Each file system has its particular strengths and weaknesses, which have to be taken into account. Even the most sophisticated file system cannot substitute for a reasonable backup strategy, however.

The terms "data integrity" or "data consistency", when used in this chapter, do not refer to the consistency of the user space data (the data your application writes to its files). Whether this data is consistent must be controlled by the application itself.

Note

Setting up File Systems

Unless stated otherwise in this chapter, all the steps required to set up or to change partitions and file systems can be performed using the easy-to-use YaST module.

Note

Ext2

The origins of Ext2 go back to the early days of Linux history. Its predecessor, the Extended File System, was implemented in April 1992 and integrated in Linux 0.96c. The Extended File System underwent a number of modifications and, as Ext2, became the most popular Linux file system for years. With the creation of journaling file systems and their astonishingly short recovery times, Ext2 became less important.

A brief summary of Ext2's strengths might help you to understand why it was — and in some areas still is — the favorite Linux file system of many a Linux user.

Solidity Being quite an "old-timer", Ext2 underwent many improvements and was heavily tested. This may be the reason why people often refer to it as "rock-solid". After a system outage when the file system could not be cleanly unmounted, e2fsck starts to analyze the file system data. Metadata is brought into a consistent state and pending files or data blocks are written to a designated directory (called `lost+found`). In contrast to journaling file systems, e2fsck analyzes the entire file system and not just the recently modified bits of metadata. This takes significantly longer than checking the log data of a journaling file system. Depending on file system size, this procedure can take half an hour or more. Therefore, you would not choose Ext2 for any server that needs high availability. Yet, as Ext2 does not maintain a journal and uses significantly less memory, it is sometimes faster than other file systems.

Easy upgradability The code for Ext2 is the strong foundation on which Ext3 could become a highly-acclaimed next-generation file system. Its reliability and solidity were elegantly combined with the advantages of a journaling file system.

Ext3

Ext3 was designed by Stephen Tweedie. In contrast to all other "next-generation" file systems, Ext3 does not follow a completely new design principle. It is based on Ext2. These two file systems are very closely related to each other. An Ext3 file system can be easily built on top of an Ext2 file system. The most important difference between Ext2 and Ext3 is that Ext3 supports journaling.

Summed up, Ext3 has three major advantages to offer:

Easy and highly reliable file system upgrades from Ext2 As Ext3 is based on the Ext2 code and shares its on-disk format as well as its metadata format, upgrades from Ext2 to Ext3 are incredibly easy. Unlike transitions to other journaling file systems, such as ReiserFS, JFS, or XFS, which can be quite tedious (making backups of the whole file system and recreating it from scratch), a transition to Ext3 is a matter of minutes. It is also very safe, as the recreation of an entire file system from scratch might not work flawlessly. Considering the number of existing Ext2 systems that await an upgrade to a journaling file system, you can easily figure out why Ext3 might be of some importance to many system administrators. Downgrading from Ext3 to Ext2 is as easy as the upgrade. Just perform a clean unmount of the Ext3 file system and remount it as an Ext2 file system.

Reliability and performance Other journaling file systems follow the "metadata-only" journaling approach. This means your metadata will always be kept in a consistent state but the same cannot be automatically guaranteed for the file system data itself. Ext3 is designed to take care of both metadata and data. The degree of "care" can be customized. Enabling Ext3 in the `data=journal` mode offers maximum security (i.e., data integrity), but can slow down the system as both metadata and data are journaled. A relatively new approach is to use the `data=ordered` mode, which ensures both data and metadata integrity, but uses journaling only for metadata. The file system driver collects all data blocks that correspond to one metadata update. These blocks are grouped as a "transaction" and will be written to disk before the metadata is updated. As a result, consistency is achieved for metadata and data without sacrificing performance. A third option to use is `data=writeback`, which allows data to be written into the main file system after its metadata has been committed to the journal. This option is often considered the best in performance. It can, however, allow old data to reappear in files after crash and recovery while internal file system integrity is maintained. Unless you specify something else, Ext3 is run with the `data=ordered` default.

Tip

Converting an Ext2 File System into an Ext3 File System

Converting from Ext2 to Ext3 involves two separate steps:

Creating the journal Log in as `root` and execute the command `tune2fs -j`. This creates an Ext3 journal with the default parameters. If you want to decide yourself how large the journal should be and on which device it should reside, execute the command `tune2fs -J` instead, together with the desired journal options `size=` and `device=`. More information about the tune2fs program is available in its manual page (`man 8 tune2fs`).

Specifying the file system type in /etc/fstab To ensure that the Ext3 file system is recognized as such, edit the file `/etc/fstab`, changing the file system type specified for the corresponding partition from `ext2` to `ext3`. The change takes effect after the next reboot.

Tip

ReiserFS

Officially one of the key features of the 2.4 kernel release, ReiserFS has been available as a kernel patch for 2.2.x SuSE kernels since SuSE Linux version 6.4. ReiserFS was designed by Hans Reiser and the Namesys development team. ReiserFS has proven to be a powerful alternative to the old Ext2. Its key assets are better disk space utilization, better disk access performance, and faster crash recovery. However, there is a minor drawback: ReiserFS pays great care to metadata but not to the data itself. Future generations of ReiserFS will include data journaling (both metadata and actual data are written to the journal) as well as ordered writes.

ReiserFS's strengths, in more detail, are:

Better disk space utilization In ReiserFS, all data is organized in a structure called B*-balanced tree. The tree structure contributes to better disk space utilization as small files can be stored directly in the B*tree leaf nodes instead of being stored elsewhere and just maintaining a pointer to the actual disk location. In addition to that, storage is not allocated in chunks of 1 or 4 kB, but in portions of the exact size needed. Another benefit lies in the dynamic allocation of inodes. This keeps the file system more flexible than traditional file systems, like Ext2, where the inode density has to be specified at file system creation time.

Better disk access performance For small files, you will often find that both file data and "stat_data" (inode) information are stored next to each other. They can be read with a single disk IO operation, meaning that only one access to disk is required to retrieve all the information needed.

Fast crash recovery Using a journal to keep track of recent metadata changes makes a file system check a matter of seconds, even for huge file systems.

JFS

JFS, the "Journaling File System" was developed by IBM. The first beta version of the JFS Linux port reached the Linux community in the summer of 2000. Version 1.0.0 was released in 2001. JFS is tailored to suit the needs of high throughput server environments where performance is the ultimate goal. Being a full 64-bit file system, JFS supports both large files and partitions, which is another reason for its use in server environments.

A closer look at JFS shows why this file system might prove a good choice for your Linux server:

Efficient journaling JFS follows a "metadata only" approach like ReiserFS. Instead of an extensive check, only metadata changes generated by recent file system activity get checked, which saves a great amount of time in recovery. Concurrent operations requiring multiple concurrent log entries can be combined into one group commit, greatly reducing performance loss of the file system through multiple write operations.

Efficient directory organization JFS holds two different directory organizations. For small directories, it allows the directory's content to be stored directly into its inode. For larger directories, it uses B^+trees, which greatly facilitate directory management.

Better space usage through dynamic inode allocation For Ext2, you have to define the inode density in advance (the space occupied by management information), which restricted the maximum number of files or directories of your file system. JFS spares you these considerations — it dynamically allocates inode space and frees it when it is no longer needed.

XFS

Originally intended as file system for their IRIX OS, SGI started XFS development back in the early 1990s. The idea behind XFS was to create a high-performance 64-bit journaling file system to meet the extreme computing challenges of today. XFS is very good at manipulating large files and performs well on high-end hardware. However, you will find a drawback even in XFS. Like ReiserFS, XFS takes a great deal of care of metadata integrity, but less of data integrity.

A quick review of XFS's key features explains why it may prove a strong competitor for other journaling file systems in high-end computing.

High scalability through the use of allocation groups At creation time of an XFS file system, the block device underlying the file system is divided into eight or more linear regions of equal size. Those are referred to as "allocation groups". Each allocation group manages its own inodes and free disk space. Practically, allocation groups can be seen as "file systems in a file system." As allocation groups are rather independent of each other, more than one of them can be addressed by the kernel simultaneously. This feature is the key to XFS's great scalability. Naturally, the concept of independent allocation groups suits the needs of multiprocessor systems.

High performance through efficient management of disk space Free space and inodes are handled by B^+ trees inside the allocation groups. The use of B^+ trees greatly contributes to XFS's performance and scalability. A feature truly unique to XFS is "delayed allocation". XFS handles allocation by breaking the process into two pieces. A pending transaction is stored in RAM and the appropriate amount of space is reserved. XFS still does not decide where exactly (speaking of file system blocks) the data should be stored. This decision is delayed until the last possible moment. Some short-lived temporary data may never make its way to disk, because it may be obsolete at the time XFS decides where to actually save it. Thus XFS increases write performance and reduces file system fragmentation. Because delayed allocation results in less frequent write events than in other file systems, it is likely that data loss after a crash during a write is more severe.

Preallocation to avoid file system fragmentation Before writing the data to the file system, XFS "reserves" (preallocates) the free space needed for a file. Thus, file system fragmentation is greatly reduced. Performance is increased as the contents of a file will not be distributed all over the file system.

Some Other Supported File Systems

Table A.1 summarizes some other file systems supported by Linux. They are supported mainly to ensure compatibility and interchange of data with different kinds of media or foreign operating systems.

`cramfs`	*Compressed ROM file system*: A compressed read-only file system for ROMs.
`hpfs`	*High Performance File System*: the IBM OS/2 standard file system — only supported in read-only mode.
`iso9660`	Standard file system on CD-ROMs.
`minix`	This file system originated from academic projects on operating systems and was the first file system used in Linux. Nowadays, it is used as a file system for floppy disks.
`msdos`	*fat*, the file system originally used by DOS, is today used by various operating systems.
`ncpfs`	file system for mounting Novell volumes over networks.
`nfs`	*Network File System*: Here, data can be stored on any machine in a network and access may be granted via a network.
`smbfs`	*Server Message Block*: used by products such as Windows to enable file access over a network.
`sysv`	Used on SCO UNIX, Xenix, and Coherent (commercial UNIX systems for PCs).
`ufs`	Used by BSD, SunOS, and NeXTstep. Only supported in *read-only* mode.
`umsdos`	*UNIX on MSDOS*: applied on top of a normal `fat` file system. Achieves UNIX functionality (permissions, links, long file names) by creating special files.
`vfat`	*Virtual FAT*: extension of the `fat` file system (supports long file names).
`ntfs`	*Windows NT file system*, read-only.

Table A.1: *File System Types in Linux*

Large File Support in Linux

Originally, Linux supported a maximum file size of 2 GB. This was enough before the explosion of multimedia and as long as no one tried to manipulate huge databases on Linux. Becoming more and more important for server computing, the kernel and C library were modified to support file sizes larger than 2 GB when using a new set of interfaces that applications must utilize. Nowadays, (almost) all major file systems offer LFS support, allowing you to perform high-end computing.

Table A.2 offers an overview of the current limitations of Linux files and file systems for Kernel 2.4.

File System	File Size Limit [Byte]	File System Size [Byte]
Ext2 or Ext3 (1 kB block size)	2^{34} (16 GB)	2^{41} (2 TB)
Ext2 or Ext3 (2 kB block size)	2^{38} (256 GB)	2^{43} (8 TB)
Ext2 or Ext3 (4 kB block size)	2^{41} (2 TB)	2^{44} (16 TB)
Ext2 or Ext3 (8 kB block size) (systems with 8 kB pages (like Alpha))	2^{46} (64 TB)	2^{45} (32 TB)
ReiserFS 3.5	2^{32} (4 GB)	2^{44} (16 TB)
ReiserFS 3.6 (Linux 2.4)	2^{60} (1 EB)	2^{44} (16 TB)
XFS	2^{63} (8 EB)	2^{63} (8 EB)
JFS (512 Bytes block size)	2^{63} (8 EB)	2^{49} (512 TB)
JFS (4 kB block size)	2^{63} (8 EB)	2^{52} (4 PB)
NFSv2 (client side)	2^{31} (2 GB)	2^{63} (8 EB)
NFSv3 (client side)	2^{63} (8 EB)	2^{63} (8 EB)

Table A.2: *Maximum Sizes of File Systems*

Note

Linux Kernel Limits

Table A.2 on the preceding page describes the limitations regarding the on-disk format. The following kernel limits (kernel version 2.4.x) exist:

- *32-bit systems:* The maximum size of any file or block device is limited to 2 TB. Using LVM to combine several block devices allows you to handle larger file systems.
- *64-bit systems:* File and file system sizes are limited to 2^{63} (8 EB). This limit may not yet be reached due to a lack of hardware driver support.

Note

For More Information

Each of the file system projects described above maintains its own home page where you can find mailing list information as well as further documentation and FAQs.

`http://e2fsprogs.sourceforge.net/`
`http://www.zipworld.com.au/~akpm/linux/ext3/`
`http://www.namesys.com/`
`http://oss.software.ibm.com/developerworks/opensource/jfs/`
`http://oss.sgi.com/projects/xfs/`
A comprehensive multipart tutorial on Linux file systems can be found at *IBM developerWorks*:
`http://www-106.ibm.com/developerworks/library/l-fs.html`

For a comparison of the different journaling file systems in Linux, look at Juan I. Santos Florido's article at *Linuxgazette*: `http://www.linuxgazette.com/issue55/florido.html`.

Those interested in an in-depth analysis of LFS in Linux should try Andreas Jaeger's LFS site: `http://www.suse.de/~aj/linux_lfs.html`.

Access Control Lists in Linux

This chapter provides a brief summary of the background and functions of POSIX ACLs for Linux file systems. Learn how the traditional permission concept for file system objects can be expanded with the help of ACLs (*Access Control Lists*) and which advantages this concept provides.

Advantages of ACLs 522
Definitions 523
Handling ACLs 523
Outlook 532

Advantages of ACLs

Note

POSIX ACLs

The term "POSIX ACL" suggests that this is a true POSIX (*Portable Operating System Interface*) standard. The respective draft standards POSIX 1003.1e and POSIX 1003.2c have been withdrawn for several reasons. Nevertheless, ACLs as found on many systems belonging to the UNIX family are based on these documents and the implementation of file system ACLs as described in this chapter follows these two standards as well. They can be viewed at `http://wt.xpilot.org/publications/posix.1e/`

Note

Traditionally, a file object in Linux is associated with three sets of permissions. These sets includes the read (`r`), write (`w`), and execute (`x`) permissions for each on of three types of users — the file owner, the group, and other users. In addition to that, it is possible to set the *set user id*, *set group id*, and the *sticky* bit. A more detailed discussion of this topic can be found in the section *Users and Access Permissions* of the *User Guide*.

This lean concept is fully adequate for most practical cases. However, for more complex scenarios or advanced applications, system administrators formerly had to use a number of tricks to circumvent the limitations of the traditional permission concept.

ACLs can be used for situations that require an extension of the traditional file permission concept. They allow assignment of permissions to individual users or groups even if these do not correspond to the original owner or the owning group. Access Control Lists are a feature of the Linux kernel and are currently supported by ReiserFS, Ext2, Ext3, JFS, and XFS. Using ACLs, complex scenarios can be realized without implementing complex permission models on the application level.

The advantages of ACLs are clearly evident in situations such as the replacement of a Windows server by a Linux server. Some of the connected workstations may continue to run under Windows even after the migration. The Linux system offers file and print services to the Windows clients with Samba.

Given than Samba supports access control lists, user permissions can be configured both on the Linux server and in Windows with a graphical user interface (only Windows NT and later). With winbindd, it is even possible to assign permissions to users that only exist in the Windows domain without any account on the Linux server. On the server side, edit the Access Control Lists using getfacl and setfacl.

Definitions

User class The conventional POSIX permission concept uses three *classes* of users for assigning permissions in the file system: the owner, the owning group, and other users. Three permission bits can be set for each user class, giving permission to read (`r`), write (`w`), and execute (`x`). An introduction to the user concept in Linux is provided in the *User Guide* in *Users and Access Permissions*.

Access ACL The user and group access permissions for all kinds of file system objects (files and directories) are determined by means of access ACLs.

Default ACL Default ACLs can only be applied to directories. They determine the permissions a file system object inherits from its parent directory when it is created.

ACL entry Each ACL consists of a set of ACL entries. An ACL entry contains a type (see Table B.1 on the next page), a qualifier for the user or group to which the entry refers, and a set of permissions. For some entry types, the qualifier for the group or users is undefined.

Handling ACLs

The following section explains the basic structure of an ACL and its various characteristics. The interrelation between ACLs and the traditional permission concept in the Linux file system is briefly demonstrated by means of several figures. Two examples show how you can create your own ACLs using the correct syntax. In conclusion, find information about the way ACLs are interpreted by the operating system.

Structure of ACL Entries

There are two basic classes of ACLs: A *minimum* ACL merely comprises the entries for the types owner, owning group, and other, which correspond to the conventional permission bits for files and directories. An *extended* ACL goes beyond this. It must contain a *mask* entry and may contain several entries of the *named user* and *named group* types. Table B.1 provides a summary of the various types of ACL entries that are possible.

Type	Text Form
owner	`user::rwx`
named user	`user:name:rwx`
owning group	`group::rwx`
named group	`group:name:rwx`
mask	`mask::rwx`
other	`other::rwx`

Table B.1: *ACL Entry Types*

The permissions defined in the entries *owner* and *other* are always effective. Except for the *mask* entry, all other entries (*named user*, *owning group*, and *named group*) can be either effective or masked. If permissions exist in one of the above-mentioned entries as well as in the mask, they are effective. Permissions contained only in the mask or only in the actual entry are not effective. The example in Table B.2 demonstrates this mechanism.

Entry Type	Text Form	Permissions
named user	`user:jane:r-x`	`r-x`
mask	`mask::rw-`	`rw-`
	effective permissions:	`r--`

Table B.2: *Masking Access Permissions*

ACL Entries and File Mode Permission Bits

Figure B.1 on the facing page and Figure B.2 on the next page illustrate the two cases of a minimum ACL and an extended ACL. The figures are structured in three blocks — the left block shows the type specifications of the ACL entries, the center block displays an example ACL, and the right block shows the respective permission bits according to the conventional permission concept as displayed by `ls -l`, for instance.

In both cases, the *owner class* permissions are mapped to the ACL entry *owner*. Equally, *other class* permissions are mapped to the respective ACL entry. However, the mapping of the *group class* permissions is different in both cases:

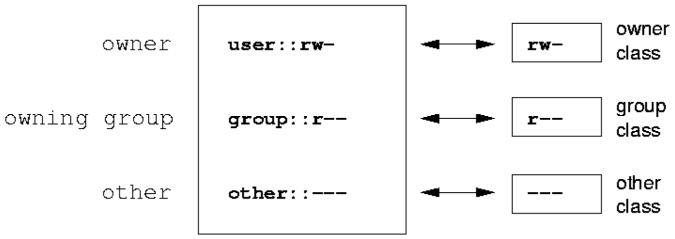


***Figure B.1:** Minimum ACL: ACL Entries Compared to Permission Bits*

- In the case of a minimum ACL — without *mask* — the *group class* permissions are mapped to the ACL entry *owning group*. This is shown in Figure B.1.
- In the case of an extended ACL — with *mask* — the *group class* permissions are mapped to the *mask* entry. This is shown in Figure B.2.

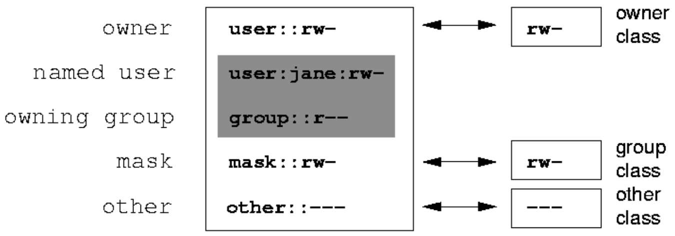


***Figure B.2:** Extended ACL: ACL Entries Compared to Permission Bits*

This mapping approach ensures the smooth interaction of applications with ACL support and those without ACL support. The access permissions that were assigned by means of the permission bits represent the upper limit for all other "fine adjustments" made by means of ACLs. All permissions not reflected here were either not set in the ACL or are not effective. If permission bits are changed, this is also reflected in the respective ACL and vice versa.

A Directory with Access ACL

The handling of access ACLs is demonstrated in three steps by means of the following example:

- Creating a file system object (a directory in this case)
- Modifying the ACL
- Using masks

1. Before you create the directory, use the `umask` command to determine which access permissions should be masked from the outset:

   ```
   umask 027
   ```

   The command `umask 027` sets the default permissions by giving the owner the full range of permissions (`0`), denying the group write access (`2`), and giving other users no permissions at all (`7`). `umask` actually masks the corresponding permission bits or turns them off. For details, consult the corresponding man page (`man umask`).

   ```
   mkdir mydir
   ```

   This should create the `mydir` directory with the default permissions as set by `umask`. Use the following command to check if all permissions were assigned correctly:

   ```
   ls -dl mydir
   drwxr-x--- ... tux project3 ... mydir
   ```

2. Check the initial state of the ACL and insert a new user entry and a new group entry.

   ```
   getfacl mydir

   # file: mydir
   # owner: tux
   # group: project3
   user::rwx
   group::r-x
   other::---
   ```

   The output of `getfacl` precisely reflects the mapping of permission bits and ACL entries as described in *ACL Entries and File Mode Permission Bits* on page 524. The first three output lines display the name, owner, and owning group of the directory. The next three lines contain the three ACL entries *owner*, *owning group*, and *other*. In fact, in the case of this minimum ACL, the `getfacl` command does not produce any information you could not have obtained with `ls`.

Your first modification of the ACL is the assignment of read, write, and execute permissions to an additional user `jane` and an additional group `djungle`.

```
setfacl -m user:jane:rwx,group:djungle:rwx mydir
```

The option `-m` prompts `setfacl` to modify the existing ACL. The following argument indicates the ACL entries to modify (several entries are separated by commas). The final part specifies the name of the directory to which these modifications should be applied.

Use the `getfacl` command to take a look at the resulting ACL.

```
getfacl mydir

# file: mydir
# owner: tux
# group: project3
user::rwx
user:jane:rwx
group::r-x
group:djungle:rwx
mask::rwx
other::---
```

In addition to the entries initiated for the user `jane` and the group `djungle`, a *mask* entry has been generated. This *mask* entry is set automatically to reduce all entries in the *group class* to a common denominator. Furthermore, `setfacl` automatically adapts existing *mask* entries to the settings modified, provided you do not deactivate this feature with `-n`. *mask* defines the maximum effective access permissions for all entries in the *group class*. This includes *named user*, *named group*, and *owning group*. The *group class* permission bits that would be displayed by `ls -dl mydir` now correspond to the `mask` entry.

```
ls -dl mydir
drwxrwx---+ ... tux project3 ... mydir
```

The first column of the output now contains an additional + to indicate that there is an *extended* ACL for this item.

3. According to the output of the `ls` command, the permissions for the *mask* entry include write access. Traditionally, such permission bits would mean that the *owning group* (here `project3`) also has write access to the directory `mydir`. However, the effective access permissions for the *owning group* correspond to the overlapping portion of the permissions defined for the *owning group* and for the *mask* — which is `r-x` in our example (see Table B.2 on page 524). As far as the effective permissions of the *owning group* are concerned, nothing has changed even even after the addition of the ACL entries.

   Edit the *mask* entry with `setfacl` or `chmod`.

   ```
   chmod g-w mydir
   ls -dl mydir

   drwxr-x---+ ... tux project3 ... mydir

   getfacl mydir

   # file: mydir
   # owner: tux
   # group: project3
   user::rwx
   user:jane:rwx          # effective: r-x
   group::r-x
   group:djungle:rwx      # effective: r-x
   mask::r-x
   other::---
   ```

   After executing the `chmod` command to remove the write permission from the *group class* bits, the output of the `ls` command is sufficient to see that the *mask* bits must have changed accordingly: write permission is again limited to the owner of `mydir`. The output of the `getfacl` confirms this. This output includes a comment for all those entries where the effective permission bits do not correspond to the original permissions, because they are filtered according to the *mask* entry. Of course, the original permissions can be restored at any time with `chmod`:

   ```
   chmod g+w mydir
   ls -dl mydir

   drwxrwx---+ ... tux project3 ... mydir

   getfacl mydir
   ```

```
# file: mydir
# owner: tux
# group: project3
user::rwx
user:jane:rwx
group::r-x
group:djungle:rwx
mask::rwx
other::---
```

A Directory with a Default ACL

Directories can be equipped with a special kind of ACL — a default ACL. The default ACL defines the access permissions all objects under this directory inherit when they are created. A default ACL affects subdirectories as well as files.

Effects of a Default ACL

There are two different ways in which the permissions of a directory's default ACL are handed down to the files and subdirectories in it:

- A subdirectory inherits the default ACL of the parent directory both as its own default ACL and as an access ACL.
- A file inherits the default ACL as its own access ACL.

All system calls that create file system objects use a `mode` parameter that defines the access permissions for the newly created file system object:

- If the parent directory does not have a default ACL, the permission bits as defined by the `umask` are subtracted from the permissions as passed by the `mode` parameter, with the result being assigned to the new object.
- If a default ACL exists for the parent directory, the permission bits assigned to the new object correspond to the overlapping portion of the permissions of the `mode` parameter and those that are defined in the default ACL. The umask is disregarded.

Application of Default ACLs

The following three examples show the main operations for directories and default ACLs:

- Creating a default ACL for an existing directory
- Creating a subdirectory in a directory with default ACL
- Creating a file in a directory with default ACL

1. Add a default ACL to the existing directory `mydir`:

   ```
   setfacl -d -m group:djungle:r-x mydir
   ```

   The option `-d` of the `setfacl` command prompts `setfacl` to perform the following modifications (option `-m`) in the default ACL.

   Take a closer look at the result of this command:

   ```
   getfacl mydir

   # file: mydir
   # owner: tux
   # group: project3
   user::rwx
   user:jane:rwx
   group::r-x
   group:djungle:rwx
   mask::rwx
   other::---
   default:user::rwx
   default:group::r-x
   default:group:djungle:r-x
   default:mask::r-x
   default:other::---
   ```

   `getfacl` returns both the access ACL and the default ACL. The default ACL is formed by all lines that start with `default`. Although you merely executed the `setfacl` command with an entry for the `djungle` group for the default ACL, `setfacl` automatically copied all other entries from the access ACL to create a valid default ACL. Default ACLs do not have an immediate effect on access permissions. They only come into play when file system objects are created. These new objects inherit permissions only from the default ACL of their parent directory.

2. In the next example, use `mkdir` to create a subdirectory in `mydir`, which will "inherit" the default ACL.

```
mkdir mydir/mysubdir
getfacl mydir/mysubdir

# file: mydir/mysubdir
# owner: tux
# group: project3
user::rwx
group::r-x
group:djungle:r-x
mask::r-x
other::---
default:user::rwx
default:group::r-x
default:group:djungle:r-x
default:mask::r-x
default:other::---
```

   As expected, the newly-created subdirectory `mysubdir` has the permissions from the default ACL of the parent directory. The access ACL of `mysubdir` is an exact reflection of the default ACL of `mydir`, just as the default ACL that this directory will hand down to its subordinate objects.

3. Use `touch` to create a file in the `mydir` directory:

```
touch mydir/myfile
ls -l mydir/myfile

-rw-r-----+ ... tux project3 ... mydir/myfile

getfacl mydir/myfile

# file: mydir/myfile
# owner: tux
# group: project3
user::rw-
group::r-x          # effective:r--
group:djungle:r-x   # effective:r--
mask::r--
other::---
```

   Important in this example: `touch` passes on `mode` with the value `0666`, which means that new files are created with read and write permissions for all user classes, provided no other restrictions exist in `umask` or in the default ACL (see *Effects of a Default ACL* on page 529).

If effect, this means that all access permissions not contained in the `mode` value are removed from the respective ACL entries. Although no permissions were removed from the ACL entry of the *group class*, the *mask* entry was modified to mask permissions not set via `mode`.

This approach ensures the smooth interaction of applications, such as compilers, with ACLs. You can create files with restricted access permissions and subsequently mark them as executable. The `mask` mechanism makes sure that the respective users and groups are assigned the permissions they are granted in the default ACL.

The ACL Check Algorithm

The following section provides brief information on the check algorithm applied to all processes or applications before they are granted access to an ACL-protected file system object. As a basic rule, the ACL entries are examined in the following sequence: *owner*, *named user*, *owning group* or *named group*, and *other*. The access is handled in accordance with the entry that best suits the process; permissions do not accumulate.

Things are more complicated if a process belongs to more than one group and would potentially suit several *group* entries. An entry is randomly selected from the suitable entries with the required permissions. It is irrelevant which of the entries triggers the final result “access granted”. Likewise, if none of the suitable *group* entries contains the correct permissions, a randomly selected entry triggers the final result “access denied”.

Outlook

As described in the preceding sections, ACLs can be used to implement very complex permission scenarios that meet the requirements of modern applications. The traditional permission concept and ACLs can be combined in a smart manner. However, some important applications still lack ACL support. Except for the star archiver, there are currently no backup applications that guarantee the full preservation of ACLs.

The basic file commands (`cp`, `mv`, `ls`, and so on) do support ACLs, but many editors and file managers (such as Konqueror) do not. When copying files with Konqueror, for instance, the ACLs of these files are lost. When modifying files with an editor, the ACLs of files are sometimes preserved, sometimes not, depending on the backup mode of the editor used:

- If the editor writes the changes to the original file, the access ACL will be preserved.
- If the editor saves the updated contents to a new file that is subsequently renamed to the old file name, the ACLs may be lost, unless the editor supports ACLs.

With (hopefully) more ACL-enabled applications released over time, Linux systems will be able to benefit from this feature to the full extent.

Tip

Additional Information

Detailed information about ACLs is available at the following URLs:

`http://sdb.suse.de/en/sdb/html/81_acl.html`

`http://acl.bestbits.at/`

and in the man page for `getfacl` (`man 1 getfacl`), the man page for `acl` (`man 5 acl`), and the man page for `setfacl` (`man 1 setfacl`).

Tip

Manual Page of e2fsck

```
E2FSCK(8)                                                    E2FSCK(8)



NAME
       e2fsck - check a Linux second extended file system

SYNOPSIS
       e2fsck  [  -pacnyrdfvstFSV ] [ -b superblock ] [ -B block-
       size ] [ -l|-L bad_blocks_file ] [ -C fd ] [ -j  external-
       journal ] [ device

DESCRIPTION
       e2fsck  is used to check a Linux second extended file sys-
       tem (e2fs).  E2fsck also supports ext2  filesystems  coun-
       taining  a journal, which are also sometimes known as ext3
       filesystems.

       device is the special file  corresponding  to  the  device
              (e.g /dev/hdc1).

OPTIONS
       -a     This  option  does the same thing as the -p option.
              It is provided for backwards compatibility only; it
              is  suggested  that  people  use -p option whenever
              possible.

       -b superblock
              Instead of using  the  normal  superblock,  use  an
              alternative  superblock  specified  by  superblock.
              This option  is  normally  used  when  the  primary
              superblock has been corrupted.  The location of the
              backup superblock is dependent on the  filesystem's
              blocksize.   For  filesystems with 1k blocksizes, a
              backup superblock can be found at block  8193;  for
              filesystems with 2k blocksizes, at block 16384; and
              for 4k blocksizes, at block 32768.
              Additional backup superblocks can be determined  by
              using  the  mke2fs  program  using the -n option to
              print out where the superblocks were created.   The
              -b  option  to mke2fs, which specifies blocksize of
              the filesystem must be specified in order  for  the
              superblock  locations  that  are  printed out to be
              accurate.

              If an alternative superblock is specified  and  the
              filesystem  is  not  opened  read-only, e2fsck will
              make sure that the primary  superblock  is  updated
              appropriately  upon  completion  of  the filesystem
              check.

       -B blocksize
              Normally, e2fsck will search for the superblock  at
              various different block sizes in an attempt to find
              the appropriate block size.   This  search  can  be
              fooled in some cases.  This option forces e2fsck to
              only try locating the superblock  at  a  particular
              blocksize.   If the superblock is not found, e2fsck
              will terminate with a fatal error.

       -c     This option causes e2fsck to run  the  badblocks(8)
              program  to  find  any  blocks which are bad on the
              filesystem, and then marks them as  bad  by  adding
              them to the bad block inode.

       -C     This  option  causes  e2fsck  to  write  completion
              information to the  specified  file  descriptor  so
              that  the  progress  of the filesystem check can be
              monitored.  This option is typically used  by  pro-
              grams  which  are  running  e2fsck.   If  the  file
              descriptor specified is 0, e2fsck will print a com-
              pletion  bar  as  it goes about its business.  This
              requires that e2fsck is running on a video  console
              or terminal.

       -d     Print  debugging  output  (useless  unless  you are
              debugging e2fsck).

       -f     Force checking even if the file system seems clean.

       -F     Flush  the filesystem device’s buffer caches before
              beginning.  Only really  useful  for  doing  e2fsck
              time trials.

       -j external-journal
              Set  the  pathname  where  the external-journal for
              this filesystem can be found.

       -l filename
```

```
              Add the blocks listed  in  the  file  specified  by
              filename  to the list of bad blocks.  The format of
              this file is the same as the one generated  by  the
              badblocks(8) program.
       -L filename
              Set  the  bad  blocks list to be the list of blocks
              specified by filename.  (This option is the same as
              the  -l  option,  except  the  bad  blocks  list is
              cleared before the blocks listed in  the  file  are
              added to the bad blocks list.)

       -n     Open the filesystem read-only, and assume an answer
              of 'no' to all questions.  Allows e2fsck to be used
              non-interactively.   (Note:  if  the  -c, -l, or -L
              options are specified in addition to the -n option,
              then  the  filesystem will be opened read-write, to
              permit the bad-blocks list to be updated.  However,
              no other changes will be made to the filesystem.)

       -p     Automatically  repair  ("preen")  the  file  system
              without any questions.

       -r     This option does nothing at  all;  it  is  provided
              only for backwards compatibility.

       -s     This  option  will byte-swap the filesystem so that
              it is using  the  normalized,  standard  byte-order
              (which  is i386 or little endian).  If the filesys-
              tem is already in the standard  byte-order,  e2fsck
              will take no action.

       -S     This  option will byte-swap the filesystem, regard-
              less of its current byte-order.

       -t     Print timing statistics for e2fsck.  If this option
              is  used  twice,  additional  timing statistics are
              printed on a pass by pass basis.

       -v     Verbose mode.

       -V     Print version information and exit.

       -y     Assume an answer of 'yes' to all questions;  allows
              e2fsck to be used non-interactively.

EXIT CODE
       The exit code returned by e2fsck is the sum of the follow-
       ing conditions:
            0    - No errors
            1    - File system errors corrected
            2    - File system errors corrected, system should
                   be rebooted if file system was mounted
            4    - File system errors left uncorrected
            8    - Operational error
            16   - Usage or syntax error
            128  - Shared library error

SIGNALS
       The following signals have the following effect when  sent
       to e2fsck.

       SIGUSR1
              This  signal  causes  e2fsck  to start displaying a
              completion bar.  (See discussion of the -C option.)

       SIGUSR2
              This signal causes e2fsck to stop displaying a com-
              pletion bar.

REPORTING BUGS
       Almost any piece of software will have bugs.  If you  man-
       age  to find a filesystem which causes e2fsck to crash, or
       which e2fsck is unable to repair, please report it to  the
       author.

       Please include as much information as possible in your bug
       report.  Ideally, include a  complete  transcript  of  the
       e2fsck  run,  so I can see exactly what error messages are
       displayed.  If you have a writeable filesystem  where  the
       transcript can be stored, the script(1) program is a handy
       way to save the output of e2fsck to a file.

       It is also useful to send the output of dumpe2fs(8).  If a
       specific  inode  or inodes seems to be giving e2fsck trou-
       ble, try running the debugfs(8) command and send the  out-
       put  of the stat(1u) command run on the relevant inode(s).
       If the inode is a directory, the debugfs dump command will
       allow  you to extract the contents of the directory inode,
       which can sent to me after being first run  through  uuen
       code(1).

       Always  include  the full version string which e2fsck dis-
       plays when it is run, so I know which version you are run-
       ning.

AUTHOR
       This  version  of  e2fsck  was  written  by  Theodore Ts’o
       <tytso@mit.edu>.

SEE ALSO
       mke2fs(8), tune2fs(8), dumpe2fs(8), debugfs(8)


E2fsprogs version 1.25    September 2001              E2FSCK(8)
```

Manual Page of reiserfsck

```
REISERFSCK(8)                                          REISERFSCK(8)


NAME
       reiserfsck - check a Linux Reiserfs file system

SYNOPSIS
       reiserfsck  [  -afprVy  ]  [  --check  |  --fix-fixable  |
       --rebuild-sb | --rebuild-tree | --clean-attributes ] [  -j
       |  --journal-device  device ] [ --no-journal-available ] [
       -z | --adjust-file-size ] [ -S | --scan-whole-partition  ]
       [  -l  |  --logfile  filename  ]  [  -n | --nolog ] [ -q |
       --quiet ] device

DESCRIPTION
       Reiserfsck searches for a Reiserfs filesystem on a device,
       replays  any  necessary transactions, and either checks or
       repairs the file system.

       device is the special file corresponding to the device  or
              partition  (e.g /dev/hdXX for IDE disk partition or
              /dev/sdXX for SCSI disk partition).

OPTIONS
       --check
              This default action checks file system  consistency
              and reports but does not repair any corruption that
              it finds. This option may be used  on  a  read-only
              file  system  mount.  The --check option exits with
              status 0 to indicate that no corruption was  found.
              Otherwise, reiserfsck returns 1 to indicate corrup
              tion that can be fixed with --fix-fixable and 2  to
              indicate corruption that requires --rebuild-tree.

       --fix-fixable
              This  option  recovers  certain kinds of corruption
              that do not require rebuilding the entire file sys
              tem  tree  (--rebuild-tree). Normally you only need
              this option if the --check option reports  "corrup
              tion  that  can  be fixed with --fix-fixable". This
              includes: zeroing invalid data-block pointers, cor
              recting  st_size and st_blocks for directories, and
              deleting invalid directory entries.

       --rebuild-sb
              This option recovers the superblock on  a  Reiserfs
              partition.   Normally  you only need this option if
              mount reports "read_super_block: can’t find a reis
              erfs  file system" and you are sure that a Reiserfs
              file system is there.

       --rebuild-tree
              This option rebuilds the entire  file  system  tree
              using leaf nodes found on the device.  Normally you
              only need this option if the --check option reports
              "corruption   that   can   be   fixed  only  during
              --rebuild-tree".  You are  strongly  encouraged  to
              make  a  backup  copy of the whole partition before
              attempting the --rebuild-tree option.

       --clean-attributes
              This option cleans  reserved  fields  of  Stat-Data
              items.

       --journal-device device , -j device
              This option supplies the device name of the current
              file system journal.  This option is required  when
              the  journal  resides on a separate device from the
              main data device (although it can be  avoided  with
              the expert option --no-journal-available).

       --adjust-file-size, -z
              This option causes reiserfsck to correct file sizes
              that are larger than the offset of the last discov
              ered byte.  This implies that holes at the end of a
              file will be removed.  File sizes that are  smaller
              than  the  offset  of  the last discovered byte are
              corrected by --fix-fixable.

       --logfile filename, -l  filename
              This option causes reiserfsck to report any corrup
              tion it finds to the specified log file rather than
              stderr.

       --nolog, -n
              This option prevents reiserfsck from reporting  any
              kinds of corruption.

       --quiet, -q
```

```
              This  option prevents reiserfsck from reporting its
              rate of progress.

       -a, -p These options are usually passed by fsck -A  during
              the  automatic  checking  of /etc/fstab partitions.
              For compatibility, these options simply cause reis
              erfsck  to  print  information  about the specified
              file system.  No checks are performed.  When it  is
              set  - reiserfsck assumes that it is called by fsck
              -A, provides some information about  the  specified
              filesystem and exits.

       -V     This  option  prints  the reiserfsprogs version and
              exit.

       -r, -p, -y
              These options are ignored.

       -V, -f prints version and exits

EXPERT OPTIONS
       DO NOT USE THESE OPTIONS UNLESS  YOU  KNOW  WHAT  YOU  ARE
       DOING.   WE  ARE  NOT  RESPONSIBLE  IF  YOU LOSE DATA AS A
       RESULT OF THESE OPTIONS.

       --no-journal-available
              This option allows reiserfsck to proceed  when  the
              journal device is not available. This option has no
              effect when the journal is located on the main data
              device.  NOTE:  after  this  operation you must use
              reiserfstune to specify a new journal device.

       --scan-whole-partition, -S
              This option causes --rebuild-tree to scan the whole
              partition, not only used space on the partition.

EXAMPLE OF USING
       1. You think something may be wrong with a reiserfs parti
       tion on /dev/hda1 or you would  just  like  to  perform  a
       periodic disk check.

       2.  Run  reiserfsck --check --logfile check.log /dev/hda1.
       If reiserfsck --check exits with  status  0  it  means  no
       errors were discovered.

       3.  If reiserfsck --check exits with status 1 (and reports
       about fixable corruptions) it means that  you  should  run
       reiserfsck  --fix-fixable --logfile fixable.log /dev/hda1.

       4. If reiserfsck --check exits with status 2 (and  reports
       about  fatal  corruptions)  it  means that you need to run
       reiserfsck --rebuild-tree.  If reiserfsck --check fails in
       some  way  you  should also run reiserfsck --rebuild-tree,
       but we also encourage you to submit this as a bug  report.

       5. Before running reiserfsck --rebuild-tree, please make a
       backup of the whole partition before proceeding. Then  run
       reiserfsck --rebuild-tree --logfile rebuild.log /dev/hda1.

       6. If the --rebuild-tree step fails or  does  not  recover
       what you expected, please submit this as a bug report. Try
       to provide as much information as possible and we will try
       to help solve the problem.

EXIT CODE
       reiserfsck uses the following exit codes:
            0      - No errors
            1      - File system errors corrected
            2      - File system errors corrected, system should
                     be rebooted if file system was mounted
            4      - File system errors left uncorrected
            8      - Operational error
            16     - Usage or syntax error

AUTHOR
       This  version  of  reiserfsck  has  been written by Vitaly
       Fertman   <vitaly@namesys.com>   and   Vladimir   Saveliev
       <vs@namesys.com>.

BUGS
       There  are  likely  to be some bugs. Please report bugs to
       the ReiserFS mail-list <reiserfs-list@namesys.com>.

TODO
       Faster recovering, signal handling,  i/o  error  handling,
       return reasonable exit codes, etc.

SEE ALSO
       mkreiserfs(8), debugreiserfs(8), reiserfstune(8)



Reiserfsprogs-3.6.2       January 2002            REISERFSCK(8)
```

The GNU General Public License

GNU General Public License

Foreword

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the *GNU General Public License* is intended to guarantee your freedom to share and change free software — to make sure the software is free for all its users. This *General Public License* applies to most of the *Free Software Foundation's* software and to any other program whose authors commit to using it. (Some other *Free Software Foundation* software is covered by the *GNU Library General Public License* instead.) You can apply it to your programs, too.

When we speak of *"free" software*, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

The precise terms and conditions for copying, distribution and modification follow.

GNU General, Public License

Terms and Conditions for Copying, Distribution and Modification

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this *General Public License*. The "Program", below, refers to any such program or work, and a *work based on the Program* means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term "modification".) Each licensee is addressed as "you".

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

a) You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change.

b) You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License.

c) If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.

6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.

7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty–free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.

If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other circumstances.

It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.

This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.

9. The *Free Software Foundation* may publish revised and/or new versions of the *General Public License* from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and "any later version", you have the option of following the terms and conditions either of that version or of any later version published by the *Free Software Foundation*. If the Program does not specify a version number of this License, you may choose any version ever published by the *Free Software Foundation*.

10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the *Free Software Foundation*, write to the *Free Software Foundation*; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all derivatives of our free software and of promoting the sharing and reuse of software generally.

No Warranty

11. Because the program is licensed free of charge, there is no warranty for the program, to the extent permitted by applicable law. Except when otherwise stated in writing the copyright holders and/or other parties provide the program "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability and

fitness for a particular purpose. The entire risk as to the quality and performance of the program is with you. Should the program prove defective, you assume the cost of all necessary servicing, repair or correction.

12. In no event unless required by applicable law or agreed to in writing will any copyright holder, or any other party who may modify and/or redistribute the program as permitted above, be liable to you for damages, including any general, special, incidental or consequential damages arising out of the use or inability to use the program (including but not limited to loss of data or data being rendered inaccurate or losses sustained by you or third parties or a failure of the program to operate with any other programs), even if such holder or other party has been advised of the possibility of such damages.

End of Terms and Conditions

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the "copyright" line and a pointer to where the full notice is found.

> *one line to give the program's name and a brief idea of what it does.*
> Copyright (C) 19*yy* *name of author*
> This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.
> This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.
> You should have received a copy of the GNU General Public License along with this program; if not, write to the Free Software Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.

Also add information on how to contact you by electronic and paper mail.

If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

> Gnomovision version 69, Copyright (C) 19*yy* *name of author*
> Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type 'show w'. This is free software, and you are welcome to redistribute it under certain conditions; type 'show c' for details.

The hypothetical commands `show w` and `show c` should show the appropriate parts of the General Public License. Of course, the commands you use may be called something other than `show w` and `show c`; they could even be mouse–clicks or menu items — whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a "copyright disclaimer" for the program, if necessary. Here is a sample; alter the names:

> Yoyodyne, Inc., hereby disclaims all copyright interest in the program 'Gnomovision' (which makes passes at compilers) written by James Hacker.
> *Signed by Ty Coon*, 1 April 1989
> Ty Coon, President of Vice

This *General Public License* does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the *GNU Library General Public License* instead of this License.

Index

A

ACLs . . . 521–533
- access . . . 523, 526
- check algorithm . . . 532
- default . . . 523, 529
- masks . . . 527
- structure . . . 524

addresses
- IP . . . 297
- MAC . . . 298

ADSL
- configuring . . . 444–445
- dial-on-demand . . . 444
- starting . . . 444

Apache . . . 47, 253, 375
- apxs . . . 382
- CGI (Common Gateway Interface) 390
- configuration . . . 382
- content negotiation . . . 378
- DocumentRoot . . . 384
- flags . . . 383
- installation . . . 380
- modules . . . 377, 383
  - · mod_perl . . . 392
  - · mod_php4 . . . 394
  - · mod_python . . . 394
  - · mod_ruby . . . 395
- security . . . 398
- Squid . . . 458
- SSI (Server-Side Includes) . . . 387, 389
- troubleshooting . . . 399
- virtual hosts . . . 377, 395

APM
- kernel parameters . . . 45

AppleTalk . . . *see* Netatalk

ASCII
- encoding . . . 171

autofs . . . 46

B

Bash
- .bashrc . . . 253
- .profile . . . 253
- profile . . . 253

BIND . . . 323–331

BIOS . . . 70
- virus protection . . . 15

boot loaders
- GRUB . . . 73

Booten . . . 539

booting . . . 69–92, 279
- BIOS . . . 70
- boot loaders . . . 260
- boot managers . . . 69–92
- boot sectors . . . 70–71
- CD2, from . . . 22
- CMOS . . . 70
- DOS . . . 71
- floppy, from . . . 21, 71
- graphic . . . 15
  - · disabling . . . 15
- GRUB . . . 73–82
- initial ramdisk . . . 259–263
- initrd
  - · creating . . . 262
- LILO . . . 15, 82–90
- linuxrc . . . 260
- map files . . . 72
- MBR . . . 70
- methods . . . 15
- PCMCIA, from . . . 203

- securing . . . 86
- SYSLINUX . . . 21
- system freezes . . . 15
- Windows . . . 71

C

cardctl . . . 200
cardmgr . . . 313
cards
- graphics
  · drivers . . . 109
- network
  · hotplugging . . . 197
  · testing . . . 311
- PCMCIA . . . 200–210, 313
  · removing . . . 202
- wireless . . . 312
CD-ROM drives
- ATAPI . . . 22
- supported . . . 22
Check . . . 539
clients
- diskless . . . 372
CMOS . . . 70
commands
- cardctl . . . 209
- free . . . 257
- ifport . . . 207
- mii_tool . . . 207
configuration
- Apache . . . 382–387
- SSH . . . 470
configuration files
- printcap . . . 143
configuration files
- lpdfilter . . . 143
configuration files
- lpd.perms . . . 137
configuration files
- .lpoptions . . . 161
- modules.conf . . . 132
- suseservers . . . 67
configuration files . . . 315
- .bashrc . . . 253, 256
- .config . . . 243
- .emacs . . . 258
- .lpoptions . . . 157
- .mailsync . . . 416
- .profile . . . 253
- .xsession . . . 474
- /boot/grub/menu.lst . . . 74
- /etc/foomatic/filter.conf . . . 49
- /etc/grub.conf . . . 79
- /etc/init.d/boot . . . 45
- /etc/logfiles . . . 46
- /etc/xinetd.d/cups-lpd . . . 191
- /etc/xml/catalog . . . 49
- /etc/xml/suse-catalog.xml . . . 49
- acpi . . . 225
- afpd.conf . . . 431
- AppleVolumes.default . . . 432
- AppleVolumes.system . . . 434
- atalkd.conf . . . 431
- crontab . . . 253
- csh.cshrc . . . 276
- CUPS
  · lpoptions . . . 161
- cupsd.conf . . . 154
- dhclient.conf . . . 369
- dhcp . . . 315
- dhcpd.conf . . . 369
- exports . . . 366, 367, 457
- fstab . . . 28, 271
- host.conf . . . 288, 316
  · alert . . . 317
  · multi . . . 317
  · nospoof . . . 317
  · order . . . 316
  · trim . . . 317
- HOSTNAME . . . 320
- hosts . . . 301, 316
- hotplug . . . 196, 197
- httpd.conf . . . 253
- ifcfg-* . . . 315
- inittab . . . 274, 280, 282
- intersync . . . 410
- irda . . . 231
- kernel . . . 262
- krb5.conf . . . 487, 489, 492
- krb5.keytab . . . 491
- language . . . 275, 276
- lilo.conf . . . 83–261
- logrotate.conf . . . 255
- lpd.conf . . . 137
- lpdfilter . . . 144
- menu.lst . . . 248, 260
- modules.conf . . . 246
- modules.dep . . . 246
- named.conf . . . 323–331, 450
- netatalk . . . 431
- netatalk.conf . . . 431, 435
- network . . . 208, 315
  · providers . . . 444
- networks . . . 316
- nscd.conf . . . 319
- nsswitch.conf . . . 317, 349

- nwserv.conf . . . 437
- openldap . . . 494
- options . . . 465
- pam_unix2.conf . . . 348, 492
- papd.conf . . . 434
- pcmcia . . . 201, 202, 204, 206
- permissions . . . 506
- powermanagement . . . 220, 224, 227
- printcap . . . 137, 143
- profile . . . 253, 256, 276
- rc.config . . . 45, 288
- resolv.conf . . . 257, 319, 323, 449
- routes . . . 321
- samba . . . 427
- services . . . 427
- slapd.conf . . . 339, 495, 496
- smb.conf . . . 157, 422, 423
- smppd.conf . . . 442
- smpppd-c.conf . . . 443
- squid . . . 450
- squid.conf . . . 449–456, 459, 461
- squidguard.conf . . . 461
- ssh_config . . . 493
- sshd_config . . . 474, 493
- suseconfig . . . 289
- sysconfig . . . 45, 288–289
- syslinux.cfg . . . 261
- wireless . . . 315
- XF86Config . . . 95–113
· Device . . . 108
· Monitor . . . 109
· Screen . . . 107
configuring . . . 288
- boot loaders
· GRUB . . . 73
- DNS . . . 323
- IPv6 . . . 313
- IrDA . . . 231
- Netatalk . . . 431
- networks
· manually . . . 313–322
- printing . . . 126–131
- routing . . . 321
- Samba . . . 423–428
- Squid . . . 450
- X . . . 96–105
consoles
- assigning . . . 274
- graphical
· disabling . . . 15
- switching . . . 274
core files . . . 256
Crash . . . 539
cron . . . 253
CVS . . . 405, 414–416

D
daemons
- lpd . . . 137
depmod . . . 246
DHCP . . . 368–372
- dhcpd . . . 369–370
- packages . . . 368
- server . . . 369–370
- static address assignment . . . 371
digital cameras
- hotplugging . . . 196
disks
- boot
· creating . . . 90
· creating in DOS . . . 19
· creating in UNIX . . . 20
· creating with dd . . . 20
· creating with rawrite . . . 19
· custom kernel and . . . 21
· using . . . 21
- floppy
· formatting . . . 20
- hard
· parallel use of . . . 26
- module
· creating with rawrite . . . 20
· creating in UNIX . . . 21
DNS . . . 300–301
- BIND . . . 323–331
- configuring . . . 323–331
- forwarding . . . 324
- logging . . . 326
- mail exchanger . . . 301
- NIC . . . 301
- options . . . 325
- reverse lookup . . . 330
- security and . . . 504
- Squid and . . . 450
- starting . . . 323
- top level domain . . . 301
- troubleshooting . . . 323
- zones . . . 327
· files . . . 328
domain name system . . . *see* DNS
DOS
- sharing files . . . 422

E
e-mail
- synchronizing . . . 405

· mailsync 416–419
e2fsck
- man page 535
editors
- Emacs 258–259
Emacs 258–259
- .emacs 258
- default.el 258
environment variables
- CUPS_SERVER 152
environment variables
- PRINTER 139

F
fdisk 88
- mbr 88
FHS .... *see* file systems, FHS
file systems 511–520
- access control lists 521–533
- Ext2 513
- Ext3 514–515
- FHS 252
- JFS 516
- limitations 519
- ReiserFS 515–516
- repairing 273
- selecting 512
- supported 518
- terms 512
- TeX and 252
- usbdefs 195
- XFS 517
files
- finding 46
- large 519
- printing 139, 141, 159, 162
- synchronizing
· CVS 405, 414–416
· InterMezzo 404, 409–411
· mailsync 405, 416–419
· Unison 405, 412–413
- syncronizing 403–419
firewalls 464–470
- packet filters 464, 466
- Squid and 456
- SuSEfirewall2 .... 464, 466–470
fonts
- Asian 110
- encodings 111
- Unicode 112
- X 110
FTP
- servers 252
FTP server 47

G
Ghostscript 163–166
- drivers 122
GNU
- GPL 543–550
graphics
- 3D 113–115
· 3Ddiag 114
· diagnosing 114
· permissions 114
· testing 114
· troubleshooting 114
- cards
· drivers 109
- GLIDE 113–115
- OpenGL 113–115
· drivers 113
· testing 114
graphics cards
- 3D 113–115
· drivers 113
· installation support for 115
· support for 113
- clock chips 103
- FireGL 9
- nVidia 113
groups
- name changes 46
GRUB 73
- /etc/grub.conf 79
- boot menu 74
- boot password 80
- device names 75
- GRUB shell 80
- partition names 75
- troubleshooting 81
- uninstalling 88
gs .... *see* Ghostscript

H
harden_suse 47
hardware
- CD-ROM drives
· ATAPI 22
· supported 22
- graphics cards
· FireGL 9
- Promise controller 41
help
- info pages 256
- man pages 256

- X 109
hotplugging 193–198
- cameras 196
- coldplugging 194
- configuring 195
- keyboards 196
- mice 196
- network devices 196
- network interfaces 197
- PCI 196
- PCMCIA 196
- storage devices 195
- USB 195
HTTP server *see* Apache

I
I18N 275
id 114
inetd 48
info pages 256
init 280
- adding scripts 285
- inittab 280
- scripts 283–286
insmod 245
installation
- packages 50
installation support
- 3D graphics cards and 115
installing
- boot loader 15
- GRUB 73
- kernel modules 11
- linuxrc 9
- network, from 17–18
- PCMCIA 208
- text-based 8–14
Internet
- cinternet 443
- dial-up 442–443
- kinternet 443
- smpppd 442–443
- web server *see* Apache
IP addresses 297–301
- classes 298
- dynamic assignment 368
- IPv6 302
· configuring 313
- masquerading 464–465
- netmasks 298–300
- private 300
IPX *see* MARSNWE
IrDA 230–233
- configuring 231
- starting 231
- stopping 231
- troubleshooting 232

J
jade *see* SGML, openjade
`jade_dsl` 48

K
Kerberos 475–481
- administering 481–496
- authenticators 476
- clients
· configuring 486–489
- clock skew 489
- clock synchronization 483
- configuring
· clients 486–489
- credentials 476
- installing 481–496
- kadmin 490
- KDC 482–486
· administering 489
· nsswitch.conf 483
· resolv.conf 483
· starting 486
- keytab 491
- LDAP and 494–496
- logging 484
- master key 484
- PAM support 492
- principals 476
· creating 486
· host 491
- realms 482
· creating 485
- session key 477
- SSH configuration 493
- ticket-granting service 479
- tickets 476, 479
kernel
- module
· parport 132
kernel parameters
- APM 45
kernels 241–249
- caches 257
- compiling 241–249
- configuring 243–247
- errors messages 247
- installing 248–249
- Kmod 246–247

- limits . . . 520
- modules . . . 244–247
· network card . . . 311
· PCMCIA . . . 200
- modules.conf . . . 246
- pcmcia . . . 204
- problems . . . 262
- sources . . . 243
- System.map . . . 249
- transparent proxies and . . . 456
keyboard
- configuring with xf86config . . . 97
- layout . . . 274
- mapping . . . 274
· compose . . . 274
· multikey . . . 274
Kmod . . . 246–247

L
L10N . . . 275
LANs
- configuring . . . 311–322
- wireless . . . 312
laptops . . . 199–210
- IrDA . . . 230–233
- power management . . . 217–230
LDAP . . . 334–357
- access control . . . 342
- ACLs . . . 340
- adding data . . . 344
- administering groups . . . 353
- administering users . . . 353
- configuring
· YaST . . . 348
- deleting data . . . 347
- directory tree . . . 336
- Kerberos and . . . 494–496
- ldapadd . . . 344
- ldapdelete . . . 347
- ldapmodify . . . 346
- ldapsearch . . . 347
- modifying data . . . 346
- searching data . . . 347
- server configuration . . . 339
- YaST
· modules . . . 350
· templates . . . 350
Lightweight Directory Access Protocol . . . *see* LDAP
LILO . . . 82–90
- boot sector, in . . . 83
- booting with another boot manager 83
- configuring . . . 15, 83
- floppy disk, on . . . 83
- installing . . . 87
- lilo.conf . . . 84
- map files . . . 82
- MBR . . . 83
- memory test . . . 87
- message files . . . 82
- other systems . . . 87
- parameters . . . 85
- uninstalling . . . 88, 90
- updating . . . 87–88
Linux
- networks and . . . 293
- sharing files with another OS . 422, 430
- uninstalling . . . 88
Linux Standard Base . . . 252
Local Area Networks . . . *see* LANs
locate . . . 46
log files . . . 254
- boot.msg . . . 222
- installation . . . 44
- InterMezzo . . . 411
- messages . . 195, 197, 202, 205, 323, 370, 469
- Squid . . . 450, 452, 458
- Unison . . . 413
- XFree86 . . . 115
- XFree86.0.log . . . 95
logging
- logrotate . . . 254
· configuring . . . 255
Logical Volume Manager . . . *see* LVM
logrotate . . . 254
lprsetup . . . 137
LSB . . . *see* Linux Standard Base
LSB (Linux Standard Base)
- installing packages . . . 50
lsmod . . . 246
LVM
- YaST . . . 29

M
MacOS
- sharing files . . . 430
man pages . . . 256
MARSNWE . . . 437–440
- configuring . . . 437–439
- IPX . . . 437, 440
- permissions . . . 439
- printing . . . 439
- starting . . . 437
masquerading . . . 464–465
- configuring with SuSEfirewall2 . . . 467

- ipchains 465
- iptables 465
- problems 465
Master Boot Record *see* MBR
MBR 70
- LILO 83
memory
- RAM 257
modinfo 246
modprobe 246
modules
- loading 265
- parameters 265
monitors
- configuring with xf86config 98
mountd 367
mouse
- configuring with xf86config 96
- emulating middle button 97
- types 96

N
name servers *see* DNS
NAT *see* masquerading
Netatalk 430–436
- afpd 430
- AppleDouble 433
- atalkd 430
- configuring 431–434
- guest servers 431
- papd 430
- permissions 432
- printing 434–435
- restrictions 430
- starting 435
- TCP/IP and 432
Netware
- administering from Linux 440
- emulating 437–440
network
- printing in 173
Network
- printing 154
Network File System *see* NFS
Network Information Service *see* NIS
networks 293
- authentication
· Kerberos 475–481
- base network address 300
- broadcast address 300
- configuration files 315–320
- configuring 311, 313–322
· IPv6 313
- DHCP 368
- DNS 300–301
- integrating 311–322
- IP addresses 297–301
- localhost 300
- netmasks 298
- routing 297–300
- TCP/IP 294
- testing cards 311
NFS 364–367
- clients 364
- exporting 365
- importing 364
- mounting 364
- permissions 366
- servers 365–367
nfsd 367
NIS 358–363
- autofs 46
- clients 362
- masters 358–361
- slaves 358–361
Notebook
- SCPM 210
notebooks *see* laptops, *see* laptops
NSS 317
- databases 318
nVidia 48

O
OpenOffice.org
- printing
· Cups 157
OpenSSH *see* SSH
OS/2
- sharing files 422

P
package
- `a2ps` 166
- `aaa_base` 254
- `alsa-devel` 50
- `apache` 380, 381
- `apache-devel` 381
- `apache-doc` 381
- `apache-example-pages` 381
- `apache2` 380, 381
- `apache2-devel` 381
- `apache2-doc` 381
- `apache2-example-pages` 381
- `apache2-mod_php4` 394
- `apache2-mod_python` 395
- `apache2-prefork` 381

- apache2-worker 381
- apmd 219–221
- binutils 243
- build 58
- bzip 47
- bzip2 47
- cups 127, 153, 156, 159
- cups-client 127, 158, 159, 191
- cups-drivers 49, 127, 153
- cups-drivers-stp 127, 153, 156
- cups-libs 127
- docbook-toys 48
- emacs 258
- emacs-auctex 259
- emacs-el 258
- emacs-info 258
- emacs-nox 258
- emacs-x11 258
- fhs 252
- find-locate 46
- footmatic-filters 49, 127
- ftpdir 47, 252
- gcc 243
- Ghostscript 127
- ghostscript-fonts-std 128
- ghostscript-library 128
- ghostscript-x11 128
- gimp-devel 50
- glibc 57
- glibc-devel 243
- glibc-info 277
- gnuserv 259
- howtoen 462, 466
- ipxrip 440
- irda 136, 231
- isapnp 45
- jade_dsl 48
- kbd 45
- KDE 127
- kdelibs-devel 50
- kernel-source 243
- km_intersync 410
- libcinfo 317
- libgimpprint 128
- libz 47
- logrotate 254
- lpdfilter 127
- lprng 127, 137, 191
- lvm 45
- mailsync 419
- mesa 115
- mesa3dfx 115
- mod_perl 381
- mod_php4 381, 394
- mod_php4-core 394
- mod_python 381, 395
- ncpfs 439, 440
- netatalk 430
- NVIDIA_kernel 48
- openjade 48
- openldap 47
- openldap2 47
- pcmcia 207, 209
- pcmcia-cardinfo 209
- pcmcia-modules 209
- pmtools 225
- popt 47
- popt-devel 47
- postgres 41
- proxy-suite 466
- psgml 258, 259
- psutils 145, 167, 168
- rpm 47, 57
- rpm-devel 47
- rzsz 48
- samba 423
- Samba 127
- samba-client 154, 156
- sdb_en 45
- squidGuard 461
- su1 47
- sudo 47
- SuSEfirewall2 152, 464
- syslinux 21, 91
- sysvinit 57
- tcl 244
- tk 244
- tpctl 219
- unison 413
- wget 56
- Wine 127
- xf86 244
- XFree86-doc 115
- xntp-doc 374
- yast2-trans-* 47
- yast2-trans-cs 47
- yast2-trans-de 47
- yast2-trans-es 47
- yudit 112
- zlib 47
- zlib-devel 47

packages
- building 49
- compiling 56
- compiling with build 58
- installing 50

- LSB 50
- package manager 49
- RPMs 49
- uninstalling 50
- verifying 50

packet filters *see* firewalls

partitioning
- fdisk 88
- partition table 70
- YaST 28

partitions
- expert partitioning 23
- partition table 70
- swap 24

PCI
- hotplugging 196

PCMCIA 200–210
- booting from 203
- card manager 201
- cardctl 209
- configuring 202–204
- driver assignment 206
- hotplugging 196
- IDE 203
- installing with 208
- IrDA 230–233
- ISDN 203
- modems 203
- modules 201
- network cards 203, 313
- problems 204
- removing cards 202
- restarting 201
- SCSI 203
- starting
  · preventing 205
- supported cards 200
- switching configurations 204
- systems 200
- troubleshooting 204
- utilities 209

permissions
- ACLs 521–533
- file permissions 255

pine 46

ports
- scanning 458

PostgreSQL
- updating 41

PostScript
- reformatting 167–171

power management 217–230
- ACPI 217, 221–229
- APM 217, 219–221
- hibernation 218
- standby 218
- suspend 218

printing 117
- a2ps 166
- applications, from 131, 158
- banner (cover) page 131
- command line 138
- command line, from the 159
- configuration
  · Lprng and lpdfilter 137
  · Lprng and lpdfilter 137
  · ports 132–136
- Configuration
  · CUPS 153–154
- configuring 126
  · YaST 126
- CUPS 126, 152–158
  · OpenOffice.org 157
  · trouble shooting 162
  · troubleshooting 158
- CUPS network server 174
- CUPS server 174
- cups-lpd 174
- drivers 122–125
- duplex 146
- files 139, 141, 159, 162
- filters 118
  · configuring 144
  · customizing 144–145
  · example 145
  · lpdfilter 142–151
  · troubleshooting 151
- footmatic-filters 49
- GDI printer 124–125
  · Configuration 149
  · supported 125
- Ghostscript
  · drivers 122–123
- Ghostscript drivers 122
- IPP 152
- IPP server 174
- IrDA 232
- jobs
  · processing 155
- languages 118
- lpc 140
- LPD server 174
- lpq 141
- lpr 139, 141
- LPRng 49, 127
  · commands 138

- lprsetup 137
- network 173
  · troubleshooting 188
- network printers 154
- PPD 153
- print jobs
  · deleting 160, 162
  · status 160
- Print jobs
  · removing 139, 141
  · status 139, 141
- print queues 126, 130
  · color 126
- print server 173
- print server box 173
- processing 155
- protocols 175
- queues 118
  · controlling 140–141
  · managing 159–162
  · options 160
  · raw 143, 157
  · remote 141
  · removing jobs 139, 141
  · status 139, 141, 160, 162
  · Tools 139–142
  · within the net 161–162
- Requirements 122
- Samba 423
- spooler 118
  · lpd 137–138
- supported printers 122
- troubleshooting 142
  · CUPS 158, 162
  · network 188
Printing
- Ghostscript 163
- printer languages
  · ESC 118
- printer languages 118
  · ASCII 118
  · PCL 118
  · PostScript 118
- Printing Basics 118–121
- Processing 118–119
printing system *see* spooling system
protocols
- IPP 152
- SMB 422
proxies
- advantages 446
- caches 445
- Squid 445–462
- transparent 455

R

RAID
- soft 35
`reiserfsck` 539
remote login 46
rescue system 267
- preparing 268
- starting 270
- using 271
RFCs 294
rmmod 245
routing 297, 321–322
- masquerading 464–465
- netmasks 298–300
- routes 321
- static 321
RPM 49
- database
  · rebuilding 52, 56
- dependencies 51
- patches 52
- queries 54
- rpmnew 50
- rpmorig 50
- rpmsave 50
- security 507
- SRPMS 57
- tools 59
- uninstalling 52
- updating 51
- verify 55
- verifying 50
- version 4 49
rpmbuild 49
runlevels 280–283
- changing 282–283
- editing in YaST 286

S

Samba 422–429
- clients 422–423, 428
- configuring 423–428
- help 429
- installing 423
- login 427
- names 422
- NetBIOS 422
- optimizing 429
- permissions 426
- printers 423
- printing 428

- security 426–427
- servers 423–428
- shares 423, 424
- SMB 422
- starting 423
- stopping 423
- swat 427
- TCP/IP and 422

SaX2
- 3D graphics 114

SCPM 204, 210
- configuring 212
- managing profiles 212

scrips
- acpid_proxy 227

script
- lpdfilter
  · guess 143

scripts
- apmd_proxy 221
- checkhotmounts 195
- hotplug 194, 196, 201
- ifup 197
- init.d 280, 283–286, 321
  · boot 284
  · boot.local 284
  · boot.setup 284
  · halt 284
  · inetd 321
  · netatalk 435
  · network 321
  · nfsserver 321, 366
  · portmap 321, 366
  · rc 282–284
  · sendmail 321
  · squid 449
  · ypbind 321
  · ypserv 321
- irda 231
- lpdfilter 142
  · guess 143
- mkinitrd 262
- modify_resolvconf 257, 320
- pcmcia 201, 313
  · network 207
- rchotplug 195
- SuSEconfig 288–289
  · disabling 289

security 464–470, 496, 508
- attacks 503–505
- booting 498–499
- bugs and 500, 503
- DNS 504
- firewalls 464–470
- local 498–502
- network 502–505
- passwords 498–499
- permissions 500
- reporting problems 507
- RPM signatures 507
- Samba 426
- serial terminals 498
- social engineering 497
- Squid 446
- SSH 470–475
- tcpd 507
- tips and tricks 505
- viruses 501
- worms 505
- X and 502

serial ports
- USB 135

serial ports
- IrDA 136
- parallel 132–134
- serial 136
- USB 134

series
- `doc` 45

SGML
- openjade 48

SMB .... *see* Samba

software
- compiling 56

source
- compiling 56

spm 56

spooling system 117

Squid 445–462
- access controls 459
- ACLs 453
- Apache 458
- cachemgr.cgi 458–460
- caches 445, 446
  · size 448
- Calamaris 462
- configuring 450–455
- CPU and 449
- directories 449
- DNS 450
- features 446
- firewalls and 456
- log files 450, 452, 458
- object status 447
- permissions 449, 453
- protocols 446

- RAM and 449
- reports 462
- SARG 462
- security 446
- squidGuard 460–461
- starting 449
- statistics 458–460
- stopping 450
- system requirements 448
- transparent proxies 455–458
- troubleshooting 450
- uninstalling 450

SSH 470–475
- authentication mechanisms 473
- daemon 472
- key pairs 472, 473
- scp 471
- sftp 472
- ssh 471
- ssh-agent 474
- ssh-keygen 473
- sshd 472
- X and 474

sx 48

system
- freezes 15
- information 264
- limiting resource use 256
- localizing 275
- optimizing 26
- rescuing 267
- resources
  · viewing 207
- updating 39–49, 59

system services, configuring *see* sysconfig

T

T-DSL *see* ADSL

TCP/IP 294–297
- ICMP 295
- IGMP 295
- layer model 295–297
- packets 295, 296
- services 294
- TCP 294
- UDP 294

U

ulimit 256
- options 256

uninstalling
- GRUB 88
- LILO 88
- Linux 88

update
- /etc/skel 44
- profile 44

updating 39–49, 59
- base system 42
- loadlin 44
- log files 44
- manually 42
- problems 41, 44
- YaST 42

USB
- connecting devices 195
- file system 195

USB stick
- booting from 71

users
- name changes 46

V

Variable
- `ACPI_BUTTON_LID` 227
- `ACPI_BUTTON_POWER` 227
- `APMD_AC` 220
- `APMD_BATTERY` 220
- `APMD_PCMCIA_EJECT_ON_SUSPEND` 220
- `HOME` 40
- `HTTPD_SEC_PUBLIC_HTML` 387
- `PATH` 3, 390
- `QUERY_STRING` 390

variables
- environment 275

W

web server *see* Apache

web servers
- setting up 253

whois 301

Windows
- sharing files 422

X

X 93–95
- configuring 96–105
  · keyboard 97
  · monitors 98
  · mouse 96
- drivers 109
- fonts 110
- graphics cards 99
- help 109
- history 94

- modules 95
- optimizing 105–113
- SaX2 105
- security 502
- servers 99
- SSH and 474
- virtual screen 108
- xf86config 96–105
- XFree86 94

X Window System ..... *see* X
xinetd 48
XML
- catalog 49
- openjade 48

Y

YaST 45
- 3D 113
- LVM 29
- network configuration 311–313
- NIS clients 362
- partitioning 28
- printing 126
  · suppressing autodetection 126
- runlevel editor 286
- soft RAID 35
- sysconfig editor 289
- text mode 63–68
  · modules 66
- text-based 8–14
  · troubleshooting 8
- updating 42
- YOU
  · cron 67–68
  · text-mode 67

YP ..... *see* NIS