



System Administration Guide, Volume II

Sun Microsystems, Inc.
901 San Antonio Road
Palo Alto, CA 94043
U.S.A.

Part No: 805-3728-10
October 1998

Copyright 1998 Sun Microsystems, Inc. 901 San Antonio Road, Palo Alto, California 94303-4900 U.S.A. All rights reserved.

This product or document is protected by copyright and distributed under licenses restricting its use, copying, distribution, and decompilation. No part of this product or document may be reproduced in any form by any means without prior written authorization of Sun and its licensors, if any. Third-party software, including font technology, is copyrighted and licensed from Sun suppliers.

Parts of the product may be derived from Berkeley BSD systems, licensed from the University of California. UNIX is a registered trademark in the U.S. and other countries, exclusively licensed through X/Open Company, Ltd.

Sun, Sun Microsystems, the Sun logo, SunSoft, SunDocs, SunExpress, Solstice, Solstice AdminSuite, Solstice Disk Suite, Solaris Solve, Java, JavaStation, DeskSet, OpenWindows and Solaris are trademarks, registered trademarks, or service marks of Sun Microsystems, Inc. in the U.S. and other countries. All SPARC trademarks are used under license and are trademarks or registered trademarks of SPARC International, Inc. in the U.S. and other countries. Products bearing SPARC trademarks are based upon an architecture developed by Sun Microsystems, Inc. DecWriter, LaserWriter, Epson, NEC, Adobe

The OPEN LOOK and Sun™ Graphical User Interface was developed by Sun Microsystems, Inc. for its users and licensees. Sun acknowledges the pioneering efforts of Xerox in researching and developing the concept of visual or graphical user interfaces for the computer industry. Sun holds a non-exclusive license from Xerox to the Xerox Graphical User Interface, which license also covers Sun's licensees who implement OPEN LOOK GUIs and otherwise comply with Sun's written license agreements.

RESTRICTED RIGHTS: Use, duplication, or disclosure by the U.S. Government is subject to restrictions of FAR 52.227-14(g)(2)(6/87) and FAR 52.227-19(6/87), or DFAR 252.227-7015(b)(6/95) and DFAR 227.7202-3(a).

DOCUMENTATION IS PROVIDED "AS IS" AND ALL EXPRESS OR IMPLIED CONDITIONS, REPRESENTATIONS AND WARRANTIES, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT, ARE DISCLAIMED, EXCEPT TO THE EXTENT THAT SUCH DISCLAIMERS ARE HELD TO BE LEGALLY INVALID.

Copyright 1998 Sun Microsystems, Inc. 901 San Antonio Road, Palo Alto, Californie 94303-4900 Etats-Unis. Tous droits réservés.

Ce produit ou document est protégé par un copyright et distribué avec des licences qui en restreignent l'utilisation, la copie, la distribution, et la décompilation. Aucune partie de ce produit ou document ne peut être reproduite sous aucune forme, par quelque moyen que ce soit, sans l'autorisation préalable et écrite de Sun et de ses bailleurs de licence, s'il y en a. Le logiciel détenu par des tiers, et qui comprend la technologie relative aux polices de caractères, est protégé par un copyright et licencié par des fournisseurs de Sun.

Des parties de ce produit pourront être dérivées du système Berkeley BSD licenciés par l'Université de Californie. UNIX est une marque déposée aux Etats-Unis et dans d'autres pays et licenciée exclusivement par X/Open Company, Ltd.

Sun, Sun Microsystems, le logo Sun, SunSoft, SunDocs, SunExpress, Solstice, Solstice AdminSuite, Solstice DiskSuite, Solaris Solve, Java, JavaStation, DeskSet, OpenWindows et Solaris sont des marques de fabrique ou des marques déposées, ou marques de service, de Sun Microsystems, Inc. aux Etats-Unis et dans d'autres pays. Toutes les marques SPARC sont utilisées sous licence et sont des marques de fabrique ou des marques déposées de SPARC International, Inc. aux Etats-Unis et dans d'autres pays. Les produits portant les marques SPARC sont basés sur une architecture développée par Sun Microsystems, Inc. DecWriter, LaserWriter, Epson, NEC, Adobe

L'interface d'utilisation graphique OPEN LOOK et Sun™ a été développée par Sun Microsystems, Inc. pour ses utilisateurs et licenciés. Sun reconnaît les efforts de pionniers de Xerox pour la recherche et le développement du concept des interfaces d'utilisation visuelle ou graphique pour l'industrie de l'informatique. Sun détient une licence non exclusive de Xerox sur l'interface d'utilisation graphique Xerox, cette licence couvrant également les licenciés de Sun qui mettent en place l'interface d'utilisation graphique OPEN LOOK et qui en outre se conforment aux licences écrites de Sun.

CETTE PUBLICATION EST FOURNIE "EN L'ETAT" ET AUCUNE GARANTIE, EXPRESSE OU IMPLICITE, N'EST ACCORDEE, Y COMPRIS DES GARANTIES CONCERNANT LA VALEUR MARCHANDE, L'APTITUDE DE LA PUBLICATION A REpondre A UNE UTILISATION PARTICULIERE, OU LE FAIT QU'ELLE NE SOIT PAS CONTREFAISANTE DE PRODUIT DE TIERS. CE DENI DE GARANTIE NE S'APPLIQUERAIT PAS, DANS LA MESURE OU IL SERAIT TENU JURIDIQUEMENT NUL ET NON AVENU.



Contents

About This Book xxix

Part I Managing Printing Services

- 1. Print Management (Overview)** 3
 - The Solaris Print Software 3
 - Redesign of Print Packages 4
 - Print Protocol Adaptor 5
 - Using Print Clients 5
 - Enhanced Network Printer Support 6
 - Printing in the Solaris Operating Environment 6
 - Choosing a Method to Manage Printers 7
 - The LP Print Service 8
 - Managing Network Printers 9
 - Administering Printers 9
 - Setting Definitions for Printers 9
 - Administering Character Sets, Filters, Forms, and Fonts 10
 - Customizing the LP Print Service 10
 - Using the Print Client Software 10
 - The Print Client Process 11
 - Print Clients 11

	Printer Configuration Resources	12
	Using Print Servers	15
2.	Planning Printers on Your Network (Overview)	17
	Distributing Printers on the Network	17
	Assigning Print Servers and Print Clients	18
	Print Server Requirements and Recommendations	20
	Spooling Space	20
	Disk Space	20
	Memory	21
	Swap Space	21
	Hard Disk	21
	Planning for Printer Setup	21
	Setting Definitions for Printers	21
	Selecting a Printer Type	25
	Selecting a File Content Type	26
3.	Setting Up Printers (Tasks)	29
	Updating Print Clients to Access Existing Printers	30
	Updating Print Clients to Access Existing Printers Task Map	30
	Converting Existing Printer Configuration Information	31
	▼ How to Convert Printer Information For a System Running the SunOS 5.5.1 Release or Compatible Versions	32
	▼ How to Convert Printer Information For a System Running the SunOS 4.1 Release	32
	Setting Up Printing	33
	Setting Up Printing Task Map	33
	Starting Admintool	35
	▼ How to Start Admintool	35
	Setting Up a Print Server	36
	▼ How to Add a Local Printer Using Admintool	36

▼	How to Add a Local Printer Using LP Commands	38
	Setting Up a Print Client	41
▼	How to Add Printer Access on the Print Client Using Admintool	42
▼	How to Add Access on the Print Client using LP Commands	43
	Adding Access to a Remote Printer Using a Name Service	44
▼	How to Add Domain-Wide Access to a Printer using NIS	44
▼	How to Add Domain-Wide Access to a Printer using NIS+	45
	Enabling Print Clients to Access Existing Printers	46
▼	How to Use the <code>/etc/printers.conf</code> File to Load NIS	46
▼	How to Use the <code>/etc/printers.conf</code> File to Load NIS+	47
	Setting Up a <code>.printers</code> File	47
	(Optional) How to Set Up a <code>.printers</code> File	48
	Adding a Network Printer	48
	Printer Vendor Supplied Software for Network Printers	50
	Sun Support for Network Printers	50
	Invoking the Network Printer Support	50
	Selecting the Protocol	50
	Selecting the Printer Node Name	51
	Selecting the Network Printer Access Name	51
	Setting the Timeout Value	52
	Managing Network Printer Access	52
▼	How to Add a Network Printer Using Printer Vendor Supplied Tools	53
▼	How To Add A Network Printer Using LP Commands	54
4.	Administering Printers (Tasks)	59
	Managing Printers and the Print Scheduler	60
	Deleting Printers and Printer Access	60
▼	How to Delete a Printer and Remote Printer Access	60
	Checking Printer Status	63

- ▼ How to Check the Status of Printers 63
 - Restarting the Print Scheduler 65
- ▼ How to Stop the Print Scheduler 65
- ▼ How to Restart the Print Scheduler 66
- Setting or Resetting Miscellaneous Printer Definitions 66
 - ▼ How to Add a Printer Description 66
 - Setting Up a Default Printer Destination 67
 - ▼ How to Set a System's Default Printer 68
 - Printing Banner Pages 68
 - ▼ How to Make Banner Pages Optional 69
 - ▼ How to Turn Off Banner Pages 70
 - Setting Up Printer Classes 70
 - ▼ How to Define a Class of Printers 71
 - Setting Up Printer Fault Alerts 71
 - ▼ How to Set Fault Alerts for a Printer 72
 - Setting Up Printer Fault Recovery 73
 - ▼ How to Set Printer Fault Recovery 75
 - Limiting User Access to a Printer 75
 - ▼ How to Limit User Access to a Printer 77
- Managing Print Requests 78
 - ▼ How to Check the Status of Print Requests 79
 - Processing or Stopping Printing 81
 - ▼ How to Accept or Reject Print Requests for a Printer 81
 - Accepting or Rejecting Print Requests 82
 - ▼ How to Enable or Disable a Printer 84
 - Canceling a Print Request 85
 - ▼ How to Cancel a Print Request 85
 - ▼ How to Cancel a Print Request From a Specific User 86

	Moving a Print Request	87
▼	How to Move Print Requests to Another Printer	88
	Changing the Priority of Print Requests	89
▼	How to Change the Priority of a Print Request	89
5.	Managing Character Sets, Filters, Forms, and Fonts (Tasks)	91
	Managing Character Sets	92
	Selectable Character Sets	92
	Hardware-Mounted Character Sets	93
	Tracking Print Wheels	94
	Alerts for Mounting Print Wheels or Cartridges	94
▼	How to Define a Print Wheel or Font Cartridge	94
▼	How to Unmount and Mount a Print Wheel or Font Cartridge	95
▼	How to Set an Alert to Mount a Print Wheel or Font Cartridge	96
▼	How to Set Up an Alias for a Selectable Character Set	98
	Managing Print Filters	100
	Creating Print Filters	100
	Adding, Changing, Removing, and Restoring Print Filters	101
▼	How to Add a Print Filter	102
▼	How to Delete a Print Filter	103
▼	How to View Information About a Print Filter	103
	Managing Forms	105
	Adding, Changing, or Deleting Forms	105
	Mounting Forms	106
	Tracking Forms	106
	Defining Alerts for Mounting Forms	106
	Checking Forms	106
	Limiting Access to Forms	107
▼	How to Add a Form	107

- ▼ How to Delete a Form 108
- ▼ How to Unmount and Mount a Form 108
- ▼ How to Set an Alert to Mount a Form 110
- ▼ How to View Information About a Form 112
- ▼ How to View the Current Status of a Form 113
- ▼ How to Limit User Access to a Form 113
- ▼ How to Limit Printer Access to a Form 114
- Managing Fonts 115
 - Managing Printer-Resident Fonts 116
 - Downloading Host-Resident Fonts 117
 - Installing and Maintaining Host-Resident Fonts 117
 - ▼ How to Install Downloaded PostScript Fonts 118
 - ▼ How to Install Host-Resident PostScript Fonts 118
- 6. Customizing the LP Print Service (Tasks) 121**
 - Adjusting Printer Port Characteristics 121
 - ▼ How to Adjust the Printer Port Characteristics 123
 - Adding a `terminfo` Entry for an Unsupported Printer 124
 - ▼ How to Add a `terminfo` Entry for an Unsupported Printer 127
 - Customizing the Printer Interface Program 128
 - The Standard Printer Interface Program 129
 - Customizing `stty` Modes 129
 - Exit Codes 130
 - Fault Messages 131
 - Using a Customized Printer Interface Program 131
 - ▼ How to Set Up a Custom Printer Interface Program 131
 - Creating a New Print Filter 133
 - Writing a Print Filter Program 133
 - Creating a Print Filter Definition 136

- ▼ How to Create a New Print Filter 142
- Creating a New Printer Form 144
- ▼ How to Create a New Form Definition 147
- 7. **LP Print Service Reference Information 149**
 - The LP Print Service 149
 - The Structure of the LP Print Service 150
 - LP Print Service Commands 158
 - Functions of the LP Print Service 160
 - How LP Administers Files and Schedules Local Print Requests 160
 - Scheduling Network Print Requests 162
 - Filtering Print Files 162
 - What the Printer Interface Program Does 162
 - How the `lpsched` Daemon Tracks the Status of Print Requests 163
 - Cleaning Out Log Files 163
 - ▼ How to Change Frequency of Printer Request Log Rotation 164
 - How Local Printing Works 164
 - How Remote Printing Works 165
- Part II Working With Remote Systems**
- 8. **Working With Remote Systems (Tasks) 171**
 - Logging In to a Remote System (`rlogin`) 172
 - Authentication for Remote Logins (`rlogin`) 172
 - Linking Remote Logins 175
 - Direct vs. Indirect Remote Logins 176
 - What Happens After You Log In Remotely 178
 - ▼ How to Search for and Remove `.rhosts` Files 179
 - ▼ How to Find Out If a Remote System Is Operating 180
 - ▼ How to Find Who Is Logged In to a Remote System 181
 - ▼ How to Log In to a Remote System (`rlogin`) 181

- ▼ How to Log Out From a Remote System (`exit`) 182
- Logging In to a Remote System (`ftp`) 183
 - Authentication for Remote Logins (`ftp`) 183
 - Essential `ftp` Commands 183
 - ▼ How to Open an `ftp` Connection to a Remote System 185
 - ▼ How to Close an `ftp` Connection to a Remote System 186
 - ▼ How to Copy Files From a Remote System (`ftp`) 186
 - ▼ How to Copy Files to a Remote System (`ftp`) 188
 - Remote Copying With `rcp` 191
 - Security Considerations for Copy Operations 191
 - Specifying Source and Target 191
 - ▼ How to Copy Files Between a Local and a Remote System (`rcp`) 193
- Part III Managing Terminals and Modems**
- 9. Managing Terminals and Modems (Overview) 201**
 - Terminals, Modems, Ports, and Services 201
 - Terminals 202
 - Modems 202
 - Ports 202
 - Services 203
 - Port Monitors 203
 - Tools for Managing Terminals and Modems 204
 - Admintool 205
 - Service Access Facility 206
- 10. Setting Up Terminals and Modems (Tasks) 207**
 - Setting Up Terminals and Modems 207
 - Setting Up Terminals 210
 - Setting Up Modems 211
 - ▼ How to Start Admintool 213

- ▼ How to Set Up a Terminal 214
- ▼ How to Set Up a Modem 215
- ▼ How to Set Up a Modem for Use With UUCP 217
- ▼ How to Initialize a Port 218
- ▼ How to Disable a Port 219
- ▼ How to Remove a Port Service 220

Troubleshooting Terminal and Modem Problems 221

11. **Setting Up Terminals and Modems With the Service Access Facility (Tasks) 223**

Using the Service Access Facility 223

Overall Administration: `sacadm` Command 225

Service Access Controller: SAC Program 225

SAC Initialization Process 225

Port Monitor Service Administrator: `pmadm` Command 226

A Port Monitor at Work: `ttymon` 226

Port Initialization Process 227

Bidirectional Service 228

Port Monitors: TTY Monitor and Network Listener 228

TTY Port Monitor: `ttymon` 228

`ttymon` and the Console Port 229

Special `ttymon`-Specific Administrative Command: `ttyadm` 230

Network Listener Service: `listen` 230

Special `listen`-Specific Administrative Command: `nlsadmin` 230

Administering `ttymon` Port Monitors 231

- ▼ How to Add a `ttymon` Port Monitor 231
- ▼ How to View `ttymon` Port Monitor Status 231
 - Example—Viewing `ttymon` Port Monitor Status 232
- ▼ How to Stop a `ttymon` Port Monitor 233

- ▼ How to Start a `ttymon` Port Monitor 233
- ▼ How to Disable a `ttymon` Port Monitor 233
- ▼ How to Enable a `ttymon` Port Monitor 233
- ▼ How to Remove a `ttymon` Port Monitor 234
- Administering `ttymon` Services 234
 - ▼ How to Add a Service 234
 - ▼ How to View the Status of a TTY Port Service 236
 - Example—Viewing the Status of a TTY Port Monitor Service 237
 - ▼ How to Enable a Port Monitor Service 238
 - ▼ How to Disable a Port Monitor Service 239
- Reference Material for Service Access Facility Administration 239
 - Files Associated With SAF 239
 - The `/etc/saf/_sactab` File 240
 - The `/etc/saf/pmtab/_pmtab` File 241
 - Service States 242
 - Port Monitor States 242
 - Port States 243
- Part IV Managing System Security**
- 12. Managing System Security (Overview) 247**
 - Where to Find System Security Tasks 247
 - Granting Access to a Computer System 248
 - Maintaining Physical Site Security 248
 - Maintaining Login and Access Control 248
 - Restricting Access to Data in Files 249
 - Maintaining Network Control 249
 - Monitoring System Usage 249
 - Setting the Correct Path 249
 - Securing Files 250

	Installing a Firewall	250
	Reporting Security Problems	250
	File Security	251
	File Administration Commands	251
	File Encryption	251
	Access Control Lists (ACLs)	252
	System Security	252
	Login Access Restrictions	253
	Special Logins	253
	Managing Password Information	254
	Using the Restricted Shell	255
	Tracking Superuser (Root) Login	256
	Network Security	256
	Firewall Systems	257
	Authentication and Authorization	258
	Sharing Files	260
	Restricting Superuser (Root) Access	260
	Using Privileged Ports	260
	Using Automated Security Enhancement Tool (ASET)	261
13.	Securing Files (Tasks)	263
	File Security Features	263
	User Classes	264
	File Permissions	264
	Directory Permissions	264
	Special File Permissions (setuid, setgid and Sticky Bit)	265
	Default umask	267
	Displaying File Information	267
	▼ How to Display File Information	267

Changing File Ownership	269
▼ How to Change the Owner of a File	269
▼ How to Change Group Ownership of a File	270
Changing File Permissions	271
▼ How to Change Permissions in Absolute Mode	274
▼ How to Change Special Permissions in Absolute Mode	275
▼ How to Change Permissions in Symbolic Mode	276
Searching for Special Permissions	277
▼ How to Find Files With <code>setuid</code> Permissions	277
Executable Stacks and Security	279
▼ How to Disable Programs From Using Executable Stacks	279
▼ How to Disable Executable Stack Message Logging	280
Using Access Control Lists (ACLs)	280
ACL Entries for Files	281
ACL Entries for Directories	282
▼ How to Set an ACL on a File	283
▼ How to Copy an ACL	285
▼ How to Check If a File Has an ACL	285
▼ How to Modify ACL Entries on a File	286
▼ How to Delete ACL Entries From a File	287
▼ How to Display ACL Entries for a File	288
14. Securing Systems (Tasks)	291
Displaying Security Information	291
▼ How to Display a User's Login Status	291
▼ How to Display Users Without Passwords	293
Temporarily Disabling User Logins	293
▼ How to Temporarily Disable User Logins	294
Saving Failed Login Attempts	294

- ▼ How to Save Failed Login Attempts 295
 - Password Protection Using Dial-Up Passwords 295
- ▼ How to Create a Dial-Up Password 298
- ▼ How to Temporarily Disable Dial-up Logins 300
 - Restricting Superuser (root) Access on the Console 300
- ▼ How to Restrict Superuser (root) Login to the Console 300
 - Monitoring Who Is Using the `su` Command 301
- ▼ How to Monitor Who Is Using the `su` Command 301
- ▼ How to Display Superuser (root) Access Attempts to the Console 302
- 15. Using Authentication Services (Tasks) 303**
 - Overview of Secure RPC 303
 - NFS Services and Secure RPC 304
 - DES Encryption 304
 - Diffie-Hellman Authentication 305
 - Kerberos Version 4 308
 - Administering Diffie-Hellman Authentication 310
 - ▼ How to Restart the Keyserver 310
 - ▼ How to Set Up NIS+ Credentials for Diffie-Hellman Authentication 310
 - ▼ How to Set Up NIS Credentials with Diffie-Hellman Authentication 312
 - ▼ How to Share and Mount Files With Diffie-Hellman Authentication 314
 - Administering Kerberos Version 4 Authentication 315
 - ▼ How to Share and Mount Files With Kerberos Authentication 315
 - ▼ How to Acquire a Kerberos Ticket for Superuser on a Client 315
 - ▼ How to Log In to Kerberos Service 316
 - ▼ How to List Kerberos Tickets 317
 - ▼ How to Access a Directory With Kerberos Authentication 317
 - ▼ How to Destroy a Kerberos Ticket 318
 - Introduction to PAM 318

Benefits of Using PAM	319
Overview of PAM	319
PAM Module Types	319
Stacking Feature	320
Password-Mapping Feature	320
PAM Functionality	320
PAM Library	321
PAM Modules	321
PAM Configuration File	322
Configuring PAM	328
Planning for PAM	328
▼ How to Add a PAM Module	329
▼ How to Prevent Unauthorized Access from Remote Systems with PAM	329
▼ How to Initiate PAM Error Reporting	329
16. Using Automated Security Enhancement Tool (Tasks)	331
Automated Security Enhancement Tool (ASET)	331
ASET Security Levels	332
ASET Tasks	333
ASET Execution Log	335
ASET Reports	336
ASET Master Files	339
ASET Environment File (asetenv)	340
Configuring ASET	340
Restoring System Files Modified by ASET	343
Network Operation Using the NFS System	343
Environment Variables	344
ASET File Examples	348
Running ASET	350

- ▼ How to Run ASET Interactively 350
- ▼ How to Run ASET Periodically 351
- ▼ How to Stop Running ASET Periodically 352
- ▼ How to Collect Reports on a Server 352
- Troubleshooting ASET Problems 354
 - ASET Error Messages 354
- Part V Managing System Resources**
- 17. Managing System Resources (Overview) 361**
 - Where to Find System Resource Tasks 361
 - What Are Quotas? 362
 - Executing Routine Tasks Automatically 362
 - Scheduling Repetitive Jobs: `crontab` 363
 - Scheduling a Single Job: `at` 363
 - What is System Accounting? 364
 - Accounting Components 364
 - How Accounting Works 365
- 18. Examining and Changing System Information (Tasks) 367**
 - Using Commands to Display System Information 367
 - ▼ How to Display System and Software Release Information 368
 - ▼ How to Display General System Information (`uname`) 369
 - ▼ How to Display a System's Host ID Number 369
 - ▼ How to Display a System's Installed Memory 370
 - ▼ How to Display the Date and Time 370
 - Using Commands to Change System Information 371
 - Using Network Time Protocol (NTP) in Your Network 371
 - ▼ How to Set Up a Network Time (NTP) Server 372
 - ▼ How to Set Up a Network Time (NTP) Client 372
 - ▼ How to Synchronize Date and Time From Another System 373

- ▼ How to Set a System's Date and Time Manually 373
- ▼ How to Set Up a Message of the Day 374
- ▼ How to Set the Number of Processes per User 375
- ▼ How to Increase the Number of Pseudo-ttys 376
- ▼ How to Increase Shared Memory Segments 377
- 19. Managing Disk Use (Tasks) 381**
 - Displaying Blocks and Files Used 381
 - ▼ How to Display Information About Blocks, Files, and Disk Space 381
 - Checking the Size of Files 384
 - ▼ How to Display the Size of Files 384
 - ▼ How to Find Large Files 385
 - ▼ How to Find Files That Exceed a Given Size Limit 386
 - Checking the Size of Directories 387
 - ▼ How to Display the Size of Directories, Subdirectories, and Files 387
 - ▼ How to Display the User Allocation of Local UFS File System 388
 - Finding and Removing Old and Inactive Files 389
 - ▼ How to List the Newest Files 390
 - ▼ How to Find and Remove Old or Inactive Files 390
 - ▼ How to Clear Out Temporary Directories 392
 - ▼ How to Find and Delete `core` Files 393
 - ▼ How to Delete Crash Dump Files 393
- 20. Managing Quotas (Tasks) 395**
 - Using Quotas 395
 - Soft Limits vs. Hard Limits 396
 - Difference Between Disk Block and File Limits 396
 - Setting Up Quotas 397
 - Guidelines for Setting Up Quotas 398
 - Setting Up Quotas Task Map 398

- ▼ How to Configure File Systems for Quotas 399
- ▼ How to Set Up Quotas for a User 400
- ▼ How to Set Up Quotas for Multiple Users 401
- ▼ How to Check Quota Consistency 402
- ▼ How to Turn Quotas On 402
- Checking Quotas 403
- ▼ How to Check for Exceeded Quotas 404
- ▼ How to Check Quotas on a File System 405
- Changing and Removing Quotas 406
- ▼ How to Change the Soft Time Limit Default 407
- ▼ How to Change Quotas for a User 408
- ▼ How to Disable Quotas for a User 409
- ▼ How to Turn Quotas Off 410
- 21. Scheduling System Events (Tasks) 413**
- Commands for Scheduling System Events 413
- Scheduling a Repetitive System Event (`cron`) 414
 - Inside a `crontab` File 414
 - How the `cron` Daemon Handles Scheduling 415
 - Syntax of `crontab` File Entries 416
- Creating and Editing `crontab` Files 417
 - ▼ How to Create or Edit a `crontab` File 417
 - ▼ How to Verify a `crontab` File 418
- Displaying `crontab` Files 419
 - ▼ How to Display a `crontab` File 419
- Removing `crontab` Files 420
 - ▼ How to Remove a `crontab` File 420
- Controlling Access to `crontab` 421
 - ▼ How to Deny `crontab` Access 422

- ▼ How to Limit `crontab` Access to Specified Users 423
- ▼ How to Verify Limited `crontab` Access 424
- Scheduling a Single System Event (`at`) 425
 - at Command Description 425
 - ▼ How to Create an `at` Job 426
 - ▼ How to Display the `at` Queue 427
 - ▼ How to Verify an `at` Job 427
 - ▼ How to Display `at` Jobs 427
 - ▼ How to Remove `at` Jobs 428
- Controlling Access to `at` 429
 - ▼ How to Deny `at` Access 429
 - ▼ How to Verify `at` Access Is Denied 430
- 22. Managing System Accounting (Tasks) 433**
 - Setting Up System Accounting 433
 - ▼ How to Set Up System Accounting 434
 - Billing Users 437
 - ▼ How to Bill Users 437
 - Maintaining Accounting Information 437
 - Fixing Corrupted Files and `wtmp` Errors 438
 - ▼ How to Fix a `wtmp` File 438
 - Fixing `tacct` Errors 438
 - ▼ How to Fix `tacct` Errors 439
 - Restarting `runacct` 439
 - ▼ How to Restart `runacct` 440
 - Stopping and Disabling System Accounting 440
 - ▼ How to Temporarily Stop System Accounting 440
 - ▼ How to Permanently Disable System Accounting 441
- 23. System Accounting (Reference) 443**

Daily Accounting	443
Connect Accounting	443
Process Accounting	444
Disk Accounting	444
Calculating User Fees	445
How Daily Accounting Works	445
Accounting Reports	447
Daily Accounting Reports	447
The <code>runacct</code> Program	456
Accounting Files	458
Files Produced by <code>runacct</code>	461
Part VI Managing System Performance	
24. System Performance (Overview)	465
What's New in Managing System Performance?	465
The <code>pgrep</code> and <code>pkill</code> Commands	466
Where to Find System Performance Tasks	467
System Performance and System Resources	467
Other Sources of Information	468
Processes and System Performance	468
Commands for Managing Processes	470
Process Scheduling Classes and Priority Levels	472
Disk I/O and System Performance	473
UFS Direct Input/Output (I/O)	473
▼ How to Enable Forced Direct I/O on a UFS File System	474
Memory and System Performance	475
Swap Space	475
Buffer Resources	476
Kernel Parameters and System Performance	476

	About Monitoring Performance	477
	Monitoring Tools	478
25.	Managing Processes (Tasks)	481
	Displaying Information About Processes	481
	The <code>ps</code> Command	481
	▼ How to List Processes	483
	Displaying Information About Processes (<code>/proc</code> Tools)	484
	▼ How to Display Information About Processes	485
	Controlling Processes (<code>/proc</code> Tools)	487
	▼ How to Control Processes	487
	Killing a Process (<code>pkill</code>)	489
	▼ How to Kill a Process	489
	Managing Process Class Information	490
	Changing the Scheduling Priority of Processes With <code>priocntl</code>	490
	▼ How to Display Basic Information About Process Classes	490
	▼ How to Display the Global Priority of a Process	491
	▼ How to Designate a Process Priority	491
	▼ How to Change Scheduling Parameters of a Timeshare Process	492
	▼ How to Change the Class of a Process	493
	Changing the Priority of a Timesharing Process With <code>nice</code>	494
	▼ How to Change the Priority of a Process	495
	Process Troubleshooting	496
26.	Monitoring Performance (Tasks)	497
	Displaying Virtual Memory Statistics (<code>vmstat</code>)	498
	▼ How to Display Virtual Memory Statistics (<code>vmstat</code>)	498
	▼ How to Display System Event Information	500
	▼ How to Display Swapping Statistics	501
	▼ How to Display Cache Flushing Statistics	502

- ▼ How to Display Interrupts Per Device 502
- Displaying Disk Utilization Information 503
- ▼ How to Display Disk Utilization Information 503
- ▼ How to Display Extended Disk Statistics 504
- Displaying Disk Usage Statistics 506
- ▼ How to Display File System Information 506
- Monitoring System Activities (*sar*) 507
- ▼ How to Check File Access (*sar*) 507
- ▼ How to Check Buffer Activity (*sar*) 508
- ▼ How to Check System Call Statistics (*sar*) 510
- ▼ How to Check Disk Activity (*sar*) 511
- ▼ How to Check Page-Out and Memory (*sar*) 513
- ▼ How to Check Kernel Memory Allocation (*sar*) 515
- ▼ How to Check Interprocess Communication (*sar*) 517
- ▼ How to Check Page-In Activity (*sar*) 518
- ▼ How to Check Queue Activity (*sar*) 520
- ▼ How to Check Unused Memory (*sar*) 521
- ▼ How to Check CPU Utilization (*sar*) 522
- ▼ How to Check System Table Status (*sar*) 523
- ▼ How to Check Swap Activity (*sar*) 525
- ▼ How to Check Terminal Activity (*sar*) 526
- ▼ How to Check Overall System Performance (*sar*) 528
 - Collecting System Activity Data Automatically (*sar*) 528
 - Collecting System Activity Data (*sar*) 529
- ▼ How to Set Up Automatic Data Collection 531
- 27. Monitoring Network Performance (Tasks) 533**
- Monitoring Network Performance 533
- ▼ How to Check the Response of Hosts on the Network 534

- ▼ How to Send Packets to Hosts on the Network 535
- ▼ How to Capture Packets From the Network 536
- ▼ How to Check the Network Status 536
- ▼ How to Display NFS Server and Client Statistics 539
- 28. Tuning Kernel Parameters (Tasks) 543**
 - Listing the Kernel Parameters 543
 - ▼ How to Change the Value of a Kernel Parameter 544
 - ▼ How to Set the Value of a Kernel Module Variable 544
 - Buffer Cache Parameters 545
 - UFS Parameters 545
 - STREAMS Parameters 546
 - Interprocess Communication (IPC) Parameters 546
 - ▼ How to Tune the Interprocess Communication Parameters 548
 - Memory Management Parameters 548
 - ▼ How to Tune Memory Management Parameters 549
 - Miscellaneous Parameters 550
 - ▼ How to Tune Miscellaneous Parameters 550
- 29. The Scheduler (Reference) 551**
 - About the Scheduler 551
 - Scheduler Activation 552
 - Scheduler Class Policies 552
 - Timesharing Class Policies 552
 - System Class Policies 553
 - Real-Time Class Policies 554
 - Scheduler Configuration 554
 - Default Global Priorities 555
 - Tunable Parameters 556
 - Scheduler Parameter Tables 558

Kernel-Mode Parameter Table 563

Part VII Troubleshooting Solaris Software Problems

30. Troubleshooting Software Problems (Overview) 567

Where to Find Software Troubleshooting Tasks 567

Troubleshooting a System Crash 568

 What To Do if The System Crashes 568

 Gathering Troubleshooting Data 569

Troubleshooting a System Crash Checklist 569

Viewing System Messages 570

▼ How to View System Messages 571

Customizing System Message Logging 572

▼ How to Customize System Message Logging 574

31. Managing System Crash Information 575

What's New in Managing System Crash Information? 575

 New System Crash Dump Features 575

 The `dumpadm` Command 576

System Crashes 577

 Crash Dump Files 577

 Saving Crash Dumps 578

Managing Crash Dumps Task Map 578

▼ How to Display the Current Crash Dump Configuration 579

▼ How to Modify a Crash Dump Configuration 579

▼ How to Examine a Crash Dump 581

▼ How to Recover From a Full Crash Dump Directory (Optional) 582

▼ How to Disable or Enable Saving Crash Dumps (Optional) 583

32. Troubleshooting Miscellaneous Software Problems 585

What to Do If Rebooting Fails 585

What to Do If a System Hangs 586

What to Do If a File System Fills Up 587

A File System Fills Up Because a Large File or Directory Was Created 587

The `tmpfs` File System Is Full Because the System Ran Out of Memory 588

What to Do If File ACLs Are Lost After Copy or Restore 588

Troubleshooting Backup Problems 588

The root (`/`) File System Fills Up After You Back Up a File System 588

Make Sure the Backup and Restore Commands Match 589

Check to Make Sure You Have the Right Current Directory 589

Use the Old `restore` Command to Restore Multivolume Diskette Backups 589

33. Troubleshooting File Access Problems 591

Solving Problems With Search Paths (`Command not found`) 591

▼ How to Diagnose and Correct Search Path Problems 592

Solving File Access Problems 594

Changing File and Group Ownerships 594

Recognizing Problems With Network Access 595

34. Troubleshooting Printing Problems 597

Tips on Troubleshooting 597

Troubleshooting Adding a Printer 598

Troubleshooting No Output (Nothing Prints) 598

Troubleshooting Incorrect Output 600

Troubleshooting Hung LP Print Service Commands 601

Troubleshooting Idle (Hung) Printers 602

Troubleshooting Conflicting Status Messages 603

Troubleshooting Printing Problems 603

▼ How to Troubleshoot No Printer Output 603

▼ How to Troubleshoot Incorrect Output 618

- ▼ How to Unhang the LP Print Service 624
- ▼ How to Troubleshoot an Idle (Hung) Printer 625
- ▼ How to Resolve Conflicting Printer Status Messages 627
- 35. Troubleshooting File System Problems 629**
 - Error Messages 629
 - General `fsck` Error Messages 631
 - Initialization Phase `fsck` Messages 632
 - Phase 1: Check Blocks and Sizes Messages 636
 - Phase 1B: Rescan for More DUPS Messages 640
 - Phase 2: Check Path Names Messages 641
 - Phase 3: Check Connectivity Messages 650
 - Phase 4: Check Reference Counts Messages 653
 - Phase 5: Check Cylinder Groups Messages 657
 - Cleanup Phase Messages 659
- 36. Troubleshooting Software Administration Problems 661**
 - Specific Software Administration Errors 661
 - General Software Administration Problems 662
 - Index 663**

About This Book

System Administration Guide, Volume II is part of a two-volume set that covers a significant part of the Solaris™ system administration information. It includes both SPARC™ and x86 information and describes how to use the Solstice™ AdminSuite™ tools to perform some of the system administration tasks.

This book assumes that you have already installed the SunOS™ 5.7 operating system and Solstice AdminSuite, and you have set up any networking software that you plan to use. The SunOS 5.7 operating system is part of the Solaris 7 product family, which also includes many utilities and OpenWindows™ Version 3. The SunOS 5.7 operating system is compliant with AT&T's System V, Release 4 operating system.

For the Solaris 7 release, new features interesting to system administrators are covered in sections called *What's New in ... ?* in the appropriate chapters.

Note - The term "x86" refers to the Intel 8086 family of microprocessor chips, including the Pentium and Pentium Pro processors and compatible microprocessor chips made by AMD and Cynix. In this document the term "x86" refers to the overall platform architecture, whereas "*Intel Platform Edition*" appears in the product name.

The following table describes the system administration topics covered in *System Administration Guide, Volume I* and *System Administration Guide, Volume II*.

System Administration Guide, Volume I	System Administration Guide, Volume II
“Managing User Accounts and Groups (Overview)” in <i>System Administration Guide, Volume I</i>	Chapter 1
“Managing Server and Client Support (Overview)” in <i>System Administration Guide, Volume I</i>	Chapter 8
“Shutting Down and Booting a System (Overview)” in <i>System Administration Guide, Volume I</i>	Chapter 9
“Guidelines for Using CDs and Diskettes (Overview)” in <i>System Administration Guide, Volume I</i>	Chapter 12
“Software Administration (Overview)” in <i>System Administration Guide, Volume I</i>	Chapter 17
“Device Management (Overview/Tasks)” in <i>System Administration Guide, Volume I</i>	Chapter 24
“Disk Management (Overview)” in <i>System Administration Guide, Volume I</i>	Chapter 30
“File Systems (Overview)” in <i>System Administration Guide, Volume I</i>	
“Backing Up and Restoring File Systems (Overview)” in <i>System Administration Guide, Volume I</i>	
“The 64-bit Solaris Operating Environment” in <i>System Administration Guide, Volume I</i>	

Who Should Use This Book

This book is intended for anyone responsible for administering one or more systems running the Solaris 7 release. To use this book, you should have 1-2 years of UNIX® system administration experience and preferably a Computer Science B.S. degree or equivalent knowledge.

How This Book Is Organized

This book is split into parts that each cover a major system administration topic. Each part contains chapters that provide both overview and task information.

Most of the overview information about a topic is usually described in the beginning chapters of each part, and the other chapters provide step-by-step instructions on system administration tasks that you need to perform. Each set of steps is usually followed by a way to verify that the task was successfully performed and an example of how to perform the task.

Using AnswerBook2™ to Read This Book

You can click on any cross reference, represented by underlined text, to quickly access referenced information in the AnswerBook2 collections. To return to the previous display, click on Back.

Ordering Sun Documents

The SunDocs™ program provides more than 250 manuals from Sun Microsystems, Inc. If you live in the United States, Canada, Europe, or Japan, you can purchase documentation sets or individual manuals using this program.

For a list of documents and how to order them, see the catalog section of the SunExpressSM Internet site at <http://www.sun.com/sunexpress>.

SPARC and x86 Information

This book provides system administration information for both SPARC and x86 systems. Unless otherwise noted, information throughout this book applies to both types of systems. Table P-1 summarizes the differences between the SPARC and x86 system administration tasks.

TABLE P-1 SPARC and x86 System Administration Differences

Category	SPARC	x86
System operation before kernel is loaded	<ul style="list-style-type: none"> ■ A programmable read-only memory (PROM) chip with a monitor program runs diagnostics and displays device information. ■ It is also used to program default boot parameters and test the devices connected to the system. 	<ul style="list-style-type: none"> ■ The basic input/output system (BIOS) runs diagnostics and displays device information. <p>A Solaris Device Configuration Assistant boot diskette with the Multiple Device Boot (MDB) program is used to boot from non-default boot partitions, the network, or CD-ROM.</p>
Booting the system	<ul style="list-style-type: none"> ■ Commands and options at the PROM level are used to boot the system. 	<ul style="list-style-type: none"> ■ Commands and options at the MDB, primary, and secondary boot subsystems level are used to boot the system.
Boot programs	<ul style="list-style-type: none"> ■ <code>bootblk</code>, the primary boot program, loads <code>ufsboot</code>. ■ <code>ufsboot</code>, the secondary boot program loads the kernel. 	<ul style="list-style-type: none"> ■ <code>mboot</code>, the master boot record, loads <code>pboot</code>. <p><code>pboot</code>, the Solaris partition boot program, loads <code>bootblk</code>.</p> <ul style="list-style-type: none"> ■ <code>bootblk</code>, the primary boot program, loads <code>ufsboot</code>. <p><code>ufsboot</code>, the secondary boot program, loads the kernel.</p>
System shutdown	<ul style="list-style-type: none"> ■ The shutdown and <code>init</code> commands can be used without additional operation intervention. 	<ul style="list-style-type: none"> ■ The shutdown and <code>init</code> commands are used but require operator intervention at the <code>type</code> any key to continue prompt.
Disk controllers	<ul style="list-style-type: none"> ■ SCSI 	<ul style="list-style-type: none"> ■ SCSI and IDE

TABLE P-1 SPARC and x86 System Administration Differences (continued)

Category	SPARC	x86
Disk slices and partitions	<ul style="list-style-type: none"> ■ A disk may have a maximum of eight slices, numbered 0-7. ■ The Solaris <code>fdisk</code> partition may contain up to ten slices, numbered 0-9, but only 0-7 can be used to store user data. 	<ul style="list-style-type: none"> ■ A disk may have a maximum of four <code>fdisk</code> partitions. ■ The Solaris <code>fdisk</code> partition may contain up to ten slices, numbered 0-9, but only 0-7 can be used to store user data.
Diskette drives	<ul style="list-style-type: none"> ■ Desktop systems usually contain one 3.5-inch diskette drive. 	<ul style="list-style-type: none"> ■ Systems may contain two diskette drives: a 3.5-inch and a 5.25 inch drive.

What Typographic Changes Mean

The following table describes the typographic changes used in this book.

TABLE P-2 Typographic Conventions

Typeface or Symbol	Meaning	Example
<code>AaBbCc123</code>	The names of commands, files, and directories; on-screen computer output	Edit your <code>.login</code> file. Use <code>ls -a</code> to list all files. <code>machine_name% You have mail.</code>
AaBbCc123	What you type, contrasted with on-screen computer output	<code>machine_name% su</code> <code>Password:</code>
<i>AaBbCc123</i>	Command-line placeholder: replace with a real name or value	To delete a file, type <code>rm filename</code> .
<i>AaBbCc123</i>	Book titles, new words or terms, or words to be emphasized	Read Chapter 6 in <i>User's Guide</i> . These are called <i>class</i> options. You <i>must</i> be root to do this.

Shell Prompts in Command Examples

The following table shows the default system prompt and superuser (root) prompt for the Bourne shell and Korn shell.

TABLE P-3 Shell Prompts

Shell	Prompt
Bourne shell and Korn shell prompt	\$
Bourne shell and Korn shell superuser prompt	#

General Conventions

Be aware of the following conventions used in this book.

- When following steps or using examples, be sure to type double-quotes ("), left single-quotes ('), and right single-quotes (') exactly as shown.
- The key referred to as Return is labeled Enter on some keyboards.
- It is assumed that the root path includes the `/sbin`, `/usr/sbin`, `/usr/bin`, and `/etc` directories, so the steps in this book show the commands in these directories without absolute path names. Steps that use commands in other, less common, directories show the absolute path in the example.
- The examples in this book are for a basic SunOS 5.7 software installation without the Binary Compatibility Package installed and without `/usr/ucb` in the path.



Caution - If `/usr/ucb` is included in a search path, it should always be at the end of the search path. Commands like `ps` or `df` are duplicated in `/usr/ucb` with different formats and options from the SunOS 5.7 commands.

Managing Printing Services

This part provides instructions for managing printing services in the Solaris environment. This part contains these chapters.

Chapter 1	Provides overview information for managing printing services on a network. This chapter provides information on print servers, print clients, and the LP print service.
Chapter 2	Provides overview information for planning printing services on a network, which includes information on allocating system resources and defining printers on a network.
Chapter 3	Provides step-by-step instructions for setting up a printer on a system and making it available to other systems on the network.
Chapter 4	Provides step-by-step instructions for administering printers, such as deleting printers, setting print policies, and managing print requests.
Chapter 5	Provides step-by-step instructions for setting up and maintaining character sets, print filters, forms, and fonts.
Chapter 6	Provides step-by-step instructions for customizing the LP print service, such as adjusting printer port characteristics or adding a <code>terminfo</code> entry for a unsupported printer.
Chapter 7	Provides background information on the LP print service.



Print Management (Overview)

This chapter provides information about managing printers, print clients, and the LP print service. This is a list of the overview information in this chapter.

- “The Solaris Print Software” on page 3
- “Printing in the Solaris Operating Environment” on page 6
- “The LP Print Service” on page 8
- “Using the Print Client Software” on page 10

For step-by-step instructions on print management tasks, see:

- Chapter 3
- Chapter 4
- Chapter 5
- Chapter 6

The Solaris Print Software

The Solaris print software offers a better centralized print administration than the LP print software in previous Solaris releases. Starting in the Solaris 2.6 release, you can easily set up and manage print clients using the NIS or NIS+ name services.

Solaris print software features include:

- Redesign of Print Packages
- Print Protocol Adapter
- Print Client Support
- Network Printer Support

The Solaris print software limitations include:

- No support for print servers defined as `s5` (the System V print protocol) in previous Solaris releases.
- No print filtering on print clients.

Redesign of Print Packages

Starting in the Solaris 2.6 release, print packages have been redesigned to provide greater flexibility and modularity of print software installation and to allow installation of a smaller print client footprint.

Redesign features include:

- It is possible with a custom installation to install only the client software on the print client, allowing for a smaller client footprint. All packages, client and server, are installed on print servers.

The default state is to install everything, but you can choose to install client or server software only. Print servers require that the client software is installed.

- PostScript filter software is contained in the `SUNWpsf` print package.

Table 1-1 describes the set of print packages.

TABLE 1-1 Solaris Print Packages

Package Instance	Package Name	Base Directory
<code>SUNWpcr</code>	SunSoft Print - Client	root (/)
<code>SUNWpcu</code>	SunSoft Print - Client	usr
<code>SUNWpsr</code>	SunSoft Print - LP Server	root (/)
<code>SUNWpsu</code>	SunSoft Print - LP Server	usr
<code>SUNWpsf</code>	Postscript Filters	usr
<code>SUNWscplp</code>	SunSoft Print - Source Compatibility	usr

The removed print packages are:

- `SUNWlpr` - LP print service, (root)
- `SUNWlpu` - LP print service - Client, (usr)
- `SUNWlps` - LP print service - Server, (usr)

Print commands contained in `SUNWscpu` have been moved and placed into `SUNWscplp` (SunSoft Print - Source Compatibility).

Print Protocol Adaptor

Starting in the Solaris 2.6 release, the print protocol adaptor replaces the Service Access Facility (SAF), the network listener, and `lpNet` on the inbound side of the LP spooler with a more modular, modern design.

This replacement provides the following features:

- Complete BSD print protocol implementation plus extended Solaris functionality.
- Allows multiple spooling systems to coexist on the same host and have access to the BSD print protocol.
- Extensible by third-party application developers to support other printing protocols such as Apple, Novell, etc.).

The new print protocol adaptor is compatible with print clients set up in Solaris 2.5.1 and compatible releases if the "BSD" protocol was used to configure these clients. If not, you'll have to modify the Solaris 2.5.1 and compatible print client configuration to use the "BSD" protocol using `Admintool™`, `Solstice Printer Manager`, or the `lpssystem` command.

Using Print Clients

The print client software uses a NIS map, NIS+ table, or a single file to provide centralized client administration. Features of the print client software include:

- The `/etc/lp` directory structure on client systems is replaced with a configuration database that can be stored in a:
 - User file (`$HOME/.printers`)
 - System file (`/etc/prints.conf`)
 - NIS map (`prints.conf.byname`)
 - NIS+ FNS context
- The client software utilizes a more streamlined implementation providing reduced client overhead and generally quicker and more accurate responses to print status requests.

- The `lpset(1M)` command is used to create the `printers.conf` file. See Chapter 3 for information on using the `lpset` command.
- Substantially smaller (183K total) than the previous Solaris release.
- Interoperable with BSD protocol as described in RFC-1179. This includes SunOS 4.0 and compatible versions, Solaris 2.5.1 and compatible versions, HPUX, etc. The print client software packages are `SUNWpccr` and `SUNWpcu`.

Enhanced Network Printer Support

The Solaris print software provides better support for network printers than in previous Solaris releases. Features include:

- A new interface script, `/usr/lib/lp/model/netstandard`, is specifically designed to support network printers. This script collects the spooler and print database information needed to perform network printing and passes it to the print output module.
- A new print output module, `netpr`, is called from the `netstandard` interface script to print the print job by opening a network connection to the printer, creating the correct protocol instructions, and sending the data to the printer. The `netpr` program currently supports two protocols, BSD print protocol and a TCP pass-through.
- New arguments to the `lpadmin -o` command are used to specify destination name, protocol, and timeout values for the network printer.
- Solstice AdminSuite 2.3 Printer Manager can be used to set up and manage network printers.

See Chapter 3 or the *Solstice AdminSuite 2.3 Administration Guide* for more information about setting up a network printer.

Printing in the Solaris Operating Environment

The Solaris printing software provides an environment for setting up and managing client access to printers on a network.

The Solaris printing software contains these components:

- The print client software, previously only available with the Solstice™ AdminSuite™ set of administration tools, provides the ability to make printers available to print clients via a name service.

- Admintool, a graphical user interface used to manage printing on a local system.
- The LP print service commands, a command line interface used to set up and manage printers that also provides functionality above and beyond the other print management tools.
- The Solstice AdminSuite Print Manager, a graphical user interface used to manage printers in a name service environment, is available starting in the Solaris 2.6 release.

Table 1-2 summarizes the features of the Solaris printing components.

TABLE 1-2 Solaris Printing Component Features

Component	Graphical User Interface?	Set Up Print Clients?	Manage Print Clients and Servers?	Using NIS or NIS+?
SunSoft Print Client	No	Yes	No	Yes
Admintool	Yes	Yes	Yes	No
LP commands	No	Yes	Yes	No
Solstice AdminSuite	Yes	Yes	Yes	Yes

Note - If you do not use Solstice Printer Manager to set up and manage printing, you will have to use some combination of the other components to completely manage printing in the Solaris environment.

Choosing a Method to Manage Printers

The print client software and the Printer Manager application in Solstice™ AdminSuite™ offer a graphical solution for setting up and managing printers on a network. The advantage of the print client software is that it supports a name service (NIS or NIS+), which enables you to centralize print administration for a network. `lpadmin` can also be used on the command line to configure printers on individual systems.

Admintool™ provides an alternative method to install printers in the Solaris environment. Admintool is a graphical user interface that simplifies tasks for setting

up and managing printers. See Chapter 3 for step-by-step instructions on using Admintool.

You must run Admintool on the system to which you have attached the printer, because Admintool does not enable you to make changes to a remote system. When setting up a printer, Admintool makes the appropriate changes in the system's `/etc/printers.conf` and `/etc/lp` directory as required. You can use Admintool to set up a system as a print server or print client only if it is running the SunOS 5.6 or 5.7 releases. Setting up SunOS 4.1 print servers and clients is fully described in the SunOS 4.0 and compatible versions documentation.

Most of your needs for setting up printing services should be met by Admintool. However, if you have special needs, such as writing scripts, you may want to use the LP print service commands (which underlie Admintool) directly. The setup process with commands is described in "How to Add Access on the Print Client using LP Commands" on page 43.

Use Table 1-3 to find printer setup information.

TABLE 1-3 Where To Find Printer Setup Information

For Information On ...	See ...
Setting up print clients and print servers using Admintool	Chapter 3
Setting up printer information available to print clients using a name service	Chapter 3
Setting up network printers using the LP commands	Chapter 3
Setting and managing printing (including network printers) using Solstice Printer Manager	<i>Solstice AdminSuite 2.3 Administration Guide</i>
Administering printers using the LP commands	Chapter 4

The LP Print Service

The *LP print service* is a set of software utilities that allows users to print files while they continue to work. Originally, the print service was called the LP spooler. (LP

stood for line printer, but its meaning now includes many other types of printers, such as laser printers. Spool is an acronym for system peripheral operation off-line.)

The print service consists of the LP print service software and spooler, which includes the print client software; any print filters you may provide; and the hardware (the printer, system, and network connections).

See Chapter 7 for background information about the LP print service.

Other LP print service topics covered in this part and their chapter references are described below.

Managing Network Printers

A *network printer* is a hardware device that provides printing services to print clients without being directly cabled to a print server. It has its own system name and IP address, and is connected directly to the network.

Network printers often have software support provided by the printer vendor. If your printer has printer vendor supplied software it is strongly advised that the printer vendor software be utilized. If the network printer vendor does not provide software support, the Sun supplied software is available. This software provides generic support for network printers and is not capable of providing full access to all possible printer capabilities.

See Chapter 3 for step-by-step instructions on setting up a network printer.

Administering Printers

After you set up print servers and print clients, there are a number of administration tasks you may need to perform frequently:

- Deleting a printer and remote printer access
- Checking the status of printers
- Restarting the print scheduler

See Chapter 4 for step-by-step instructions on how to perform the printer administration tasks.

Setting Definitions for Printers

Establishing definitions for the printers on your network is an ongoing task that lets you provide a more effective print environment for users. For example, you can assign printer descriptions for all your site's printers to help users find where a

printer is located, or you can define a class of printers to provide the fastest turnaround for print requests.

See Chapter 2 for information on setting up printer definitions.

Administering Character Sets, Filters, Forms, and Fonts

Depending on your site's requirements and the types of printers you have on the network, you may have to set up and administer printer-specific features of the LP print service. For example, you can assign different print wheels, filters, and forms to different printers. See Chapter 5 for background information and step-by-step instructions on how to set up and administer character sets, print filters, forms, and fonts.

Customizing the LP Print Service

Although the LP print service is designed to be flexible enough to handle most printers and printing needs, it does not handle every possible situation. You may have a printing request that is not accommodated by the standard features of the LP print service. Or you may have a printer that does not quite fit into the way the LP print service handles printers.

You can customize the LP print service in the following ways:

- Adjust the printer port characteristics
- Adjust the `terminfo` database
- Customize the printer interface program
- Create a print filter
- Define a form

See Chapter 6 for detailed descriptions and step-by-step instructions to customize the LP print service.

Using the Print Client Software

This section provides an overview of how the print client software works.

The Print Client Process

Figure 1-1 illustrates the path of a print request from the time the user initiates the request until it is printed.

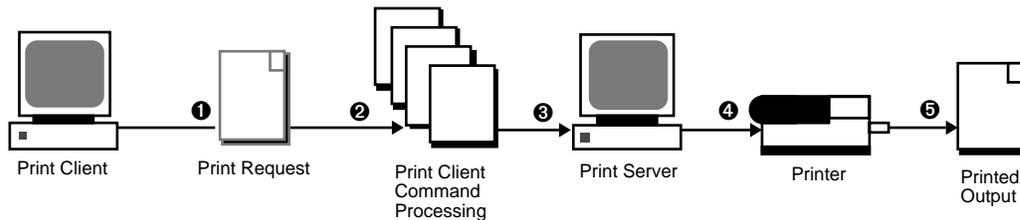


Figure 1-1 Overview of the Print Client Process

1. A user submits a print request from a print client by using a print client command.
2. The print client command checks a hierarchy of print configuration resources to determine where to send the print request.
3. The print client command sends the print request directly to the appropriate print server. A print server can be any server that accepts BSD printing protocol, including SVR4 (LP) print servers and BSD print servers (such as the SunOS 4.1 BSD print server).
4. The print server sends the print request to the appropriate printer.
5. The print request is printed.

Print Clients

This section of the overview focuses on the *print client*, a system that can send print requests to a print server, and print commands, which enable the print client to initiate print requests.

Figure 1-2 highlights the part of the print process in which the user submits a print request from a print client.

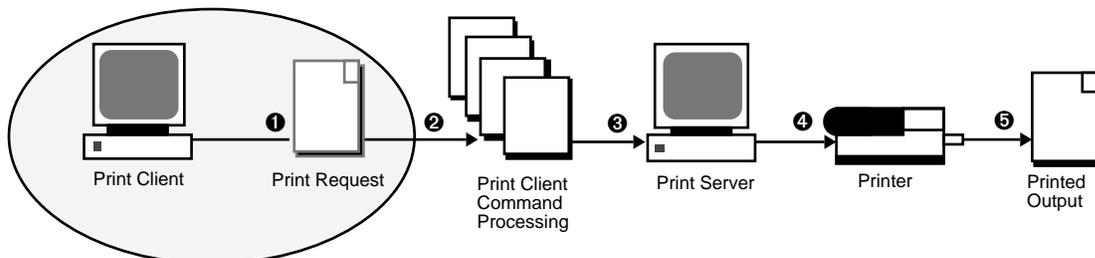


Figure 1-2 The User Submits a Print Request from a Print Client

What Is a Print Client?

A system becomes a print client when you install the print client software and enable access to remote printers on the system. The print client commands have the same names and produce the same output as the print commands of the previous Solaris releases.

How the Print Client Commands Improve the Print Process

With the print client commands, the client system becomes a more effective print client: the commands use a greater number of options to locate printer configuration information, and the client communicates directly with the print server. In the previous Solaris operating environment, the print client did not have these advantages.

The print client commands:

- Use more options to locate printer information.

The print client commands check the following resources to locate printers and printer configuration information:

- The command-line interface
- A printer alias file in the user's home directory
- Local (print client) configuration files
- A network (shared) configuration file, if you use a name service

- Enable clients to submit requests directly to the print server.

The print client sends its requests to the print server's queue; the client does not have a local queue. The client writes the print request to a temporary spooling area only if the print server is not available or if an error occurs. This streamlined path to the server decreases the print client's use of resources, reduces the chances for printing problems, and improves performance.

Printer Configuration Resources

This section describes the resources that the print client commands use to locate printer names and printer configuration information.

The print client commands can use a name service, which is a network (shared) resource for storing printer configuration information for all printers on the network. The name service (NIS or NIS+) simplifies printer configuration maintenance: When you add a printer in the name service, all print clients on the network can access it.

Figure 1-3 highlights the part of the print process in which the print client commands check a hierarchy of printer configuration resources to determine where to send the print request.

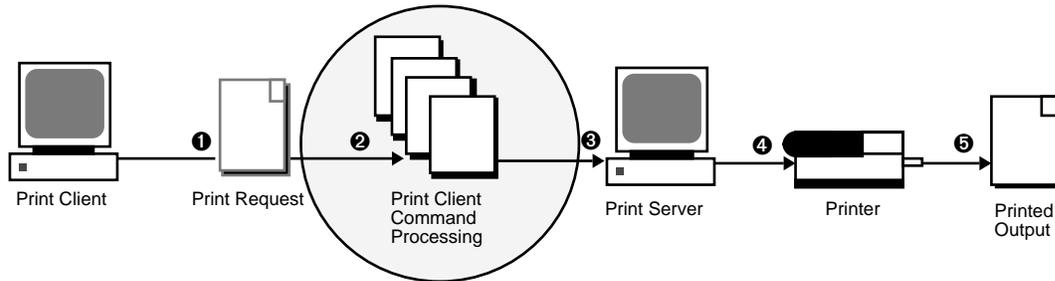


Figure 1-3 The Print Client Checks Resources to Locate Printers

How the Print Client Software Locates Printers

As shown in Figure 1-4, the print client commands use more options to locate printers and printer configuration information.

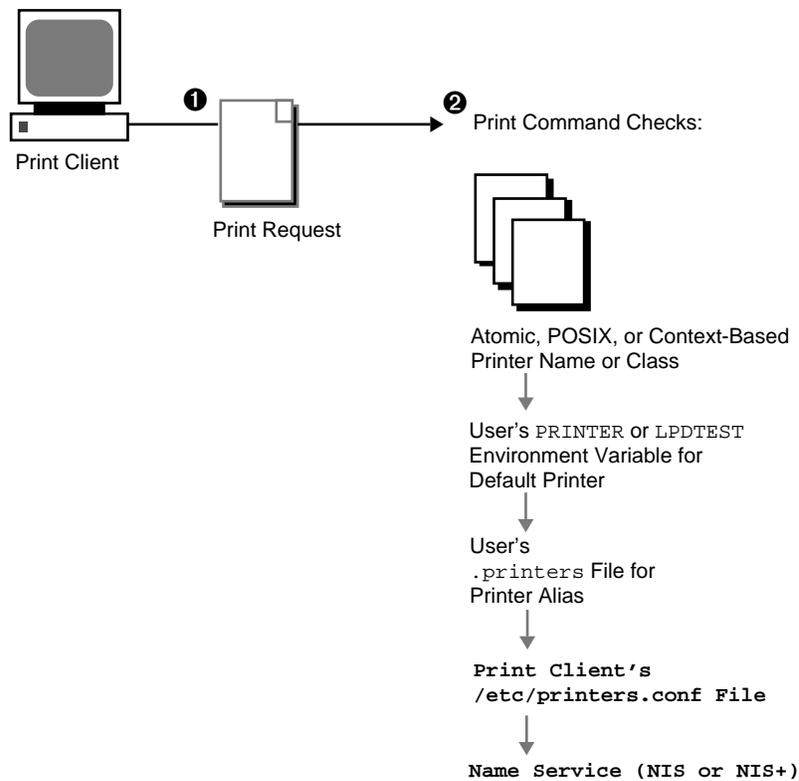


Figure 1-4 How the Print Client Software Locates Printers

1. A user submits a print request from a print client by using the `lp` or `lpr` command. The user can specify a destination printer name or class in any of three styles:

- Atomic style, which is the print command and option followed by the printer name or class, as shown in this example.

```
% lp -d neptune filename
```

- POSIX style, which is the print command and option followed by `server:printer`, as shown in the following example.

```
% lpr -P galaxy:neptune filename
```

- Context-based style, as defined in the *Federated Naming Service Programming Guide*, shown in this example.

```
% lpr -d thisdept/service/printer/printer-name filename
```

2. The print command locates a printer and printer configuration information as follows:

- It checks to see if the user specified a destination printer name or printer class in one of the three valid styles.
- If the user didn't specify a printer name or class in a valid style, the command checks the user's `PRINTER` or `LPDEST` environment variable for a default printer name.
- If neither environment variable for the default printer is defined, the command checks the `.printers` file in the user's home directory for the `_default` printer alias.
- If the command does not find a `_default` printer alias in the `.printers` file, it then checks the print client's `/etc/printers.conf` file for configuration information.
- If the printer is not found in the `/etc/printers.conf` file, the command checks the name service (NIS or NIS+), if any.

These are the advantages of the print client method to locate printers:

- You can use a name service (NIS or NIS+) to store printer information in one central location. This is the single most important feature of the print client software. If you want to add a printer and make it available to all print clients on the network, all you have to do is enter the printer information in the name service. The same principle applies to modifying and deleting printers. The printer information in the name service is available to all print clients.
- Users can manipulate their `.printers` file to customize printer information. Even though print clients know about the printers that are listed in the name service, you can customize the clients' printer configuration files to use printer aliases and

to find only certain printers when canceling print requests or getting status information.

- If you don't use a name service, you can still decrease the amount of time it takes to set up and administer printing by creating a master of the `/etc/printers.conf` file with all printers on the network and copying that file to print clients. For further information about using the `/etc/printers.conf` file, see Chapter 3.
- The print client software uses POSIX-style names, which means print clients can access printers that aren't defined on the print client or in the name service.

Who Should Use a Name Service

A name service provides the most efficient way to add, modify, and delete printer configuration information for a network. Almost every site can benefit significantly from using a name service. One exception might be a very small network with only a few printers and print clients.

Using Print Servers

This section of the overview focuses on the print server, a system that has a local printer connected to it and makes the printer available to other systems on the network. Figure 1-5 highlights the part of the print process in which the print server sends the print request to the printer.

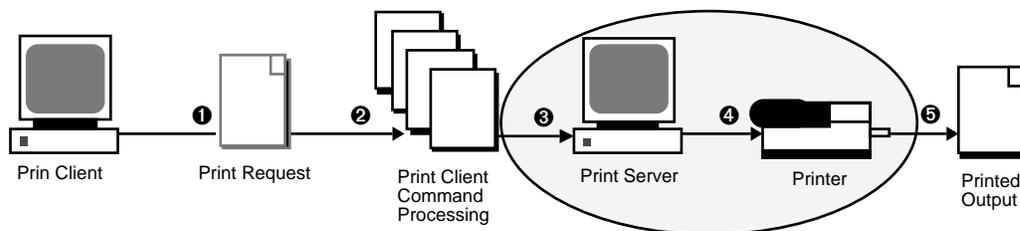


Figure 1-5 The Print Server Sends a Print Request to the Printer

The BSD Printing Protocol

The print client commands use the BSD printing protocol. One of the big advantages of this protocol is that it can communicate with a variety of print servers:

- SunOS 4.1 BSD (LPD) print servers
- SunOS 5.7 and compatible SVR4 (LP) print servers

- Any other print server or printer that accepts the BSD printing protocol

The BSD printing protocol is an industry standard. It is widely used and it provides compatibility between different types of systems from various manufacturers. Sun has chosen to support the BSD printing protocol to provide interoperability in the future.

Where to Go From Here

Go to Chapter 3 for step-by-step instructions on:

- Updating print clients to access existing printers at your site
- Setting up new printers with print client software

If you need printer planning information, see Chapter 2.

Planning Printers on Your Network (Overview)

The goal of setting up printers on a network is to give users access to one or more printers. This section provides information about distributing printers across your network to gain the best efficiency and about planning for printer setup.

- “Distributing Printers on the Network” on page 17
- “Assigning Print Servers and Print Clients” on page 18
- “Print Server Requirements and Recommendations” on page 20

For step-by-step instructions on print management tasks, see:

- Chapter 3
- Chapter 4
- Chapter 5
- Chapter 6

Distributing Printers on the Network

As an administrator, you must determine whether each printer would be best used if it is dedicated to one system or available to many systems. In a network environment, it usually works best to distribute your printers on several print servers. The advantage of setting up several print servers is that when one print server has a problem, you can route print requests to other print servers.

If you use a centralized print configuration, you can still connect printers to users' systems for convenience or for improved response. A printer that is connected to a user's system is still available to other systems on the network.

Figure 2-1 shows an example of how you can have a centralized print configuration and still connect printers to users' systems.

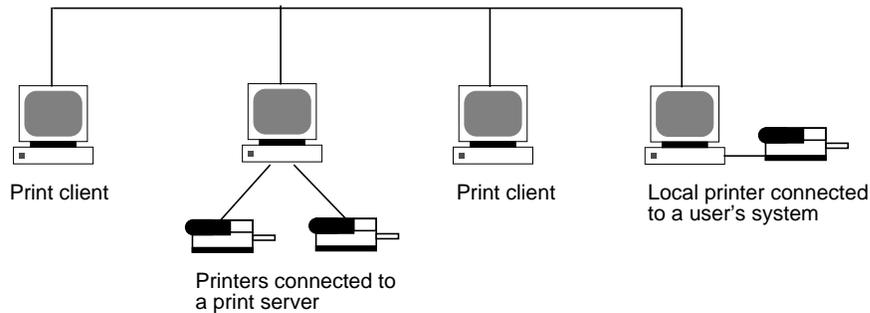


Figure 2-1 How to Distribute Printers on a Network

Assigning Print Servers and Print Clients

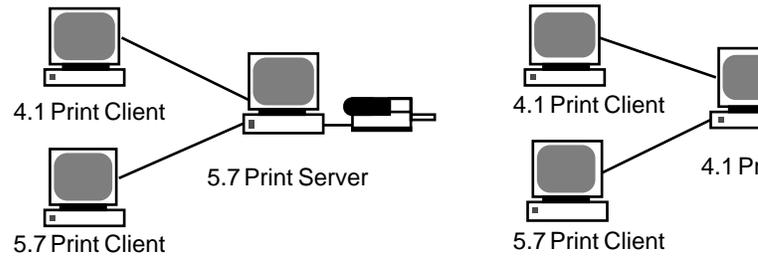
You must decide which systems will have local printers physically attached to them, and which will systems use printers on other systems. A system that has a local printer attached to it and makes the printer available to other systems on the network is called a *print server*. A system that sends its print requests to a print server is called a *print client*.

The LP print service software manages printing services in the Solaris environment. Besides physically connecting a printer to a system, you must define the printer characteristics to the LP print service and make the system a print server. Once you have print servers set up, you can set up other systems as print clients.

Print servers and print clients can run different versions of the SunOS operating system. Systems running the SunOS 5.7 and compatible versions can print to existing print servers running the SunOS 4.1 operating system, and systems running the SunOS 4.1 operating system can print to print servers running the SunOS 5.7 and compatible versions.

Note - SunOS 5.7 is part of the Solaris 7 operating environment.

Figure 2-2 shows example print configurations on a network with systems running the SunOS 5.7 and compatible versions and SunOS 4.1 operating systems.



Print Server Requirements and Recommendations

You can attach a printer to a standalone system or to any system on the network. Any networked system with a printer can be a print server, as long as the system has adequate resources to manage the printing load.

Spooling Space

Spooling space is the amount of disk space that is used to store and process requests in the print queue. Spooling space is the single most important factor to consider when deciding which systems to designate as print servers. When users submit files for printing, the files are stored in the `/var/spool/lp` directory until they have been printed. The size of the `/var` directory depends on the size of the disk and how the disk is partitioned. Spooling space may be allocated in the `/var` directory on the print server hard disk, or mounted from a file server and accessed over the network.

Note - If `/var` is not created as a separate file system, the `/var` directory uses space in the root (`/`) file system, which is likely to be insufficient.

Disk Space

When evaluating systems as possible print servers, consider their available disk space. A large spool directory can consume 600 Mbytes of disk space. Look at the size and division of disk space on systems that can be designated as print servers.

Also, carefully evaluate the printing needs and use patterns of print client systems. If users in a small group typically print only short email messages— simple ASCII files without sophisticated formatting requirements—a print server with 20 to 25 Mbytes of disk space allocated to `/var` is probably sufficient. If, however, many print client users are printing large documents or bit-mapped or raster images, they will likely fill up the spooling space quite frequently. When users cannot queue their jobs for printing, work flow is interrupted. Requests for more spooling space may force you to either add disk space for spooling or designate a different system as the print server.

If the print server has a `/var` directory that resides in a small partition, and if a large amount of disk space is available elsewhere, you can use that space as spooling space by mounting it on the `/var` directory on the print server. See “Mounting and Unmounting File Systems (Tasks)” in *System Administration Guide, Volume I* for information about mounting file systems and editing the `vfstab` file.

Memory

The Solaris environment requires a minimum of 16 Mbytes of memory to run. A print server does not require additional memory. However, you may find that more memory improves performance in filtering print requests.

Swap Space

The swap space allocation on the print server should be sufficient to handle LP print service requirements. See “Configuring Additional Swap Space (Tasks)” in *System Administration Guide, Volume I* for information about how to increase swap space.

Hard Disk

For optimal performance, the print server should have a hard disk and a local `/var` directory. You should mount spooling space for a print server on a local hard disk. If a print server has its own hard disk and a local `/var` directory, printing is much faster, and you can more accurately predict the time needed to process print requests.

Planning for Printer Setup

This section provides an overview of planning for printing in the Solaris environment that includes:

- Setting definitions for printers such a printer name, printer description, printer port
- Selecting a printer type and file content type
- Setting up fault notification and default printer destination
- Determining whether you want to print banner pages or limit user access to a printer
- Setting up printer classes and fault recovery

Setting Definitions for Printers

Establishing definitions for the printers on your network is an ongoing task that lets you provide a more effective print environment for users. For example, you can

assign parameters for all your site's printers to help users find where a printer is located, or you can define a class of printers to provide the fastest turnaround for print requests.

The `lpadmin` command lets you set all of the print definitions, while Admintool lets you set only some of them when you install or modify a printer. Table 2-1 lists the print definitions and shows whether you can assign the definition with Admintool.

TABLE 2-1 Print Definitions Set With Admintool

Print Definition	Can You Set It With Admintool?
Printer name	Yes
Printer description	Yes
Printer port	Yes
Printer type	Yes
File contents	Yes, but with less functionality than the <code>lpadmin</code> command
Fault notification	Yes, but with less functionality than the <code>lpadmin</code> command
Default printer destination	Yes
Printing banner pages	Yes, but with less functionality than the <code>lpadmin</code> command
Limiting user access to a printer	Yes, but with less functionality than the <code>lpadmin</code> command
Printer class	No
Fault recovery	No

Printer Name

When adding a printer to a system, you specify a *printer name* for the printer. A printer name must be:

- Unique among all printers within the bounds of an administrative domain
- A maximum of 14 alphanumeric characters, which may include dashes and underscores

- Easy to remember and may identify the type of printer, its location, or the print server name

Establish a naming convention that works for your site. For example, if you have different types of printers on the network, including the printer type as part of the printer name can help users choose an appropriate printer. For instance, you could identify PostScript™ printers with the letters PS. If, however, all of the printers at your site are PostScript printers, you would not need to include the initials PS as part of the printer name.

Printer Description

You can assign a description to a printer by using the `lpadmin -D` command or Admintool. The printer's description should contain information to help users identify the printer. You might include the room number where the printer is located, the type of printer, the manufacturer, or the name of the person to call if there are printing problems.

Users can look at a printer description by using the following command:

```
$ lpstat -D -p printer-name
```

Printer Port

When you install a printer or later change its setup, you can specify the device, or the *printer port*, to which the printer is connected, by using Admintool or the `lpadmin -p printer-name -v device-name` command.

Most systems have two serial ports and a parallel port. Unless you add ports, you cannot connect more than two serial printers and a parallel printer to one system.

With Admintool, you can select either `/dev/term/a` or `/dev/term/b`, or choose Other and specify any port name that the print server recognizes. These options give you as much flexibility as the `lpadmin` command.

The LP print service initializes the printer port using the settings from the standard printer interface program. See “Managing Print Filters” on page 100 for more information about printer interface programs. If you have a parallel printer or a serial printer for which the default settings do not work, see “Adjusting Printer Port Characteristics” on page 121 for information about customizing the port settings.

Note - If you use multiple ports on an x86 system microprocessor-based system, only the first port is enabled by default. The second and any subsequent ports are disabled by default. To use more than one port, you must manually edit the device driver port configuration file for each additional `asy` (serial) port or `lp` (parallel) port. The pathnames for the x86 port configuration files are:

```
/platform/i86pc/kernel/drv/asy.conf
```

```
/platform/i86pc/kernel/drv/lp.conf
```

See the *Solaris 7 (Intel Platform Edition) Installation Library* for information about configuring serial and parallel ports on x86 systems.

Printer Type

The printer type is a generic name for a type of printer. It identifies the `terminfo` database entry that contains various control sequences for the printer. By convention, printer type is usually derived from the manufacturer's model name. For example, the printer type name for the DECwriter[™] printer is `decwriter`. However, the common printer type `PS` does not follow this convention. `PS` is used as the printer type for many models of PostScript printers, such as LaserWriter[®]I and LaserWriterII printers.

You can specify the printer type by using the `lpadmin -T` command or `Admintool`. With `Admintool`, you can specify the printer type only when you are installing a printer. If you want to change the type of an existing printer, you must delete the printer and reinstall it by using `Admintool`, otherwise change the printer type by using the `lpadmin` command.

`Admintool` lets you select a printer type from a menu or choose `Other` and specify any printer type in the `terminfo` database. This provides you as much capability as the `lpadmin` command.

Printer Names in the terminfo Database

Information about each printer type is stored in the `terminfo` database (`/usr/share/lib/terminfo`). This information includes the printer capabilities and initialization control data. The printer you install must correspond to an entry in the `terminfo` database.

```
$ pwd
/usr/share/lib/terminfo
$ ls
1 4 7 A M a d g j m p s u x
```

(continued)

(Continuation)

```
2 5 8 B P b e h k n q t v y
3 6 9 H S c f i l o r t i w z
$
```

Each subdirectory contains compiled database entries for terminals or printers. The entries are organized by the first letter of the printer or terminal type. For example, if you have an Epson® printer, look in `/usr/share/lib/terminfo/e` to find your particular model of Epson printer.

```
$ cd /usr/share/lib/terminfo/e
$ ls
emots          ep2500+high  ep48          ergo4000     exidy2500
env230         ep2500+low   epson250      esprit
envision230    ep40         epson2500-80  ethernet
ep2500+basic  ep4000      epson2500-h   ex3000
ep2500+color  ep4080      epson2500-hi8 exidy
$
```

The entries for Epson printers are included in the preceding example.

If you have a NEC® printer, look in the `/usr/share/lib/terminfo/n` directory for your NEC printer model.

```
$ cd /usr/share/lib/terminfo/n
$ ls
ncr7900        ncr7901      netty-Tabs    newhpkeyboard
ncr7900-na     nec          netty-vi      nuc
ncr7900i       net          network       nucterm
ncr7900i-na    netronics    netx
ncr7900iv      netty        newhp
$
```

The entry in this directory for NEC is included in the preceding example.

Selecting a Printer Type

For a local PostScript printer, use a printer type of either PostScript (PS) or Reverse PostScript (PSR). If your printer supports PostScript, choose PS or PSR even if the specific printer type is listed in the `terminfo` database.

If your PostScript printer prints pages face up, documents appear to be printed backwards—the first page is at the bottom of the stack and the last page is on the top. If you specify the printer's type as PSR, the LP print service reverses the order

of the pages before sending them to the printer; the last page is printed first, and the pages are stacked in forward order. However, the LP print service can reliably change the page order only for PostScript files that conform to the Adobe® Document Structuring Conventions in Appendix C of the *PostScript Language Reference Manual* (written by Adobe Systems Incorporated, and published by Addison-Wesley, 1990).

If a printer can emulate more than one kind of printer, you can assign it several types by using the `lpadmin -T` command. If you specify more than one printer type, the LP print service uses the type that is appropriate for each print request.

You may not find the printer type in the appropriate `terminfo` directory. The type of printer is not necessarily linked to the manufacturer's name on the printer. For example, for any type of PostScript printer, you can use the `PS` or `PSR` entry (found in the `/usr/share/lib/terminfo/P` directory) instead of an entry specific to manufacturer or product names.

If you have an unusual type of printer, you may need to try different entries before you can determine whether a particular `terminfo` entry works for your model of printer. If possible, find an entry in the `terminfo` database that works for your printer. It will be much easier than trying to create an entry. If you have to create your own entry, "Adding a `terminfo` Entry for an Unsupported Printer" on page 124 contains some useful tips.

Selecting a File Content Type

Print filters convert the content type of a file to a content type that is acceptable to the destination printer. The *file content type* tells the LP print service the type of file contents that can be printed directly, without filtering. To print without filtering, the necessary fonts must also be available in the printer. (You must set up and use filtering for other types of files.)

You can specify the file content type for a printer by using the `lpadmin -I` command or `Admintool`. With `Admintool`, you can select a file contents type from a menu. Not all available file content types are listed on the menu. You must use the `lpadmin` command to specify file content types that are not included on the `Admintool` menu.

Many printers can print two types of files directly:

- The same type as the printer type (for example, `PS` for a PostScript printer)
- The type `simple` (an ASCII text file)

When submitting a file for printing, the user can indicate the content type of the file (`lp -T content-type`). Otherwise, a file is assumed to be `simple` (ASCII text). The LP print service uses the file content type to determine which filters to use to convert the file contents into a type the printer can handle.

`Admintool` provides a list of file content types from which you can choose when installing or modifying a local printer. The choices are translated to the names that

the LP print service uses. Table 2-2 describes the file content types you can choose with Admintool.

TABLE 2-2 Choosing File Content Type With Admintool

File Contents Choice	LP Print Service Name	Description
PostScript	postscript	PostScript files do not require filtering. ASCII files require filtering.
ASCII	simple	PostScript files require filtering. ASCII files do not require filtering.
Both PostScript and ASCII	simple,postscript	PostScript files and ASCII files do not require filtering.
None	" "	All files require filtering, except those matching the printer's type.
Any	any	No filtering required. If the printer cannot handle a file content type directly, the file will not be printed.

Choose the file content type that best matches the printer's capabilities. PostScript (which means filtering is not needed for PostScript files) is the default choice in Admintool and is probably correct most of the time.

Frequently Used Printers

This section provides the printer type and file content type for the printers most commonly used with SunOS 5.x software. Although not shown, many of these printers can also directly print files with `simple` content type.

If you have a PostScript printer, use a printer type of PS or PSR and a content type of `postscript`. PSR reverses the pagination and prints the banner page last.

Table 2-3 lists additional non-PostScript printers and shows the printer type to use for configuring each printer. For all these printers, the file content type is `simple`.

Note - Sun Microsystems does not supply filtering software for the printers listed in Table 2-3, among others. However, you can use unsupported printers if you supply filtering or if the printer can directly print the file content type. If you have questions about any printer for which Sun Microsystems does not supply filters, contact the printer manufacturer.

TABLE 2-3 Some Non-PostScript Printers for Which Sun Does Not Supply Filters

Printer	Printer Type
Daisy	daisy
Datagraphix	datagraphix
DEC LA100	la100
DEC LN03	ln03
DECwriter	decwriter
Diablo	diablo
	diablo-m8
Epson 2500 variations	epson2500
	epson2500-80
	epson2500-hi
	epson2500-hi80
Hewlett-Packard HPCL printer	hplaser
IBM Proprinter	ibmproprinter

If you want to set up a printer that is not in the `terminfo` database, see “How to Add a `terminfo` Entry for an Unsupported Printer” on page 127.

Setting Up Printers (Tasks)

This chapter explains how to set up a printer and make it accessible to systems on the network. You can perform most printer setup tasks by using Admintool. This is a list of the step-by-step instructions in this chapter.

- “How to Convert Printer Information For a System Running the SunOS 5.5.1 Release or Compatible Versions” on page 32
- “How to Convert Printer Information For a System Running the SunOS 4.1 Release” on page 32
- “How to Start Admintool” on page 35
- “How to Add a Local Printer Using Admintool” on page 36
- “How to Add Printer Access on the Print Client Using Admintool” on page 42
- “How to Add Access on the Print Client using LP Commands” on page 43
- “How to Add Domain-Wide Access to a Printer using NIS” on page 44
- “How to Add Domain-Wide Access to a Printer using NIS+” on page 45
- “How to Use the `/etc/printers.conf` File to Load NIS” on page 46
- “How to Use the `/etc/printers.conf` File to Load NIS+” on page 47
- “How to Add a Network Printer Using Printer Vendor Supplied Tools” on page 53
- “How To Add A Network Printer Using LP Commands” on page 54

For overview information about printers, see Chapter 1.

Updating Print Clients to Access Existing Printers

This section explains how to convert the printer configuration information from systems running the SunOS 5.5.1 release and compatible versions at your site and copy this information to print clients so they can access existing printers.

Note - If you have only a few existing printers, it may be easier to add access to the printers by using Solstice Printer Manager or Admintool rather than convert the printer configuration information and distribute it to print clients. See Table 3-2 information on adding access to printers.

Updating Print Clients to Access Existing Printers Task Map

Table 3-1 provides an overview of the tasks you perform to convert the printer configuration information for systems running the SunOS 5.5.1 release and compatible versions at your site and distribute the information to print clients so they can access existing printers.

TABLE 3-1 Updating Print Clients to Access Existing Printers Task Map

Task	Description	For Instructions, Go To
Convert Existing Printer Configuration Information	<p><i>Convert Printer Configuration Information For Systems Running the SunOS 5.5.1 Release and Compatible Versions</i></p> <p>If your site uses SunOS 5.5.1 release and compatible versions, convert the printer configuration information in the <code>/etc/lp/printers</code> directory to the <code>/etc/printers.conf</code> configuration file. This is usually a one-time task.</p> <p><i>Convert Printer Configuration Information For a System Running the SunOS 4.1 Release</i></p> <p>If your site uses SunOS 4.1 software, convert the printer configuration information in a 4.1 system's <code>/etc/printcap</code> file to the <code>/etc/printers.conf</code> configuration file. This is usually a one-time task.</p>	<p>“How to Convert Printer Information For a System Running the SunOS 5.5.1 Release or Compatible Versions” on page 32</p> <p>“How to Convert Printer Information For a System Running the SunOS 4.1 Release” on page 32</p>

Converting Existing Printer Configuration Information

Existing printer configuration information will automatically be converted when installing or upgrading to the Solaris 7 release or compatible versions. This section explains how to convert the printer configuration information for a system running SunOS 5.5.1 release or compatible versions or a system running the SunOS 4.1 release to the `/etc/printers.conf` printer configuration file used in the print client software. You'll use one of two print administration commands to automate the conversion task:

- The `conv_lp(1M)` command enables you to convert information in the `/etc/lp/printers` directory on a SunOS 5.7 system to entries in the system's `/etc/printers.conf` file. See “How to Convert Printer Information For a System Running the SunOS 5.5.1 Release or Compatible Versions” on page 32 for instructions.
- The `conv_lpd(1M)` command enables you to convert information in a `/etc/printcap` configuration file from a SunOS 4.1 system to entries in a `/etc/printers.conf` file. See “How to Convert Printer Information For a System Running the SunOS 4.1 Release” on page 32 for instructions.

If you are not using a name service, you should create a master `/etc/printers.conf` file that includes the existing printers at your site. You can then copy the master file to all the print clients or by loading it into the NIS or NIS+ name service. This is a good way to initially enable all the new print clients access to the existing printers at your site.



Caution - If you are using the NIS or NIS+ name service to configure printer information, do not use a `/etc/printers.conf` file on your print clients. A print client uses the `/etc/printers.conf` file first to locate a printer; however, the `/etc/printers.conf` file may conflict with the printer information in the NIS or NIS+ maps and cause unexpected results. To avoid this problem, remove the `/etc/printers.conf` file on print clients when you want them to use NIS or NIS+ for printer information.

▼ How to Convert Printer Information For a System Running the SunOS 5.5.1 Release or Compatible Versions

1. **Log in as superuser on a system that has SunOS 5.7 or compatible software and the Solaris 2.6 or compatible print client software installed.**
2. **Convert the printer configuration information in the system's `/etc/lp/printers` directory to the `/etc/printers.conf` file.**

```
# /usr/lib/print/conv_lp
```

▼ How to Convert Printer Information For a System Running the SunOS 4.1 Release

1. **Copy the `/etc/printcap` file from a SunOS 4.1 system to a system running the SunOS 5.7 or compatible software that has the SunOS 5.7 compatible print client software.**
2. **Log in as superuser on the system running the SunOS 5.7 or compatible software to which you copied the `/etc/printcap` file.**
3. **Convert the printer configuration information in the `/etc/printcap` file to the `/etc/printers.conf` file.**

```
# /usr/lib/print/conv_lpd
```

Setting Up Printing

“Setting Up Printing Task Map” on page 33 provides an overview of the tasks necessary to set up print servers (Add a Printer) and print clients (Add Access to the Printer). A local printer is one which is physically cabled to the print server; a network printer is physically attached to the network. Adding access to a printer, or adding remote access, is the process of giving print clients (all those machines which are not the server) access to the printer.

Setting Up Printing Task Map

TABLE 3-2 Task Map: Setting Up Printing

Task	Description	For Instructions, Go To
1. Add a Local Printer	<p><i>Using Admintool</i></p> <p>After physically attaching the printer to a system, use Admintool to make the printer available for printing.</p> <p><i>Using LP Commands</i></p> <p>After physically attaching the printer to a system, use the LP commands to make the printer available for printing.</p>	<p>“How to Add a Local Printer Using Admintool” on page 36</p> <p>“How to Add a Local Printer Using LP Commands” on page 38</p>
2. Add Access to a Printer	<p><i>Using Admintool</i></p> <p>Add printer access on the print client using Admintool.</p> <p><i>Using LP Commands</i></p> <p>Add printer access on the print client using the lp commands.</p> <p><i>Using a Name Service</i></p> <p>Add printer access on the print client by setting up a <code>/etc/printers.conf</code> file in the NIS or NIS+ name service.</p>	<p>“How to Add Printer Access on the Print Client Using Admintool” on page 42</p> <p>“How to Add Access on the Print Client using LP Commands” on page 43</p> <p>“Adding Access to a Remote Printer Using a Name Service” on page 44</p>

TABLE 3-2 Task Map: Setting Up Printing (continued)

Task	Description	For Instructions, Go To
3. Add Access to Existing Printers	<p><i>Copy a Master /etc/printers.conf File to Clients</i></p> <p>If you don't use a name service, copy the printer configuration information in the converted system's /etc/printers.conf file to other print clients.</p> <p><i>Use the /etc/printers.conf File to Load NIS</i></p> <p>If you use the NIS name service, copy the printer configuration information in the converted system's /etc/printers.conf file to the NIS master file.</p> <p><i>Use the /etc/printers.conf File to Load NIS+</i></p> <p>If you use the NIS+ name service, copy the printer configuration information in the converted system's /etc/printers.conf file to the NIS master file.</p>	<p>"Enabling Print Clients to Access Existing Printers" on page 46</p> <p>"How to Use the /etc/printers.conf File to Load NIS" on page 46</p> <p>"How to Use the /etc/printers.conf File to Load NIS+" on page 47</p>
4. Set Up a .printers File	<p><i>Optional.</i> Using a \$HOME/.printers file enables users to establish their own custom printer aliases.</p>	<p>"Setting Up a .printers File" on page 47</p>
5. Add a Network Printer	<p><i>Using Printer Vendor Supplied Tools</i></p> <p>After physically connecting the printer to the network, use vendor-supplied software to configure the network printer.</p> <p><i>Using LP Commands</i></p> <p>After physically connecting the printer to the network, use SunOS 5.7 or compatible supplied software to configure the network printer.</p>	<p>"How to Add a Network Printer Using Printer Vendor Supplied Tools" on page 53</p> <p>"How To Add A Network Printer Using LP Commands" on page 54</p>
6. Turn Off Banner Pages	<p><i>Optional.</i> You can turn off banner pages so they are never printed.</p>	<p>"How to Turn Off Banner Pages" on page 70</p>
7. Set Up Fault Alerts	<p><i>Optional.</i> You can set up more specific fault alerts for the printer than Admintool provides.</p>	<p>"How to Set Fault Alerts for a Printer" on page 72</p>

TABLE 3-2 Task Map: Setting Up Printing (continued)

Task	Description	For Instructions, Go To
8. Set Up Fault Recovery	<i>Optional.</i> Admintool does not enable you to set up how a printer should recover after it faults.	“How to Set Printer Fault Recovery” on page 75
9. Limit Access to the Printer	<i>Optional.</i> Admintool enables you to set up an allow list, but if you want to limit a few users’ access to the printer, you may want to set up a deny list.	“How to Limit User Access to a Printer” on page 77

Starting Admintool

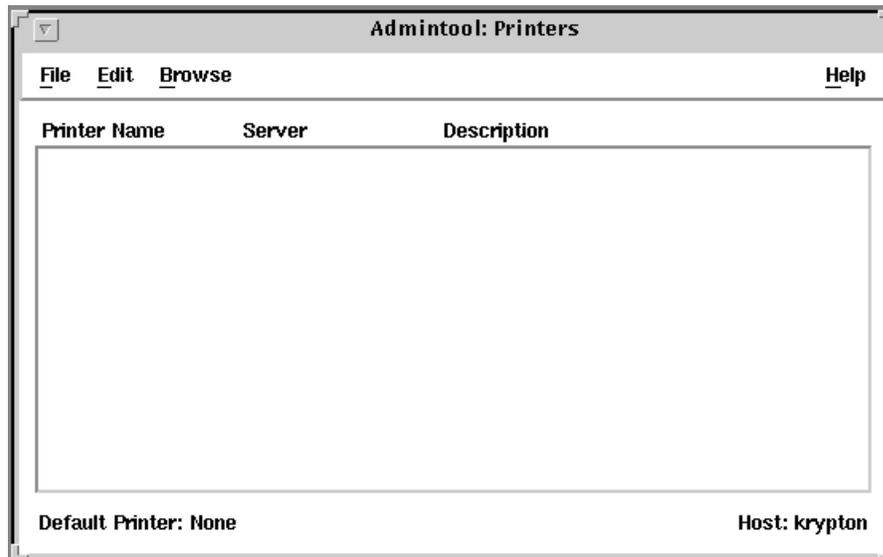
▼ How to Start Admintool

1. **Verify that the following prerequisites are met. To use the Admintool software, you must have:**
 - A bit-mapped display monitor. The Admintool software can be used only on a system with a console that is a bit-mapped screen, such as a standard display monitor that comes with a Sun workstation.
 - Running an X Window System, such as the OpenWindows environment.
 - Membership in the `sysadmin` group (group 14).
2. **Log in on the system where you want to set up the printer.**
3. **Start Admintool with the following command:**

```
$ admintool &
```

The Admintool main window is displayed.

4. **Select Printers from the Browse menu.**



The Printers window is displayed.

Setting Up a Print Server

When you add a local printer and/or a network printer to a system, the printer is made accessible to the local system. The system on which you install the printer becomes the *print server*.

A printer can be added using either Admintool or the LP print service commands. The following describes how to use each of these.

▼ How to Add a Local Printer Using Admintool

1. Select the system which is to be the printer server.

Verify that the print server has the following print packages installed by using the **pkginfo(1)** command: SUNWpcr, SUNWpcu, SUNWpsr, SUNWpsu, SUNWscplp, and SUNWpsf.

```
# pkginfo package_instance
```

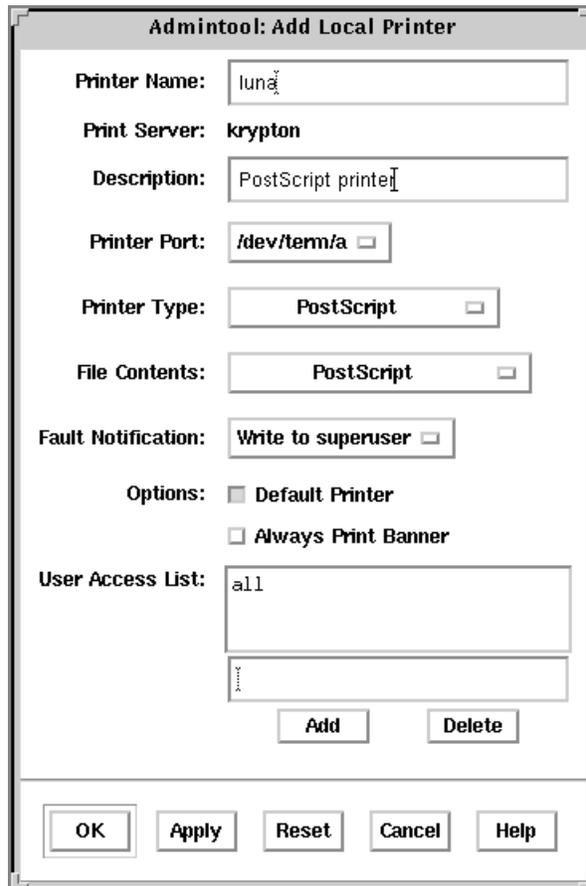
2. Connect the printer to the printer server and turn on the power to the printer.

Consult the printer vendor's installation documentation for information about the hardware switches and cabling requirements.

- 3. Start Admintool on the printer server where you connected the printer.**
See the procedure on “How to Start Admintool” on page 35 for detailed information.
- 4. Select Add Local Printer from the Edit menu.**
The Add Local Printer window is displayed.
- 5. Fill in the window.**
If you need information to complete a field, click on the Help button to see field definitions for this window.
- 6. Click on OK.**
The printer is displayed in the Admintool Printers window.
- 7. Exit Admintool.**
Click on button in upper-left corner; select quit.
- 8. Add client access to the new printer.**
Now that the printer has been added, create access to the printer for the clients. See “Setting Up a Print Client” on page 41.
- 9. Optional tasks to complete.**
There are several optional tasks you may want to complete when setting up a printer. See “Setting Up Printing Task Map” on page 33 for pointers to the remaining tasks.

Example—Completed Add Local Printer Window

In the following example, the printer `luna` is added on the print server `krypton`.



▼ How to Add a Local Printer Using LP Commands

Adding a local printer may also be accomplished using the command line interface.

1. Select the system which is to be the printer server.

Verify that the print server has the following print packages installed by using the `pkginfo(1)` command: `SUNWpcr`, `SUNWpcu`, `SUNWpsr`, `SUNWpsu`, `SUNWscplp`, and `SUNWpsf`.

```
# pkginfo package_instance
```

2. Connect the printer to the printer server and turn on the power to the printer.

Consult the printer vendor's installation documentation for information about the hardware switches and cabling requirements.

3. Set lp ownership and read/write access on the port device.

```
# chown lp /dev/term/device
# chmod 600 /dev/term/device
```

4. Define the printer name, the device, the printer type and content type by using the lpadmin(1M) command.

a. Define the printer name and the port device the printer will use.

```
# lpadmin -p printer-name -v /dev/term/device
```

b. Set the printer type of the printer.

```
# lpadmin -p printer-name -T printer-type
```

c. Specify the file content types of the printer.

```
# lpadmin -p printer-name -I content-type
```

5. Add filters to the print server by using the lpfilter(1M) command.

a. First, determine if the needed filters are installed.

```
# lpfilter -l -f all
```

If the filter is not installed, you will see the message:

```
ERROR: No filter by the name "" exists.
```

b. If you have determined that filter installation is needed, use the lpfilter command to install the filters.

```
# cd /etc/lp/fd
# for filter in *.fd;do
> name=`basename $filter .fd`
> lpfilter -f $name -F $filter
> done
```

(continued)

(Continuation)

6. Allow the printer to accept printer requests and enable the printer to print the requests.

```
# accept printer-name  
# enable printer-name
```

7. Verify the printer is correctly configured by using the `lpstat(1)` command.

```
# lpstat -p printer-name
```

8. (Optional) Add a description to the printer.

```
# lpadmin -p printer_name -D "description"
```

9. Add client access to the new printer.

Now that the printer has been added, create access to the printer for the clients. See “Setting Up a Print Client” on page 41.

10. Optional tasks to complete.

There are several optional tasks you may want to complete when setting up a printer. See “Setting Up Printing Task Map” on page 33 for pointers to the remaining tasks.

Example—Adding a Local Printer Using LP Commands

This example shows how to make a local PostScript printer available for printing on a print server. The commands in this example must be executed on the print server

where the printer is connected. The following information is used in the example and may change depending on your situation:

- Printer name: luna
- Port device: /dev/term/b
- Printer type: PS
- File content type: postscript

```
1 # chown lp /dev/term/b
# chmod 600 /dev/term/b
2 # lpadmin -p luna -v /dev/term/b
3 # lpadmin -p luna -T PS
4 # lpadmin -p luna -I postscript
# cd /etc/lp/fd
5 # for filter in *.fd;do
  > name=`basename $filter .fd`
  > lpfilter -f $name -F $filter
  > done
6 # accept luna destination ``luna`` now accepting requests
# enable luna printer ``luna`` now enabled
7 # lpadmin -p luna -D "Room 1954 ps"
8 # lpstat -p luna
printer luna is idle. enabled since Jun 16 10:25 1998.
available.
```

Setting Up a Print Client

A print client is a system that is not the server for the printer, yet has access to the printer. A print client uses the services of the print server to spool, schedule and filter the print jobs. Note that one system may be a print server for one printer and be a print client for another printer.

Access to a remote printer may be configured on a domain-wide basis or on a per-machine basis. A combination of these two may also be used. To add access to a remote printer on a per machine basis see “How to Add Printer Access on the Print Client Using Admintool” on page 42 or “How to Add Access on the Print Client using LP Commands” on page 43. To add access on a domain wide basis, follow the

-
1. Gives lp ownership and sole access to a port device.
 2. Defines the printer name and the port device the printer will use.
 3. Sets the printer type of the printer.
 4. Specifies the file content types to which the printer can print directly.
 5. Adds print filters to the print server.
 6. Accepts print requests for the printer and enables the printer.
 7. Adds a description for the printer.
 8. Verifies that the printer is ready.

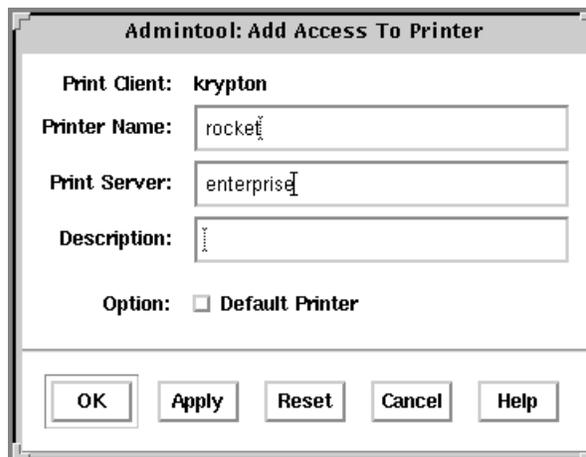
instructions under “Adding Access to a Remote Printer Using a Name Service” on page 44.

▼ How to Add Printer Access on the Print Client Using Admintool

- 1. Start Admintool on the system where you want to add access to a remote printer.**
See the procedure on “How to Start Admintool” on page 35 for detailed information.
- 2. Select Add Access to Remote Printer from the Edit menu.**
The Add Access to Remote Printer window is displayed.
- 3. Fill in the window.**
If you need information to complete a field, click on the Help button to see field definitions for this window.
- 4. Click on OK.**
The printer is displayed in the Admintool Printers window.
- 5. Exit Admintool.**
Click on button in upper-left corner; select quit.

Example—Adding Printer Access on the Print Client

In the following example, the print client *rogue* is given access to the printer *rocket* on the print server *enterprise*.



The screenshot shows a dialog box titled "Admintool: Add Access To Printer". It contains the following fields and options:

- Print Client:** krypton
- Printer Name:** rocket
- Print Server:** enterprise
- Description:** (empty text box)
- Option:** Default Printer

At the bottom of the dialog box, there are five buttons: OK, Apply, Reset, Cancel, and Help.

▼ How to Add Access on the Print Client using LP Commands

1. Collect the required information.

All that is required is the name of the printer and the name of the server for that printer.

2. Define the printer by using the `lpadmin` command.

```
# lpadmin -p printer_name -s server_name
```

3. (Optional) Add a description to the printer.

```
# lpadmin -p printer_name -D "description"
```

4. Verify the printer is correctly configured by using the `lpstat` command.

```
# lpstat -p printer-name
```

Example—Adding Access on the Print Client using LP Commands

If you want to print to a remote printer, you must add access to the remote printer. This example shows how to configure access to a printer named `luna`, whose print server is `saturn`. The system `saturn` becomes a print client of the printer `luna`.

```
9# lpadmin -p luna -s saturn
10# lpadmin -p luna -D "Room 1954 ps"
11# lpadmin -d luna
12# lpstat -p luna
printer luna is idle. enabled since Jun 16 10:25 1998. available.
```

-
9. Identifies the printer and the print server.
 10. Adds a description for the printer.
 11. Sets the printer as the system's default printer destination.
 12. Verifies that the printer is ready.

Adding Access to a Remote Printer Using a Name Service

Using either the NIS or NIS+ maps, access to a printer may be obtained on a domain-wide basis. See `nis+(1)`.

▼ How to Add Domain-Wide Access to a Printer using NIS

On the NIS master server, run the `lpset` command to create a `printers.conf` file; then create and push the map. This gives all members of the domain access to the printers defined in the map. See `lpset(1M)` for more information.

1. **Become superuser on the NIS master server.**
2. **Create a `printers.conf` file by using the `lpset` command for each printer.**

```
# lpset -a bsdaddr=server1,printer1,extensions printer1
```

`-a bsdaddr=server1,printer1,extensions`

Adds the print server, printer destination, and enables Solaris protocol extensions.

`printer1`

Specifies the printer name.

3. **Create and push the NIS map.**

```
# make -f /var/yp/makefile -f /usr/lib/print/Makefile.ypp printers.conf
```

`-f /var/yp/makefile`

Specifies the NIS makefile.

`-f /usr/lib/print/Makefile.ypp`

Specifies the NIS print makefile. This means implicit rules and predefined macros from both makefiles are concatenated.

`printers.conf`

Specifies the file to be created or updated.

Example—Adding Domain-Wide Access to a Printer using NIS

This example creates a `printers.conf` entry for the printer `luna`, connected to the print server, `saturn`. The `make` command pushes the `printers.conf` map.

```
# lpset -a bsdaddr=saturn,luna,Solaris -a description= "Room 1954 ps" luna
# make -f /var/yp/makefile -f /usr/lib/print/Makefile.ypp printers.conf
```

▼ How to Add Domain-Wide Access to a Printer using NIS+

On the NIS+ master server, use the `lpset` command. See `lpset(1M)` and `fns(5)` to add the printer configuration information to NIS+ via XFN.

1. **Become superuser on the NIS+ master server.**
2. **(Optional) If FNS has not been initialized, create the root organization context and its subcontents for the NIS+ root domain.**

```
# fncreate -t org org//
```

3. **Create the NIS+ map.**

```
# lpset -n fns -a bsdaddr=server1,printer1,extensions printer1
```

<code>-n fns</code>	Creates or updates the FNS content.
<code>-a bsdaddr=server1,printer1,extensions</code>	Adds the print server, printer destination, and enables Solaris protocol extensions.
<code>printer1</code>	Specifies the printer name.

Example—Adding Domain-Wide Access to a Printer using NIS+

This example creates a `printers.conf` entry for the printer `luna`, connected to the print server, `saturn`.

```
# lpset -n fns -a bsaddr=saturn,luna,solaris -a description=
"Room 1954 ps" luna
```

Enabling Print Clients to Access Existing Printers

Once you create a master `/etc/printers.conf` file that includes the existing printers at your site, you can enable all the SunSoft print clients to access the existing printers in two ways.

- If you don't use a name service, you can copy the master `/etc/printers.conf` file to all SunSoft print clients.
- If you use a name service, you can use the master `/etc/printers.conf` file to load the NIS or NIS+ master file, where the information becomes available to all SunSoft print clients.

▼ How to Use the `/etc/printers.conf` File to Load NIS

1. **Log in as superuser on the system that contains the `/etc/printers.conf` file to be copied to the NIS master server.**
2. **Copy the system's `/etc/printers.conf` file to the NIS master server's `/etc` directory.**
3. **Copy the `/usr/lib/print/Makefile.yp` makefile to the NIS master server's `/var/yp` directory.**
4. **Log in as superuser on the NIS master server.**
5. **On this system, specify how to process the files.**

```
# make -f /var/yp/makefile -f /var/yp/Makefile.yp printers.conf
```

<code>-f /var/yp/makefile</code>	Specifies the NIS makefile.
<code>-f /usr/lib/print/Makefile.ypp</code>	Specifies the NIS print makefile. This means implicit rules and predefined macros from both makefiles are concatenated.
<code>printers.conf</code>	Specifies the file to be created or updated.

▼ How to Use the `/etc/printers.conf` File to Load NIS+

1. **Make sure you are a member of the NIS+ admin group. You must have the appropriate privileges to perform this task.**
2. **Log in as superuser on the system that contains the `/etc/printers.conf` file to be copied to the NIS+ master file.**
3. **Copy the system's `/etc/printers.conf` file to the NIS+ master file.**

```
# fcreate_printer -f /etc/printers.conf thisorgunit/service/printer
```

See the *Federated Naming Service Programming Guide* if you need information about entering this command.

Where to Go From Here

After you have given SunSoft print clients access to existing printers, users may want to set up the `.printers` file in their home directory to contain custom printer aliases. For step-by-step instructions, see the next section.

Setting Up a `.printers` File

There is no need to set up a `.printers` file in your users' home directories if they don't need customized printer information. However, the `.printers` file enables users to establish their own custom printer aliases. You can use the alias `_default` to make a printer the default and also set up a special alias `_all` to define a list of printers affected when you cancel a print request or check the status of printers.

Keep in mind that the LP commands check a user's home directory to locate printer configuration information before they check the name service. This means you can tailor a user's printer configuration file to use custom printer information rather than the shared information in the name service.

See `printers(4)` for detailed information about the `.printers` file.

(Optional) How to Set Up a `.printers` File

1. Log in to the user's system as superuser.
2. Start the file editor you want to use to create a `.printers` file in the user's home directory.
3. (Optional) Set up the `_default` alias to make a specific printer your default printer, using an entry similar to the one shown in the following example.

```
# _default printer_name
```

4. (Optional) Set up the `_all` alias to define the printers affected when you cancel a print request or check the status of printers, using an entry similar to the one shown in the next example.

```
# _all printer1 printer2 printer3
```

5. Save the file as `.printers`.

Adding a Network Printer

A *network printer* is a hardware device that provides printing services to print clients without being directly cabled to a print server. It has its own system name and IP address, and is connected directly to the network. Even though a network printer is not connected to a print server, it is necessary to set up a print server for it. The print server provides queuing capabilities, filtering, and printing administration for the network printer.

Network printers use one or more special protocols that require a vendor-supplied printing program. The procedures to set up the vendor-supplied printing program can vary. If the printer does not come with vendor supplied support, the SunSoft network printer support may be used; it is strongly advised to use the print vendor supplied software when possible.

The vendor might supply an SVR4 printer interface script to replace the standard printer interface script. If so, their SVR4 interface script will call the vendor-supplied printing program to send the job to the printer. If not, you will need to modify the standard interface script to call the vendor-supplied printing program. You can do this by editing the per-printer copy of the standard interface script to call the vendor-supplied printing program.

The terms used in network printer configuration are:

- **Print server:** The machine which spools and schedules the jobs for a printer. This is the machine on which the printer is configured.
- **Printer-host device:** The printer-host device is the software and hardware supplied by a vendor which provides network printer support for a non-network capable printer. The combination of the printer-host device with one or more printers attached to it creates a *network printer*.
- **Printer node:** This is either the physical printer or the printer-host device. It is the physical printer when the network support resides in the physical printer. It is the printer-host device when an external box is used to provide the network interface. The printer node name is the machine name given with the IP address. This name is selected by the system administrator and has no default or vendor requirement. The printer nodename, as with all nodes, must be unique.
- **Printer name:** The name entered on the command line when using any of the printer commands. It is selected by the system administrator at the time of printer configuration. Any one physical printer may have several printer or queue names; each provides access to the printer.
- **Network printer access name:** The internal name of the printer node port that is used by the printer sub-system to access the printer. It is the name of the printer node, or the name of the printer node with a printer vendor port designation. Any printer vendor port designation is explicitly defined in the printer vendor documentation. It is printer specific. In the case where the printer is a printer-host device and a printer, the port designation is documented in the printer-host device documentation. The format is:

printer_node_name

or

printer_node_name:port_designation
- **Protocol:** the over-the-wire protocol used to communicate with the printer. The printer vendor documentation supplies the information regarding the protocol to select. The SunSoft network printer support supplies both BSD Printer Protocol and raw TCP. Due to implementation variations, you may want to try both.

- Timeout, or retry interval: Timeout is a seed number representing the number of seconds to wait between attempting connections to the printer. This seed number is the smallest amount of time to wait between attempted connections, and increases with an increase in failed connections. After repeated failures to connect to the printer, a message is returned to the user requesting possible human intervention. Attempts to reconnect continue until successful or the job is cancelled by the job owner.

Printer Vendor Supplied Software for Network Printers

Network printers often have software support provided by the printer vendor. If your printer has printer vendor supplied software it is strongly advised that the printer vendor software be utilized. The software is designed to support the attributes of the printer and can take full advantage of the printer capabilities. Read the printer vendor documentation to install and configure the printer under an LP print system.

Sun Support for Network Printers

If the network printer vendor does not provide software support, the Sun supplied software is available. The software provides generic support for network printers and is not capable of providing full access to all possible printer attributes.

A general discussion of how to add a network printer is provided in Chapter 3. The following is a discussion of printer management using the Sun supplied software.

Invoking the Network Printer Support

The software support for network printers is called through the interface script. Configuring a network printer with the network interface script, `netstandard`, causes the network printer support module to be called. The command to configure the printer with the network support is:

```
lpadmin -p printer_name -i /usr/lib/lp/model/netstandard
```

Selecting the Protocol

The print sub-system uses BSD print protocol and raw TCP to communicate with the printer. The printer vendor documentation will provide the information about which protocol to use. In general, we have found that the TCP protocol is more generic across printers.

The command to select the protocol is:

```
lpadmin -p printer_name -o protocol=bsd
```

or

```
lpadmin -p printer_name -o protocol=tcp
```

If the protocol selected is the BSD print protocol, you may further select the order of sending the control file to the printer. Some printers expect the control file, then the data file; others the reverse. See the printer vendor documentation for this information. The default is to send the control file first.

The command to select the ordering is:

```
lpadmin -p printer_name -o bsdctrl=first
```

or

```
lpadmin -p printer_name -o bsdctrl=last
```

Selecting the Printer Node Name

The system administrator selects the printer node name. This name must be unique, as with any node on the network. The printer node name is connected with the IP address of the printer.

Selecting the Network Printer Access Name

The print subsystem requires access information for the printer. This is the name that the subsystem uses when making the network connection to the printer. This name is supplied by the system administrator to the print sub-system through the `lpadmin` command. It becomes part of the printer configuration database. The printer access name is the name of the printer node, sometimes qualified by a port name. Port designation varies across printer vendors. You will find information about port designation in the documentation that is provided with the printer by the printer vendor. The format of printer access name is:

```
printer_node-name[ : port_designation ]
```

Example 1—Network Printer Access Name with Port Designation (Number)

A common port designation with TCP is 9100. If the printer node name is `pn1`, and the printer vendor defines the port as 9100, then the printer access name is:

`pn1:9100`. To configure a printer in this case use:

```
lpadmin -p printer_name -o dest=pn1:9100
```

Example 2—Network Printer Access Name with Port Designation (Name)

When using the BSD protocol, the port designation may not be a number, but some name defined by the printer vendor, for example: `xxx_parallel_1`. If the printer node name is `cardboard`, then the printer access name is:

`cardboard:xxx_parallel_1`. To configure a printer in this case use:

```
lpadmin -p printer_name -o dest=cardboard:xxx_parallel_1
```

Example 3—Network Printer Access Name with No Port Designation

If there is no port designation, and the printer node name is `newspaper`, the printer access name is the printer node name: `newspaper`. To configure a printer in this case use:

```
lpadmin -p printer_name -o dest=newspaper
```

Setting the Timeout Value

The timeout option is provided to allow for individual selection of the amount of time (in seconds) to wait between successive attempts to connect to the printer. Some printers have a long warm up time and a longer timeout value is advised. The default is 10 seconds.

The timeout value does not impact the success or failure of the print process. It is a seed value which the software uses as the initial timeout count; on repeated failures, this count is increased. A message is sent to the spooler when repeated attempts to connect to the printer fail. This alerts the user that intervention may be required. This could be anything from the printer being turned off, to out of paper. Should these messages be produced too often, for example when the printer is warming up, increasing the timeout value will eliminate spurious messages.

The system administrator can experiment to find the optimal timeout value. The command to set the timeout is:

```
lpadmin -p printer_name -o timeout=n
```

Managing Network Printer Access

Each network printer should have one and only one server that provides access to it. This enables the server to manage the access to the printer and keep jobs coherent.

The default device for the network printer is `/dev/null`. This is sufficient when there is only one queue for the printer. Should more queues be required, set the device to a file. This enables the print system to restrict access to the printer across queues. The following commands create a device file and configure it as the network printer device.

```
touch /path/filename
chmod 600 /path/filename
lpadmin -p printer_name -v /path/filename
```

The following is an example of creating a device file called `devtreedown`.

```
# touch /var/tmp/devtreedown
# chmod 600 /var/tmp/devtreedown
# lpadmin -p treedown -v /var/tmp/devtreedown
```

▼ How to Add a Network Printer Using Printer Vendor Supplied Tools

- 1. Connect the printer to the network and turn on the power to the printer.**

Consult the printer vendor's installation documentation for information about the hardware switches and cabling requirements. Get an IP address and select a name for the printer node. This is equivalent to adding any node to the network.
- 2. Follow the printer vendor instructions to add the network printer to a SunOS 5.7 system that has an SVR4 LP print spooler.**

Use the printer vendor instructions to configure the network printer. These will be specific to the vendor and printer.
- 3. Add client access to the new printer.**

Now that the printer has been added, create access to the printer for the clients. See "Setting Up a Print Client" on page 41.
- 4. Optional tasks to complete.**

There are several optional tasks you may want to complete when setting up a network printer. See "Setting Up Printing Task Map" on page 33 for pointers to the remaining tasks.

▼ How To Add A Network Printer Using LP Commands

Note - This describes the steps necessary to setup a network printer using the network printer support software. The use of this software is intended for those printers that do not come with vendor supplied software.

1. Connect the printer to the network and turn on the power to the printer.

Consult the printer vendor's installation documentation for information about the hardware switches and cabling requirements. Get an IP address and select a name for the printer node. This is equivalent to adding any node to the network.

2. Collect the information required to configure a network printer.

- Printer name
- Printer server
- Network printer access name
- Protocol
- Timeout

See the terms described in "Adding a Network Printer" on page 48 for more information.

3. Define the printer name, the device, the printer type and content type by using the `lpadmin(1M)` command.

a. Define the printer name and the port device the printer will use.

```
# lpadmin -p printer-name -v /dev/null
```

The device to use is `/dev/null`.

b. Identify the interface script the printer will use.

```
# lpadmin -p printer-name -i /usr/lib/lp/model/netstandard
```

The interface script that is supplied with the SunSoft network printer support software is `/usr/lib/lp/model/netstandard`.

c. Set the printer destination, protocol, and timeout values.

```
# lpadmin -p printer-name -o dest=access-name:port -o protocol=protocol
-o timeout=value
```

<code>-p printer-name</code>	Specifies the network printer name.
<code>-o dest=access-name:port</code>	Sets the printer destination to the network printer access name and a designated printer vendor port, if it is defined in the printer vendor documentation. See “Adding a Network Printer” on page 48 for more information.
<code>-o protocol:protocol</code>	Sets the over-the-wire protocol used to communicate with the printer. Both BSD and raw TCP are supported.
<code>-o timeout:value</code>	Sets a retry timeout value that represents a number of seconds to wait between attempting connections to the printer. See “Adding a Network Printer” on page 48 for more information.

d. Specify the file content types of the printer and the printer type.

```
# lpadmin -p printer-name -I content-type -T printer-type
```

4. Add filters to the print server by using the `lpfilter(1M)` command.

```
# cd /etc/lp/fd
# for filter in *.fd;do
  > name=`basename $filter .fd`
  > lpfilter -f $name -F $filter
> done
```

5. Enable the printer to accept printer requests and to print the requests.

```
# accept printer-name
# enable printer-name
```

6. Verify the printer is correctly configured by using the `lpfilter(1M)` command.

```
# lpstat -p printer-name
```

7. Add client access to the new printer.

Now that the printer has been added, create access to the printer for the clients. See “Setting Up a Print Client” on page 41.

8. Optional tasks to complete.

There are several optional tasks you may want to complete when setting up a printer. See “Setting Up Printing Task Map” on page 33 for pointers to the remaining tasks.

The commands in this example must be executed on the print server. The following information is used in the example and may change depending on your situation:

- Printer name: `luna1`
- Server: `saturn`
- Network printer access name: `nimquat:9100`
- Protocol: `tcp`
- Timeout: `5`
- Interface: `/usr/lib/lp/model/netstandard`
- Printer type: `PS`
- Content types: `postscript`
- Device: `/dev/null`

```
13# lpadmin -p luna1 -v /dev/null
14# lpadmin -p luna1 -i /usr/lib/lp/model/netstandard
15# lpadmin -p luna1 -o dest=nimquat:9100 -o protocol=tcp -o timeout=5
```

13. Defines printer name; sets the device to `/dev/null`.
14. Defines the interface script for network printers.
15. Sets the destination, protocol and timeout.

(continued)

(Continuation)

```
16 # lpadmin -p lunal -I postscript -T PS
# cd /etc/lp/fd
17 # for filter in *.fd;do
  > name=`basename $filter .fd`
  > lpfilter -f $name -F $filter
  > done
18 # accept lunal destination "lunal" now accepting requests
# enable lunal printer "lunal" now enabled
19 # lpadmin -p lunal -D "Room 1954 ps"
20 # lpstat -p lunal
  printer lunal is idle. enabled since Jun 16 10:25 1998.
available.
```

-
- 16. Specifies the file content types to which the printer can print directly, and the printer type.
 - 17. Adds print filters to the print server.
 - 18. Accepts print requests for the printer and enables the printer.
 - 19. Adds a description for the printer.
 - 20. Verifies that the printer is ready.

Administering Printers (Tasks)

This chapter provides the procedures to administer printers. This is a list of the step-by-step instructions in this chapter.

- “How to Delete a Printer and Remote Printer Access” on page 60
- “How to Check the Status of Printers” on page 63
- “How to Stop the Print Scheduler” on page 65
- “How to Restart the Print Scheduler” on page 66
- “How to Add a Printer Description” on page 66
- “How to Set a System’s Default Printer” on page 68
- “How to Make Banner Pages Optional” on page 69
- “How to Turn Off Banner Pages” on page 70
- “How to Define a Class of Printers” on page 71
- “How to Set Fault Alerts for a Printer” on page 72
- “How to Set Printer Fault Recovery” on page 75
- “How to Limit User Access to a Printer” on page 77
- “How to Check the Status of Print Requests” on page 79
- “How to Accept or Reject Print Requests for a Printer” on page 81
- “How to Enable or Disable a Printer” on page 84
- “How to Cancel a Print Request” on page 85
- “How to Cancel a Print Request From a Specific User” on page 86
- “How to Move Print Requests to Another Printer” on page 88
- “How to Change the Priority of a Print Request” on page 89

For overview information about printing and the LP print service, see Chapter 1.

Managing Printers and the Print Scheduler

This section provides instructions for day-to-day tasks you perform to manage printers and the print scheduler.

Deleting Printers and Printer Access

If a printer needs to be replaced or you want to move the printer to a different location, you must delete the printer information from the LP print service before you physically remove it from the print server. You should also make sure that all the current print requests on the printer are printed or moved to another printer to be printed.

Not only does the printer information need to be deleted from the print server, but it also needs to be deleted from the print clients or network name service. If you delete a local printer from a print server, you should delete the remote printer entry from the print clients or network name service. If you move a printer to another print server, you need to delete the old remote print entry from the print clients or network name service and add access to the remote printer in its new location.

See “How to Delete a Printer and Remote Printer Access” on page 60 for detailed information on how to delete a local and remote printer. You can use Admintool to delete a local or remote printer; however, Admintool does not enable you to move queued print requests to another printer.

▼ How to Delete a Printer and Remote Printer Access

1. **Log in as superuser or lp on a print client that has access to the printer you want to delete.**
2. **Delete information about the printer from the print client.**

```
print-client# lpadmin -x printer-name
```

`-x` Deletes the specified printer.

`printer-name` Name of the printer you want to delete.

Information for the specified printer is deleted from the print client's `/etc/lp/printers` directory.

- 3. If the print client does not use another printer on the same print server, delete information about the print server from the print client.**

```
print-client# lpsystem -r print-server
```

`-r` Removes the specified print server.

`print-server` Name of the print server you want to delete.

The print server is deleted from the print client's `/etc/lp/Systems` file.

- 4. Repeat Step 2 on page 60 through Step 3 on page 61 on each print client that has access to the printer.**
- 5. Log in as superuser or lp on the print server.**
- 6. Stop accepting print requests on the printer.**

```
print-server# reject printer-name
```

`reject printer-name` Rejects print requests for the specified printer.

This step prevents any new requests from entering the printer's queue while you are in the process of removing the printer. See "How to Accept or Reject Print Requests for a Printer" on page 81 for a detailed description.

- 7. Stop the printer.**

```
print-server# disable printer-name
```

This step stops print requests from printing. See “How to Enable or Disable a Printer” on page 84 for a detailed description on how to stop printing.

8. Move any print requests that are still in the queue to another printer.

See “How to Move Print Requests to Another Printer” on page 88 for a detailed description on how to move print requests to another printer.

9. Delete the printer from the print server.

```
print-server# lpadmin -x printer-name
```

Configuration information for the printer is deleted from the print server’s `/etc/lp/printers` directory.

10. Delete information about the print clients that were using the printer you just deleted, unless they are still using another printer on the print server.

```
print-server# lpsystem -x print-client1 [ ,print-client2... ]
```

<code>-x</code>	Removes the specified print client.
<code>print-client</code>	Name of the print client you want to delete from the print server. You can specify multiple print clients in this command. Use a space or a comma to separate print client names. If you use spaces, enclose the list of print clients in quotes.

The specified print clients are deleted from the print server’s `/etc/lp/Systems` file.

11. Verify the printer information has been deleted.

a. Check the printer information has been deleted on the print client.

```
print-client$ lpstat -p printer-name -l
```

You should receive an error indicating that the printer does not exist in the output of the above command.

b. Check the printer information has been deleted on the print server.

```
print-server$ lpstat -p printer-name -l
```

You should receive an error indicating that the printer does not exist in the output of the above command.

Example—Deleting a Printer and Remote Printer Access

In the following example, the commands delete the printer `luna` from the print client `terra` and from the print server `jupiter`, and also delete the print client `terra` from the print server.

```
terra# lpadmin -x luna
Removed ``luna``.
terra# lpstat -p luna -l
jupiter# lpadmin -x luna
jupiter# lpsystem -r terra
Removed ``terra``.
jupiter# lpstat -p luna -l
```

Checking Printer Status

Many routine printer administration tasks require information about the status of the LP print service or a specific printer. For example, you may need to determine which printers are available for use and examine the characteristics of those printers. You can use the `lpstat` command to find out status information about the LP print service or a specific printer.

▼ How to Check the Status of Printers

1. **Log in on any system on the network.**
2. **Check the status of printers by using the `lpstat` command.**
Only the most commonly used options are shown here. See `lpstat(1)` for other options.

```
$ lpstat [-d] [-p printer-name [-D] [-l]] [-t]
```

<code>-d</code>	Shows the system's default printer.
<code>-p printer-name</code>	Shows if a printer is active or idle, when it was enabled or disabled, and whether it is accepting print requests. You can specify multiple printer names with this command. Use a space or a comma to separate printer names. If you use spaces, enclose the list of printer names in quotes. If you don't specify <i>printer-name</i> , the status of all printers is displayed.
<code>-D</code>	Shows the description of the specified <i>printer-name</i> .
<code>-l</code>	Shows the characteristics of the specified <i>printer-name</i> .
<code>-t</code>	Shows status information about the LP print service, including the status of all printers: whether they are active and whether they are accepting print requests.

Examples—Checking the Status of Printers

In the following example, the command requests the name of the system's default printer.

```
$ lpstat -d
system default destination: luna
```

In the following example, the command requests the status of the printer `luna`.

```
$ lpstat -p luna
printer luna is idle. enabled since Jun 16 10:09 1998. available.
```

In the following example, the command requests a description of the printers `asteroid` and `luna`.

```
$ lpstat -p "asteroid luna" -D
printer asteroid faulted. enabled since Jun 16 10:09 1998. available.
unable to print: paper misfeed jam

Description: Printer by break room.
printer luna is idle. enabled since Jun 16 10:09 1998. available.
Description: Printer by server room.
```

In the following example, the command requests the characteristics of the printer luna.

```
$ lpstat -p luna -l
printer luna is idle. enabled since Jun 16 10:11 1998.
available.
Content types: any
Printer types: unknown
Description: Printer by server room.
Users allowed:
(all)
Forms allowed:
(none)
Banner not required
Character sets:
(none)
Default pitch:
Default page size:
```

Restarting the Print Scheduler

The print scheduler, `lpsched`, handles print requests on print servers. However, there may be times when the print scheduler stops running on a system, so print requests stop being accepted or printed.

To restart the print scheduler, you can use the `/usr/lib/lp/lpsched` command. If a print request was printing when the print scheduler stopped running, the print request will be printed in its entirety when you restart the print scheduler.

▼ How to Stop the Print Scheduler

1. Log in as superuser or `lp` on the print server.
2. Check to see if the print scheduler is running.

```
# lpstat -r
```

If the print scheduler is not running, the message `scheduler is not running` is displayed.

3. If the print scheduler is running, stop it.

```
# /usr/lib/lp/lpshut
```

▼ How to Restart the Print Scheduler

1. Log in as superuser or lp on the print server.
2. Check to see if the print scheduler is running.

```
# lpstat -r
```

If the print scheduler is not running, the message scheduler is not running is displayed.

3. If the print scheduler is not running, start it.

```
# /usr/lib/lp/lpsched
```

Setting or Resetting Miscellaneous Printer Definitions

This section provides step-by-step instructions on setting or resetting printer definitions. Some of the following printer definitions can be set using Admintool or Solstice Printer Manager. The procedures below use the lp commands to quickly set or reset printer definitions.

▼ How to Add a Printer Description

1. Log in as superuser or lp on the print server.
2. Add a printer description by using the `lpadmin(1M)` command.

```
# lpadmin -p printer-name -D "comment"
```

<code>-p printer-name</code>	Name of the printer for which you are adding a description.
<code>-D "comment"</code>	Specifies the characteristics of the printer, such as location or administrative contact. Enclose characters that the shell might interpret (like *, ?, \, !, ^) in single quotation marks.

The printer description is added in the print server's `/etc/lp/printers/printer-name/comment` file.

3. Verify the Description information is correct.

```
$ lpstat -p printer-name -l
```

Example—Adding a Printer Description

In the following example, the command adds a printer description for the printer luna.

```
# lpadmin -p luna -D "Nathans office"
```

Setting Up a Default Printer Destination

You can specify a default printer destination for a system so you don't need to type the printer name when using the print commands. Before you can designate a printer as the default, the printer must be known to the print service on the system. You can set a system's default printer destination by setting any of the following:

- LPDEST environment variable
- PRINTER environment variable
- System's default printer (by using the `lpadmin -d` command or Admintool)

When an application provides a printer destination, that destination is used by the print service, regardless of whether you have set a system's default printer destination. If an application doesn't provide a printer destination or if you don't provide a printer name when using a print command, the print command searches for the default printer in a specific order. Table 4-1 shows the search order for a system's default printer destination.

TABLE 4-1 Search Order for Default Printer Destinations

Search Order	Using <code>/usr/bin/lp</code> Command	Using SunOS/BSD Compatibility Commands (<code>lpr</code> , <code>lpq</code> , and <code>lprm</code>)
First	LPDEST variable	PRINTER variable
Second	PRINTER variable	LPDEST variable
Third	System's default printer	System's default printer

▼ How to Set a System's Default Printer

1. Log in as superuser or lp on the system for which you want to set a default printer.
2. Set the system's default printer by using the `lpadmin` command.

```
# lpadmin -d [printer-name]
```

`-d printer-name` Name of the printer you are assigning as the system's default printer. If you don't specify *printer-name*, the system is set up with no default printer.

The default printer name is entered in the system's `/etc/lp/default` file.

3. Check the system's default printer by using the `lpstat` command.

```
$ lpstat -d
```

Example—Setting a System's Default Printer

In the following example, the command sets the printer `luna` as the system's default printer. This means that `luna` will be used as the system's default printer if the `LPDEST` or `PRINTER` environment variables are not set.

```
# lpadmin -d luna
# lpstat -d
system default destination: luna
```

Printing Banner Pages

A banner page identifies who submitted the print request, the print request ID, and when the request was printed. A banner page will also have a modifiable title to help users identify their printouts.

Banner pages make identifying the owner of a print job easy, which is especially helpful when many users submit jobs to the same printer. Printing banner pages uses more paper, however, and may not be necessary if a printer has only a few users. In some cases, printing banner pages is undesirable. For example, if a printer has special paper or forms mounted, like paycheck forms, printing banner pages may cause problems.

By default, the print service forces banner pages to be printed. However, you can give users a choice to turn off printing of a banner page when they submit a print

request. You can set this choice through the `lpadmin` command or through Admintool. If you give the users a choice, they have to use the `-o nobanner` option to turn off printing of a banner page.

Also, you can turn off banner pages for a printer so they are never printed. This is important if you have a situation where you don't need or want banner pages. You can turn off banner page printing through the command line interface only. For step-by-step command-line instructions, see "How to Turn Off Banner Pages" on page 70.

▼ How to Make Banner Pages Optional

1. Log in as superuser or lp on the print server.
2. Make banner pages optional by using the `lpadmin` command.

```
# lpadmin -p printer-name -o nobanner
```

`-p printer-name` Name of the printer for which you are making banner pages optional.

`-o nobanner` Enables users to specify no banner page when they submit a print request.

If you want to force a banner page to print with every print request, specify the `-o banner` option.

The banner page setting is entered in the print server's `/etc/lp/printers/printer-name/configuration` file.

3. Verify the output from the following command contains the line `Banner not required.`

```
$ lpstat -p printer-name -l
```

Example—Making Banner Pages Optional

In the following example, the command enables users to request no banner page on the printer `luna`.

```
# lpadmin -p luna -o nobanner
```

▼ How to Turn Off Banner Pages

1. Log in as superuser or lp on the print server.
2. Change directory to the `/etc/lp/interfaces` directory.

```
# cd /etc/lp/interfaces
```

3. Edit the file that has the name of the printer for which you want to turn off banner pages.
4. Change the `nobanner` variable to `yes`.

```
nobanner="yes"
```

Change the `nobanner` variable to `no` if you want to turn banner pages on again. The banner page setting is entered in the print server's `/etc/lp/printers/printer-name/configuration` file.

5. Submit a print request to the printer to make sure a banner page does not print.

Setting Up Printer Classes

The print service enables you to group several locally attached printers into one class. You can perform this task only by using the `lpadmin -c` command.

When you have set up a printer class, users can then specify the class (rather than individual printers) as the destination for a print request. The first printer in the class that is free to print is used. The result is faster turnaround because printers are kept as busy as possible.

There are no default printer classes known to the print service; printer classes exist only if you define them. Here are some ways you could define printer classes:

- By printer type (for example, PostScript)
- By location (for example, 5th floor)
- By work group or department (for example, Accounting)

Alternatively, a class might contain several printers that are used in a particular order. The LP print service always checks for an available printer in the order in which printers were added to a class. Therefore, if you want a high-speed printer to be accessed first, you would add it to the class before you add a low-speed printer. As a result, the high-speed printer would handle as many print requests as possible. The low-speed printer would be reserved as a backup printer when the high-speed printer is in use.

Note - Print requests are balanced between printers in a class only for local printers.

Class names, like printer names, must be unique and may contain a maximum of 14 alphanumeric characters and underscores.

You are not obligated to define printer classes. You should add them only if you determine that using printer classes would benefit users on the network.

▼ How to Define a Class of Printers

1. Log in as superuser or lp on the print server.
2. Define a class of printers by using the `lpadmin` command.

```
# lpadmin -p printer-name -c printer-class
```

`-p printer-name` Name of the printer you are adding to a class of printers.

`-c printer-class` Name of a class of printers.

The specified printer is added to the end of the list in the class in the print server's `/etc/lp/classes/printer-class` file. If the printer class does not exist, it is created.

3. Verify the printers in a printer class by using the `lpstat` command.

```
$ lpstat -c printer-class
```

Example—Defining a Class of Printers

In the following example, the command adds the printer `luna` in the class `roughdrafts`.

```
# lpadmin -p luna -c roughdrafts
```

Setting Up Printer Fault Alerts

If you choose, the print service can notify you when it detects a printer fault. You can select any of the following methods to receive printer fault notification with the `lpadmin -A` command or with `Admintool`:

- Write a message to the terminal on which root is logged in

- Electronic mail to root
- No notification

However, the `lpadmin -A` command offers you an additional option of receiving a message specified by the program of your choice. It also enables you to selectively turn off notification for an error that you already know about.

Unless you specify a program to deliver fault notification, the content of the fault alert is a predefined message that says the printer has stopped printing and needs to be fixed.

Table 4-2 lists the alert values that you can set for a printer with the `lpadmin -A` command. These alert values can also be set for print wheels, font cartridges, and forms.

TABLE 4-2 Values for Printing Problem Alerts

Value for <code>-A</code> alert	Description
<code>'mail [user-name]'</code>	Send the alert message by email to root or lp on the print server, or the specified <i>user-name</i> , which is a name of a user.
<code>'write [user-name]'</code>	Send the alert message to the root or lp console window on the print server, or to the console window of the specified <i>user-name</i> , which is a name of a user. The specified user must be logged in to the print server to get the alert message.
<code>'command'</code>	Run the <i>command</i> file for each alert. The environment variables and current directory are saved and restored when the file is executed.
<code>quiet</code>	Stop alerts until the fault is fixed. Use this when you (root or specified user) receive repeated alerts.
<code>none</code>	Do not send any alerts. This is the default if you don't specify fault alerts for a printer.

▼ How to Set Fault Alerts for a Printer

1. Log in as superuser or lp on the print server.
2. Set fault alerts for a printer with the `lpadmin` command.

```
# lpadmin -p printer-name -A alert [-W minutes]
```

<code>-p printer-name</code>	Name of the printer for which you are specifying an alert for printer faults.
<code>-A alert</code>	Specifies what kind of alert will occur when the printer faults. See Table 4-2 for detailed information about the valid values for <i>alert</i> . Some valid values are <i>mail</i> , <i>write</i> , and <i>quiet</i> .
<code>-W minutes</code>	Specifies how often (in minutes) the fault alert will occur. If you don't specify this option, the alert is sent once.

The fault alert setting is entered in the print server's `/etc/lp/printers/printer-name/alert.sh` file.

3. Check the information following the `On fault` heading from the output of the following command.

```
$ lpstat -p printer-name -l
```

Examples—Setting Fault Alerts for a Printer

In the following example, the command sets up the printer `mars` to send fault alerts by email to a user named `joe`, with reminders every 5 minutes.

```
# lpadmin -p mars -A 'mail joe' -W 5
```

In the following example, the command sets up the printer `venus` to send fault alerts to the console window, with reminders every 10 minutes.

```
# lpadmin -p venus -A write -W 10
```

In the following example, the command stops fault alerts for the printer `mercury`.

```
# lpadmin -p mercury -A none
```

In the following example, the command stops fault alerts until the printer `venus` has been fixed.

```
# lpadmin -p venus -A quiet
```

Setting Up Printer Fault Recovery

If you choose not to send any fault notification, you may want a way to find out about printing faults so you can correct the problem. The LP print service will not continue to use a printer that has a fault. In addition to alerts for printer faults, you

can also provide alerts that tell the system administrator to mount print wheels, font cartridges, and forms when print requests require them.

You can define the fault recovery options for a printer only by using the `lpadmin -F` command. This task is not available in Admintool.

Printer faults can be as simple as running out of paper or needing to replace a toner cartridge. Other more serious problems may include complete printer failure or power failure. After you fix a printer fault, the print request that was active when the fault occurred begins printing in one of three ways:

- Starts printing from the beginning
- Continues printing from the top of the page where printing stopped
- After you enable the printer, continues printing from the top of the page where the printing stopped

A print filter is required to continue printing from the top of a page where the printing stopped. A print filter records the control sequences used by the printer to track page boundaries, which the default filters used by the print service cannot do. You will be notified by the print service if recovery cannot proceed with the specified print filter. For information about writing filters, see “How to Create a New Print Filter” on page 142.

If you want printing to resume immediately after a printer fault is fixed, enable the printer by using the `enable` command.

Table 4-3 lists the fault recovery values you can set for a printer with the `lpadmin -F` command.

TABLE 4-3 Values for Printer Fault Recovery

Value for <code>-F recover-options</code>	Description
<code>beginning</code>	After a fault recovery, printing restarts from the beginning of the file.
<code>continue</code>	After a fault recovery, printing starts at the top of the page where the printing stopped. This recovery option requires a print filter.
<code>wait</code>	After a fault recovery, printing stops until you enable the printer. After you enable the printer (<code>enable</code> command), printing starts at the top of the page where printing stopped. This recovery option requires a print filter.

▼ How to Set Printer Fault Recovery

1. Log in as superuser or lp on the print server.
2. Set up fault recovery for the printer with the `lpadmin(1M)` command.

```
# lpadmin -p printer-name -F recovery-options
```

<code>-p printer-name</code>	Name of the printer for which you are specifying fault recovery.
<code>-F recovery-options</code>	One of the three valid recovery options: beginning, continue, or wait. See Table 4-3 for detailed information about the valid values for <i>recovery-options</i> .

The fault recovery setting is entered in the print server's `/etc/lp/printers/printer-name/configuration` file.

3. Check the information following the `After fault` heading in the output of the following command.

```
$ lpstat -p printer-name -l
```

Example—Setting Printer Fault Recovery

In the following example, the command sets up the printer `luna` to continue printing at the top of the page where printing stopped.

```
# lpadmin -p luna -F continue
```

Limiting User Access to a Printer

You may want to control which users can access some or all of the available printers. For example, you may want to prevent some users from printing on a high-quality printer to minimize expense. To restrict user access to printers, you can create `allow` and `deny` lists using the `lpadmin -u` command on the print server. (Admintool enables you to create only allow lists.) If you create neither, a printer is available to all users who can access the printer.

An allow list contains the names of users allowed access to the specified printer; a deny list contains the names of users denied access to the specified printer.

The rules for allow and deny lists are:

When You ...	Then ...
Do not create allow and deny lists, or if you leave both lists empty	All users may access the printer.
Specify <code>all</code> in the allow list	All users may access the printer.
Specify <code>all</code> in the deny list	All users, except root and lp (on the server), are denied access to the printer.
Make any entry in the allow list	The deny list is ignored. Only those users who are listed can access the printer.
Create a deny list, but you do not create an allow list or you leave the allow list empty	Users who are listed in the deny list are denied access to the printer.

Because the print server is actually controlling access to the printer, allow and deny lists can only be created on the print server itself. If you create allow and deny lists, the print server will exclusively control user access to printers.

Table 4-4 lists the values you can add to an allow or deny list to limit user access to a printer.

TABLE 4-4 Values for Allow and Deny Lists

Value for <i>user-list</i>	Description
<code>user</code>	User on any system
<code>all</code>	All users on all systems
<code>none</code>	No user on any system
<code>system!user</code>	User on <i>system</i> only
<code>!user</code>	User on local system only
<code>all!user</code>	User on any system
<code>all!all</code>	All users on all systems

TABLE 4-4 Values for Allow and Deny Lists (continued)

Value for <i>user-list</i>	Description
<code>system!all</code>	All users on <i>system</i>
<code>!all</code>	All users on local system

▼ How to Limit User Access to a Printer

1. Log in as superuser or lp on the print server.
2. Allow or deny users access to a printer by using the `lpadmin` command.

```
# lpadmin -p printer-name -u allow:user-list [ deny:user-list]
```

<code>-p printer-name</code>	Name of the printer to which the allow or deny user access list applies.
<code>-u allow:user-list</code>	User names to be added to the allow user access list. You can specify multiple user names with this command. Use a space or a comma to separate names. If you use spaces, enclose the list of names in quotes. Table 4-4 provides the valid values for <i>user-list</i> .
<code>-u deny:user-list</code>	User names to be added to the deny user access list. You can specify multiple user names with this command. Use a space or a comma to separate names. If you use spaces, enclose the list of names in quotes. Table 4-4 provides the valid values for <i>user-list</i> .

The specified users are added to the allow or deny user access list for the printer in one of the following files on the print server:

```
/etc/lp/printers/printer-name/users.allow
```

```
/etc/lp/printers/printer-name/users.deny
```

Note - If you specify none as the value for *user-list* in the allow user access list, the following files are not created for the print server:

```
/etc/lp/printers/printer-name/alert.sh  
/etc/lp/printers/printer-name/alert.var  
/etc/lp/printers/printer-name/users.allow  
/etc/lp/printers/printer-name/users.deny
```

3. Check the information following the `Users allowed` or `Users denied` heading in the output of the following command.

```
$ lpstat -p printer-name -l
```

Examples—Limiting User Access to a Printer

In the following example, the command allows only the users `nathan` and `george` access to the printer `luna`.

```
# lpadmin -p luna -u allow:nathan,george
```

In the next example, the command denies the users `nathan` and `george` access to the printer `asteroid`.

```
# lpadmin -p asteroid -u deny:"nathan george"
```

Managing Print Requests

When a user submits a print request from a print client, the print request is added to a queue on the print server before it is sent to the printer. While a print request is in the queue, you can cancel or gain status information on the request from a client system. To move, hold, resume, or change the priorities of print requests you must login to the print server. These actions can help you keep printing services operating smoothly.

The LP commands enable you to perform all print request management tasks. Admintool enables you to perform some print request management tasks when you

modify a print server. Table 4-5 lists the print request management tasks you can perform with Admintool.

TABLE 4-5 Print Request Management With Admintool

Task	Can You Do With Admintool?
Canceling a print request	No
Moving a print request	No
Changing priority of print requests	No
Accepting or rejecting print requests	Yes
Processing or stopping printing	Yes

Table 4-6 lists the values for changing the priority of a print request with the `lp -H` command.

TABLE 4-6 Values for Changing the Priority of a Print Request

Value for <code>-H change-priority</code>	Description
<code>hold</code>	Places the print request on hold until you cancel it or instruct the LP print service to resume printing the request.
<code>resume</code>	Places a print request that has been on hold back in the queue. It will be printed according to its priority and placement in the queue. If you put a hold on a print job that is already printing, <code>resume</code> puts the print request at the head of the queue so it becomes the next request printed.
<code>immediate</code>	Places a print request at the head of the queue. If a request is already printing, you can put it on hold to allow the next request to print immediately.

▼ How to Check the Status of Print Requests

1. **Log in on any system on the network.**
2. **Check the status of printers and print requests by using the `lpstat` command.**

Only the most commonly used options are shown here. See `lpstat(1)` for other valid options.

```
$ lpstat -o [list] | -u [user-list]
```

`-o list`

Shows the status of print requests on a specific printer. *list* can be one or more printer names, printer class names, or print request IDs.

You can specify multiple printer names, class names, and IDs for *list*. Use a space or a comma to separate values. If you use spaces, enclose the list of values in quotes.

If you don't specify *list*, the status of print requests to all printers is displayed.

`-u user-list`

Shows the status of print requests for a specific user. *user-list* can be one or more user names.

You can specify multiple users with this command. Use a space or a comma to separate user names. If you use spaces, enclose the list of names in quotes.

If you don't specify *user-list*, the status of print requests for all users is displayed.

When used to check the status of print requests, the `lpstat` command displays one line for each print request. From left to right, the line shows the request ID, the user, the output size in bytes, the date and time of the request, and information about the request, such as “being filtered.”

Examples—Checking the Status of Print Requests

In the following example, the command shows that user `fred` has one print request queued to the printer `luna`.

```
$ lpstat
luna-1    fred      1261     Mar 12 17:34
```

In the following example, the command shows that the user `paul` currently has no print requests in queue.

```
$ lpstat -u paul
```

In the following example, the command shows that there are two print requests on the printer `moon`.

```
$ lpstat -o moon
moon-78    root      1024    Jan 14 09:07
moon-79    root      1024    Jan 14 09:08
```

Processing or Stopping Printing

The `enable(1)` and `disable(1)` commands (or the Process Print Requests field on Admintool's Modify Printer window) control whether a printer prints or stops printing requests that are in the print queue. When you disable a printer, the printer stops printing requests in queue; however, requests are still added to the queue. (You must set the printer to reject print requests so requests are not added to the queue. See "Accepting or Rejecting Print Requests" on page 82 for information about rejecting print requests.)

You must enable the printer whenever it has been disabled, which may happen when a printer fault occurs. When you enable a printer, it prints requests from the print queue until the queue is empty, even if the print service rejects additional requests for the print queue.

Figure 4-1 shows the point at which processing of print requests is interrupted when a printer is disabled.

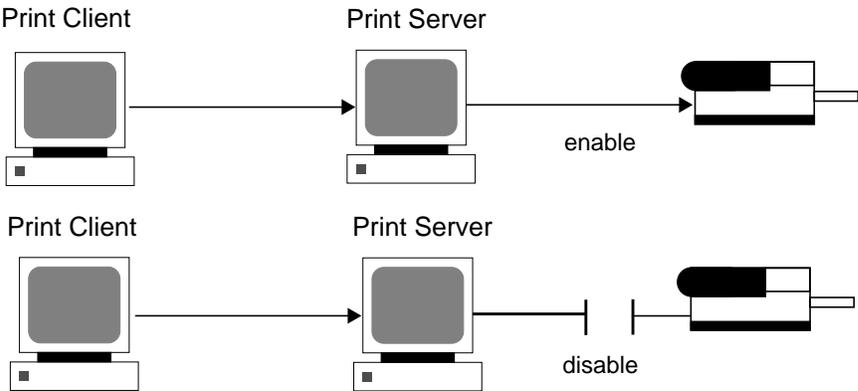


Figure 4-1 What Happens When a Printer Is Enabled or Disabled

▼ How to Accept or Reject Print Requests for a Printer

- 1. Log in as superuser or lp on the print server.
- 2. Stop accepting print requests for the printer by using the `reject(1M)` command.

```
# reject [-r "reason"] printer-name
```

`-r "reason"` Provides users a reason why the printer is rejecting print requests. The reason is stored and displayed whenever a user checks on the status of the printer (`lpstat -p`).

`printer-name` Name of the printer that will stop accepting print requests.

The queued requests will continue printing as long as the printer is enabled. For instructions on disabling a printer so it stops printing, see “How to Enable or Disable a Printer” on page 84.

3. Start accepting print requests for the printer by using the `accept(1M)` command.

```
# accept printer-name
```

4. Check the status of the printer to see whether it is accepting or rejecting print requests by using the `lpstat` command.

```
$ lpstat -p printer-name
```

Examples—Accepting or Rejecting Print Requests for a Printer

In the following example, the command stops the printer `luna` from accepting print requests.

```
# reject -r "luna is down for repairs" luna
destination "luna" will no longer accept requests
```

In the following example, the command sets the printer `luna` to accept print requests.

```
# accept luna
destination "luna" now accepting requests
```

Accepting or Rejecting Print Requests

The `accept` and `reject` commands—or the Accept Print Requests field in Admintool’s Modify Printer window—enable you to turn on or turn off a print queue that stores requests to be printed.

When you use the `reject` command, the print queue for a specified printer is turned off—no new print requests can enter the queue on the print server. All print requests that are in the queue are still printed. You must disable the printer if you want it to stop printing requests that are already in the queue. Table 4-7 compares the functions of the `accept`, `reject`, `enable`, and `disable` commands.

TABLE 4-7 Functions of `accept/reject` and `enable/disable` Commands

Command	Function
<code>accept</code>	Accept print requests that are sent to the print queue.
<code>enable</code>	Print the requests that are in the print queue.
<code>reject</code>	Reject print requests that are sent to the print queue.
<code>disable</code>	Stop printing requests that are currently in the print queue.

See “Processing or Stopping Printing” on page 81 for information about disabling a printer.

If a print request is rejected, the print service writes or mails a message to the user who submitted the request, saying that print requests are not being accepted for the specified printer.

You can also specify a reason for not accepting requests through the command line. The reason is displayed on users’ systems when one tries to check the printer’s queue. Figure 4-2 shows the point at which processing of print requests is interrupted when a print queue rejects print requests.

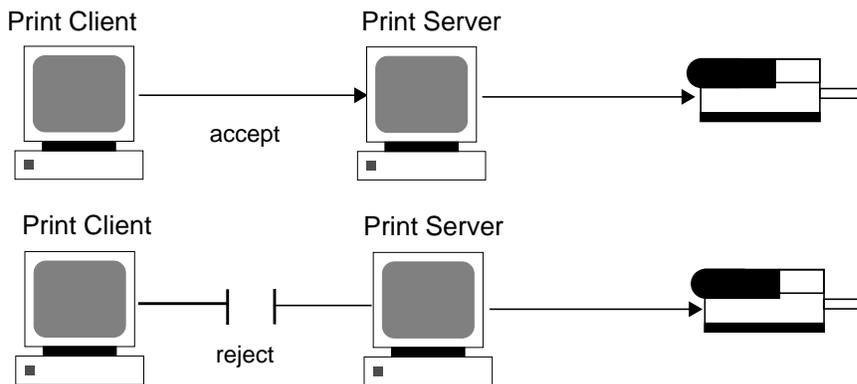


Figure 4-2 What Happens When a Print Queue Accepts or Rejects Requests

▼ How to Enable or Disable a Printer

1. Log in as superuser or `lp` on the print server.
2. Stop printing print requests on the printer by using the `disable` command.

```
# disable [-c | -W] [-r "reason"] printer-name
```

<code>disable</code>	Cancels the current job, then disables the printer. The current job is saved to reprint when the printer is enabled.
<code>-c</code>	Cancels the current job, then disables the printer. The current job is not printed later.
<code>-W</code>	Waits until the current job is finished before disabling the printer.
<code>-r "reason"</code>	Provides users with a reason why the printer is disabled. The reason is stored and displayed whenever a user checks on the status of the printer (<code>lpstat -p</code>).
<code>printer-name</code>	Name of the printer that will stop printing print requests.

Note - You cannot enable or disable classes of printers. Only individual printers can be enabled or disabled.

3. Start printing print requests on the printer by using the `enable` command.

```
# enable printer-name
```

4. Verify the printer is enabled.

```
$ lpstat -p printer-name
```

Examples—Enabling or Disabling a Printer

In the following example, the command stops the current job on the printer `luna`, saves it to print later, and provides a reason why the printer has stopped printing print requests.

```
# disable -r "changing the form" luna
```

In the following example, the command starts printing print requests on the printer luna.

```
# enable luna
printer "luna" enabled
```

Canceling a Print Request

You can use the `cancel(1)` to cancel print requests from printer queues or to cancel jobs that are printing. There are three ways to use the `cancel` command:

- Cancel requests by request identification number (request ID)
- Cancel requests from a specific user on all, or specified, printers
- Cancel the job currently printing

When you use `cancel`, a message tells you the request(s) are canceled, and the next request in queue is printed. You can cancel a print request only if you are:

- The user who submitted the request and you are logged in on the system from which you submitted the request
- The user who submitted the request on any client system and the print server has the “user-equivalence” option configured for the printer in its `/etc/printers.conf` file.
- Logged in as superuser or `lp` on the print server.

To cancel a specific request, you need to know its request ID. The request ID is comprised of the name of the printer, a dash, and the number of the print request—for example, `luna-185`. When you submit the print request, the request ID is displayed. If you do not remember the print request ID, you can find it by using the `lpstat` command with the `-o printer` option.

▼ How to Cancel a Print Request

1. **If you are going to cancel print requests of other users, become superuser or `lp`.**
2. **Determine the request IDs of the print requests to cancel by using the `lpstat` command.**
See “How to Check the Status of Print Requests” on page 79 for more details.
3. **Cancel a print request by using the `cancel` command.**

```
$ cancel request-id | printer-name
```

<i>request-id</i>	Request ID of a print request to be canceled. You can specify multiple request IDs with this command. Use a space or a comma to separate request IDs. If you use spaces, enclose the list of request IDs in quotes.
<i>printer-name</i>	Specifies the printer for which you want to cancel the currently printing print request. You can specify multiple printer names with this command. Use a space or a comma to separate printer names. If you use spaces, enclose the list of printer names in quotes.

4. Verify the print requests are canceled.

```
$ lpstat -o printer-name
```

Examples—Canceling a Print Request

In the following example, the command cancels the luna-3 and luna-4 print requests.

```
$ cancel luna-3 luna-4
request "luna-3" cancelled
request "luna-4" cancelled
```

In the following example, the command cancels the print request that is currently printing on the printer luna.

```
# cancel luna
request "luna-9" cancelled
```

▼ How to Cancel a Print Request From a Specific User

1. (Optional) Become superuser or lp if you are going to cancel print requests of other users.
2. Cancel a print request from a specific user with the `cancel` command.

```
$ cancel -u user-list [printer-name]
```

<code>-u <i>user-list</i></code>	<p>Cancels the print request for a specified user.</p> <p><i>user-list</i> can be one or more user names. Use a space or a comma to separate user names. If you use spaces, enclose the list of names in quotes.</p>
<code><i>printer-name</i></code>	<p>Specifies the printer for which you want to cancel the specified user's print requests.</p> <p><i>printer-name</i> can be one or more printer names. Use a space or a comma to separate printer names. If you use spaces, enclose the list of printer names in quotes.</p> <p>If you don't specify <i>printer-name</i>, the user's print requests will be canceled on all printers.</p>

Examples—Canceling a Print Request From a Specific User

In the following example, the command cancels all the print requests submitted by the user `george` on the printer `luna`.

```
# cancel -u george luna
request "luna-23" cancelled
```

In the following example, the command cancels all the print requests submitted by the user `george` on all printers.

```
# cancel -u george
request "asteroid-3" cancelled
request "luna-8" cancelled
```

Moving a Print Request

If you plan to change the way a printer is used or decide to take a printer out of service, you should set up the LP print service to reject additional print requests, and then move or cancel any requests that are currently queued to the printer. You can use the `lpmove(1M)` command to move individual or all print requests to another local printer.

Request IDs are not changed when you move print requests, so users can still find their requests. Print requests that have requirements (such as file content type or forms) that cannot be met by the newly specified printer cannot be moved; they must be canceled.

▼ How to Move Print Requests to Another Printer

To move all print requests from one printer to another, you do not need to know the request IDs; however, it is a good idea to see how many print requests are affected before you move them.

1. **Log in as superuser or lp on the print server.**
2. **(Optional) Check the request IDs of the print requests on the original printer.**

```
# lpstat -o printer-name1
```

3. **(Optional) Check if the destination printer is accepting print requests.**

```
# lpstat -p printer-name2
```

`-p printer-name2` Name of the printer to which you are moving the print requests.

4. **Move all the print requests from the original printer to the destination printer.**

```
# lpmove printer-name1 printer-name2
```

`printer-name1` Name of the printer from which all print requests will be moved.

`printer-name2` Name of the printer to which all print requests will be moved.

If some requests cannot be printed on the destination printer, they are left in the original printer's queue. By using request IDs, you can also move specific print requests to another printer with the `lpmove` command.

5. **Start accepting print requests on the original printer.**

If you move all the print requests to another printer, the `lpmove` command automatically stops accepting print requests for the printer. This step is necessary if you want to begin accepting new print requests for the printer.

```
# accept printer-name1
```

6. Check for any remaining print requests in the original printer's queue by using the following command.

```
$ lpq -P printer-name1
```

Make sure all specified print requests were moved to the destination printer's queue by using the following command.

```
$ lpq -P printer-name2
```

Example—Moving Print Requests to Another Printer

In the following example, the `lpmove` command moves print requests from the printer `luna` to the printer `terra`, and the `accept` command tells the original printer `luna` to resume accepting print requests.

```
# lpmove luna terra
# accept luna
```

Changing the Priority of Print Requests

After a user has submitted a print request, you can change its priority in the print server's queue by:

- Putting any print request on hold if it has not finished printing. Putting a request on hold stops it, if it is currently printing, and keeps it from printing until you resume printing it. Other print requests go ahead of the on-hold request.
- Moving any print request to the head of the queue, where it will be the next job eligible for printing. If you want a job to start printing immediately, you can interrupt the job that is currently printing by putting it on hold.
- Changing the priority of a job still waiting to be printed, moving it in the queue so it is ahead of lower priority requests and behind requests at the same level or at a higher priority.

▼ How to Change the Priority of a Print Request

1. Log in as superuser or lp on the print server that is holding the print request.
2. Determine the request IDs of the print requests whose priority you want to change by using the `lpstat` command.
See “How to Check the Status of Print Requests” on page 79 for more information.

3. Change the priority of a print request by using the `lp` command.

```
# lp -i request-id -H change-priority
```

`-i request-id`

Request ID of a print request you want to change.

You can specify multiple request IDs with this command. Use a space or a comma to separate request IDs. If you use spaces, enclose the list of request IDs in quotes.

`-H change-priority`

One of the three ways to change the priority of a print request: `hold`, `resume`, `immediate`.

See Table 4-6 for detailed information about valid values for *change-priority*.

You can also use the `lp -q` command to change the priority level of a specified print request. You can change the priority level from 0, the highest priority, to 39, the lowest priority.

Example—Changing the Priority of a Print Request

In the following example, the command changes a print request with the request ID `asteroid-79`, to priority level 1.

```
# lp -i asteroid-79 -q 1
```

Managing Character Sets, Filters, Forms, and Fonts (Tasks)

This chapter provides background information and step-by-step instructions for setting up and administering character sets, print filters, forms, and fonts.

This is a list of the step-by-step instructions in this chapter.

- “How to Define a Print Wheel or Font Cartridge” on page 94
- “How to Unmount and Mount a Print Wheel or Font Cartridge” on page 95
- “How to Set an Alert to Mount a Print Wheel or Font Cartridge” on page 96
- “How to Set Up an Alias for a Selectable Character Set” on page 98
- “How to Add a Print Filter” on page 102
- “How to Delete a Print Filter” on page 103
- “How to View Information About a Print Filter” on page 103
- “How to Add a Form” on page 107
- “How to Delete a Form” on page 108
- “How to Unmount and Mount a Form” on page 108
- “How to Set an Alert to Mount a Form” on page 110
- “How to View Information About a Form” on page 112
- “How to View the Current Status of a Form” on page 113
- “How to Limit User Access to a Form” on page 113
- “How to Limit Printer Access to a Form” on page 114
- “How to Install Downloaded PostScript Fonts” on page 118
- “How to Install Host-Resident PostScript Fonts” on page 118

For overview information about printing, see Chapter 1.

Managing Character Sets

Printers differ in the method they use to print text in various font styles. For example, PostScript printers treat text as graphics. These printers can generate text in different fonts, and place the text in any position, size, or orientation on the page. Other types of printers support a more limited number of font styles and sizes, using either print wheels, font cartridges, or preprogrammed selectable character sets. Usually, only one of these printing methods applies to a given printer type.

Print wheels and font cartridges, from the perspective of the LP print service, are similar, because someone must intervene and mount the hardware on the printer, when needed. Character sets that require you to physically mount a wheel or cartridge are referred to as *hardware character sets*. Character sets that do not require hardware mounting, that come preprogrammed with the printer, and can be selected by a print request, are referred to as *software character sets*.

When you set up a non-PostScript printer, you need to tell the LP print service which print wheels or selectable character sets are available to users. When users submit print requests, the `lp -S` command enables them to specify a print wheel or selectable character set to use for the print job. Users do not have to know which type of character set applies; they just refer to the font style by the name you have defined. For example, you may have defined a print wheel as `gothic`. To request the `gothic` print wheel, the user would enter `lp -S gothic`.

Selectable Character Sets

The selectable character sets supported by a printer are listed in the `terminfo` entry for that printer. For example, the entry for the `ln03` printer is `/usr/share/lib/terminfo/l/ln03`. You can find the names of selectable character sets for any printer type in the `terminfo` database by using the `tput` command. The syntax for the `tput` command is:

```
tput -T printer-type csn
```

The `csn` option is an abbreviation for character set number. The number starts with 0, which is always the default character set number after the printer is initialized. You can repeat the command, using `-1`, `-2`, `-3`, and so on in place of the `-0`, to display the names of the other character sets. For each selectable character set, a `terminfo` name (for example, `usascii`, `english`, `finnish`, and so forth) is returned.

In general, the `terminfo` character set names should closely match the character set names used in the manufacturer's documentation for the printer. Because manufacturers do not all use the same character set names, the `terminfo` character set names may differ from one printer type to the next.

You do not have to register the selectable character set names with the LP print service. However, you can give them more meaningful names or aliases.

Note - If you do not specify the selectable character sets that can be used with a printer, the LP print service assumes that the printer can accept any character set name (such as `cs0`, `cs1`, or `cs2`) or the `terminfo` name known for the printer.

Users can use the `lpstat -p -l` command to display the names of the selectable character sets that you have defined for each printer on a print server.

Note - Character sets for PostScript printers are not listed when you use the `lpstat -p -l` command because the PostScript fonts are controlled by PostScript filters, not by entries in the `terminfo` database. See “Managing Fonts” on page 115 for information about how to administer PostScript fonts.

Hardware-Mounted Character Sets

Another method to obtain alternative character sets is to use removable print wheels or font cartridges that you physically attach, or mount, in a printer.

To administer hardware-mounted character sets, you inform the LP print service of the names you want to use for the available print wheels, and how you want to be alerted when a printer needs a different print wheel. Then, when a user requests a particular character set with the `lp -S` command, the scheduler sends an alert to mount the print wheel, and the print request is placed in the print queue. When you mount the correct print wheel and tell the LP print service that the print wheel is mounted, the job is printed. See “How to Unmount and Mount a Print Wheel or Font Cartridge” on page 95 for more information.

If you do not specify multiple print wheels or cartridges for a printer, the LP print service assumes that the printer has a single, fixed print wheel or cartridge, and users cannot specify a special print wheel or cartridge when using the printer.

Unlike selectable character sets, the names you use for print wheels or cartridges are not tied to entries in the `terminfo` database. Print wheel or cartridge names are used only for the purpose of communicating with the LP print service and its users.

The names you choose for print wheels or cartridges, however, should have meaning to the users; the names should refer to font styles. In addition, the names should be the same across printers that have similar print wheels or cartridges, or selectable character sets. That way, users can ask for a font style (character set) without regard to which printer—or even whether a print wheel or cartridges—or selectable character set will be used.

Of course, you and the printer users should agree on the meanings of print wheel or cartridge names. Otherwise, what a user asks for and what you mount, may not be the same character set.

Tracking Print Wheels

The procedure for tracking print wheels is similar to the procedure for tracking forms. Some printers (usually letter-quality printers) have removable print heads, such as print wheels or print cartridges, that provide a particular font or character set. A user can request a named character set. If that character set is not available, the LP print service notifies root of the request. The job is stored in the print queue until the print wheel is changed.

Alerts for Mounting Print Wheels or Cartridges

You request alerts for mounting print wheels or cartridges in the same way you request other alerts from the LP print service. See “Setting Up Printer Fault Alerts” on page 71 for general information about alerts.

▼ How to Define a Print Wheel or Font Cartridge

1. **Log in as superuser or lp on the print server.**
2. **Define a print wheel or font cartridge that can be used with the printer.**

```
print-server# lpadmin -p printer-name -s hard-charset1[,hard-charset2...]
```

<code>-p printer-name</code>	Name of the printer for which you are defining a print wheel or font cartridge.
<code>-s hard-charset</code>	Hardware character set name of the print wheel or font cartridge. You can specify multiple hardware character sets with this command. Use commas or spaces to separate character set names. If you use spaces, enclose the list of character set names in quotes. Define names that are meaningful to users, and inform the users of the names.

The print wheel or font cartridge definition is added in the print server's `/etc/lp/printers/printer-name/configuration` file.

3. **Log in as superuser or lp on a system that is a print client of the print server.**
4. **Define the same print wheel or font cartridge for the print client.**

```
print-client# lpadmin -p printer-name -S hard-charset1[,hard-charset2...]
```

In this command, the variables are the same as those in Step 2 on page 94.

The print wheel or font cartridge definition is added in the print client's `/etc/lp/printers/printer-name/configuration` file.

5. Repeat Step 3 on page 94 and Step 4 on page 94 for each print client that may need to use the print wheel or font cartridge.
6. Verify the information following the `Character sets` heading in the following output is correct on both the print server and the print client.

```
$ lpstat -p printer-name -l
```

Example—Defining a Print Wheel

In the following example, the command defines the `pica` print wheel on the printer `luna` for a print client named `asteroid`.

```
asteroid# lpadmin -p luna -S pica
```

▼ How to Unmount and Mount a Print Wheel or Font Cartridge

1. Log in as superuser or `lp` on the print server.
2. Unmount the print wheel or font cartridge that is in the printer by using the `lpadmin` command.

```
# lpadmin -p printer-name -M -S none
```

`-p printer-name` Printer on which you are unmounting a print wheel or font cartridge.

`-M -S none` Specifies unmounting the current print wheel or font cartridge.

The current print wheel or font cartridge is deleted from the print server's `/etc/lp/printers/printer-name/configuration` file.

3. Remove the print wheel or font cartridge from the printer.

4. Put the new print wheel or font cartridge in the printer.
5. Mount the new print wheel or font cartridge by using the `lpadmin` command.

```
# lpadmin -p printer-name -M -S hard-charset
```

`-p printer-name` Printer on which you are mounting a print wheel or font cartridge.

`-M -S hard-charset` Hardware character set name of the print wheel or font cartridge you want to mount.

The print wheel or font cartridge is added in the print server's `/etc/lp/printers/printer-name/configuration` file. The mounted print wheel or font cartridge remains active until it is unmounted or until a new print wheel or font cartridge is mounted.

6. Check the information under the `Print wheels` or `Character set` heading in the output of the following command. You should see the name of the print wheel or character set and the notation `(mounted)`

```
$ lpstat -p printer-name -l
```

Example—Unmounting and Mounting a Print Wheel

In the following example, the commands unmount the current print wheel on the printer `luna` and mount the `pica` print wheel.

```
# lpadmin -p luna -M -S none  
# lpadmin -p luna -M -S pica
```

▼ How to Set an Alert to Mount a Print Wheel or Font Cartridge

1. Log in as `superuser` or `lp` on the print server.
2. Set an alert to mount a print wheel or font cartridge by using the `lpadmin(1M)` command.

```
# lpadmin -S hard-charset -A alert [-Q requests] [-W minutes]
```

<code>-S <i>hard-charset</i></code>	Hardware character set name of the print wheel or font cartridge for which you want to set an alert.
<code>-A <i>alert</i></code>	Specifies what kind of alert will occur when a print wheel or font cartridge is requested. See Table 4-2 for detailed information about the valid values for <i>alert</i> . Some valid values are <i>mail</i> , <i>write</i> , and <i>quiet</i> . If you specify <i>mail</i> or <i>write</i> , a predefined alert message says to mount the specified print wheel or font cartridge and includes the names of one or more printers that have been set up to use such a print wheel or cartridge.
<code>-Q <i>requests</i></code>	Specifies the number of print requests that require the print wheel or font cartridge that must be in the queue before an alert occurs. If you don't specify this option, only one print request in the queue triggers an alert.
<code>-W <i>minutes</i></code>	Specifies how often (in minutes) the alert will occur. If you don't specify this option, the alert is sent only once.

The alert is added in the print server's
`/etc/lp/pwheels/charset-name/alert.sh` file.

3. Verify that the alert has been added for the print wheel or font cartridge by checking the output of the following command.

```
# lpadmin -S hard-charset -A list
```

Otherwise, if you have set a low number of print requests to trigger the alert, submit enough print requests to meet the minimum requirement and make sure you receive an alert to mount the print wheel or font cartridge.

Examples—Setting an Alert to Mount a Print Wheel or Font Cartridge

In the following example, the command sets email alerts to occur every five minutes for the `elite` print wheel when there are ten print requests for `elite` in the print queue.

```
# lpadmin -S elite -A mail -Q 10 -W 5
```

In the following example, the command sets email alerts to occur every minute for the `finnish` font cartridge when there are five print requests for `finnish` in the print queue.

```
# lpadmin -S finnish -A mail -Q 5 -W 1
```

In the following example, the command sets console-window alerts to occur every 10 minutes for the `elite` print wheel when there are five print requests for `elite` in the print queue.

```
# lpadmin -S elite -A write -Q 5 -W 10
```

In the following example, the command sets no alerts to occur for the `elite` print wheel.

```
# lpadmin -S elite -A none
```

▼ How to Set Up an Alias for a Selectable Character Set

Note - You do not need to perform this procedure if the `terminfo(4)` names for the selectable character sets are adequate. See “Adding a `terminfo` Entry for an Unsupported Printer” on page 124 for more information on using the `terminfo` database.

1. Log in as superuser or `lp` on the print server.
2. Display the names of the selectable character sets for the specified printer type by using the `tput(1)` command.

```
# tput -T printer-type csn
```

<code>-T printer-type</code>	Printer type found in the <code>terminfo</code> database. See “Printer Type” on page 24 for information on entries in the <code>terminfo</code> database.
<code>n</code>	Number (0, 1, 2, 3, 4, 5, and so on) that represents a selectable character set for the specified printer type. The system displays the selectable character set name followed by the prompt symbol. For example, <code>cs1</code> could cause the system to display <code>english#</code> .

3. Set up an alias for a selectable character set.

```
# lpadmin -p printer-name -s select-charset1=alias1[,select-charset2=alias2...]
```

<code>-p printer-name</code>	Printer on which you are setting up aliases for selectable character sets.
<code>-s select-charset</code>	Selectable character set name for which to set an alias. The name can be found in Step 2 on page 98.
<code>alias</code>	Alias for the specified selectable character set. This alias can be used in addition to the selectable character set name. You can set up more than one alias with this command. Use commas or spaces to separate the aliases. If you use spaces, enclose the list of aliases in quotes.

The alias is added in the print server's
`/etc/lp/printers/printer-name/configuration` file.

4. Log in as superuser or lp on a system that is a print client of the print server.
5. Set up an alias for the selectable character set.

```
# lpadmin -p printer-name -s select-charset1=alias1[,select-charset2=alias2...]
```

In this command, the variables are the same as those in Step 3 on page 98.

The alias is added in the print client's
`/etc/lp/printers/printer-name/configuration` file.

6. Repeat Step 4 on page 99 and Step 5 on page 99 for each print client that may need to use the alias.
7. Verify that the selectable character set alias is listed in the output of the following command on the print server and print clients.

```
$ lpstat -p printer-name -l
```

Otherwise, submit a print request that uses the alias for the selectable character set and check for output.

Example—Setting Up an Alias for a Selectable Character Set

In the following example, the commands display the names of selectable character sets and specify `text` as an alias for the `usascii` selectable character set on the printer `luna`, which is an `ln03` printer type.

```
# tput -T ln03 cs0
usascii# tput -T ln03 cs1
english# tput -T ln03 csn2
```

(Continuation)

```
finnish# tput -T ln03 csn3
japanese# tput -T ln03 cs4
norwegian#
# lpadmin -p luna -S usascii=text
```

Managing Print Filters

Print filters are programs that convert the content type of a file to a content type that is acceptable to the destination printer. The LP print service uses filters to:

- Convert a file from one data format to another so it can be printed properly on a specific type of printer
- Handle the special modes of printing, like two-sided printing, landscape printing, or draft- and letter-quality printing
- Detect printer faults and notify the LP print service of them so the print service can alert users and system administrators

Not every print filter can perform all these tasks. Because each task is printer-specific, the tasks can be implemented separately.

The LP print service provides the PostScript filters listed in Table 5-1. The filter programs are located in the `/usr/lib/lp/postscript` directory. For PostScript printing, you usually do not need to do anything beyond installing the filter programs when setting up a print server. Admintool automatically enables the supplied filters. However, if you administer other printers, you may need to administer print filters for them.

Creating Print Filters

To create a new print filter, you must write a print filter program and create a print filter definition. Filters contain input types, output types, and complex options that provide a language to process command-line arguments within the filter. See “Creating a New Print Filter” on page 133 for background information and step-by-step instructions.

Adding, Changing, Removing, and Restoring Print Filters

Print filters are added, changed, or removed on the print server only.

You use the `lpfilter(1M)` command to manage the list of available filters. System information about filters is stored in the `/etc/lp/filter.table` file. The `lpfilter` command gets the information about filters to write to the table from filter descriptor files. The filter descriptor files supplied (PostScript only) are located in the `/etc/lp/fd` directory. The actual filter programs are located under `/usr/lib/lp`.

The LP print service imposes no fixed limit on the number of print filters you can define. You may remove filters that are no longer used to avoid extra processing by the LP print service. (LP examines all filters to find one that works for a specific print request.) If in doubt, do not remove a filter.

As you add, change, or delete filters, you may overwrite or remove some of the original filters provided by the LP print service. You can restore the original set of filters, if necessary, and remove any filters you have added.

SunOS 5.7 system software provides a default set of PostScript filters, which Admintool automatically adds to a print server. Some of the TranScript filters used with SunOS 4.1 have SunOS 5.7 equivalents, but others do not. Table 5-1 lists the default PostScript filters and identifies the TranScript filters, where applicable.

TABLE 5-1 Default PostScript Filters

Filter	Action	TranScript Equivalent
download	Download fonts	
dpost	ditroff to PostScript	psdit
postdaisy	daisy to PostScript	
postdmd	dmd to PostScript	
postio	Serial interface for PostScript printer	pscomm
postior	Communicate with printer	
postmd	Matrix gray scales to PostScript	
postplot	plot to PostScript	psplot

TABLE 5-1 Default PostScript Filters (continued)

Filter	Action	TranScript Equivalent
postprint	simple to PostScript	enscript
postreverse	Reverse or select pages	psrev
posttek	TEK4014 to PostScript	ps4014

SunOS 5.7 does *not* provide the following filters:

- TEX
- oscar (NeWSprint opost)
- Enscript

The `postreverse`, `postprint`, `postio`, and `dpost` filters are provided in place of Enscript.

Admintool adds the default PostScript filters to a print server. If you have printing needs that are not met by these filters, see “How to Create a New Print Filter” on page 142 for information about writing a custom print filter.

▼ How to Add a Print Filter

1. Log in as superuser or lp on the print server.
2. Add a print filter that is based on a print filter definition by using the `lpfilter` command.

```
# lpfilter -f filter-name -F filter-def
```

`-f filter-name` Name you choose for the print filter.

`-F filter-def` Name of the print filter definition.

The print filter is added in the print server's `/etc/lp/filter.table` file.

3. Verify that the print filter was added by checking for information about the print filter in the output of the following command.

```
# lpfilter -f filter-name -l
```

Example—Adding a Print Filter

In the following example, the command adds the `daisytroff` print filter that has the `daisytroff.fd` print filter definition.

```
# lpfilter -f daisytroff -F /etc/lp/fd/daisytroff.fd
```

▼ How to Delete a Print Filter

1. Log in as superuser or `lp` on the print server.
2. Delete the print filter by using the `lpfilter` command.

```
# lpfilter -f filter-name -x
```

`-f filter-name` Name of the print filter to be deleted.

`-x` Deletes the specified filter.

The print filter is deleted from the print server's `/etc/lp/filter.table` file.

3. Verify that filter was deleted by using the following command. You should receive an error indicating that no filter by the specified name exists.

```
# lpfilter -f filter-name -l
```

Example—Deleting a Print Filter

In the following example, the command deletes the `daisytroff` print filter.

```
# lpfilter -f daisytroff -x
```

▼ How to View Information About a Print Filter

1. Log in as superuser or `lp` on the print server.
2. Request information about a print filter by using the `lpfilter` command.

```
# lpfilter -f filter-name -l
```

<code>-f filter-name</code>	Print filter for which you want to view information. Specify <code>all</code> for <i>filter-name</i> to view information about all the available print filters.
<code>-l</code>	Displays information about the specified filter.

Information about the specified print filter(s) is displayed.

Examples—Viewing Information About a Print Filter

In the following example, the command requests information for the `postdaisy` print filter, and the information that is displayed in response.

```
# lpfilter -f postdaisy -l
Input types: daisy
Output types: postscript
Printer types: any
Printers: any
Filter type: slow
Command: /usr/lib/lp/postscript/postdaisy
Options: PAGES * = -o*
Options: COPIES * = -c*
Options: MODES group = -n2
Options: MODES group\=\([2-9]\) = -n\1
Options: MODES portrait = -pp
Options: MODES landscape = -pl
Options: MODES x\=\(\-*[\.0-9]*\) = -x\1
Options: MODES y\=\(\-*[\.0-9]*\) = -y\1
Options: MODES magnify\=\([\.0-9]*\) = -m\1
```

In the following example, the command redirects information about the `daisytroff` filter to a file (creates the filter definition for that filter). This is useful if a filter definition is removed unintentionally.

```
# lpfilter -f daisytroff -l > daisytroff.fd
```

In the following example, the command displays all the print filters that have been added to the system, and the information that is displayed in response.

```
# lpfilter -f all -l | grep Filter
(Filter "download")
Filter type: fast
(Filter "postio")
Filter type: fast
(Filter "postior")
Filter type: fast
```

(continued)

(Continuation)

```
(Filter "postreverse")  
Filter type: slow
```

Managing Forms

A *form* is a sheet of paper on which information is printed in a predetermined format. Unlike plain paper stock, forms usually have text or graphics preprinted on them. Common examples of forms are company letterhead, invoices, blank checks, receipts, and labels.

The term *form* has two meanings: the physical medium (the paper) and the software that defines a form to the LP print service.

The LP print service allows you to control the use of forms. This section provides information about adding, changing, removing, mounting, and controlling access to forms.

Adding, Changing, or Deleting Forms

When you add a form, you tell the LP print service to include the form in its list of available forms. You also have to supply the information required to describe or define the form. Although you can enter such definitions when you add the form, it helps to create the definitions first and save them in files. You can then change the form definition by editing the file. See "How to Create a New Form Definition" on page 147 for information about how to create form definitions.

Note - No form definitions are supplied with the LP print service.

To change a form, you must re-add the form with a different definition.

The LP print service imposes no limit on the number of forms you can define. However, you should delete forms that are no longer appropriate. Obsolete forms may result in unnecessary processing by the print service.

Mounting Forms

To print a form, you must load the paper in the printer and use a command to *mount* the form, which notifies the LP print service that print requests submitted to the printer are to be printed using the form definition. If you use one printer for different types of printing, including forms, you should:

- Disable the printer before you load the paper and mount the form.
- Re-enable the printer when the form is ready; otherwise, the LP print service will continue to print files that do not need the form on the printer.

When you mount a form, make sure it is aligned properly. If an alignment pattern has been defined for the form, you can request that the pattern print repeatedly after you have mounted the form, until you have adjusted the printer so the alignment is correct.

When you want to change or discontinue using a form on a printer, you must notify the LP print service by unmounting the form.

Tracking Forms

The LP print service helps you track which forms are mounted on each printer and notifies you when it cannot find a description it needs to print a form. You are responsible for creating form descriptions and mounting and unmounting form paper in each printer, either as part of setting up a printer or in response to alerts from the LP print service.

Users can specify the form on which they want a job to print. As root, you can mount a specific form, then tell the LP print service that the form is available and on which printer it is mounted. Users can submit print requests specifying a particular form. When the LP print service receives the request, it sends an alert message to root requesting that you mount the form.

Defining Alerts for Mounting Forms

You request alerts for mounting forms in the same way you request other alerts from the LP print service. See “Setting Up Printer Fault Alerts” on page 71 for general information about alerts.

Checking Forms

When you have defined a form for the LP print service, you can check it with either of two commands, depending on the type of information you want to check.

Example—Adding a Form

In the following example, the command adds the `medical` form that uses the `medical.fmd` form definition.

```
# lpforms -f medical -F /etc/lp/forms/medical.fmd
```

Note - Before the form can be used, one or more printers must be given access to the form. See “How to Limit Printer Access to a Form” on page 114.

▼ How to Delete a Form

1. Log in as superuser or lp on the print server.
2. Delete the form by using the `lpforms` command.

```
# lpforms -f form-name -x
```

`-f form-name`

Form to be deleted.

`-x`

Deletes the specified form.

The form is deleted from `/etc/lp/forms/form-name` file.

3. Verify that form was deleted by using the following command. You should receive an error indicating that a form by the specified name does not exist.

```
# lpforms -f form-name -l
```

Example—Deleting a Form

In the following example, the command deletes the `medical` form.

```
# lpforms -f medical -x
```

▼ How to Unmount and Mount a Form

1. Log in as superuser or lp on the print server.

2. **Stop accepting print requests on the printer on which you are unmounting the current form by using the `reject` command.**

```
# reject printer-name
```

printer-name Name of the printer on which you are unmounting a form.

New print requests (which may not require the form) are not allowed to enter the printer's queue.

3. **Unmount the current form by using the `lpadmin` command.**

```
# lpadmin -p printer-name -M -f none
```

In this command, the variable *printer-name* is the same as in Step 2 on page 109. The current form is deleted from the print server's `/etc/lp/printers/printer-name/configuration` file.

4. **Remove the form paper from the printer.**
5. **Load the form paper for the next print request.**
6. **Mount the form by using the `lpadmin` command.**

```
# lpadmin -p printer-name -M -f form-name[-a -o filebreak]
```

`-p printer-name` Printer on which you are mounting a form.

`-M -f form-name` Name of the form to be mounted.

`-a -o filebreak` Optionally enables you to print a copy of the alignment pattern defined for the form, if it has one.

The specified form is added in the print server's `/etc/lp/printers/printer-name/configuration` file.

7. **Start accepting print requests on the printer.**

```
# accept printer-name
```

The printer is ready to print the form you just mounted.

8. Verify that the form has been mounted by checking for the form name under the `Form mounted` heading in the output of the following command.

```
$ lpstat -p printer-name -l
```

Otherwise, submit a print request that requires the new form and check the printer for output.

Examples—Unmounting and Mounting a Form

The following example shows the process of unmounting the currently mounted form on the printer `luna`.

```
# reject luna
destination "luna" will no longer accept requests
# lpadmin -p luna -M f none
# accept luna
destination "luna" now accepting requests
```

The following example shows the process of mounting the medical form on the printer `luna`.

```
# reject luna
destination "luna" will no longer accept requests
# lpadmin -p luna -M f medical -a -o filebreak
# accept luna
destination "luna" now accepting requests
```

▼ How to Set an Alert to Mount a Form

1. Log in as superuser or `lp` on the print server.
2. Set a request alert for mounting a form by using the `lpadmin` command.

```
# lpforms -f form-name -A alert [-Q requests] [-W minutes]
```

<code>-f form-name</code>	Form for which you want to set a request alert.
<code>-A alert</code>	Specifies what kind of alert will occur when a form is requested. See Table 4-2 for detailed information about the valid values for <i>alert</i> . Some valid values are <code>mail</code> , <code>write</code> , and <code>quiet</code> . If you choose <code>mail</code> or <code>write</code> , a predefined alert message says to mount the specified form and includes the names of one or more printers that have been set up to use the form.
<code>-Q requests</code>	Specifies how many print requests that require the form must be in the queue to trigger an alert. If you don't specify this option, an alert occurs with just one print request in the queue.
<code>-W minutes</code>	Specifies how often (in minutes) the alert will occur. If you don't specify this option, the alert is sent once.

The request alert is added in the print server's `/etc/lp/forms/form-name/alert.sh` file.

3. Verify that the alert has been added for the form by checking the output of the following command.

```
# lpforms -f form-name -A list
```

Otherwise, if you have set a low number of print requests to trigger the alert, submit print requests to meet the minimum requirement and make sure you receive an alert to mount the form.

Examples—Setting an Alert to Mount a Form

In the following example, the command sets email alerts to occur every five minutes for the `letterhead` form when there are 10 print requests for `letterhead` in the print queue.

```
# lpforms -f letterhead -A mail -Q 10 -W 5
```

In the following example, the command sets console window alerts to occur every 10 minutes for the `letterhead` form when there are five requests for `letterhead` in the print queue.

```
# lpforms -f letterhead -A write -Q 5 -W 10
```

In the following example, the command sets no request alerts for the `invoice` form.

```
# lpforms -f invoice -A none
```

▼ How to View Information About a Form

1. Log in as superuser or lp on the print server.
2. Request information about a form by using the `lpforms` command.

```
# lpforms -f form-name -l
```

`-f form-name` Form for which you want to view information. Specify all for *form-name* to view information about all the available forms.

`-l` Lists the specified form.

Information about the specified form(s) is displayed.

Examples—Viewing Information About a Form

In the following example, the command displays information about the `medical` form.

```
# lpforms -f medical -l
Page length: 62
Page width: 72
Number of pages: 2
Line pitch: 6
Character pitch: 12
Character set choice: pica
Ribbon color: black
Comment:
Medical claim form
```

In the following example, the command redirects the information about the `medical` form to a file. (This command creates the form definition for the form.) This is useful if a form definition gets removed unintentionally.

```
# lpforms -f medical -l > medical.fmd
```

▼ How to View the Current Status of a Form

1. Log in on the print server.
2. Request information about the current status of a form by using the `lpstat(1)` command.

```
$ lpstat -f form-name
```

`-f form-name` Form for which you want to view the current status. Specify `all` for `form-name` to view the current status of all the forms.

Information about the current status of the specified form(s) is displayed.

Example—Viewing the Current Status of a Form

In the following example, the command displays the status of the `medical` form.

```
$ lpstat -f medical,payroll
form medical is available to you
```

▼ How to Limit User Access to a Form

1. Log in as superuser or `lp` on the print server.
2. Allow or deny users access to a form by using the `lpforms` command.

```
# lpforms -f form-name -u allow:user-list | deny:user-list
```

<code>-f form-name</code>	Name of the form for which the allow or deny user access list is being created.
<code>-u allow:user-list</code>	Represents users to be added to the allow access list. Use a comma or a space to separate users' login IDs. If you use spaces, enclose the list of IDs in quotes. Table 4-4 provides the valid values for <i>user-list</i> .
<code>deny:user-list</code>	Represents users to be added to the deny user access list. Use a comma or a space to separate users' login IDs. If you use spaces, enclose the list of IDs in quotes. Table 4-4 provides the valid values for <i>user-list</i> .

The specified user(s) are added to the allow or deny user access list for the specified form in one of the following files on the print server:

```
/etc/lp/forms/form-name/allow/etc/lp/forms/form-name/deny
```

3. Verify the allow and deny user access lists by using the `lpforms` command.

```
# lpforms -f form-name -l
```

Examples—Limiting User Access to a Form

In the following example, the command allows only the users `nathan` and `marcia` access to the `check` form.

```
# lpforms -f check -u allow:nathan,marcia
```

In the following example, the command denies users `jones` and `smith` access to the `dental` form.

```
# lpforms -f dental -u deny:"jones,smith"
```

▼ How to Limit Printer Access to a Form

1. Log in as superuser or `lp` on the print server.
2. Allow or deny use of forms on a printer by using the `lpadmin` command.

```
# lpadmin -p printer-name -f allow:form-list | deny:form-list
```

<code>-p printer-name</code>	Name of the printer for which the allow or deny forms list is being created.
<code>-f allow:form-list deny:form-list</code>	Form names to be added to the allow or deny list. Use a space or a comma to separate multiple form names. If you use spaces to separate form names, enclose the list of form names in quotes.

The specified form(s) are added to the allow or deny forms list in one of the following files on the print server:

```
/etc/lp/printers/printer-name/form.allow /etc/lp/printers/printer-name/form.deny
```

3. Verify the allow and deny forms lists by using the following command.

```
# lpstat -p printer-name -l
```

Examples—Limiting Printer Access to a Form

In the following example, the command allows the printer `luna` to access only the `medical`, `dental`, and `check` forms.

```
# lpadmin -p luna -f allow:medical,dental,check
```

In the following example, the command denies the printer `luna` from accessing the `medical`, `dental`, and `check` forms.

```
# lpadmin -p luna -f deny:"medical dental payroll"
```

Managing Fonts

If you have a laser printer, you may need to install and maintain PostScript fonts. You may also have to decide where to install PostScript fonts and how to manage them. For many printers, the fonts are set up as part of the printer installation process.

PostScript fonts are stored in outline form, either on the printer or on a system that communicates with the printer. When a document is printed, the PostScript interpreter generates each character as needed (in the appropriate size) from the outline description of it. If a font required for a document is not stored on the printer

being used, it must be transmitted to that printer before the document can be printed. This transmission process is called *downloading fonts*.

Fonts are stored and accessed in several ways:

- *Printer-resident fonts* are stored permanently on a printer. These fonts are installed in read-only memory (ROM) on the printer by the manufacturer. If the printer has a disk, you may need to install fonts on that disk. Most PostScript printers are shipped with 35 standard fonts.
- A *permanently downloaded font* is transmitted to a printer with a PostScript `exitserver` program. A permanently downloaded font remains in printer memory until the printer is turned off. Memory allocated to a downloaded font reduces the memory available on the server for PostScript print requests. Use of an `exitserver` program requires the printer system password and may be reserved for the printer administrator. You should permanently download a font if most print requests serviced by the printer use that font.
- Fonts that are used infrequently or for special purposes can be stored on a user's system. The user can specify these fonts when submitting the print request. The fonts are appended to the print request and transmitted to the printer. When the print request is processed, the space allocated for the font is freed for other requests.
- Host-resident *fonts* are stored on a system shared by many users. The system that stores the fonts may be a print server or a print client. Each user may request fonts in the document to be printed. This method is useful when there are numerous available fonts, or when these fonts are not used by all print requests. If the fonts will be used only on printers attached to a print server, they should be stored on the print server. If the fonts are to be used by the users on one system and the users may submit requests to multiple printers on a network, the fonts should be stored on the users' system.

The LP print service provides a special download filter to manage host-resident fonts. It also supplies `troff` width tables for the 35 standard PostScript fonts which reside on many PostScript printers, for use by the `troff(1)` program.

Managing Printer-Resident Fonts

Most PostScript printers come equipped with fonts resident in the printer ROM. Some printers have a disk on which additional fonts are stored. When a printer is installed, you should add the list of printer-resident fonts to the font list for that printer. By identifying printer-resident fonts, you prevent fonts from being transmitted unnecessarily across a network. Each printer has its own list of resident fonts, which is contained in the file:

```
/etc/lp/printers/printer-name/residentfonts
```

When the printer is attached to a print server, make sure the list in the `residentfonts` file includes fonts that are on the print server and which are available for downloading to the printer.

You must edit the files containing the list of printer-resident fonts by using a text editor such as `vi`.

Downloading Host-Resident Fonts

When a PostScript document contains a request for fonts not loaded on the printer, the download filter manages this request. The download filter uses PostScript document structuring conventions to determine which fonts to download.

LP print filters are either fast or slow. A fast filter quickly prepares a file for printing, and it must have access to the printer while the filter is processing. A slow filter takes longer to convert a file, and it does not need to access the printer while the filter is processing. An example of a slow filter is ASCII to PostScript.

The download filter is a fast filter; it downloads fonts automatically if the fonts are on the print server. The download filter may also be used to send fonts to a print server. To do this, you may create a new filter table entry that calls the download filter as a slow filter by using the `lp -y` command. Alternatively, you may force selection of this filter by changing the input type.

The download filter performs five tasks:

1. It searches the PostScript document to determine which fonts are requested. These requests are documented with the following PostScript structuring comments:
`%DocumentFonts: font1 font2 ...` in the header comments.
2. It searches the list of printer-resident fonts to determine if the requested font must be downloaded.
3. If the font is not resident on the printer, the download filter searches the host-resident font directory (by getting the appropriate file name from the map table) to determine if the requested font is available.
4. If the font is available, the filter takes the file for that font and appends it to the file to be printed.
5. It sends the font definition file and the source file (the file to be printed) to the PostScript printer.

Installing and Maintaining Host-Resident Fonts

Some fonts reside on the host system and are transmitted to the printer as needed for particular print requests. As the administrator, you make PostScript fonts available to all users on a system. To do so, you must know how and where to install these fonts. Because fonts are requested by name and stored in files, the LP print service keeps a map file that shows the correspondence between the names of fonts and the names

of the files containing those fonts. Both the map and the font list must be updated when you install host-resident fonts.

The fonts available for use with PostScript printers are stored in directories you create called `/usr/share/lib/hostfontdir/typeface/font`, where *typeface* is replaced by a name like `palatino` or `helvetica`, and *font* is replaced by a name like `bold` or `italic`.

▼ How to Install Downloaded PostScript Fonts

1. Log in as superuser or lp on the print server or print client.
2. Change directory to the `/etc/lp/printers/printer-name` directory.

```
# cd /etc/lp/printers/printer-name
```

printer-name Name of the printer on which you want to install downloaded PostScript fonts.

3. Create the `residentfonts` file, if it does not already exist.

```
# touch residentfonts
```

This file may not exist if this is the first time you are adding permanently downloaded fonts.

4. Edit the `residentfonts` file by adding all the printer-resident fonts and fonts to be permanently downloaded.
You can use any text editor, such as `vi`.
5. Save the file.

▼ How to Install Host-Resident PostScript Fonts

1. Log in as superuser or lp on the print server or print client.
2. Create the `hostfontdir` directory, if it does not already exist.

```
# cd /usr/share/lib  
# mkdir hostfontdir
```

(Continuation)

```
# chmod 775 hostfontdir
```

3. Create a directory for a new typeface, if the directory does not already exist.

```
# mkdir typeface
```

4. Copy the font file to the appropriate directory.

```
# cp filename /usr/share/lib/hostfontdir/typeface/font
```

5. Add the name of the font and the name of the file in which it resides to the map table.

- a. Change to the `/usr/share/lib/hostfontdir` directory.

- b. Edit the `map` file using a text editor such as `vi`.

Add a one-line entry for each font you want to add to the table, with the font name first, followed by a space, followed by the name of the file where the font resides. For example:

```
Palatino-Bold /usr/share/lib/hostfontdir/palatino/bold
```

- c. Save the file.

When an example entry exists in the map table on the appropriate system, users will be able to apply the font (for example, Palatino Bold) in their print jobs. When they submit a print request containing this font, the LP print service appends a copy of the file

`/usr/share/lib/hostfontdir/palatino/bold` to that file before sending it to the printer.

6. If you are using `troff`, you must create new width tables for this font in the standard `troff` font directory.

Customizing the LP Print Service (Tasks)

This chapter provides background information and procedures for customizing the LP print service.

This is a list of the step-by-step instructions in this chapter.

- “How to Adjust the Printer Port Characteristics” on page 123
- “How to Add a `terminfo` Entry for an Unsupported Printer” on page 127
- “How to Set Up a Custom Printer Interface Program” on page 131
- “How to Create a New Print Filter” on page 142
- “How to Create a New Form Definition” on page 147

For overview information about printers, see Chapter 1.

Adjusting Printer Port Characteristics

The printer port characteristics set by the LP print service must be compatible with the printer communication settings. If the default printer port settings provided by the LP print service do not work with a printer, refer to the printer manual from the manufacturer to find out what settings the printer requires from the LP print service. Use the `stty` command to set and display printer communication settings.

Table 6-1 shows the default `stty` settings used by the LP print service.

TABLE 6-1 stty Default Settings Used by the LP Print Service

Option	Meaning
-9600	Set baud to 9600
-cs8	Set 8-bit bytes
-cstopb	Send one stop bit per byte
-parity	Do not generate parity
-ixon	Enable XON/XOFF (also known as START/STOP or DC1/DC3)
-opost	Do "output post-processing" using all the settings that follow in this table
-olcuc	Do not map lowercase to uppercase
-onlcr	Change line feed to carriage return/line feed
-ocrnl	Do not change carriage returns into line feeds
-onocr	Output carriage returns even at column 0
-n10	No delay after line feeds
-cr0	No delay after carriage returns
-tab0	No delay after tabs
-bs0	No delay after backspaces
-vt0	No delay after vertical tabs
-ff0	No delay after form feeds

▼ How to Adjust the Printer Port Characteristics

1. Log in as superuser or lp on the print server.
2. Adjust the printer port characteristics by using the `lpadmin` command.

```
# lpadmin -p printer-name -o "stty=options"
```

`-p printer-name`

Name of the printer for which you are adjusting the port characteristics.

`-o "stty=options"`

Sets the port characteristic (`stty` option) specified by *options*. You can change more than one `stty` option setting with this command. Enclose each option in single quotation marks and use a space to separate the options. See `stty(1)` for a complete list of options. Table 6-1 shows the default `stty` settings used by the LP print service.

3. Verify that the printer port characteristics have been changed by using the following command.

```
# stty -a
```

Examples—Adjusting the Printer Port Characteristics

In the following example, the command sets the port characteristics for the printer `luna`. The `parenb` option enables parity checking/generation, `parodd` sets odd parity generation, and `cs7` sets the character size to 7 bits.

```
# lpadmin -p luna -o "stty='parenb parodd cs7'"
```

In the following example, the command sets the terminal baud rate to 19200 for the printer `venus`.

```
# lpadmin -p venus -o "stty=19200"
```

Adding a `terminfo` Entry for an Unsupported Printer

The LP print service uses an interface program and the `terminfo` database to initialize each printer and establish a selected page size, character pitch, line pitch, and character set.

Each printer is identified in the `terminfo` database with a short name. The name required by the `terminfo` database is identical to the name used to set the `TERM` shell variable. This name is also the printer type you specify when setting up a printer. For example, the entries for different types of PostScript printers are in `/usr/share/lib/terminfo/P`. The default entries provided with the SunOS 5.7 system are `PS` (for PostScript) and `PSR` (for PostScript Reverse).

If you cannot find a `terminfo` entry for your printer, you still may be able to use the printer with the LP print service without the automatic selection of page size, pitch, and character sets. However, you may have trouble keeping the printer set in the correct modes for each print request.

If there is no `terminfo` entry for your type of printer and you want to keep the printer set in the correct modes, you can either customize the interface program used with the printer or add an entry to the `terminfo` database. A terminal or printer entry in the `terminfo` database contains and defines hundreds of items. The LP print service, however, uses fewer than 50 of these items. Table 6-2 lists the required `terminfo` items for a printer.

TABLE 6-2 Required `terminfo` Items for a Printer

Item	Meaning
Booleans:	
<code>cpix</code>	Changing character pitch changes resolution
<code>daisy</code>	Printer requires an operator to change character set
<code>lpix</code>	Changing line pitch changes resolution
Numbers:	
<code>bufsx</code>	Number of bytes buffered before printing
<code>cols</code>	Number of columns in a line

TABLE 6-2 Required terminfo Items for a Printer (continued)

Item	Meaning
cps	Average print rate in characters per second
it	Tabs initially every <i>n</i> spaces
lines	Number of lines on a page
orc	Horizontal resolution, in units per character
orhi	Horizontal resolution, in units per inch
orl	Vertical resolution, in units per line
orvi	Vertical resolution, in units per inch
Strings:	
chr	Change horizontal resolution
cp	Change number of characters per inch
cr	Carriage return
csnm	List of character set names
cudl	Down one line
cud	Move carriage down <i>n</i> lines
cuf	Move carriage right <i>n</i> columns
cvr	Change vertical resolution
ff	Page eject
hpa	Horizontal position absolute
ht	Tab to next 8-space tab stop

TABLE 6-2 Required terminfo Items for a Printer (continued)

Item	Meaning
if	Name of initialization file
iprogr	Path name of initialization program
is1	Printer initialization string
is2	Printer initialization string
is3	Printer initialization string
Strings:	
lpi	Change number of lines per inch
mgc	Clear all margins (top, bottom, and sides)
rep	Repeat a character <i>n</i> times
rwidm	Disable double-wide printing
scs	Select character set
scsd	Start definition of a character set
slines	Set page length to <i>n</i> lines per page
smgl	Set left margin at current column
smglp	Set left margin
smgr	Set right margin at current column
smgrp	Set right margin
smglr	Set both left and right margins
msgt	Set top margin at current line

TABLE 6-2 Required `terminfo` Items for a Printer (continued)

Item	Meaning
<code>smgtp</code>	Set top margin
<code>smgb</code>	Set bottom margin at current line
<code>smgbp</code>	Set bottom margin
<code>smgtb</code>	Set both top and bottom margins
<code>swidm</code>	Enable double-wide printing
<code>vpa</code>	Vertical position absolute

▼ How to Add a `terminfo` Entry for an Unsupported Printer

Note - Before you create a `terminfo` entry for a printer, you should first make sure none of the existing `terminfo` entries will support the printer. To do so, try to set up the printer with an entry for a similar printer, if there is one.

1. Log in as superuser or `lp` on the print server.

1. Determine a `terminfo` entry name for the printer.

The directories in the `/usr/share/lib/terminfo` directory contain all the valid `terminfo` entries. Use them as a guide for choosing a name for the printer.

2. Create a `terminfo` entry file for the printer.

Table 6-2 shows the items you must define in the `terminfo` entry to add a new printer to the LP print service. For more details about the structure of the `terminfo` database, see `terminfo(4)`.

To help you start writing a new `terminfo` entry, use the `infocmp` command to save an existing `terminfo` entry to a file. This is helpful if there is a `terminfo` entry that is similar to one you want to create. For example, the following command saves the `ps` entry to the `ps_cust` file, which will become the new `terminfo` entry.

```
infocmp ps > ps_cust
```

3. Compile the `terminfo` entry file into the `terminfo` database.

```
# tic terminfo_entry
```

`terminfo_entry`

The `terminfo` entry file you created.

4. Check for the new `terminfo` entry file in the `/usr/share/lib/terminfo` directory.

Customizing the Printer Interface Program

If you have a printer that is not supported by the standard printer interface program, you can furnish your own printer interface program. You can copy the standard program and then tell the LP print service to use it for a specified printer. But first you need to understand what is in the standard program. The following section describes the standard program.

A printer interface program should:

- Initialize the printer port, if necessary. The standard printer interface program uses the `stty` command to initialize the printer port.
- Initialize the printer hardware. The standard printer interface program gets the control sequences from the `terminfo` database and the `TERM` shell variable.
- Print a banner page, if necessary.
- Print the number of copies specified by the print request.



Caution - If you have a printer interface program from a release of UNIX System V prior to Release 3.2, it will probably work with the SunOS 5.7 or compatible LP print service. However, several `-o` options have been standardized in the SunOS 5.7 or compatible LP print service and will be passed to every printer interface program. These options may interfere with similarly named options used by the old interface.

The LP print service, not a printer interface program, is responsible for opening the printer port. The printer port is given to the printer interface program as standard output, and the printer is identified as the “controlling terminal” for the printer

interface program so that a “hang-up” of the port will cause a SIGHUP signal to be sent to the printer interface program.

The Standard Printer Interface Program

The standard (model) printer interface program, `/usr/lib/lp/model/standard`, is used by the LP print service to set the printing defaults shown in Table 6-3.

TABLE 6-3 Default Printer Port Characteristics

Characteristic	Default Setting
Default filter	None
Character pitch	None
Line pitch	None
Page width	None
Page length	None
Character set	None
stty options	9600 cs8 -cstopb -parenb -parodd ixon -ixany opost -olcuc onlcr -ocrnl -onocr -onlret -ofill nl0 cr0 tab0 bs0 vt0 ff0
Exit code	0

Customizing stty Modes

If you need to change the terminal characteristics, like baud rate or output options, look for the section of the standard printer interface program that begins with the following comment:

```
## Initialize the printer port
```

Exit Codes

When printing is complete, your interface program should exit with a code that shows the status of the print job. The exit code is the last entry in the printer interface program.

Table 6-4 shows the exit codes and how they are interpreted by the LP print service.

TABLE 6-4 Printer Interface Program Exit Codes

Code	Meaning to the LP Print Service
0	The print request has been successfully completed. If a printer fault occurred, it has been cleared.
1 to 127	A problem was encountered when printing a request (for example, too many nonprintable characters or the request exceeds the printer capabilities). The LP print service notifies the person who submitted the request that there was an error when printing it. This error will not affect future print requests. If a printer fault has occurred, it has been cleared.
128	This code is reserved for internal use by the LP print service. Interface programs must not exit with this code.
129	A printer fault was encountered when printing the request. This fault will affect future print requests. If the fault recovery for the printer directs the LP print service to wait for the administrator to correct the problem, the LP print service disables the printer. If the fault recovery is to continue printing, the LP print service will not disable the printer, but it will try printing again in a few minutes.
>129	These codes are reserved for internal use by the LP print service. Interface programs must not exit with codes in this range.

If the program exits with a code of 129, root is alerted of a printer fault. The LP print service must also reprint the request from the beginning, after the fault has been cleared. If you do not want the entire request to be reprinted, you can have the interface program send a fault message to the LP print service, but wait for the fault to be cleared. When the fault is cleared, the interface program can resume printing the file. When printing is finished, the printer interface program can give a zero exit code, just as if the fault had never occurred. An added advantage of this approach is that the interface program can detect when the fault is cleared automatically, so that the administrator does not need to re-enable the printer.

Fault Messages

You can use the `lp.tell` program to send fault messages to the LP print service. This program is referenced by the `LPTELL` shell variable in the standard printer interface code. The program takes standard input and sends it to the LP print service, where it is put into the message that alerts the administrator to the printer fault. If its standard input is empty, `lp.tell` does not initiate an alert. For an example of how the `lp.tell` program is used, examine the standard printer interface code immediately after the following comment:

```
# Here's where we set up the $LPTELL program to capture fault messages
```

If you use the special exit code 129 or the `lp.tell` program, the printer interface program does not need to disable the printer itself. The interface program can disable the printer directly, but doing so will override the fault-alerting mechanism. Alerts are sent only if the LP print service detects that the printer has a fault, and the special exit code and the `lp.tell` program are its main detection tools.

If the LP print service has to interrupt printing of a file at any time, it kills the interface program with a signal `TERM` (trap number 15). (See `kill(1)` and `signal(3B)`.) If the printer interface program dies from receipt of any other signal, the LP print service assumes that future print requests will not be affected, and continues to use the printer. The LP print service notifies the user who submitted the request that the request has not been finished successfully.

When the interface is first invoked, the signals `HUP`, `INT`, `QUIT`, and `PIPE` (trap numbers 1, 2, 3, and 13) are ignored. The standard interface changes this so the signals are trapped at appropriate times. The standard interface interprets receipt of these signals as warnings that the printer has a problem; when it receives a signal, it issues a fault alert.

Using a Customized Printer Interface Program

You can create a customized printer interface program and use it in place of the standard printer interface program on the print server. To do so, you use the `lpadmin` command to register the program with the LP print service for a specific printer.

▼ How to Set Up a Custom Printer Interface Program

1. **Log in as superuser or lp on the print server.**
2. **Determine your next step based on whether you have a custom printer interface program.**

If You ...	Then ...
Need to create a custom printer interface program	Go to Step 3 on page 132.
Already have a custom printer interface program	Go to Step 5 on page 132.

3. Copy the standard printer interface program.

```
# cp /var/spool/lp/model/standard custom-interface
```

4. Change the copy of the standard printer interface program to meet your needs.

Refer to the description of the program in “The Standard Printer Interface Program” on page 129 to determine what you need to change.

5. Set up the custom printer interface program for a specific printer.

```
# lpadmin -p printer-name -i custom-interface
```

`-p printer-name` The printer that will use the custom printer interface program.

`-i custom-interface` Name of the custom printer interface program.

The custom printer interface program is registered with the LP print service, and will be used by that printer when users submit print requests.

6. Verify that the custom printer interface program has been added in the `/etc/lp/printers/printer-name/configuration` file.

Examples—Setting Up a Custom Printer Interface Program

In the following example, the command sets up a custom printer interface program named `custom` for the printer `luna`.

```
# lpadmin -p luna -i custom
```

In the following example, the command sets up a custom printer interface program that the system `venus` is using on the printer `asteroid`.

```
# lpadmin -p asteroid -e venus
```

Creating a New Print Filter

A filter is used by the LP print service each time it has to print a type of file that the printer cannot interpret. Creating a new print filter is not easy; it usually requires extensive experimentation. The process of defining a new print filter consists of two steps:

- Writing a print filter program
- Creating a print filter definition

A print filter can be as simple or as complex as needed. Filters contain input types, output types, and complex options that provide a language to process command-line arguments within the filter.

If you have non-PostScript printers, you have to create and add print filters as required. First, you need to understand what print filters are and the requirements that must be met by a filter program.

Writing a Print Filter Program

The SunOS 5.7 print service provides filter programs in the `/usr/lib/lp/postscript` directory. These filters cover most PostScript printing situations—where the destination printer requires the data to be in PostScript format. A print filter program must be a binary executable.

Types of Filters

There are two types of print filters: fast filters and slow filters.

Fast filters do not require much processing time to prepare a file for printing. They must have access to the printer when they run. To be capable of detecting printer faults, a print filter must be a fast filter. Any filter that uses the `PRINTER` keyword as a filter option must be installed as a fast filter.

Slow filters require a great deal of processing time to prepare a file for printing. They do not require access to the printer when they run. Slow filters are run in the background so they do not tie up the printer, allowing other files that do not need slow filtering to be printed.

Converting Files

The LP print service uses print filters to convert files from one content type to another. You can specify the accepted file content types for each printer. The user

specifies the file content type when submitting a print request, and the LP print service finds a printer that can print files of that content type. Because many applications can generate files for various printers, this is often sufficient. However, some applications may generate files that cannot be printed on any available printers.

Each time the LP print service receives a request to print a type of file that is in a format that cannot be accepted directly by a printer, the LP print service tries to match the content type of the print request with the content type of the available (or specified) printer. If there is a match, the file can be sent directly to the printer without filtering. If no match is found, or if the content type specifies that a filter be used, the LP print service tries to match the content type of the file with the input content type of available filters, and match the output type of the filter with the content type of the printer. When an appropriate filter is found, the print request is passed through the filter.

Handling Special Printing Modes

A print filter handles special modes and requests to print specific pages. A special printing mode is needed to print any characteristics of print requests that require a customized filter. Filters handle the following characteristics:

- Printer type
- Character pitch
- Line pitch
- Page length
- Page width
- Pages to print
- Character set
- Form name
- Number of copies

The LP print service provides default settings for these characteristics; however, a print filter may handle some characteristics more efficiently. For example, some printers can handle multiple copies more efficiently than the LP print service, and, in this case, you may want to provide a filter for multiple-copy page control.

Detecting Printer Faults

Each printer has its own way of detecting printer faults and transmitting fault signals to the LP print service. The LP print service only checks for hang-ups (loss of carrier) and excessive delays in printing.

Some printers provide good fault coverage and can send a message describing the reason for a fault. Other printers indicate a fault by using signals other than the

signals indicating loss of carrier signal or shut off of data flow. A filter is required to interpret this additional printer fault information.

A filter can also put a print request on hold, wait for a printer fault to clear, and then resume printing. With this capability, the print request that was interrupted does not need to be reprinted in its entirety. Only a filter that knows the control sequences used by a printer can determine where to break a file into pages. Consequently, only such a filter can find the place in the file where printing should start after a fault is cleared.

When a print filter generates messages, those messages are handled by the LP print service, and alerts are sent to the system administrator if alerts are enabled. For further information, see “Setting Up Printer Fault Alerts” on page 71.

Requirements for a Print Filter Program

A print filter can be simple or complex, but it has to meet the following requirements:

- The filter should get the contents of a file from its standard input and send the converted file to the standard output.
- A program cannot be used as a filter if it references external files. You may be tempted to use a program like `troff`, `nroff`, or a similar word processing program as a filter. The LP print service does not recognize references to other files, known as include files, from a filter program. Because `troff` and `nroff` allow include files, they may fail when used as filters. If the program needs other files to complete its processing, it should not be used as a filter.
- The filter should not depend on files that normally would not be accessible to a user. If a filter fails when run directly by a user, it will fail when run by the LP print service.
- A slow filter can send messages about errors in the file to standard error; a fast filter should not. Error messages from a slow filter are collected and sent to the user who submitted the print request.
- If a slow filter dies because it received a signal, the print request is stopped and the user who submitted the request is notified. Likewise, if a slow filter exits with a non-zero exit code, the print request is stopped and the user is notified. The exit codes from fast filters are treated differently.

If you want the filter to detect printer faults, it should also meet the following requirements:

- If possible, the filter should wait for a fault to be cleared before exiting. It should also continue to print at the top of the page where printing stopped after the fault is cleared. If you do not want use the continuation feature, the LP print service will stop the filter before alerting the administrator.
- The filter should send printer fault messages to its standard error as soon as the fault is recognized. It does not have to exit; it can wait for the fault to be cleared.

- The filter should not send messages about errors in the file to standard error. These messages should be included in the standard output, where they can be read by the user.
- The filter should exit with a zero exit code if the file is finished printing (even if errors in the file have prevented it from being printed correctly).
- The filter should exit with a non-zero exit code only if a printer fault has prevented it from finishing a print request.
- When added to the filter table, the filter must be added as a fast filter.

Creating a Print Filter Definition

A print filter definition tells the LP print service about the filter, what print filter program to run, what kind of conversion it does, and so on. A set of filter descriptor files are provided in the `/etc/lp/fd` directory. These files describe the characteristics of the filters (for example, fast or slow filter), and point to the filter programs (for example, `/usr/lib/lp/postscript/postdaisy`).

When defining a new print filter, in addition to writing a filter program, you must create a print filter definition. A print filter definition contains the following information used by the LP print service:

- Name of the filter program to run
- Input types it accepts
- Output types it produces
- Printer types to which it can send jobs
- Names of specific printers to which it can send jobs
- Filter types (either fast or slow)
- Options

You can type the characteristics as direct input to the `lpfilter` command. You also can create a file that specifies the filter's characteristics, and use the file name as input to the `lpfilter` command. Such a file is called a *filter descriptor file* and should be located in the `/etc/lp/fd` directory. These files are not the filters themselves, but rather point to the filters.

Whether you store the information in a file, or enter it directly on the command line, use the following format:

```
Command: command-pathname [options]
Input types: input-type-list
Output types: output-type-list
Printer types: printer-type-list
```

(continued)

(Continuation)

```
Printers: printer-list  
Filter type: fast or slow  
Options: template-list
```

Note - If you provide more than one definition (that is, more than one line) for any filter characteristic other than `Options`, only the second definition will be used by the print service.

The information can be arranged in any order, and not all the information is required. When you do not specify values, those shown in Table 6-5 are assigned by default. They are not very useful, which is why you should specify explicit values.

TABLE 6-5 Default Values for `lpfilter` Arguments

Item	Default
Input types	any
Output type	any
Printer types	any
Printers	any
Filter type	slow

Command

Use the full path of the filter program. If there are any fixed options that the program always needs, include them here.

Input Types

Input types is a list of file content types that the print filter can process. The LP print service does limit the number of input types, but most filters can accept only one

type. Several file types may be similar enough that the filter can deal with them. You can use whatever names you like, with a maximum of 14 alphanumeric characters and dashes. Do not use underscores as part of the input type name.

The LP print service uses these names to match a filter to a file type, so follow a consistent naming convention. For example, if more than one filter can accept the same input type, use the same name for that input type when you specify it for each filter. Inform your users of these names so they know how to identify the file type when submitting a file for printing.

Output Types

Output types is list of file types that the filter can produce as output. For each input type, the filter produces a single output type. The output type may vary, however, from job to job. The name of the output type is restricted to 14 alphanumeric characters and dashes.

The output type names should either match the types of available (local or remote) printers, or match the input types handled by other filters. The LP print service groups filters in a shell pipeline if it finds that several passes by different filters are needed to convert a file. It is unlikely that you will need this level of sophistication, but the LP print service allows it. Try to find a set of filters that takes as input types all the different files the users may want printed, and that converts those files directly into file types the printer can handle.

Printer Types

Printer types is a list of the types of printers into which the print filter can convert files. For most printers and filters, you can leave this part of the filter definition blank, because it is identical to the list of output types. But it can be different. For example, you could have a printer with a single printer type for purposes of initialization, but which can recognize several different file content types. Essentially, this printer has an internal filter that converts the various file types into one that it can handle. Thus, a filter may produce one of several output types that match the file types that the printer can handle. The print filter should be marked as working with that printer type.

As another example, you may have two different models of printers that are listed as accepting the same file types. Due to slight differences in manufacture, however, one printer deviates in the results it produces. You label the printers as being of different printer types, say A and B, where B is the one that deviates. You create a filter that adjusts files to account for the deviation produced by printers of type B. Because this filter is needed only for those printer types, you would list it as working only on type B printers.

Printers

A print filter is normally able to work with all printers that accept its output, so you can usually skip this part of the filter definition.

You may, however, have some printers that are or inappropriate for the output that the filter produces. For example, you may want to dedicate one printer for fast turnaround, only sending files that require no filtering to that printer. Other printers of identical type may be used for files that need extensive filtering before they can be printed.

Filter Type

The LP print service recognizes fast and slow filters, as described in “Types of Filters” on page 133.

Slow filters that are invoked by printing modes (using the `lp -y` command) must be run on the system from which the print request originated. The LP print service cannot pass values for modes to print servers. It can, however, match a file content type (specified after the `-T` option of the `lp` command) to a content type on a print server. Therefore, if you want to activate special modes on a print server, you must specify content types that permit the LP print service to match input types and output types.

Options

Options specify how different types of information are converted into command-line arguments to the filter command. This information may include specifications from a user (with the print request), the printer definition, and the specifications implemented by any filters used to process the request.

Defining Print Filter Options With Templates

There are 13 sources of information for defining print filter options, each of which is represented by a *keyword*. Each option is defined in a *template*. A template is a statement in a filter definition that defines an option to be passed to the filter command, based on the value of one of the characteristics of the filter.

The options specified in a filter definition may include none, all, or any subset of the 13 keywords. In addition, a single keyword may be defined more than once, if multiple definitions are required for a complete filter definition. Table 6-6 contains descriptions of the 13 keywords available for defining `Options` in a print filter definition.

TABLE 6-6 Print Filter Options Keywords

Characteristic	Keyword	Possible Patterns	Example
Content type (input)	INPUT	<i>content-type</i>	troff
Content type (output)	OUTPUT	<i>content-type</i>	postscript, impress
Printer type	TERM	<i>printer-type</i>	att495
Printer name	PRINTER	<i>printer-name</i>	lp1
Character pitch	CPI	<i>scaled-decimal</i>	10
Line pitch	LPI	<i>scaled-decimal</i>	6
Page length	LENGTH	<i>scaled-decimal</i>	66
Page width	WIDTH	<i>scaled-decimal</i>	80
Pages to print	PAGES	<i>page-list</i>	1-5,13-20
Character set	CHARSET	<i>character-set</i>	finnish
Form name	FORM	<i>form-name</i>	invoice2
Number of copies	COPIES	<i>integer</i>	3
Special modes	MODES	<i>mode</i>	landscape

A print filter definition can include more than one template. Multiple templates are entered on a single line and separated with commas, or they are entered on separate lines, preceded by the Options: prefix.

The format of a template is as follows:

keywordpattern = replacement

The keyword identifies the type of option being registered for a particular characteristic of the filter.

The *pattern* is a specific option for the keyword.

The *replacement* is what happens when the keyword has the noted value.

For an example of how an option is defined for a particular filter, suppose you want to have the print service scheduler assign print requests to filters following this criteria:

- If the type of OUTPUT to be produced by the filter is `impress`, then pass the `-I` option to the filter.
- If the type of OUTPUT to be produced by the filter is `postscript`, then pass the `-P` option to the filter.

To specify these criteria, provide the following templates as options to the `lpfilter` command:

```
Options: OUTPUT impress=-I, OUTPUT postscript=-P
```

If the `Options` line becomes too long, put each template on a separate line, as follows:

```
Options: OUTPUT impress=-I
Options: OUTPUT postscript=-P
```

In both templates, the *keyword* is defined as `OUTPUT`. In the first template, the pattern is `impress` and the value of the *replacement* is `-I`. In the second template, the value of *pattern* is `postscript` and the value of *replacement* is `-P`.

To find out which values to supply for each type of template (that is, for the *pattern* and *replacement* arguments for each keyword), consider the following:

- The values for the `INPUT` templates come from the file content type that needs to be converted by the filter.
- The values for the `OUTPUT` templates come from the output type that has to be produced by the filter.
- The value for the `TERM` template is the printer type.
- The value for the `PRINTER` template is the name of the printer that will print the final output.
- The values for the `CPI`, `LPI`, `LENGTH`, and `WIDTH` templates come from the user's print request, the form being used, or the default values for the printer.
- The value for the `PAGES` template is a list of pages that should be printed. Typically, it is a list of page ranges separated by commas. Each page range consists of a pair of numbers separated by a dash, or a single number. (For example, `1-5,6,8,10` indicates pages 1 through 5, plus pages 6, 8, and 10.) However, whatever value was given in the `-P` option to a print request is passed unchanged.
- The value for the `CHARSET` template is the name of the character set to be used.
- The value for the `FORM` template is the name of the form requested by the `lp -f` command (the command used to submit a print request).

- The value of the `COPIES` template is the number of copies of the file to print. If the filter uses this template, the LP print service will reduce to one the number of copies of the filtered file it prints, since this “single copy” includes the multiple copies produced by the filter.
- The value of the `MODES` template comes from the `lp -y` command. Because a user can specify several `-y` options, there may be several values for the `MODES` template. The values will be applied in the left-to-right order given by the user.

The *replacement* part of a template shows how the value of a template should be given to the filter program. It is typically a literal option, sometimes with the placeholder asterisk (*) included to show where the value goes. The *pattern* and *replacement* also can use the regular expression syntax of `ed(1)` for more complex conversion of user input options into filter options. All regular expression syntax of `ed(1)` is supported, including the `\(. . . \)` and `\n` constructions, which can be used to extract portions of the *pattern* for copying into the *replacement*, and the `&`, which can be used to copy the entire *pattern* into the *replacement*.

Note - If a comma or an equal sign (=) is included in a *pattern* or a *replacement*, precede it with a backslash (\). A backslash in front of any of these characters is removed when the *pattern* or *replacement* is used.

▼ How to Create a New Print Filter

1. **Log in as superuser or lp on the print server.**
2. **Create a print filter program.**
See “Writing a Print Filter Program” on page 133 for information on print filter programs. By convention, filter programs for PostScript printers are located in the `/usr/lib/lp/postscript` directory. You should put programs you create under `/usr/lib/lp` in a directory of your choosing.
3. **Create a print filter definition.**
See “Creating a Print Filter Definition” on page 136 for information on print filter definitions. You should save the printer filter definition in a text file. By convention, filter definitions are located in the `/etc/lp/fd` directory and are identified with the `.fd` suffix.
4. **Add the print filter to a print server.**
For instructions, see “How to Add a Print Filter” on page 102.

Examples—Creating a New Print Filter

The following example shows a print filter definition to convert `N37` or `Nlp` to `simple`.

```
Input types: N37, Nlp, simple
Output types: simple
Command: /usr/bin/col
Options: MODES expand = -x
Options: INPUT simple = -p -f
```

In this example, the print filter program is named `col`. Once you add the new print filter to a print server, a user's print requests will be handled as follows:

- When a user enters the following command:

```
$ lp -y expand report.doc
```

The print filter program is run with the following arguments to convert the file:

```
/usr/bin/col -x -p -f
```

- When a user enters the following command:

```
$ lp -T N37 -y expand report.doc
```

The print filter program is run with the following arguments to convert the file:

```
/usr/bin/col -x
```

The following example shows a print filter definition to convert from `troff` to PostScript.

```
Input types: troff
Output types: postscript
Printer types: PS
Filter type: slow
Command: /usr/lib/lp/postscript/dpost
Options: LENGTH * = -l*
Options: MODES port = -pp, MODES land = -pl
Options: MODES group \=\\([1-9]\\) = -n\\l
```

In this example, the filter program is named `dpost`. It takes one input type, `troff`, produces a `postscript` output, and works with any printer of type `PS` (PostScript). Users need to give just the abbreviation `port` or `land` when they ask for the paper orientation to be in portrait mode or landscape mode. Because these options are not intrinsic to the LP print service, users must specify them using the `lp -y` command.

After you add the new print filter to a print server, print requests will be handled as follows:

- When a user enters the following command to submit a troff file type for printing on a PostScript printer (type PS), with requests for landscape orientation and a page length of 60 lines:

```
$ lp -T troff -o length=60 -y land -d luna chl.doc
```

The print filter program `dpost` is run with the following arguments to convert the file:

```
/usr/lib/lp/postscript/dpost -l60 -pl luna chl.doc
```

- When a user enters the following command:

```
$ lp -T troff -y group=4 -d luna chl.doc
```

The print filter program `dpost` is run with the following arguments to convert the file:

```
/usr/lib/lp/postscript/dpost -n4
```

Creating a New Printer Form

When you want to provide a new form, you must define its characteristics by entering information about nine required characteristics (such as page length and page width) as input to the `lpforms` command. The LP print service uses this information to:

- Initialize the printer so that printing is done properly on the form
- Send reminders to the system administrator about how to handle the form

The form name can be anything you choose, as long as it does not contain more than 14 alphanumeric characters and underscores. The information must be in the following format:

```
Page length: scaled number  
Page width: scaled number  
Number of pages: integer  
Line pitch: scaled number  
Character pitch: scaled number  
Character set choice: character-set-name [,mandatory]  
Ribbon color: ribbon-color
```

(continued)

(Continuation)

```
Comment:  
informal notes about the form  
Alignment pattern: [content-type] alignment pattern
```

The optional phrase [,mandatory] means that the user cannot override the character set choice in the form. The *content-type* can be given, although this is optional, with an alignment pattern. If this attribute is given, the print service uses it to determine, as necessary, how to filter and print the file.

With two exceptions, the information may appear in any order. The exceptions are the `Alignment pattern` (which must always be last), and the *comment* (which must always follow the line with the `Comment:` prompt). If the comment contains a line beginning with a `>` character so the key phrase is not at the beginning of the line. The initial `>` character is stripped from the comment and is not displayed.

Not all of the information must be given. When you do not specify values for the items listed in Table 6-7 the default values are assigned. Before running the `lpforms` command, gather the following information about the new form:

TABLE 6-7 Default Form Values

Item	Default	Description
Page length	66 lines	The length of the form, or the length of each page in a multipage form. This information can be the number of lines, or the size in inches or centimeters.
Page width	80 columns	The width of the form, in characters, inches, or centimeters.
Number of pages	1	The number of pages in a multipage form. The LP print service uses this number with a print filter (if available) to restrict the alignment pattern to a length of one form. See the description of alignment pattern below. If no filter is available, the LP print service does not truncate the output.

TABLE 6-7 Default Form Values (continued)

Item	Default	Description
Line pitch	6 lines per inch	A measurement of how close lines appear on the form. This is also called leading. It is the distance between two lines, from baseline to baseline, measured by either lines per inch or lines per centimeter.
Character pitch	10 characters per inch	A measurement of how close together characters appear on the form. It is the distance between characters, measured by either characters per inch or characters per centimeter.
Character set choice	Any	The character set, print wheel, or font cartridge that should be used when this form is used. Users may choose a different character set for their own print requests when using this form, or you can require that only one character set be used.
Ribbon color	Any	If the form should always be printed using a certain color ribbon, the LP print service can give a mount alert message indicating which color to use.
Comment	(No default)	Any remarks that might help users understand the form. For example, the remarks could indicate the name of the form, its revision, its purpose, or restrictions on its use.
Alignment pattern	(No default)	A sample file that the LP print service uses to fill one blank form. When mounting the form, you can print this pattern on the form to align it properly. You can also define a content type for this pattern so that the print service knows how to print it.

Note - The LP print service does not try to mask sensitive information in the alignment pattern. If you do not want sensitive information printed on sample forms—for example when you align checks—then you should mask the appropriate data. The LP print service keeps the alignment pattern stored in a safe place, where only those logged in as root or lp can read it.

When you have gathered the information for the form, you enter it as input to the `lpforms` command. You should record this information first in a separate file so you can edit it before entering it with `lpforms`. You can then use the file as input instead of typing each piece of information separately after a prompt.

▼ How to Create a New Form Definition

1. **Log in as superuser or lp on the print server.**
2. **Create a form definition file.**
See “Creating a New Printer Form” on page 144 for a description on creating print forms. You should save the printer definition in a text file.
3. **Add the form to the LP print service by using the `lpadmin` command.**

```
# lpadmin -p printer-name -M -f form-name
```

4. **Add the form to a print server.**
For instructions, see “How to Add a Form” on page 107.

LP Print Service Reference Information

This chapter provides background information on the LP print service.

- “The Structure of the LP Print Service” on page 150
- “LP Print Service Commands” on page 158
- “Functions of the LP Print Service” on page 160
- “How LP Administers Files and Schedules Local Print Requests” on page 160
- “Scheduling Network Print Requests” on page 162
- “Filtering Print Files” on page 162
- “What the Printer Interface Program Does” on page 162
- “How the `lpsched` Daemon Tracks the Status of Print Requests” on page 163
- “Cleaning Out Log Files” on page 163

For step-by-step instructions on print management tasks, see:

- Chapter 3
- Chapter 4
- Chapter 5
- Chapter 6

The LP Print Service

The *LP print service* is a set of software utilities that allows users to print files while they continue to work. Originally, the print service was called the LP spooler. (LP stood for line printer, but its meaning now includes many other types of printers, such as laser printers. Spool is an acronym for system peripheral operation off-line.)

The print service consists of the LP print service software, any print filters you may provide, and the hardware (the printer, system, and network connections).

The Structure of the LP Print Service

This section describes the directory structure, files, logs, and commands of the LP print service.

Directories

The files of the LP print service are distributed among seven directories, as shown in Table 7-1.

TABLE 7-1 Directories for the LP Print Service

Directory	Contents
<code>/usr/bin</code>	The LP print service user commands
<code>/etc/lp</code>	A hierarchy of LP server configuration files
<code>/usr/share/lib</code>	The terminfo database directory
<code>/usr/sbin</code>	The LP print service administrative commands
<code>/usr/lib/lp</code>	The LP daemons; directories for binary files and PostScript filters; and the <code>model</code> directory (which contains the standard printer interface program)
<code>/var/lp/logs</code>	The logs for LP activities: <code>lp sched.n</code> - Messages from <code>lp sched</code> and <code>requests.n</code> - Information about completed print requests
<code>/var/spool/lp</code>	The spooling directory where files are queued for printing

Configuration Files

The scheduler stores configuration information in LP configuration files located in the `/etc/lp` directory, as described in Table 7-2.



Caution - The configuration files listed in Table 7-2 are private interfaces, and are subject to change in future releases. You should not build software that relies on these files being in their current locations or that relies on the data being in the format currently used.

TABLE 7-2 Contents of the `/etc/lp` Directory

File	Type	Description
<code>classes</code>	Directory	Files identifying classes provided by the <code>lpadmin -c</code> command.
<code>fd</code>	Directory	Description of existing filters.
<code>filter.table</code>	File	Print filter lookup table.
<code>forms</code>	Directory	Location to put files for each form. Initially, this directory is empty.
<code>interfaces</code>	Directory	Printer interface program files.
<code>logs</code>	Link to <code>/var/lp/logs</code>	Log files of printing activities.
<code>model</code>	Link to <code>/usr/lib/lp/model</code>	The standard printer interface program.
<code>printers</code>	Directory	Directories for each local printer. Each directory contains configuration information and alert files for an individual printer.
<code>pwheels</code>	Directory	Print wheel or cartridge files.

These configuration files serve a similar function to the `/etc/printcap` file in the SunOS 4.1 release.

Note - You can check the contents of the configuration files, but you should not edit them directly. Instead, use the `lpadmin(1M)` command to make configuration changes. Your changes will be written to the configuration files in the `/etc/lp` directory. The `lp sched` daemon administers and updates the configuration files.

The `/etc/lp/printers` directory has a subdirectory for each local printer known to the system. The following example shows the `/etc/lp/printers` subdirectories of printers `sparc1` and `luna`.

```
$ ls -l /etc/lp/printers
drwxrwxr-x 2 lp lp 512 Jan 23 23:53 luna
drwxrwxr-x 2 lp lp 512 Jan 11 17:50 sparc1
```

Within each of the printer-specific directories, the following files can describe the printer:

- `alert.sh` – Shell to execute in response to alerts
- `alert.vars` – Alert variables
- `configuration` – Configuration file
- `users.deny` – List of users to whom printer access is denied
- `comment` – Printer description

The configuration file for the printer `luna`, `/etc/lp/printers/luna/configuration`, would typically appear as follows:

```
Banner: on: Always
Content types: PS
Device: /dev/term/b
Interface: /usr/lib/lp/model/standard
Printer type: PS
Modules: default
```

The terminfo Database

The `/usr/share/lib` directory contains the `terminfo` database directory, which contains definitions for many types of terminals and printers. The LP print service uses information in the `terminfo` database to initialize a printer, to establish a selected page size, character pitch, line pitch, and character set, as well as to communicate the sequence of codes to a printer.

Each printer is identified in the `terminfo` database with a short name. See “Printer Type” on page 24 for a description of the structure of the `terminfo` database. If necessary, you can add entries to the `terminfo` database, but it is a tedious and time-consuming process. See “Adding a `terminfo` Entry for an Unsupported Printer” on page 124.

Daemons and LP Internal Files

The `/usr/lib/lp` directory contains daemons and files used by the LP print service, as described in Table 7-3.

TABLE 7-3 Contents of the `/usr/lib/lp` Directory

File	Type	Description
<code>bin</code>	Directory	Contains files for generating printing alerts, slow filters, and queue management programs.
<code>lpsched</code>	Daemon	Manages scheduling of LP print requests.
<code>model</code>	Directory	Contains the standard printer interface program.
<code>postscript</code>	Directory	Contains all PostScript filter programs provided by the SunOS 5.7 or compatible LP print service. These filters come with descriptor files in the <code>/etc/lp/fd</code> directory that tell the LP print service the characteristics of the filters and where to locate them.

Log Files

The LP print service maintains two sets of log files:

- `/var/spool/lp` — A list of current requests that are in the print queue
- `/var/lp/logs/requests` — An ongoing history of print requests

Print Queue Logs

The scheduler for each system keeps a log of print requests in the directories `/var/spool/lp/tmp/system` and `/var/spool/lp/requests/system`. Each print request has two files (one in each directory) that contain information about the request. The information in the `/var/spool/lp/requests/system` directory can be accessed only by root or lp. The information in the `/var/spool/lp/tmp/system` can be accessed only by the user who submitted the request, root, or lp.

The following example shows the contents of the `/var/spool/lp/tmp/terra` directory:

```
$ ls /var/spool/lp/tmp/terra
20-0 21-0
```

(continued)

(Continuation)

```
terra$ cat 21-0
C 1
D slw2
F /etc/default/login
P 20
t simple
U tamiro
s 0x1000
```

These files remain in their directories only as long as the print request is in the queue. Once the request is finished, the information in the files is combined and appended to the file `/var/lp/logs/requests`, which is described in the next section.

Use the information in the `/var/spool/lp` logs if you need to track the status of a print request that is currently in the queue.

History Logs

The LP print service records a history of printing services in two log files: `lpsched` and `requests`. These log files are located in the `/var/lp/logs` directory. You can use the information in these logs to diagnose and troubleshoot printing problems. This is an example of the contents of the `/var/lp/logs` directory:

```
# cd /var/lp/logs
# ls
lpsched.1   requests   requests.2
lpsched     lpsched.2  requests.1
#
```

The files with the `.1` and `.2` suffixes are copies of the previous day's logs. Each day, the `lp` cron job cleans out the `lpsched` and `requests` log files and keeps copies for two days. See "Creating and Editing `crontab` Files" on page 417 for suggestions on modifying the cron job for cleaning out the `requests` log.

The two most important log files for troubleshooting is the `lpsched` log, which contains information about local printing requests

The `requests` log contains information about print requests that are completed and no longer in the print queue. Once a request is finished printing, the information in the `/var/spool/lp` log files is combined and appended to the `/var/lp/logs/requests` log.

The `requests` log has a simple structure, so that you can extract data using common UNIX shell commands. Requests are listed in the order they are printed, and are separated by lines showing their request IDs. Each line below the separator

line is marked with a single letter that identifies the kind of information contained in that line. Each letter is separated from the data by a single space.

The following example shows the contents of a `requests` log:

```
# pwd
/var/lp/logs
# tail requests.2
= slw2-20, uid 200, gid 200, size 5123, Tue Jun 17 10:16:10 MDT
1998
z slw2
C 1
D slw2
F /etc/motd
P 20
t simple
U irving
s 0x0100
#
```

Table 7-4 shows the letter codes and the content of their corresponding lines in the LP `requests` log.

TABLE 7-4 Letter Codes in the LP `requests` Log

Letter	Content of Line
=	The separator line. It contains the following items: request ID, user ID (UID), and group IDs (GIDs) of the user, the total number of bytes in the original (unfiltered) file size, and the time when the request was queued.
C	The number of copies printed.
D	The printer or class destination or the word <code>any</code> .
F	The name of the file printed. The line is repeated for each file printed; files were printed in the order shown.
f	The name of the form used.
H	One of three types of special handling: <code>resume</code> , <code>hold</code> , and <code>immediate</code> .
N	The type of alert used when the print request was successfully completed. The type is the letter <code>M</code> if the user was notified by email or <code>w</code> if the user was notified by a message to the terminal.
O	The printer-dependent <code>-o</code> options (for example, <code>nobanner</code>).

TABLE 7-4 Letter Codes in the LP `requests` Log (continued)

Letter	Content of Line
P	The priority of the print request.
p	The list of pages printed.
r	A single-letter line that is included if the user asked for “raw” processing of the files (the <code>lp -r</code> command).
S	The character set, print wheel, or cartridge used.
s	The outcome of the request, shown as a combination of individual bits expressed in hexadecimal form. Several bits are used internally by the print service. The bits and what they mean are describe in Table 7-5.
T	The title placed on the banner page.
t	The type of content found in the files.
U	The name of the user who submitted the print request.
x	The slow filter used for the print request.
Y	The list of special modes for the print filters used to print the request.
z	The printer used for the request. This printer differs from the destination (the D line) if the request was queued for any printer or a class of printers, or if the request was moved to another destination.

Table 7-5 shows the outcome codes in the LP `requests` log and their descriptions.

TABLE 7-5 Outcome Codes in the LP `requests` Log

Outcome Code	Description
0x0001	The request was held pending resume.
0x0002	Slow filtering is running.
0x0004	Slow filtering finished successfully.

TABLE 7-5 Outcome Codes in the LP requests Log *(continued)*

Outcome Code	Description
0x0008	The request is on the printer.
0x0010	Printing finished successfully.
0x0020	The request was held pending user change.
0x0040	The request was canceled.
0x0080	The request will print next.
0x0100	The request failed filtering or printing.
0x0200	The request is in transit to a remote printer. (obsolete)
0x0400	The user will be notified.
0x0800	A notification is running.
0x1000	A remote system has accepted the request. (obsolete)
0x2000	The administrator placed a hold on the request.
0x4000	The printer had to change filters.
0x8000	The request is temporarily stopped.

Spooling Directories

Files queued for printing are stored in the `/var/spool/lp` directory until they are printed, which may be only seconds. Table 7-6 shows the contents of the `/var/spool/lp` directory.

TABLE 7-6 Contents of the `/var/spool/lp` Directory

File	Type	Description
SCHEDLOCK	File	Lock file for the scheduler. Check for this file if the scheduler dies and will not restart.
admins	Directory	Link to <code>/etc/lp</code> .
bin	Directory	Link to <code>/usr/lib/lp/bin</code> .
logs	Link	Link to <code>../lp/logs</code> where completed print requests are logged.
model	Link	Link to <code>/usr/lib/lp/model</code> .
requests	Directory	Directory that contains subdirectories for each configured printer where print requests are logged until printed. Users cannot access this log.
system	Directory	A print status file for the system.
temp	Link	Link to <code>/var/spool/lp/tmp/hostname</code> , which contains the spooled requests.
tmp	Directory	Directory for each configured printer where print requests are logged until printed. Changes to existing print requests are also recorded in this log.

LP Print Service Commands

Table 7-7 lists frequently used LP print service commands. You must be root or `lp` to use the `lM` commands.

TABLE 7-7 Quick Reference to LP Print Service Commands

Command	Task
<code>enable(1)</code>	Activate a printer
<code>cancel(1)</code>	Cancel a print request
<code>lp(1)</code>	Send one or more file(s) to a printer
<code>lpstat(1)</code>	Report the status of the LP print service
<code>disable(1)</code>	Deactivate one or more printers
<code>accept(1M)</code>	Permit print requests to be queued for a specific destination
<code>reject(1M)</code>	Prevent print requests from being queued for a specific destination
<code>lpadmin(1M)</code>	Set up or change printer configuration
<code>lpfilter(1M)</code>	Set up or change filter definitions
<code>lpforms(1M)</code>	Set up or change preprinted forms
<code>lpadmin(1M)</code>	Mount a form
<code>lpmove(1M)</code>	Move output requests from one destination to another

TABLE 7-7 Quick Reference to LP Print Service Commands (continued)

Command	Task
<code>lpsched(1M)</code>	Start the LP print service scheduler
<code>lpshut(1M)</code>	Stop the LP print service scheduler
<code>lpusers(1M)</code>	Set or change the default priority and priority limits that can be requested by users of the LP print service

Functions of the LP Print Service

The LP print service performs the following functions:

- Administers files and schedules local print requests
- Receives and schedules network requests
- Filters files (if necessary) so they print properly
- Starts programs that interface with the printers
- Tracks the status of jobs
- Tracks forms mounted on the printer
- Tracks print wheels currently mounted
- Delivers alerts to mount new forms or different print wheels
- Delivers alerts about printing problems

“The Structure of the LP Print Service” on page 150 describes the directory structure and commands.

How LP Administers Files and Schedules Local Print Requests

The LP print service has a scheduler daemon called `lpsched`. The scheduler daemon updates the LP system files with information about printer setup and configuration.

The `lpsched` daemon schedules all local print requests on a print server, as shown in Figure 7-1, whether users issue the requests from an application or from the

command line. Also, the scheduler tracks the status of printers and filters on the print server. When a printer finishes a request, the scheduler schedules the next request, if there is one, in the queue on the print server.

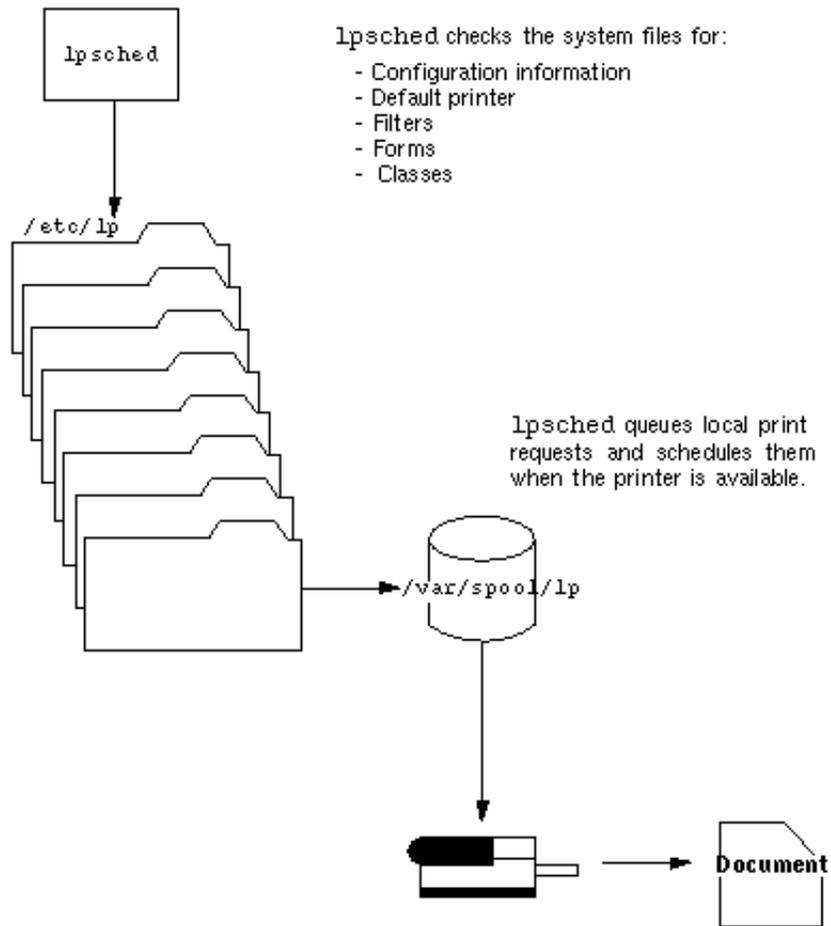


Figure 7-1 The `lpsched` Daemon Schedules Local Print Requests

Each print server must have *only* one LP scheduler running. The scheduler is started when a system is booted (or enters run level 2) by the control script `/etc/rc2.d/S80lp`. Without rebooting the systems, you can stop the scheduler with the `/usr/lib/lp/lpshut` command and restart the scheduler with the `lpsched` command. The scheduler for each system manages requests issued to the system by the `lp` commands.

Scheduling Network Print Requests

Each print client communicates directly with a print sever over the network. The communication is done between the requesting command (`lp`, `lpstat`, `cancel`, `lpr`, `lpq`, or `lprm`) and the print service on the print server. Doing so, reduces the print system overhead on client only systems, improving scalability, performance and accuracy of data.

Print servers now listen for print request with the Internet services daemon (`inetd`). Upon hearing a request for print service from the network, `inetd` starts a program called the “protocol adaptor” (`in.lpd`). The protocol adaptor translates the print request and communicates it to the print spooler, returning the results to the requestor. It starts on demand and exits when it has serviced the network request. This eliminates idle system overhead for printing. It also eliminates any additional system configuration for networked printing support as was the case in previous versions of Solaris printing.

Filtering Print Files

Print filters are programs on the print server that convert the content of a queued file from one format to another.

A print filter can be as simple or as complex as needed. SunOS 5.7 system software provides print filters in the `/usr/lib/lp/postscript` directory that cover most situations where the destination printer requires the data to be in PostScript format. If you need filters for non-PostScript printers, you have to create the filters and add them to the systems that need them.

A set of *print filter descriptor files* are provided in the `/etc/lp/fd` directory. These descriptor files describe the characteristics of the filter (for example, fast or slow filter), and point to the filter program (for example, `/usr/lib/lp/postscript/postdaisy`).

What the Printer Interface Program Does

The LP print service interacts with other parts of the operating system. It uses a standard printer interface program to:

- Initialize the printer port, if necessary. The standard printer interface program uses the `stty` command to initialize the printer port.
- Initialize the printer. The standard printer interface program uses the `terminfo` database and the `TERM` shell variable to find the appropriate control sequences.
- Print a banner page, if necessary.
- Print the correct number of copies specified by the print request.

The LP print service uses the standard interface program (found in the `/usr/lib/lp/model` directory) unless you specify a different one. You can create custom interface programs, but you must make sure that the custom program does not terminate the connection to the printer or interfere with proper printer initialization.

How the `lp` Daemon Tracks the Status of Print Requests

The `lp` daemon on both the print server and print client keeps a log of each print request that it processes and notes any errors that occur during the printing process. This log is kept in the `/var/lp/logs/lpsched` file. Every night, the `lp` cron job renames `/var/lp/logs/lpsched` to a new `lpsched.n` file and starts a new log file. If errors occur or jobs disappear from the print queue, you can use the log files to determine what `lp` has done with a printing job.

Cleaning Out Log Files

The `lpsched` and `requests` log files in the `/var/lp/logs` directory grow as information is appended. The LP print service uses a default cron job to clean out the log files. The `lp` cron job is located in the `/var/spool/cron/crontabs/lp` file. It periodically moves the contents of the log files. The contents of `log` are moved to `log.1`, and the contents of `log.1` are moved to `log.2`. The contents of `log.2` are lost (that is, replaced by the former contents of `log.1`) when `log.2` gets overwritten.

```
# pwd
/var/lp/logs
# tail requests
s 0x1010
= slw2-20, uid 200, gid 200, size 5123, Mon Jun 16 12:27:33 MDT
1997
z slw2
C 1
D slw2
F /etc/motd
P 20
t simple
U irving
s 0x1010
#
```

▼ How to Change Frequency of Printer Request Log Rotation

Starting with the Solaris 2.6 release, the `requests` log file on the printer server is rotated weekly rather than daily. You may want to change the rotation interval back to daily if the printer server is busy.

1. **Become superuser or `lp` on the printer server.**

2. **Set the `EDITOR` environment variable.**

```
# EDITOR=vi
# export EDITOR
```

3. **Edit the `lp` crontab file.**

```
# crontab -e lp
```

4. **Change the first line of the file which rotates the `requests` log files every Sunday (0) to an asterisk (*) for daily rotation:**

```
13 3 * * * cd /var/lp/logs; if [ -f requests ]; then if
[ -f requests.1 ]; then /bin/mv requests.1 requests.2; fi; /usr/bin/cp
requests requests.1; >requests; fi
```

5. **Save the file and exit.**

How Local Printing Works

Figure 7-2 shows what happens when a user submits a request to print a PostScript file on a *local* printer, which is a printer connected to the user's system. The local system does all processing; however, the print request follows the same path it would if the client and server were separate systems. Requests always flow from client to server following the same path.

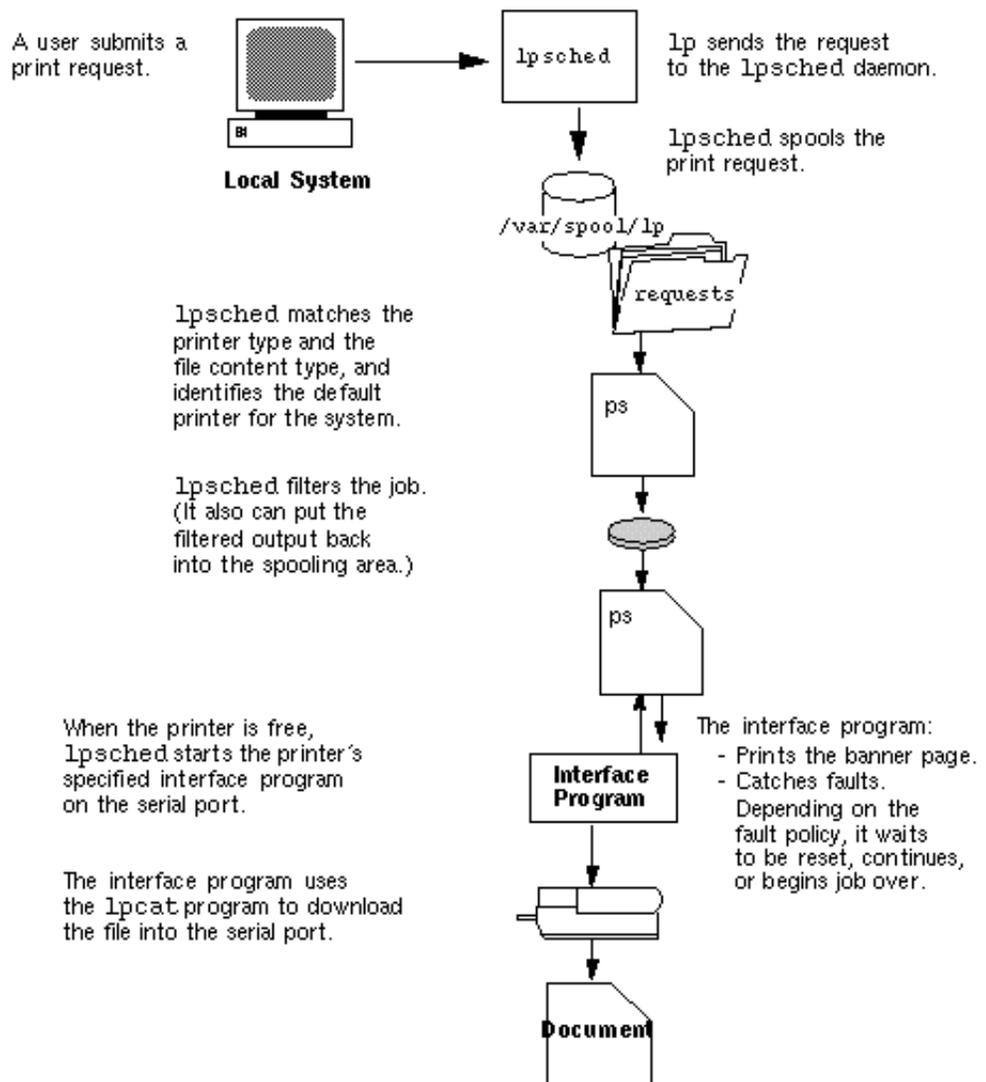
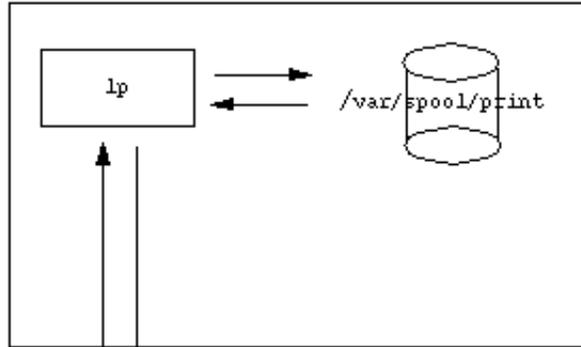


Figure 7-2 The Local Printing Process

How Remote Printing Works

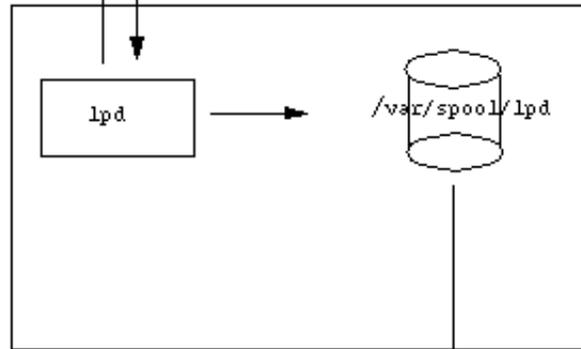
Figure 7-3 shows what happens when a user on a SunOS 5.7 and compatible print client submits a print request to a SunOS 4.1 print server. The command opens a connection and handles it's own communications with the print server directly.

5.7 Print Client



lp sends a print request to the 4.1 print server.

4.1 Print Server



lpd accepts the request, spools it, filters it, and schedules the local printing.

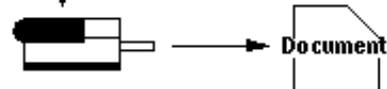
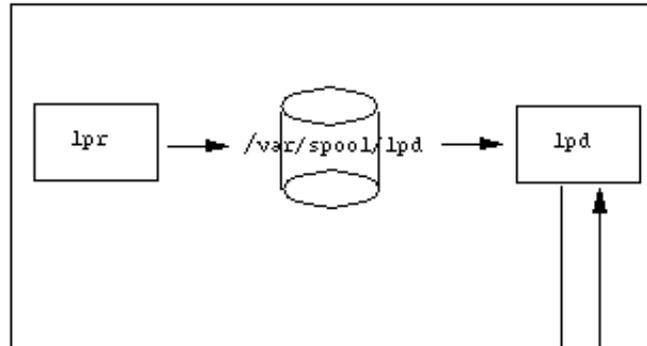


Figure 7-3 Network Printing Between a SunOS 5.7 or Compatible Print Client and a SunOS 4.1 Print Server

Figure 7-4 shows a SunOS 4.1 print client submitting a print request to a SunOS 5.7 or compatible print server. The `lpd` daemon handles the local part of the print request and the connection to the print server. On the print server, the network listen process, `inetd`, waits for network printing requests and starts a protocol adaptor to service the request. The protocol adaptor communicates with the `lpsched` daemon, which processes the request on the print server.

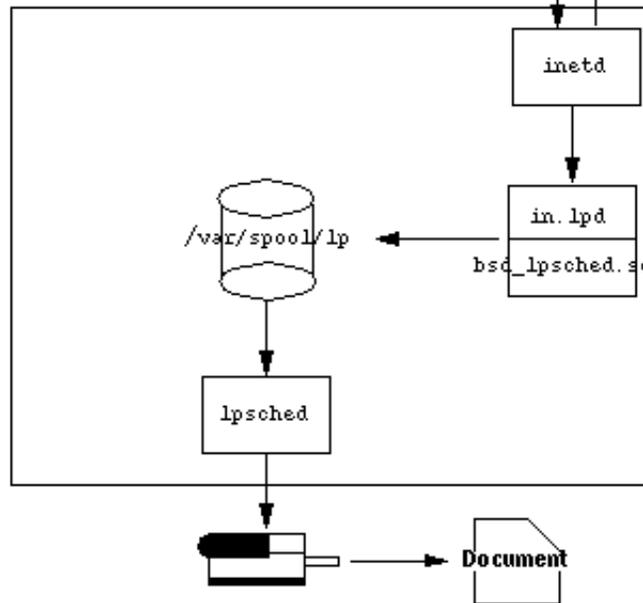
4.1 Print Client



lpr submits print request to lpd, which spools it.

lpd checks the spool file, looks in the /etc/printcap file to find the printer location, and connects to the network if the printer is remote.

5.7 Print Server



inetd listens for a request and starts in.lpd. in.lpd looks at the request and loads bsd_lpsched.so.

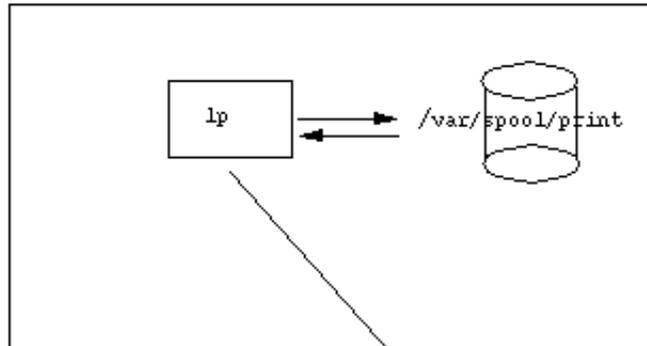
in.lpd passes the request through bsd_lpsched.so to lpsched for local printing.

Figure 7-4 Network Printing Between a SunOS 4.1 Print Client and a SunOS 5.7 or Compatible Print Server

Figure 7-5 shows what happens when a user of a SunOS 5.7 or compatible print client submits a print request to a SunOS 5.7 or compatible print server. The print command on the print client handles the local part of each print request by communicating directly with the print server.

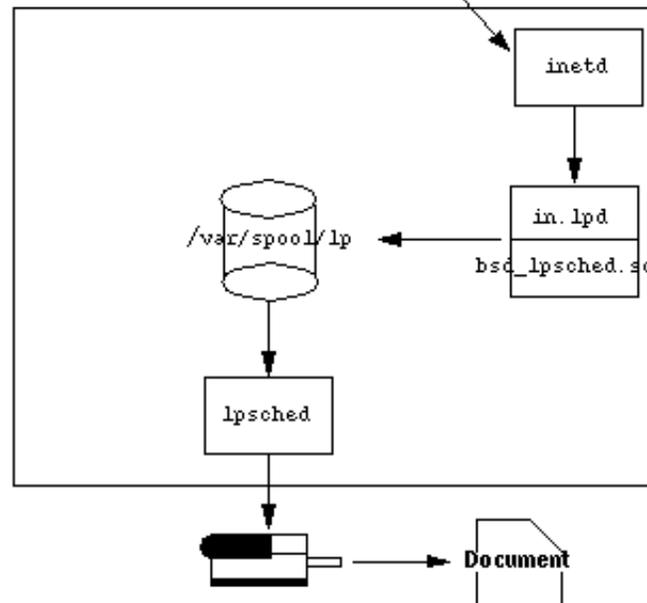
The `inetd` process on the print server monitors network printing requests and starts a protocol adaptor to communicate with the `lp` daemon on the print server, which processes the print request.

5.7 Print Client



`lp` sends a request to the 5.6 print server.

5.7 Print Server



`inetd` listens for a request and starts `in.lpd`. `in.lpd` looks at the request and loads `bsd_lpsched.so`.

`in.lpd` passes the request through `bsd_lpsched.so` to `lp` for local printing.

Figure 7-5 Network Printing Between a SunOS 5.7 or Later Print Client and a SunOS 5.7 or Compatible Print Server

PART II Working With Remote Systems

This part provides instructions for working with remote systems in the Solaris environment. This part contains this chapter.

Chapter 8

Step-by-step instructions for working with remote systems using the `rlogin`, `ftp`, and `rcp` commands, and remote authorization and authentication.



Working With Remote Systems (Tasks)

This chapter describes all the tasks required to log in to remote systems and work with their files. This is a list of the step-by-step instructions in this chapter.

- “How to Search for and Remove `.rhosts` Files” on page 179
- “How to Find Out If a Remote System Is Operating” on page 180
- “How to Find Who Is Logged In to a Remote System” on page 181
- “How to Log In to a Remote System (`rlogin`)” on page 181
- “How to Log Out From a Remote System (`exit`)” on page 182
- “How to Open an `ftp` Connection to a Remote System” on page 185
- “How to Close an `ftp` Connection to a Remote System” on page 186
- “How to Copy Files From a Remote System (`ftp`)” on page 186
- “How to Copy Files to a Remote System (`ftp`)” on page 188
- “How to Copy Files Between a Local and a Remote System (`rcp`)” on page 193

For the purpose of this chapter, a remote system is a workstation or server that is connected to the local system with any type of physical network and configured for TCP/IP communication, shown in Figure 8-1:

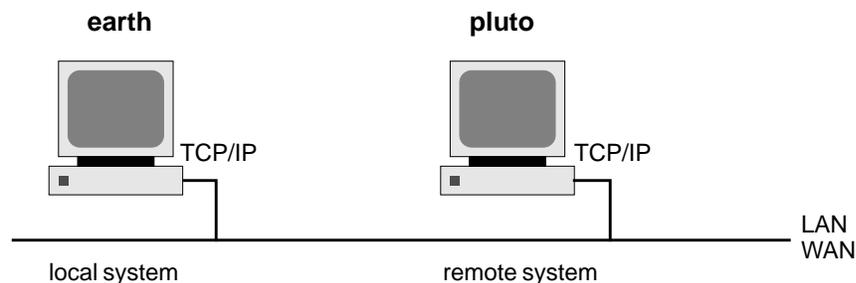


Figure 8-1 A Remote System

On systems running the Solaris release, TCP/IP configuration is established automatically during start-up. For more information, see the *TCP/IP and Data Communications Administration Guide*.

Logging In to a Remote System (`rlogin`)

The `rlogin` command enables you to log in to a remote system. Once logged in, you can navigate through the remote file system and manipulate its contents (subject to authorization), copy files, or execute remote commands.

If the system you are logging into is in a remote domain, be sure to append the domain name to the system name. In this example, `SOLAR` is the name of the remote domain:

```
rlogin pluto.SOLAR
```

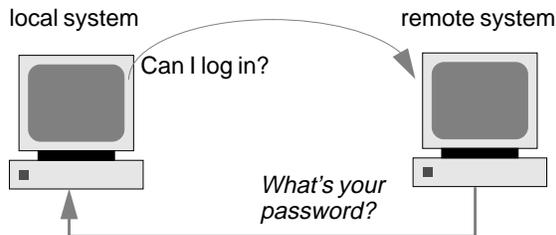
Also, you can interrupt a remote login operation at any time by typing Control-d.

Authentication for Remote Logins (`rlogin`)

Authentication (establishing who you are) for `rlogin` operations can be performed either by the remote system or by the network environment.

The main difference between these forms of authentication lies in the type of interaction they require from you and the way they are established. If a remote system tries to authenticate you, you will be prompted for a password, unless you set up the `/etc/hosts.equiv` or `.rhosts` file. If the network tries to authenticate you, you won't be asked for a password, since the network already knows who you are. Figure 8-2 shows a simplified illustration to describe authentication for remote logins.

Authentication by the Remote System



Authentication by the Network

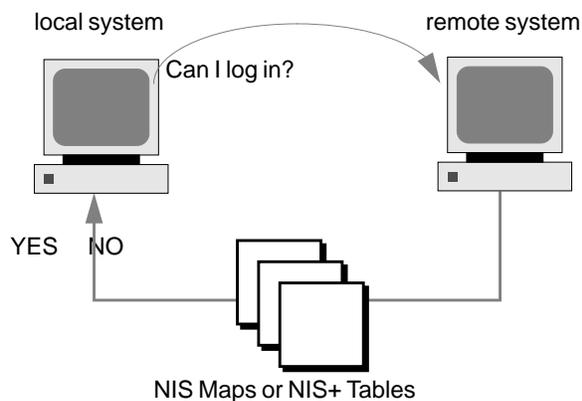


Figure 8-2 Authentication for Remote Logins (`rlogin`)

When the remote system attempts to authenticate you, it relies on information in its local files; specifically if:

- Your system name and user name appears in the remote system's `/etc/hosts.equiv` file, or
- Your system name and user name appears in the remote user's `.rhosts` file, under the remote user's home directory

Network authentication relies on one of these two methods:

- A "trusting network environment" that has been set up with your local network information service and the automounter
- One of the network information services pointed to by the remote system's `/etc/nsswitch.conf` file contains information about you

Note - Network authentication generally supersedes system authentication.

The `/etc/hosts.equiv` File

The `/etc/hosts.equiv` file contains a list of trusted hosts for a remote system, one per line. If a user attempts to log in remotely (using `rlogin`) from one of the hosts listed in this file, and if the remote system can access the user's password entry, the remote system allows the user to log in without a password.

A typical `hosts.equiv` file has the following structure:

```
host1
host2 user_a
+@group1
-@group2
```

When a simple entry for a host is made in `hosts.equiv`, such as the entry above for `host1`, it means that the host is trusted, and so is any user at that machine.

If the user name is also mentioned, as in the second entry in the example, then the host is trusted only if the specified user is attempting access.

A group name preceded by a plus sign (+) means that all the machines in that netgroup are considered trusted.

A group name preceded by a minus sign (-) means that none of the machines in that netgroup are considered trusted.

Security Risks When Using the `/etc/hosts.equiv` File

The `/etc/hosts.equiv` file presents a security risk. If you maintain a `/etc/hosts.equiv` file on your system, you should include only trusted hosts in your network. The file should not include any host that belongs to a different network, or any machines that are in public areas. (For example, do not include a host that is located in a terminal room.)

This can create a serious security problem. Either replace the `/etc/hosts.equiv` file with a correctly configured one, or remove the file altogether.

A single line of + in the `/etc/hosts.equiv` file indicates that every known host is trusted.

The `.rhosts` File

The `.rhosts` file is the user equivalent of the `/etc/hosts.equiv` file. It contains a list of host-user combinations, rather than hosts in general. If a host-user combination is listed in this file, the specified user is granted permission to log in remotely from the specified host without having to supply a password.

Note that a `.rhosts` file must reside at the top level of a user's home directory. `.rhost` files located in subdirectories are not consulted.

Users can create `.rhosts` files in their home directories. Using the `.rhosts` file is another way to allow trusted access between their own accounts on different systems without using the `/etc/hosts.equiv` file.

Security Risks When Using the `.rhosts` File

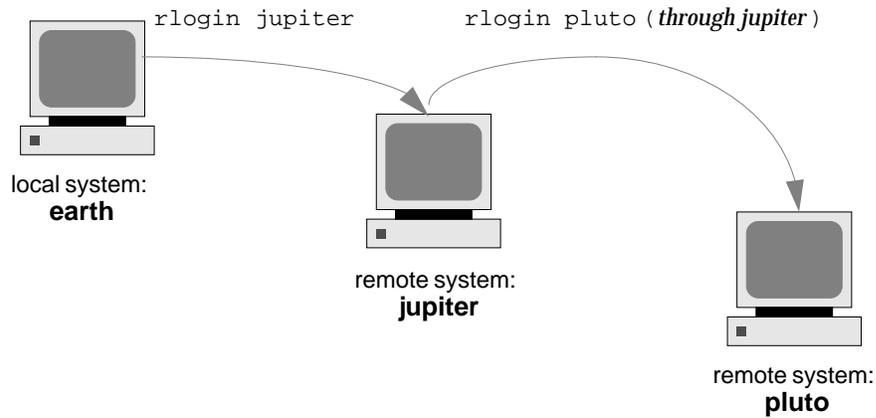
Unfortunately, the `.rhosts` file presents a major security problem. While the `/etc/hosts.equiv` file is under the system administrator's control and can be managed effectively, any user may create a `.rhosts` file granting access to whomever the user chooses without the system administrator's knowledge.

In a situation in which all of the users' home directories are on a single server and only certain people have superuser access on that server, a good way to prevent a user from using a `.rhosts` file is to create an empty file as superuser in their home directory. You would then change the permissions in this file to 000 so that it would be difficult to change it, even as superuser. This would effectively prevent a user from risking system security by using a `.rhosts` file irresponsibly. It would not, however, solve anything if the user is able to change the effective path to his or her home directory.

The only secure way to manage `.rhosts` files is to completely disallow them. See "How to Search for and Remove `.rhosts` Files" on page 179 for detailed instructions. As system administrator, you can check the system often for violations of this policy. One possible exception to this policy is for the root account—you may need to have a `.rhosts` file to perform network backups and other remote services.

Linking Remote Logins

Provided your system is configured properly, you can link remote logins. In this example, a user on `earth` logs in to `jupiter`, and from there decides to log in to `pluto`:



Of course, the user could have logged out of `jupiter` and then logged in directly to `pluto`, but this type of linking can be more convenient.

To link remote logins without having to supply a password, you must have the `/etc/hosts.equiv` or `.rhosts` file set up correctly.

Direct vs. Indirect Remote Logins

The `rlogin` command allows you to log in to a remote system directly or indirectly, as shown in Figure 8-3.

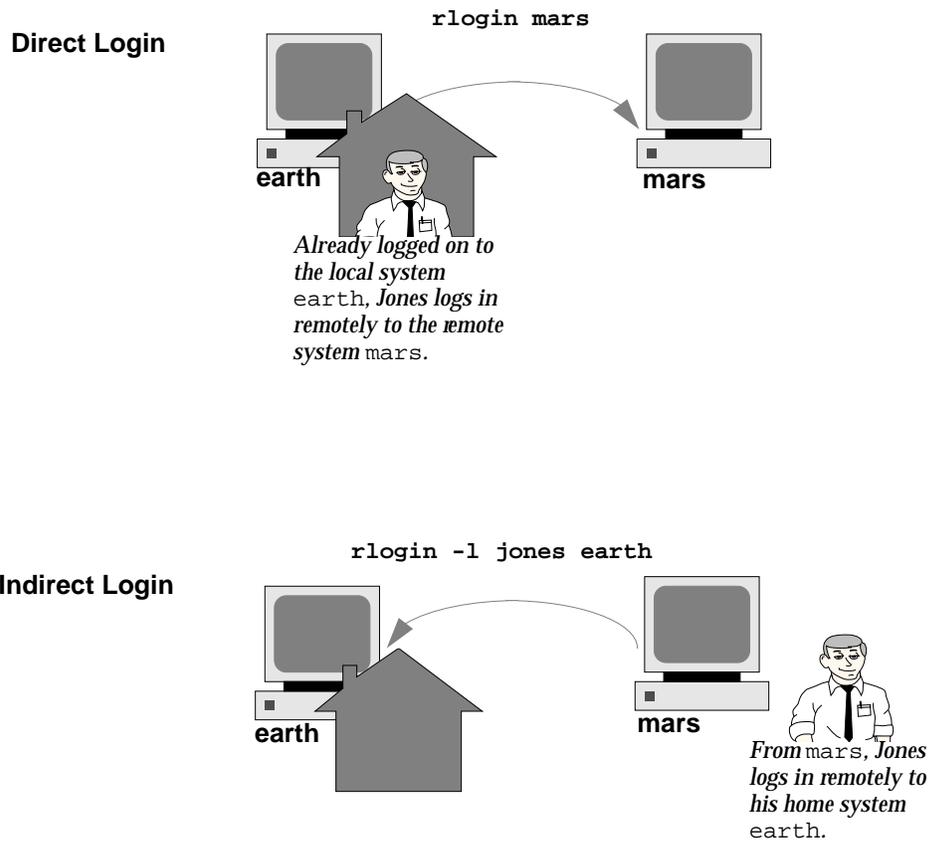


Figure 8-3 Direct and Indirect Logins

A direct remote login is attempted with the default user name; that is, the user name of the individual currently logged in to the local system. This is the most common form of remote login.

An indirect remote login is attempted with a different user name, which is supplied during the remote login operation. This is the type of remote login you might attempt from a workstation that you borrowed temporarily. For instance, if you were in a coworker's office and needed to examine files in your home directory, you might log in to your system remotely, from your coworker's system, but you would perform an indirect remote login, supplying your own user name.

The dependencies between direct and indirect logins and authentication methods are summarized in Table 8-1.

TABLE 8-1 Dependencies Between Login Method and Authentication Method (rlogin)

Type of Login	User Name Supplied By	Authentication	Password
Direct	System	Network	None
		System	Required
Indirect	User	Network	None
		System	Required

What Happens After You Log In Remotely

When you log in to a remote system, the `rlogin` command attempts to find your home directory. If the `rlogin` command can't find your home directory, it will assign you to the remote system's root (`/`) directory. For example:

```
Unable to find home directory, logging in with /
```

However, if the `rlogin` command finds your home directory, it sources both your `.cshrc` and `.login` files. Therefore, after a remote login, your prompt is your standard login prompt, and the current directory is the same as when you log in locally.

For example, if your usual prompt displays your system name and working directory, and when you log in, your working directory is your home directory, your login prompt looks like this:

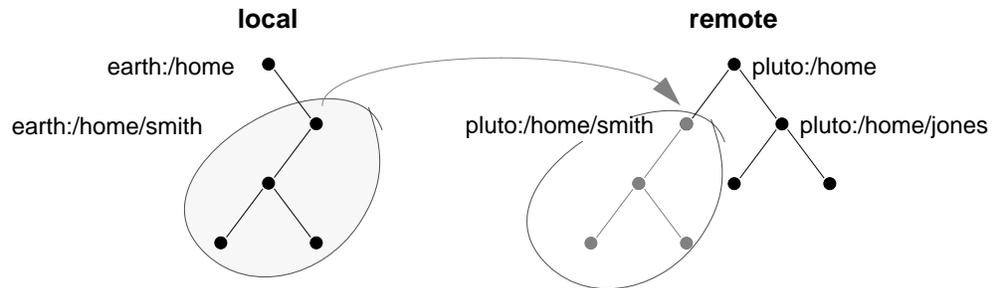
```
earth(/home/smith):
```

Then when you log in to a remote system, you will see a similar prompt and your working directory will be your home directory, regardless of the directory from which you entered the `rlogin` command:

```
earth(/home/smith):rlogin pluto
.
.
.
pluto(/home/smith):
```

The only difference is that the name of the remote system would take the place of your local system at the beginning of the prompt. Where, then, is the remote file system? It is parallel to your home directory, as shown below:

Your home directory has been mounted on the remote system, parallel to the remote user's home directory.



In other words, if you `cd` to `/home` and then run `ls`, this is what you'll see:

```
earth(home/smith): cd ..  
earth(/home): ls  
smith jones
```

▼ How to Search for and Remove `.rhosts` Files

1. Become superuser.
2. Search for and remove `.rhosts` files by using the `find(1)` command.

```
# find home-directories -name .rhosts -print -exec rm{}
```

home-directories

Identifies the path to a directory where users' home directories are located. Note that you can enter multiple paths to search more than one home directory at a time.

`-name .rhosts`

Identifies the filename.

`-print`

Prints the current pathname.

`-exec rm {} \;`

Tells the `find` command to apply the `rm` command to all files identified using the matching filename.

The `find` command starts at the designated directory and searches for any file named `.rhosts`. If it finds any, it prints the path on the screen and removes it.

Example—Searching For and Removing `.rhosts` Files

The following example searches and removes `.rhosts` files in all the user's home directories located in the `/export/home` directory.

```
# find /export/home -name .rhosts -print | xargs -i -t rm{}
```

▼ How to Find Out If a Remote System Is Operating

Find out if a remote system is operating by using the `ping(1M)` command.

```
$ ping system-name | ip-address
```

system-name The name of the remote system.

ip-address The IP address of the remote system.

The `ping` command returns one of three messages:

Status Message	Explanation
<i>system-name</i> is alive	The system can be accessed over the network.
ping:unknown host <i>system-name</i>	The system name is unknown.
ping:no answer from <i>system-name</i>	The system is known, but is not currently operating.

If the system you “ping” is located in a different domain, the return message may also contain routing information, which you can ignore.

The `ping` command has a time-out of 20 seconds. In other words, if it does not get a response within 20 seconds, it returns the third message. You can force `ping` to wait longer (or less) by entering a *time-out* value, in seconds:

```
$ ping system-name | ip-address time-out
```

For more information, see the `ping` man page.

▼ How to Find Who Is Logged In to a Remote System

Find who is logged in to a remote system by using the `rusers(1)` command.

```
$ rusers [-l] remote-system-name
```

`rusers` (No options) Displays the name of the system followed by the name of users currently logged in to it, including root.

`-l` Displays additional information about each user: the user's login window, login time and date, amount of time logged in, and the name of the remote system from which the user logged on.

Example—Finding Who Is Logged In to a Remote System

The following example shows the short output of `rusers`.

```
$ rusers pluto
pluto smith jones
```

In the following example, the long version of `rusers` show that two users are logged in to the remote system named `pluto`. The first user logged in from the system console on November 18 and has been logged on for 4 hours and 10 minutes. The second user logged in from a remote system, `mars`, on the same date, and has been logged on for a similar amount of time.

```
$ rusers -l pluto
smith pluto:console Nov 18 09:19 4:10
jones mars:console Nov 18 09:20 4:11 (mars)
```

▼ How to Log In to a Remote System (`rlogin`)

Log in to a remote system using the `rlogin(1)` command.

```
$ rlogin [-l user-name] system-name
```

<code>rlogin</code>	(No options) Logs you in to the remote system <i>directly</i> ; in other words, with your current user name.
<code>-l user-name</code>	Logs you into the remote system <i>indirectly</i> ; in other words, with the user name you supply.

If the network attempts to authenticate you, you won't be prompted for a password. If the remote system attempts to authenticate you, you will be asked to provide a password.

If the operation succeeds, the `rlogin` command displays brief information about your latest remote login to that system, the version of the operating system running on the remote system, and whether you have mail waiting for you in your home directory.

Example—Logging In to a Remote System (`rlogin`)

The following example shows the output of a direct remote login to `pluto`. The user has been authenticated by the network.

```
$ rlogin pluto
Last login: Thu Feb 26 08:00:40 from earth
Sun Microsystems Inc. SunOS 5.7 September 1998
You have mail.
pluto%
```

The following example shows the output of an indirect remote login to `pluto`, with the user being authenticated by the remote system.

```
$ rlogin -l smith pluto
password: user-password
Last login: Thu Feb 26 09:03:53 from earth
Sun Microsystems Inc. SunOS 5.7 September 1998
You have mail.
pluto%
```

▼ How to Log Out From a Remote System (`exit`)

Log out from a remote system by using the `exit(1)` command.

```
$ exit
```

Example—Logging Out From a Remote System (`exit`)

This example shows the user `smith` logging out from the system `pluto`.

```
$ exit
pluto% logout
Connection closed.
earth%
```

Logging In to a Remote System (`ftp`)

The `ftp` command opens the user interface to the Internet's File Transfer Protocol. This user interface, called the command interpreter, enables you to log in to a remote system and perform a variety of operations with its file system. The principal operations are summarized in Table 8-2.

The main benefit of `ftp` over `rlogin` and `rcp` is that `ftp` does not require the remote system to be running UNIX. (The remote system does, however, need to be configured for TCP/IP communications.) On the other hand, `rlogin` provides access to a richer set of file manipulation commands than `ftp` does.

Authentication for Remote Logins (`ftp`)

Authentication for `ftp` remote login operations can be established either by:

- Including your password entry in the remote system's `/etc/passwd` file or equivalent network information service map or table.
- Establishing an anonymous `ftp` account on the remote system.

Essential `ftp` Commands

TABLE 8-2 Essential `ftp` Commands

Command	Description
<code>ftp</code>	Accesses the <code>ftp</code> command interpreter
<code>ftp remote-system</code>	Establishes an <code>ftp</code> connection to a remote system. For instructions, see “How to Open an <code>ftp</code> Connection to a Remote System” on page 185
<code>open</code>	Logs in to the remote system from the command interpreter
<code>close</code>	Logs out of the remote system and returns to the command interpreter
<code>bye</code>	Quits the <code>ftp</code> command interpreter
<code>help</code>	Lists all <code>ftp</code> commands or, if a command name is supplied, briefly describes what the command does
<code>reset</code>	Re-synchronizes the command-reply sequencing with the remote <code>ftp</code> server
<code>ls</code>	Lists the contents of the remote working directory
<code>pwd</code>	Displays the name of the remote working directory
<code>cd</code>	Changes the remote working directory
<code>lcd</code>	Changes the local working directory
<code>mkdir</code>	Creates a directory on the remote system
<code>rmdir</code>	Deletes a directory on the remote system
<code>get, mget</code>	Copies a file (or multiple files) from the remote working directory to the local working directory
<code>put, mput</code>	Copies a file (or multiple files) from the local working directory to the remote working directory
<code>delete, mdelete</code>	Deletes a file (or multiple files) from the remote working directory

For more information, see `ftp(1)`.

▼ How to Open an `ftp` Connection to a Remote System

1. Make sure you have `ftp` authentication.

You must have `ftp` authentication, as described in “Authentication for Remote Logins (`ftp`)” on page 183.

2. Open a connection to a remote system by using the `ftp` command.

```
$ ftp remote-system
```

If the connection succeeds, a confirmation message and prompt is displayed.

3. Enter your user name.

```
Name (remote-system: user-name): user-name
```

4. If prompted, enter your password.

```
331 Password required for user-name:  
Password: password
```

If the system you are accessing has established an anonymous `ftp` account, you will not be prompted for a password. If the `ftp` interface accepts your password, it displays a confirmation message and the (`ftp>`) prompt.

You can now use any of the commands supplied by the `ftp` interface, including help. The principal commands are summarized in Table 8-2.

Example—Opening an `ftp` Connection to a Remote System

This `ftp` session was established by the user `smith` on the remote system `pluto`:

```
$ ftp pluto  
Connected to pluto.  
220 pluto FTP server (UNIX(r) System V Release 4) ready.  
Name (pluto:smith): smith  
331 Password required for smith:  
Password: password  
230 User smith logged in.
```

(continued)

(Continuation)

```
ftp>
```

▼ How to Close an `ftp` Connection to a Remote System

Close an `ftp` connection to a remote system by using the `bye` command.

```
ftp> bye
221 Goodbye.
earth%
```

A good-bye message appears, followed by your usual shell prompt.

▼ How to Copy Files From a Remote System (`ftp`)

1. **Change to a directory on the local system where you want the files from the remote system to be copied.**

```
$ cd target-directory
```

2. **Establish an `ftp` connection.**

See “How to Open an `ftp` Connection to a Remote System” on page 185.

3. **Change to the source directory.**

```
ftp> cd source-directory
```

If your system is using the automounter, the home directory of the remote system’s user appears parallel to yours, under `/home`.

4. **Make sure you have Read permission for the source files.**

```
ftp> ls -l
```

5. **To copy a single file, use the `get` command.**

```
ftp> get filename
```

6. To copy multiple files at once, use the `mget` command.

```
ftp> mget filename [filename ...]
```

You can supply a series of individual file names and you can use wildcard characters. The `mget` command will copy each file individually, asking you for confirmation each time.

7. Close the `ftp` connections.

```
ftp> bye
```

Examples—Copying Files From a Remote System (`ftp`)

In this example, the user `kryten` opens an `ftp` connection to the system `pluto`, and uses the `get` command to copy a single file from the `/tmp` directory:

```
$ cd $HOME
ftp pluto
Connected to pluto.
220 pluto FTP server (SunOS 5.7) ready.
Name (pluto:kryten): kryten
331 Password required for kryten.
Password: xxx
230 User kryten logged in.
ftp> cd /tmp
250 CWD command successful.
ftp> ls
200 PORT command successful.
150 ASCII data connection for /bin/ls (129.152.221.238,34344)
(0 bytes).
dtdbcache_:0
filea
files
ps_data
speckeyd.lock
226 ASCII Transfer complete.
53 bytes received in 0.022 seconds (2.39 Kbytes/s)
ftp> get filea
200 PORT command successful.
150 ASCII data connection for filea (129.152.221.238,34331)
(0 bytes).
226 ASCII Transfer complete.
ftp> bye
221 Goodbye.
```

In this example, the same user `kryten` uses the `mget` command to copy a set of files from the `/tmp` directory to his home directory. Note that `kryten` can accept or reject individual files in the set.

```

$ ftp> cd /tmp
250 CWD command successful.
ftp> ls files
200 PORT command successful.
150 ASCII data connection for /bin/ls (129.152.221.238,34345)
(0 bytes).
fileb
filec
filed
226 ASCII Transfer complete.
remote: files
21 bytes received in 0.015 seconds (1.36 Kbytes/s)
ftp> cd files
250 CWD command successful.
ftp> mget file*
mget fileb? y
200 PORT command successful.
150 ASCII data connection for fileb (129.152.221.238,34347)
(0 bytes).
226 ASCII Transfer complete.
mget filec? y
200 PORT command successful.
150 ASCII data connection for filec (129.152.221.238,34348)
(0 bytes).
226 ASCII Transfer complete.
mget filed? y
200 PORT command successful.
150 ASCII data connection for filed (129.152.221.238,34351)
(0 bytes).
226 ASCII Transfer complete.200 PORT command successful.
ftp> bye
221 Goodbye.

```

▼ How to Copy Files to a Remote System (ftp)

1. Change to the source directory on the local system.

The directory from which you enter the `ftp` command will be the local working directory, and thus the source directory for this operation.

2. Establish an `ftp` connection.

See “How to Open an `ftp` Connection to a Remote System” on page 185.

3. Change to the target directory.

```
ftp> cd target-directory
```

Remember, if your system is using the automounter, the home directory of the remote system’s user appears parallel to yours, under `/home`.

4. Make sure you have Write permission to the target directory.

```
ftp> ls -l target-directory
```

5. To copy a single file, use the `put` command.

```
ftp> put filename
```

6. To copy multiple files at once, use the `mput` command.

```
ftp> mput filename [filename ...]
```

You can supply a series of individual file names and you can use wildcard characters. The `mput` command will copy each file individually, asking you for confirmation each time.

7. To close the `ftp` connection, type `bye`.

```
ftp> bye
```

Examples—Copying Files to a Remote System (`ftp`)

In this example, the user `kryten` opens an `ftp` connection to the system `pluto`, and uses the `put` command to copy a file from his system to the `/tmp` directory on system `pluto`:

```
$ cd /tmp
ftp pluto
Connected to pluto.
220 pluto FTP server (SunOS 5.7) ready.
Name (pluto:kryten): kryten
331 Password required for kryten.
Password: xxx
230 User kryten logged in.
ftp> cd /tmp
250 CWD command successful.
ftp> put filef
200 PORT command successful.
150 ASCII data connection for filef (129.152.221.238,34356).
226 Transfer complete.
ftp> ls
200 PORT command successful.
150 ASCII data connection for /bin/ls (129.152.221.238,34357) (0 bytes).
dtddbcache_0
filea
```

(continued)

(Continuation)

```
filef
files
ps_data
speckeyd.lock
226 ASCII Transfer complete.
60 bytes received in 0.058 seconds (1.01 Kbytes/s)
ftp> bye
221 Goodbye.
```

In this example, the same user kryten uses the `mput` command to copy a set of files from his home directory to the `/tmp` directory system pluto. Note that kryten can accept or reject individual files in the set.

```
$ cd $HOME/testdir
$ ls
test1 test2 test3
$ ftp pluto
Connected to pluto.
220 pluto FTP server (SunOS 5.7) ready.
Name (pluto:kryten): kryten
331 Password required for kryten.
Password: xxx
230 User kryten logged in.
ftp> cd /tmp
250 CWD command successful.
ftp> mput test*
mput test1? y
200 PORT command successful.
150 ASCII data connection for test1 (129.152.221.238,34365).
226 Transfer complete.
mput test2? y
200 PORT command successful.
150 ASCII data connection for test2 (129.152.221.238,34366).
226 Transfer complete.
mput test3? y
200 PORT command successful.
150 ASCII data connection for filef (129.152.221.238,34356).
226 Transfer complete.
ftp> bye
221 Goodbye.
```

Remote Copying With `r`cp

The `r`cp command copies files or directories between a local and a remote system or between two remote systems. You can use it from a remote system (after logging in with the `rlogin` command) or from the local system (without logging in to a remote system).

With `r`cp, you can perform the following remote copy operations:

- Copy a file or directory from your system to a remote system
- Copy a file or directory from a remote system to your local system
- Copy a file or directory between remote systems from your local system

If you have the automounter running, you can perform these remote operations with the `cp` command. However, the range of `cp` is constrained to the virtual file system created by the automounter and to operations relative to a user's home directory and, since `r`cp performs the same operations without these constraints, this section will describe only the `r`cp versions of these tasks.

Security Considerations for Copy Operations

To copy files or directories between systems, you must have permission to log in and copy files.



Caution - Both the `cp` and `r`cp commands can overwrite files without warning. Make sure file names are correct before executing the command.

Specifying Source and Target

With the `r`cp command in the C-shell, you can specify source (the file or directory you want to copy) and target (the location into which you will copy the file or directory) with either absolute or abbreviated pathnames.

	Absolute Pathnames	Abbreviated Pathnames
From Local System	<code>mars:/home/jones/MyFile.txt</code>	<code>~jones/MyFile.txt</code>
After Remote Login	<code>/home/jones/MyFile.txt</code>	<code>~jones/MyFile.txt</code>

Absolute pathnames identify files or directories mounted on a particular system. In the example above, the first absolute pathname identifies a file (`MyFile.txt`) on the `mars` system. Abbreviated pathnames identify files or directories relative to a user's home directory, wherever that may reside. In the first example above, the abbreviated pathname identifies the same file, `MyFile.txt`, but uses “~” symbol to indicate the `jones` home directory. In effect . . .

```
~ = mars:/home/jones
```

The examples on the second line, above, demonstrate the user of absolute and abbreviated pathnames after a remote login. There is no difference for the abbreviated pathname, but because the remote login operation mounted the `jones` home directory onto the local system (parallel to the local user's home directory), the absolute pathname no longer requires the system name `mars`. For more information about how a remote login operation mounts another user's home directory, see “What Happens After You Log In Remotely” on page 178.

Table 8-3 provides a representative sample of absolute and abbreviated pathnames recognized by the C shell. It uses the following terminology:

- working directory—The directory from which the `rcp` command is entered. Can be remote or local.
- current user—The user name under which the `rcp` command is entered.

TABLE 8-3 Allowed Syntaxes for Directory and File Names

Logged in to	Syntax	Description
Local system	.	The local working directory
	<i>path/filename</i>	The <i>path</i> and <i>filename</i> in the local working directory
	~	The current user's home directory
	~/ <i>path/filename</i>	The <i>path</i> and <i>filename</i> beneath the current user's home directory
	~ <i>user</i>	The home directory of <i>user</i>
	~ <i>user/path/filename</i>	The <i>path</i> and <i>filename</i> beneath the home directory of <i>user</i>
Remote system	<i>remote-system:path/filename</i>	The <i>path</i> and <i>filename</i> in the remote working directory
	.	The remote working directory

TABLE 8-3 Allowed Syntaxes for Directory and File Names (continued)

Logged in to	Syntax	Description
	<i>filename</i>	The <i>filename</i> in the remote working directory
	<i>path/filename</i>	The <i>path</i> and <i>filename</i> in the remote working directory
	~	The current user's home directory
	~/ <i>path/filename</i>	The <i>path</i> and <i>filename</i> in the current user's home directory
	~ <i>user</i>	The home directory of <i>user</i>
	~/ <i>user/path/filename</i>	The <i>path</i> and <i>filename</i> beneath the home directory of <i>user</i>
	<i>local-system:path/filename</i>	The <i>path</i> and <i>filename</i> in the local working directory

▼ How to Copy Files Between a Local and a Remote System (r`cp`)

1. Be sure you have permission to copy.

You should at least have read permission on the source system and write permission on the target system.

2. Determine the location of the source and target.

If you don't know the path of the source or target, you can first log into the remote system with the `rlogin` command, as described in "How to Log In to a Remote System (`rlogin`)" on page 181. Then, navigate through the remote system until you find the location. You can then perform the next step without logging out.

3. Copy the file or directory.

```
$ rcp [-r]source-file | directory target-file | directory
```

- `rcp` (No options) Copies a single file from the source to the target.
- `-r` Copies a directory from the source to the target.

This syntax applies whether you are logged in to the remote system or in to the local system. Only the pathname of the file or directory changes, as described in Table 8-3 and as illustrated in the examples below.

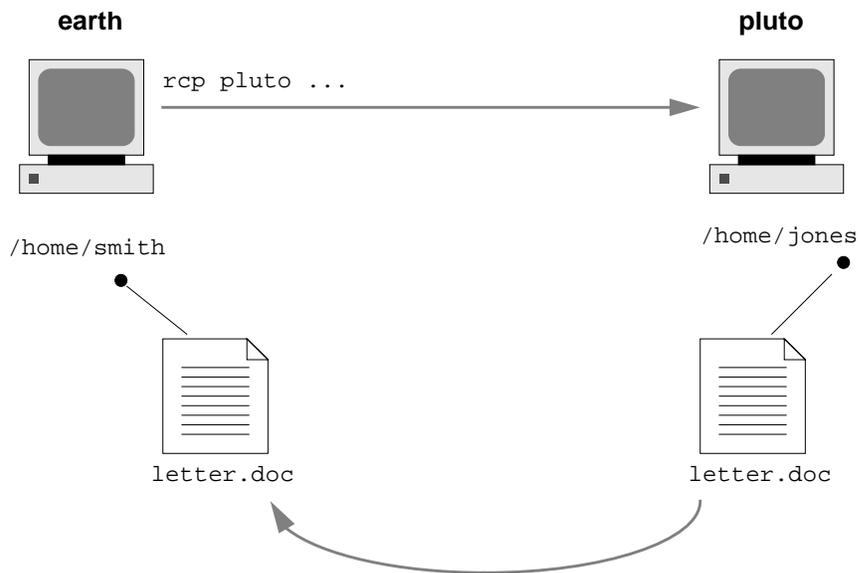
You can use the “~” and “.” characters to specify the path portions of the local file or directory names. Note, however, that “~” applies to the current user, not the remote system, and that “.” applies to system you are logged into. For explanations of these symbols, see Table 8-3.

Examples—Copying Files Between a Local and a Remote System (`rcp`)

Here are a few examples. In the first two, the source is remote; in the last two, the source is local.

In this example, `rcp` copies the file `letter.doc` from the `/home/jones` directory of the remote system `pluto` to the working directory (`/home/smith`) on the local system, `earth`:

```
earth(/home/smith): rcp pluto:/home/jones/letter.doc .
```



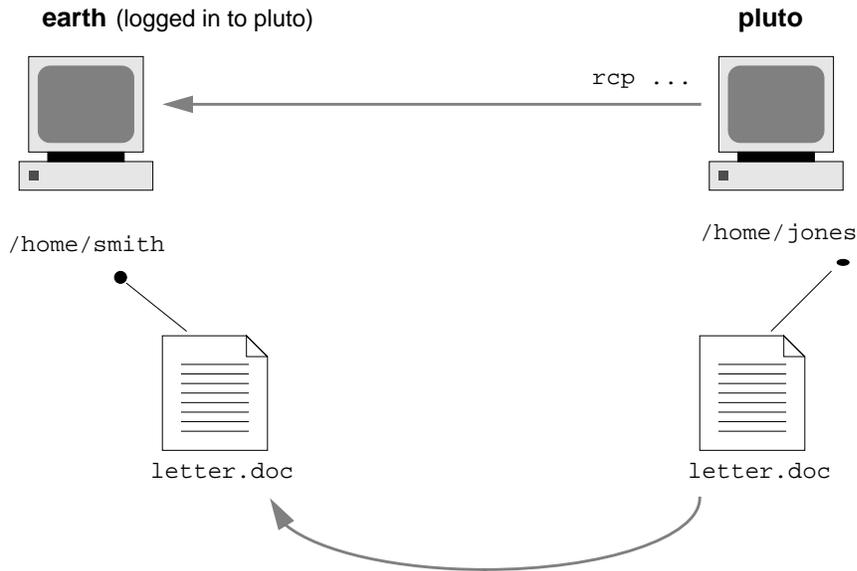
Since the `rcp` operation is performed without a remote login, the “.” symbol applies to the local system, not the remote system.

The working directory happens to be the local user's home directory, so it could have been specified with the “~” symbol as well:

```
earth(home/smith): rcp pluto:/home/jones/letter.doc ~
```

In the following example, `rcp` is used —while logged in to the remote system— to perform the same operation. Although the flow of the operation is the same, the paths change to take into account the remote login:

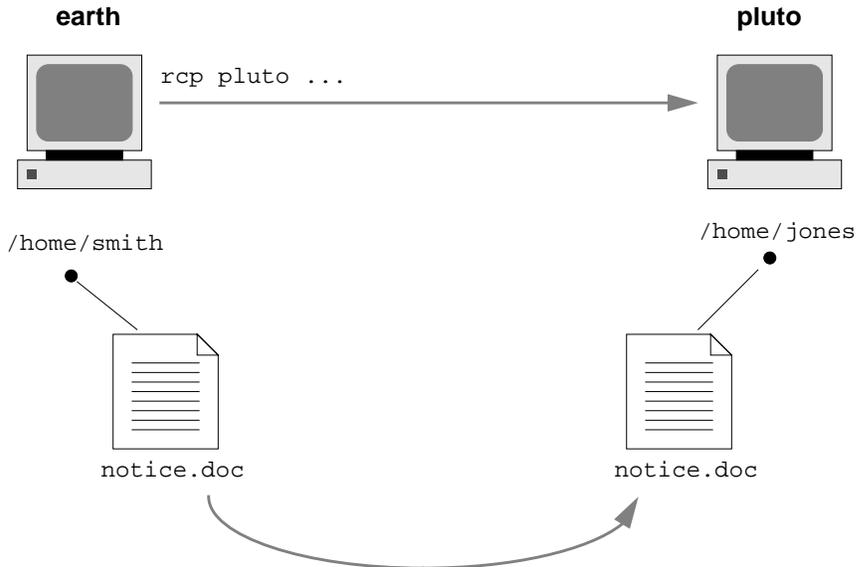
```
earth(/home/smith): rlogin pluto
.
.
.
pluto(/home/jones): rcp letter.doc ~
```



Use of the “.” symbol would be inappropriate in this instance because of the remote login; it would simply apply to the remote system, essentially directing `rcp` to create a duplicate file. The “~” symbol, however, refers to the current user's home directory, even when logged in to a remote system.

In the following example, `rcp` copies the file `notice.doc` from the home directory (`/home/smith`) of the local system `earth` to the `/home/jones` directory of the remote system, `pluto`:

```
earth(/home/smith): rcp notice.doc pluto:/home/jones
```



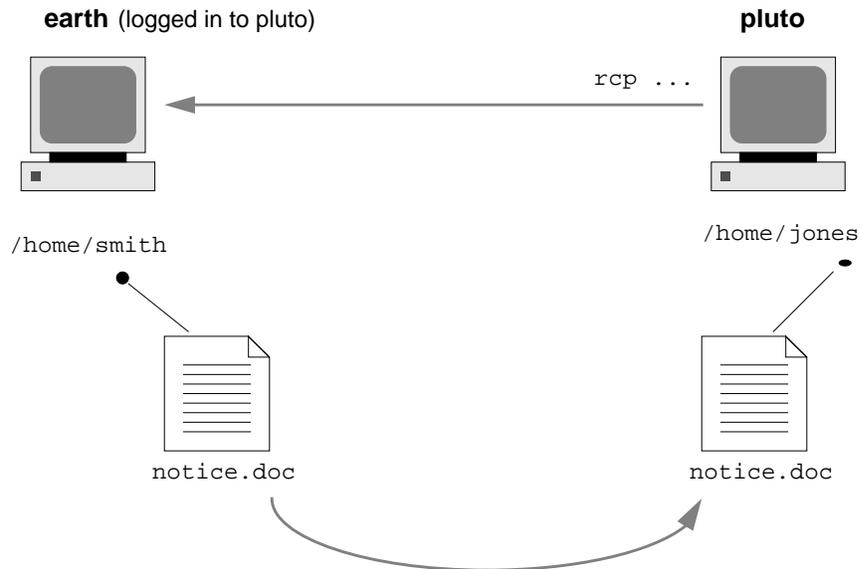
Because no remote filename is provided, the file `notice.doc` is copied into the `/home/jones` directory with the same name.

In this example, the operation is repeated, but `rcp` is entered from a different working directory on the local system (`/tmp`). Note the use of the “`~`” symbol to refer to the current user’s home directory:

```
earth(/tmp): rcp ~/notice.doc pluto:/home/jones
```

In this example, `rcp` is used —while logged in to the remote system— to perform the same operation as in the previous example. Although the flow of the operation is the same, the paths change the take into account the remote login:

```
earth(/home/smith): rlogin pluto
.
.
.
pluto(/home/jones): rcp ~/notice.doc .
```



In this instance, the “~” symbol can be used to denote the current user’s home directory, even though it is on the local system. The “.” symbol refers to the working directory on the remote system because the user is logged in to the remote system. Here is an alternative syntax that performs the same operation:

```
pluto(/home/jones): rcp earth:/home/smith/notice.doc /home/jones
```


PART III Managing Terminals and Modems

This part provides instructions for managing terminals and modems. This part contains these chapters.

Chapter 9	Provides overview information about terminals and modems.
Chapter 10	Provides step-by-step instructions for setting up terminals and modems.
Chapter 11	Provides step-by-step instructions for using SAF commands to set up terminals and modems.



Managing Terminals and Modems (Overview)

This chapter provides the overview information for managing terminals and modems. This is a list of the overview information in this chapter.

- “Terminals, Modems, Ports, and Services” on page 201
- “Tools for Managing Terminals and Modems” on page 204
- “Admintool” on page 205
- “Service Access Facility” on page 206

For step-by-step instructions about how to set up terminals and modems with Admintool, see Chapter 10.

For step-by-step instructions about how to set up terminals and modems with the Service Access Facility (SAF), see Chapter 11.

Terminals, Modems, Ports, and Services

Terminals and modems provide both local and remote access to system and network resources. Setting up terminals and modem access is an important responsibility of a system administrator. This section explains some of the concepts behind modem and terminal management in the Solaris environment.

Terminals

Your system's bit-mapped graphics display is not the same as an alphanumeric terminal, which connects to a serial port and displays only text. You don't have to perform any special steps to administer the graphics display.

Modems

Modems can be set up in three basic configurations:

- Dial-out
- Dial-in
- Bidirectional

A modem connected to your home computer might be set up to provide *dial-out* service, meaning you can access other computers from your own home, but nobody outside can gain access to your machine.

Dial-in service is just the opposite. It allows people to access a system from remote sites, but it does not permit calls to the outside world.

Bidirectional access, as the name implies, provides both dial-in and dial-out capabilities.

Ports

A *port* is a channel through which a device communicates with the operating system. From a hardware perspective, a port is a "receptacle" into which a terminal or modem cable may be plugged.

However, a port is not strictly a physical receptacle, but an entity with hardware (pins and connectors) and software (a device driver) components. A single physical receptacle often provides multiple ports, allowing connection of two or more devices.

Common types of ports include serial, parallel, small computer systems interface (SCSI), and Ethernet.

A *serial* port, using a standard communications protocol, transmits a byte of information bit-by-bit over a single line.

Devices that have been designed according to RS-232-C or RS-423 standards (this includes most modems, alphanumeric terminals, plotters, and some printers) can be plugged interchangeably (using standard cables) into serial ports of computers that have been similarly designed.

When many serial port devices must be connected to a single computer, it may be necessary to add an *adapter board* to the system. The adapter board, with its driver

software, provides additional serial ports for connecting more devices than could otherwise be accommodated.

Services

Modems and terminals gain access to computing resources via the serial port software. The serial port software must be set up to provide a particular “service” for the device attached to the port. For example, you can set up a serial port to provide bidirectional service for a modem.

Port Monitors

The main mechanism for gaining access to a service is through a *port monitor*. A port monitor is a program that continuously monitors for requests to log in or access printers or files.

When a port monitor detects a request, it sets whatever parameters are required to establish communication between the operating system and the device requesting service. Then the port monitor transfers control to other processes that provide the services needed.

Table 9–1 describes the two types of port monitors included in the Solaris environment.

TABLE 9–1 Port Monitor Types

Port Monitor	Description
<code>listen(1M)</code>	Controls access to network services, such as handling remote print requests prior to the Solaris 2.6 release. The default Solaris operating environment no longer uses this port monitor type.
<code>ttymon(1M)</code>	Provides access to the login services needed by modems and alphanumeric terminals. Solstice Serial Port Manager automatically sets up a <code>ttymon</code> port monitor to process login requests from these devices. Using Solstice Serial Port Manager to set up terminals and modems is described in Chapter 10.

You may be familiar with an older port monitor called `getty(1M)`. The new `ttymon` is more powerful; a single `ttymon` can replace multiple occurrences of `getty`. Otherwise, these two programs serve the same function.

Tools for Managing Terminals and Modems

Table 9-2 lists the recommended tools for managing terminals and modems. Table 9-3 lists specific differences in functionality between the Service Access Facility (SAF) and the Solstice™ Serial Port Manager.

TABLE 9-2 Recommended Tools For Managing Terminals and Modems

If You Want The Tool That Is ...	Then Use ...	To Start This Tool See ...
The most comprehensive	Service Access Facility (SAF) commands	"Service Access Facility" on page 206
The quickest setup	Admintool graphical user interface (for local systems only)	Chapter 10
	Solstice AdminSuite's Serial Port Manager graphical user interface (for local and remote systems in a networked, name service environment)	<i>Solstice AdminSuite 2.3 Administration Guide</i>

TABLE 9-3 Functionality Differences Between Solstice Serial Port Manager and Service

TABLE 9-3 Functionality Differences Between Solstice Serial Port Manager and Service Access Facility *(continued)*

Access Facility

If You Need To ...	Then Use ...	Comment
Inform users that a port is disabled	Service Access Facility <code>ttyadm -i</code>	<code>ttyadmin -i</code> specifies the inactive (disabled) response message. The message is sent to a terminal or modem when a user attempts to log in when the port is disabled. This functionality is not provided when a port is disabled using Solstice Serial Port Manager.
Keep the modem connection when a user logs off a host	Service Access Facility <code>ttyadm -h</code>	<code>ttyadm -h</code> specifies that the system will not hang up on a modem before setting or resetting to the default or specified value. If <code>ttyadm -h</code> is not used, when the user logs out of a host, the host will hang up the modem.
Require the user to type a character before the system displays a prompt	Service Access Facility <code>ttyadm -r</code>	<code>ttyadm -r</code> specifies that <code>ttymon</code> should require the user to type a character or press Return a specified number of times before the login prompt appears. When <code>-r</code> is not specified, pressing Return one or more times will print the prompt anyway. This option prevents a terminal server from issuing a welcome message that the Solaris host might misinterpret to be a user trying to log in. Without the <code>-r</code> option, the host and terminal server might begin looping and printing prompts to each other.

Admintool

Admintool sets up the serial port software to work with terminals and modems by calling the `pmadm` command with the appropriate information. It also provides:

- Templates for common terminal and modem configurations
- Multiple port setup, modification, or deletion
- Quick visual status of each port

Service Access Facility

The SAF is the tool used for administering terminals, modems, and other network devices. In particular, SAF enables you to set up:

- `ttymon` and `listen` port monitors (using the `sacadm` command)
- `ttymon` port monitor services (using the `pmadm` and `ttyadm` commands)
- `listen` port monitor services (using the `pmadm` and `nlsadmin` commands)
- And troubleshoot `tty` devices
- And troubleshoot incoming network requests for printing service
- And troubleshoot the Service Access Controller (using the `sacadm` command)

The SAF is an open-systems solution that controls access to system and network resources through `tty` devices and local-area networks (LANs). SAF is not a program. It is a hierarchy of background processes and administrative commands.

Setting Up Terminals and Modems (Tasks)

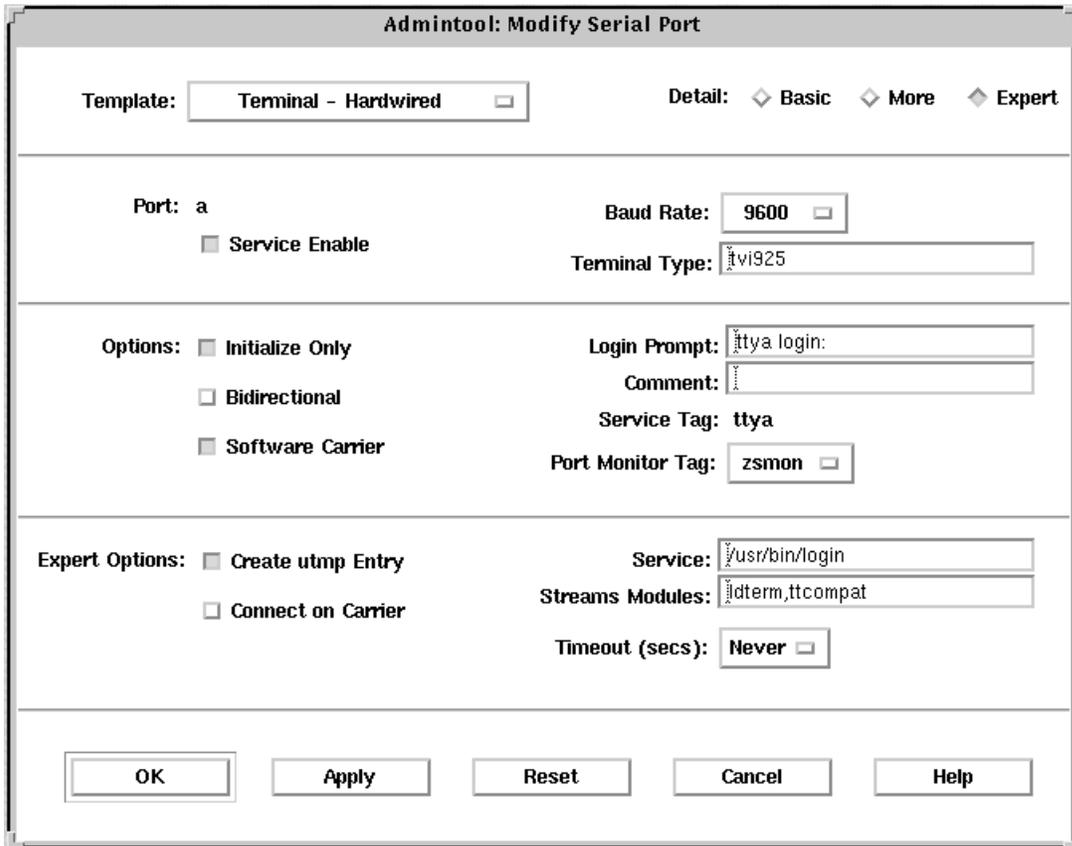
This chapter provides step-by-step instructions for setting up terminals and modems using Admintool. This is a list of the step-by-step instructions in this chapter.

- “How to Start Admintool” on page 213
- “How to Set Up a Terminal” on page 214
- “How to Set Up a Modem” on page 215
- “How to Set Up a Modem for Use With UUCP” on page 217
- “How to Initialize a Port” on page 218
- “How to Disable a Port” on page 219
- “How to Remove a Port Service” on page 220

For overview information about terminals and modems, see Chapter 9.

Setting Up Terminals and Modems

When setting up serial port information, start Admintool, and select Serial Ports from the Browse menu. Select a serial port from the Serial Ports window and then choose Modify from the Edit menu to bring up the Modify Serial Port window. This window provides access to the port templates and provides information on the port in three levels of detail—Basic, More, and Expert.



Note - The Modify Serial Port window appears in the Basic detail mode. To view More or Expert details, select the More or Expert option from the Detail menu.

The descriptions of each item in the Modify Serial window are listed in Table 10-1.

TABLE 10-1 Modify Serial Port Window Items

Detail	Item	Description
Basic	Port	Lists the port or ports you selected from Serial Ports main window.
	Service	Specifies that the service for the port is turned on (enabled).
	Baud Rate	Specifies the line speed used to communicate with the terminal. The line speed represents an entry in the /etc/ttydefs file.

TABLE 10-1 Modify Serial Port Window Items *(continued)*

Detail	Item	Description
	Terminal Type	Shows the abbreviation for the type of terminal, for example, <code>ansi</code> or <code>vt100</code> . Similar abbreviations are found in <code>/etc/termcap</code> . This value is set in the <code>\$TERM</code> environment variable.
More	Option: Initialize Only	Specifies that the port software is initialized but not configured.
	Option: Bidirectional	Specifies that the port line is used in both directions.
	Option: Software Carrier	Specifies that the software carrier detection feature is used. If the option is <i>not</i> checked, the <i>hardware</i> carrier detection signal is used.
	Login Prompt	Shows the prompt displayed to a user after a connection is made.
	Comment	Shows the comment field for the service.
	Service Tag	Lists the service tag associated with this port—typically an entry in the <code>/dev/term</code> directory.
	Port Monitor Tag	Specifies the name of the port monitor to be used for this port. Note: The default monitor is typically correct.
Expert	Create utmp Entry	Specifies that a <code>utmp</code> entry is created in the accounting files upon login. Note: This item must be selected if a login service is used. See the Service item.
	Connect on Carrier	Specifies that a port's associated service is invoked immediately when a connect indication is received.
	Service	Shows the program that is run upon connection.
	Streams Modules	Shows the STREAMS modules that are pushed before the service is invoked.
	Timeout (secs)	Specifies the number of seconds before a port is closed if the open process on the port succeeds and no input data is received.

Setting Up Terminals

Table 10-2 describes the menu items (and their default values) when setting up a terminal using Serial Ports.

TABLE 10-2 Terminal - Hardwired Default Values

Detail	Item	Default Value
Basic	Port	—
	Service	Enabled
	Baud Rate	9600
	Terminal Type	—
More	Option: Initialize Only	no
	Option: Bidirectional	no
	Option: Software Carrier	yes
	Login Prompt	login:
	Comment	Terminal - Hardwired
	Service Tag	—
Expert	Port Monitor Tag	zsmom
	Create utmp Entry	yes
	Connect on Carrier	no
	Service	/usr/bin/login
	Streams Modules	ldterm,ttcompat
	Timeout (secs)	Never

Setting Up Modems

Table 10-3 describes the three modem templates available when setting up a modem using Serial Ports.

TABLE 10-3 Modem Templates

Modem Configuration	Description
Dial-In Only	Users may dial in to the modem but cannot dial out.
Dial-Out Only	Users may dial out from the modem but cannot dial in.
Bidirectional	Users may either dial in or out from the modem.

Table 10-4 describes the default values of each template.

TABLE 10-4 Modem Template Default Values

Detail	Item	Modem - Dial-In Only	Modem - Dial-Out Only	Modem - Bidirectional
Basic	Port	—	—	—
	Service	Enabled	Enabled	Enabled
	Baud Rate	9600	9600	9600
	Terminal Type	—	—	—
More	Option: Initialize Only	yes	no	no
	Option: Bidirectional	no	no	yes
	Option: Software Carrier	no	no	no
	Login Prompt	login:	login:	login:

TABLE 10-4 Modem Template Default Values *(continued)*

Detail	Item	Modem - Dial-In Only	Modem - Dial-Out Only	Modem - Bidirectional
	Comment	Modem - Dial-In Only	Modem - Dial-Out Only	Modem - Bidirectional
	Service Tag	—	—	—
	Port Monitor Tag	zsmon	zsmon	zsmon
Expert	Create utmp Entry	yes	yes	yes
	Connect on Carrier	no	no	no
	Service	/usr/bin/login	/usr/bin/login	/usr/sbin/login
	Streams Modules	ldterm,ttcompat	ldterm,ttcompat	ldterm,ttcompat
	Timeout (secs)	Never	Never	Never

Table 10-5 describes the default values for the Initialize Only template.

TABLE 10-5 Initialize Only - No Connection Default Values

Detail	Item	Default Value
Basic	Port	—
	Service	Enabled
	Baud Rate	9600
	Terminal Type	—
More	Option: Initialize Only	yes
	Option: Bidirectional	no

TABLE 10-5 Initialize Only - No Connection Default Values *(continued)*

Detail	Item	Default Value
	Option: Software Carrier	no
	Login Prompt	login:
	Comment	Initialize Only - No Connection
	Service Tag	—
	Port Monitor Tag	zsmom
Expert	Create utmp Entry	yes
	Connect on Carrier	no
	Service	/usr/bin/login
	Streams Modules	ldterm,ttcompat
	Timeout (secs)	Never

▼ How to Start Admintool

1. Verify that the following prerequisites are met. To use Admintool, you must:

- Have a bit-mapped display monitor. The Admintool software can be used only on a system with a console that is a bit-mapped screen such as a standard display monitor that comes with a Sun workstation.
- Be running an X Window System, such as the OpenWindows™ environment.
- Be a member of the `sysadmin` group (group 14).

If you want to perform administration tasks on a system with an ASCII terminal as the console, use Solaris commands instead.

Note - The system being configured must be your local system. Use Solstice AdminSuite Serial Port Manager to configure serial ports on a remote system.

2. Start Admintool.

```
$ admintool &
```

The Users main window is displayed.

▼ How to Set Up a Terminal

- 1. Start Admintool, if it's not already running.**
See "How to Start Admintool" on page 213 for more information on starting Admintool.
- 2. Select Serial Ports from the Browse menu.**
The Serial Ports menu is displayed.
- 3. Select the port or ports that will be used with a terminal.**
- 4. Choose Modify from the Edit menu.**
The Modify Serial Port window appears in the Basic Detail mode. To enter additional details, select either the More or Expert Detail modes.
- 5. Choose Terminal-Hardwired from the Use Template menu.**
See Table 10-2 for a description of the Terminal-Hardware menu items.
- 6. Change values of template entries if desired.**
- 7. Click on OK to configure the port.**
- 8. Use the `pmadm` command to verify the terminal service has been added.**

```
$ pmadm -l -s ttya
```

Example—Completed Modify Window to Set Up a Terminal

Admintool: Modify Serial Port

Template: Detail:

Port: a Baud Rate:
 Service Enable Terminal Type:

Options: Initialize Only Login Prompt:
 Bidirectional Comment:
 Software Carrier Service Tag:
Port Monitor Tag:

Expert Options: Create utmp Entry Service:
 Connect on Carrier Streams Modules:
Timeout (secs):

▼ How to Set Up a Modem

1. **Start Admintool, if it's not already running.**
See "How to Start Admintool" on page 213 for more information on starting Admintool.
2. **Select Serial Ports from the Browse menu.**
The Serial Ports menu is displayed.
3. **Select the port or ports that will be used with a modem.**
4. **Choose Modify from the Edit menu.**
The Modify Serial Port window appears in the Basic Detail mode. To enter additional details, select either the More or Expert Detail modes.

5. **Choose the modem configuration template from the Use Template menu that meets or most closely matches your modem service.**

See Table 10-3 for a description of each template.

See Table 10-4 for the default values of each template. If a UUCP service will be used to dial in to your modem on a Solaris system, see “How to Set Up a Modem for Use With UUCP” on page 217 for the rest of the procedure.

6. **Change values of template entries if desired.**
7. **Click on OK to configure the port.**
8. **Use the `pmadm` command to verify the modem service has been configured for use with UUCP.**

```
$ pmadm -l -s ttyb
```

Example—Completed Modify Window to Set Up a Modem

Admintool: Modify Serial Port

Template: Detail: Basic More Expert

Port: **b** Service Enable Baud Rate: Terminal Type:

Options: Initialize Only Login Prompt: Comment: Bidirectional Service Tag: Software Carrier Port Monitor Tag:

Expert Options: Create utmp Entry Service: Connect on Carrier Streams Modules: Timeout (secs):

▼ How to Set Up a Modem for Use With UUCP

UUCP sends information to a service using seven bits and even parity. Solaris modem configurations use eight bits and no parity for internationalization purposes. To set up your modem service to work with UUCP, follow these instructions.

1. **Start Admintool, if it's not already running.**
See "How to Start Admintool" on page 213 for more information on starting Admintool.
2. **Select Serial Ports from the Browse menu.**
The Serial Ports menu is displayed.
3. **Select the port or ports that will be used with a modem.**
4. **Choose Modify from the Edit menu.**

The Modify Serial Port window appears in the Basic Detail mode. For additional details, select either the More or Expert Detail modes.

5. Select Other from the Baud Rate menu.

A window listing baud rates from the `/etc/ttydefs` file is displayed.

6. Enter a baud rate that provides seven bit, even parity service. Click on OK.

7. Change values of other template entries if desired.

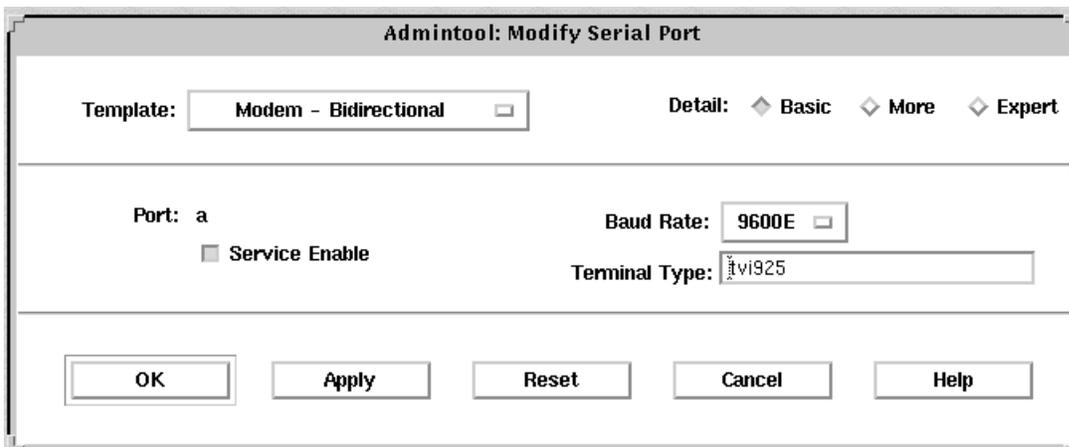
8. Click on OK to configure the port.

9. Use the `pmadm` command to verify the modem service has been configured for use with UUCP.

```
$ pmadm -l -s ttya
```

Example—Completed Modify Window to Set Up a Modem for Use With UUCP

In this example, the 9600E baud rate was selected. This provides a service with a 9600 baud rate, seven bits, and even parity.



▼ How to Initialize a Port

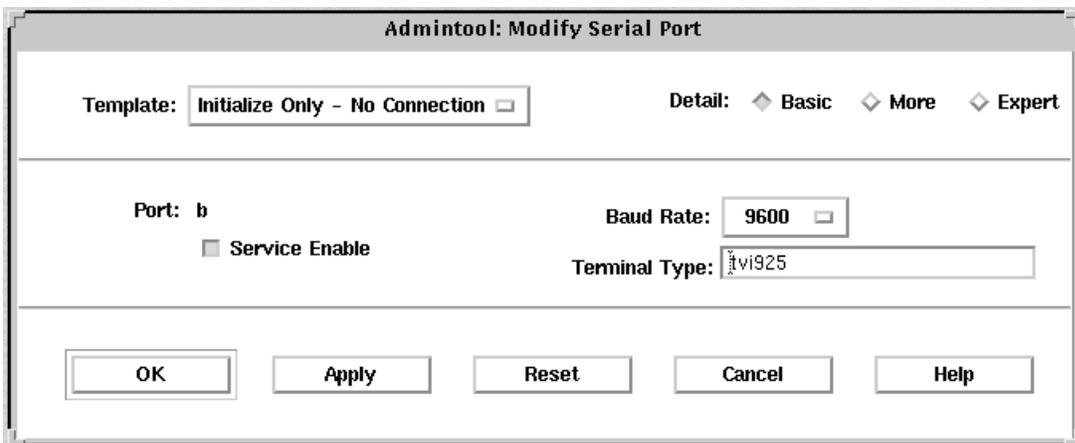
1. Start Admintool, if it's not already running.

See “How to Start Admintool” on page 213 for more information on starting Admintool.

2. **Select Serial Ports from the Browse menu.**
The Serial Ports menu is displayed.
3. **Select the port or ports that you want to initialize.**
4. **Choose Modify from the Edit menu.**
The Modify Serial Port window appears in the Basic Detail mode. To enter additional details, select either the More or Expert Detail modes.
5. **Choose Initialize Only - No Connection from the Use Template menu.**
See Table 10-5 for a description of the Initialize Only - No Connection template.
6. **Click on OK to initialize the port.**
7. **Use the `pmadm` command to verify the port has been disabled.**

```
$ pmadm -l -s ttyb
```

Example—Completed Modify Window to Initialize a Port



▼ How to Disable a Port

1. **Start Admintool, if it's not already running.**
See "How to Start Admintool" on page 213 for more information on starting Admintool.
2. **Select Serial Ports from the Browse menu.**

The Serial Ports menu is displayed.

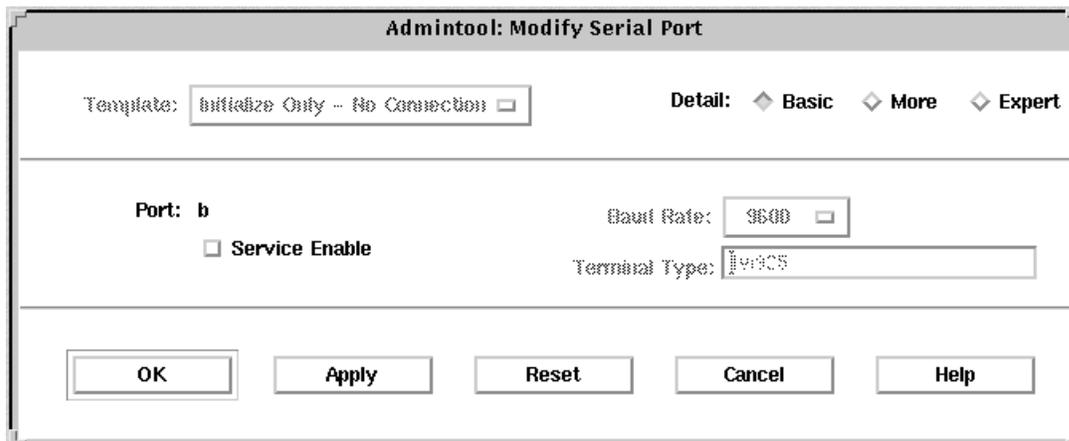
3. Select the port or ports that you want to disable.
4. Choose **Modify** from the **Edit** menu.
5. Click on the **Service Enable** button to disable the port service in the **Modify** window.

This button acts as a toggle switch to enable or disable a port service.

6. Click on **OK** to disable the port.
7. Use the `pmadm` command to verify the port service has been disabled.

```
$ pmadm -l -s ttya
```

Example—Completed Modify Window to Disable a Port



▼ How to Remove a Port Service

1. Start **Admintool**, if it's not already running.
See "How to Start Admintool" on page 213 for more information on starting Admintool.
2. Select the port or ports that has a service you want to delete.
3. Choose **Delete** from the **Edit** menu.

You are asked if you really want to delete the service for the specified port or ports. You may cancel the delete operation or continue with it.

4. Use the `pmadm` command to verify the port service has been deleted.

```
$ pmadm -l -s ttya
```

Troubleshooting Terminal and Modem Problems

If users are unable to log in over serial port lines after you have added a terminal or modem and set up the proper services, consider the following possible causes of failure.

1. Begin by checking with the user.

Malfunctions in terminals and modem use are typically reported by a user who has failed to log in or dial in. For this reason, it is best to begin troubleshooting by checking for a problem on the desktop.

Some common reasons for login failure include:

- Login ID or password is incorrect.
- Terminal is waiting for X-ON flow control key (Control-q).
- Serial cable is loose or unplugged.
- Terminal configuration is incorrect.
- Terminal is shut off or otherwise has no power.

2. Check the terminal.

Continue to troubleshoot by checking the configuration of the terminal or modem. Determine the proper *tylabel* for communicating with the terminal or modem. Verify that the terminal or modem settings match those of the *tylabel*.

3. Check the terminal server.

If the terminal checks out, continue to search for the source of the problem on the terminal or modem server. Use the `pmadm` command to verify that a port monitor has been configured to service the terminal or modem and that it has the correct *tylabel* associated with it.

```
$ pmadm -l -t ttymon
```

Examine `/etc/ttydefs` and double check the label definition against the terminal configuration. Use `sacadm` to check the port monitor's status. Use `pmadm` to check the service associated with the port the terminal uses.

4. Check the serial connection.

If the Service Access Controller is *starting* the TTY port monitor and `pmadm` reports that the service for the terminal's port is *enabled*, and if the terminal's configuration matches the port monitor's, then continue to search for the problem by checking the serial connection. A serial connection comprises serial ports, cables, and terminals. Test each of these parts by using it with two other parts that are known to be reliable.

Test all of the following:

- Serial ports
- Modems
- Cables
- Connectors

5. Do not use Admintool or Solstice™ AdminSuite™ Serial Port Manager to modify serial port settings if the serial port is being used as a console. The correct procedure for changing console settings is by modifying the following line in the `/etc/inittab` file:

```
co:234:respawn:/usr/lib/saf/ttymon -g -h -p "`uname -n` console
login: " -T terminal_type -d /dev/console -l console -m
ldterm,ttcompat
```

Setting Up Terminals and Modems With the Service Access Facility (Tasks)

This chapter explains in detail what a system or network administrator needs to know about the Service Access Facility (SAF) in the Solaris environment.

If you want to see examples of specific SAF commands, skip the first section, “Using the Service Access Facility” on page 223, and use the following list to find the instructions you need.

- “Using the Service Access Facility” on page 223
- “Overall Administration: `sacadm` Command” on page 225
- “Port Monitor Service Administrator: `pmadm` Command” on page 226
- “Port Monitors: TTY Monitor and Network Listener” on page 228
- “Administering `ttymon` Port Monitors” on page 231
- “Administering `ttymon` Services” on page 234
- “Reference Material for Service Access Facility Administration” on page 239

For overview information about terminals and modems, see Chapter 9.

Using the Service Access Facility

The SAF is the tool used for administering terminals, modems, and other network devices. The top-level SAF program is the Service Access Controller (SAC). The SAC controls port monitors which you administer through the `sacadm` command. Each port monitor can manage one or more ports.

You administer the services associated with ports through the `pmadm` command. While services provided through SAC may differ from network to network, SAC and the administrative programs `sacadm` and `pmadm` are network independent.

Table 11-1 illustrates the SAF control hierarchy. The `sacadm` command is used to administer the SAC which controls the `ttymon` and `listen` port monitors.

The services of `ttymon` and `listen` are in turn controlled by `pmadm`. One instance of `ttymon` can service multiple ports and one instance of `listen` can provide multiple services on a network interface.

TABLE 11-1 SAF Control Hierarchy

Function	Program	Description
Overall Administration	<code>sacadm</code>	Command for adding and removing port monitors
Service Access Controller	<code>sac</code>	SAF's master program
Port Monitors	<code>ttymon</code>	Monitors serial port login requests
	<code>listen</code>	Monitors requests for network services
Port Monitor Service Administrator	<code>pmadm</code>	Command for controlling port monitors services
Services	logins; remote procedure calls; other	Services to which SAF provides access
Console Administration	<code>console login</code>	The console is automatically set up via an entry in the <code>/etc/inittab</code> file using <code>ttymon-express</code> mode. Do not use the <code>pmadm</code> or <code>sacadm</code> to manage the console directly. See "ttymon and the Console Port" on page 229 for more information.

Overall Administration: `sacadm` Command

The `sacadm` command is the top level of the SAF. The `sacadm` command primarily is used to add and remove port monitors such as `ttymon` and `listen`. Other `sacadm` functions include listing the current status of port monitors and administering port monitor configuration scripts.

Service Access Controller: SAC Program

The Service Access Controller program (SAC) oversees all port monitors. A system automatically starts SAC upon entering multiuser mode.

When SAC is invoked, it first looks for, and interprets, each system's configuration script, by which SAC customizes its environment. The modifications made to the SAC environment are inherited by all the "children" of the SAC. This inherited environment may be modified by the children.

After it has interpreted the per-system configuration script, the SAC program reads its administrative file and starts the specified port monitors. For each port monitor, SAC runs a copy of itself (SAC forks a child process). Each child then interprets its per-port monitor configuration script, if such a script exists.

Any modifications to the environment specified in the per-port monitor configuration script affect the port monitor and will be inherited by all its children. Finally, the child process runs the port monitor program using the command found in the SAC administrative file.

SAC Initialization Process

The following steps summarize what happens when SAC is first started:

1. The SAC program is spawned by `init` at run level two.
2. The SAC program reads `/etc/saf/_safconfig`, the per-system configuration script.
3. The SAC program reads `/etc/saf/_sactab`, the SAC administrative file.
4. The SAC program forks a child process for each port monitor it starts.
5. Each port monitor reads `/etc/saf/pmtag/_config`, the per-port monitor configuration script.

Port Monitor Service Administrator: `pmadm` Command

The `pmadm` command enables you to administer port monitors' services. In particular, you use the `pmadm` command to add or remove a service and to enable or disable a service. You can also install or replace per-service configuration scripts, or print information about a service.

Each instance of a service must be uniquely identified by a port monitor and a port. When you use the `pmadm` command to administer a service, you specify a particular port monitor via the `pmtag` argument, and a particular port via the `svctag` argument.

For each port monitor type, the SAF requires a specialized command to format port monitor-specific configuration data. This data is used by the `pmadm` command. For `ttymon` and `listen` type port monitors, these specialized commands are `ttyadm` and `nlsadmin`, respectively.

A Port Monitor at Work: `ttymon`

Whenever you attempt to log in via a directly connected modem or alphanumeric terminal, `ttymon` goes to work, as follows.

As shown in Figure 11-1, the `init` program is the first process to be started at boot time. Consulting its administrative file (`/etc/inittab`), `init` starts other processes as they are needed. Listed among those processes is the SAC.

SAC, in turn, automatically starts up the port monitors designated in its administrative file (`/etc/saf/_sactab`). Figure 11-1 shows only a single `ttymon` port monitor.

After `ttymon` has been started, it monitors the serial port lines for service requests.

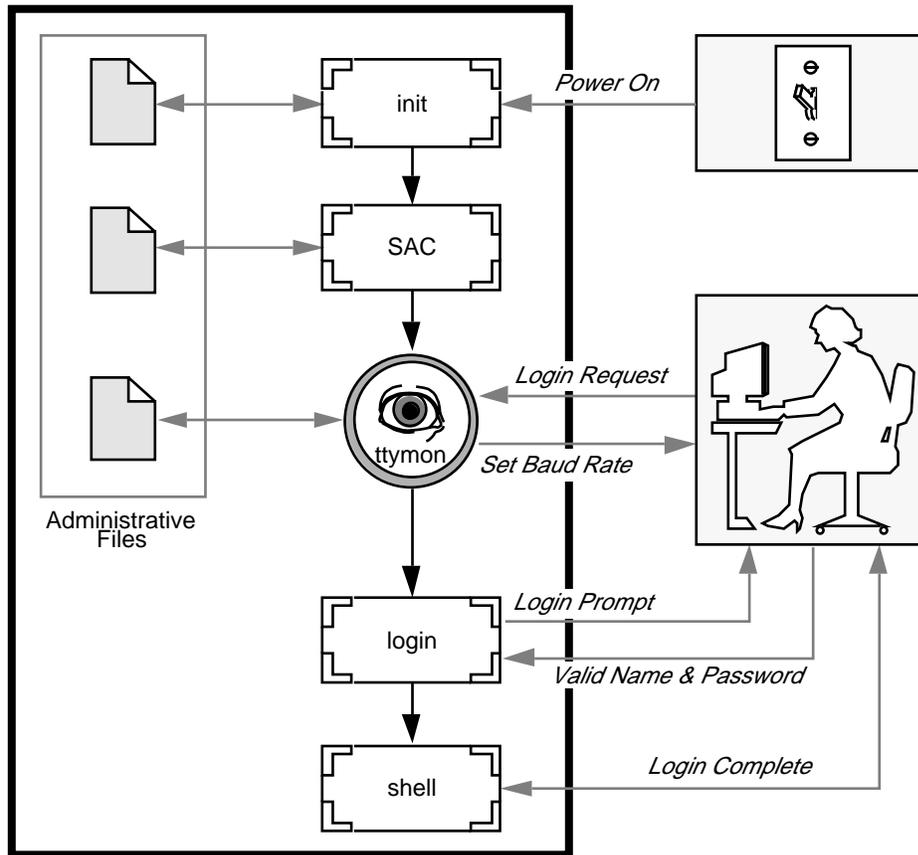


Figure 11-1 How `ttymon` Helps Process a Login Request

When someone attempts to log in via an alphanumeric terminal or a modem, the serial port driver passes the activity to the operating system. The `ttymon` port monitor notes the serial port activity, and attempts to establish a communications link. `ttymon` determines what data transfer rate, line discipline, and handshaking protocol are required to communicate with the device.

Having established the proper parameters for communication with the modem or terminal, `ttymon` passes these parameters to the `login` program and transfers control to it.

Port Initialization Process

When an instance of `ttymon` is invoked by `SAC`, `ttymon` starts to monitor its ports. For each port, `ttymon` first initializes the line disciplines, if they are specified, and the speed and terminal settings. The values used for initialization are taken from the appropriate entry in `/etc/ttydefs`.

The `ttymon` port monitor then writes the prompt and waits for user input. If the user indicates that the speed is inappropriate by pressing the Break key, `ttymon` tries the next speed and writes the prompt again.

If *autobaud* is enabled for a port, `ttymon` will try to determine the baud rate on the port automatically. Users must press Return before `ttymon` can recognize the baud rate and print the prompt.

When valid input is received, `ttymon` interprets the per-service configuration file for the port, creates a `/etc/utmp` entry if required, establishes the service environment, and invokes the service associated with the port.

After the service terminates, `ttymon` cleans up the `/etc/utmp` entry, if one exists, and returns the port to its initial state.

Bidirectional Service

If a port is configured for bidirectional service, `ttymon` will:

- Allow users to connect to a service
- Allow `uucico`, `cu`, or `ct` to use the port for dialing out (if the port's free)
- Wait to read a character before printing a prompt
- Invoke the port's associated service—without sending the prompt message—when a connection is requested (if the connect-on-carrier flag is set)

Port Monitors: TTY Monitor and Network Listener

Though SAF provides a generic means for administering any future or third-party port monitors, only two are implemented in the Solaris environment—`ttymon` and `listen`.

TTY Port Monitor: `ttymon`

The `ttymon` port monitor is STREAMS-based. It monitors ports; sets terminal modes, baud rates, and line disciplines; and invokes the login process. (It provides Solaris users the same services that `getty` did under previous versions of SunOS 4.1 software.)

The `ttymon` port monitor runs under the SAC program. It is configured using the `sacadm` command. Each instance of `ttymon` can monitor multiple ports. These ports

are specified in the port monitor's administrative file. The administrative file is configured using the `pmadm` and `ttyadm` commands.

ttymon and the Console Port

Console services are not managed by the Service Access Controller nor any explicit `ttymon` administration file. An entry in the `/etc/inittab` file is used to manage the console port using `ttymon` in *express* mode, which is a special `ttymon` mode that is invoked directly by a command that requires login service.

The default console entry in the `/etc/inittab` file looks like this:

```
co:234:respawn:/usr/lib/saf/ttymon -g -h -p "`uname -n` console login: "  
-T terminal_type -d /dev/console -l console -m ldterm,ttcompat
```

`co:234:respawn:`

`co` identifies the entry as the console; `234` identifies the run levels for the action, `respawn`, which means the console entry should be restarted if it fails or doesn't exist at run levels 2, 3, and 4.

`/usr/lib/saf/ttymon -g -h`

The `-g` option is used so the correct baud rate and terminal setting can be set on a port and connect to a login service without being preconfigured by the SAC. The `-h` option forces a line hangup by setting the line speed to zero before setting the default or specified speed.

`-p "`uname -n` console login:`

Identifies the prompt string for the console port.

`-t terminal_type`

Identifies the terminal type of the console.

`-d /dev/console -l console -m ldterm,ttcompat`

The `-d` option identifies the console device; the `-l` option identifies the `ttylabel` in the `/etc/ttydefs` file; and the `-m` option identifies the STREAMS modules to be pushed.

Special `ttymon`-Specific Administrative Command: `ttyadm`

The `ttymon` administrative file is updated by `sacadm` and `pmadm`, as well as by the `ttyadm` command. The `ttyadm` command formats `ttymon`-specific information and writes it to the standard output, providing a means for presenting formatted `ttymon`-specific data to the `sacadm` and `pmadm` commands.

Thus, `ttyadm` does not administer `ttymon` directly; rather, it complements the generic administrative commands, `sacadm` and `pmadm`. See `ttyadm(1M)` for more details.

Network Listener Service: `listen`

The `listen` port monitor runs under SAC. It monitors the network for service requests, accepts requests when they arrive, and invokes servers in response to those service requests.

The `listen` port monitor is configured using the `sacadm` command. Each instance of `listen` can provide multiple services. These services are specified in the port monitor's administrative file. This administrative file is configured using the `pmadm` and `nlsadmin` commands.

The network listener process may be used with any connection-oriented transport provider that conforms to the Transport Layer Interface (TLI) specification. In the Solaris environment, `listen` port monitors can provide additional network services not provided by `inetd`.

Special `listen`-Specific Administrative Command: `nlsadmin`

The `listen` port monitor's administrative file is updated by `sacadm` and `pmadm`, as well as by the `nlsadmin` command. The `nlsadmin` command formats `listen`-specific information and writes it to the standard output, providing a means of presenting formatted `listen`-specific data to the `sacadm` and `pmadm` commands.

Thus, `nlsadmin` does not administer `listen` directly; rather, it complements the generic administrative commands, `sacadm` and `pmadm`.

Each network can have at least one instance of the network listener process associated with it. Each network is configured separately. The `nlsadmin` command controls the operational states of `listen` port monitors.

The `nlsadmin` command can establish a `listen` port monitor for a given network, configure the specific attributes of that port monitor, and *start* and *kill* the monitor.

The `nlsadmin` command can also report on the `listen` port monitors on a machine.

See `nlsadmin(1M)` for more details.

Administering `ttymon` Port Monitors

Use the `sacadm` command to add, list, remove, kill, start, enable, disable, enable, and remove a `ttymon` port monitor.

Note - You must be superuser to perform the following procedures.

▼ How to Add a `ttymon` Port Monitor

To add a `ttymon` port monitor, type:

```
# sacadm -a -p mbmon -t ttymon -c /usr/lib/saf/ttymon -v `ttyadm
-V` -y "TTY Ports a & b"
```

- a The *add* port monitor flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag
- t Specifies the port monitor *type* as `ttymon`
- c Defines the *command* string used to start the port monitor
- v Specifies the *version* number of the port monitor
- y Defines a comment to describe this instance of the port monitor

▼ How to View `ttymon` Port Monitor Status

To see the status of a `ttymon` port monitor, type:

```
# sacadm -l -p mbmon
```

- l The *list* port monitor status flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag

Example—Viewing `ttymon` Port Monitor Status

```
# sacadm -l -p mbmon
PMTAG  PMTYPE  FLGS  RCNT  STATUS  COMMAND
mbmon  ttymon  -     0     STARTING /usr/lib/saf/ttymon #TTY Ports a & b
```

PMTAG	Identifies the port monitor name, <code>mbmon</code> .
<code>mbmon</code>	
PMTYPE	Identifies the port monitor type, <code>ttymon</code> .
<code>ttymon</code>	
FLGS	Indicates whether the following two flags are set:
-	<code>d</code> , do not enable the new port monitor, or
	<code>x</code> , do not start the new port monitor. There are no flags set in this example.
RCNT	Indicates the return count value. A return count of 0 indicates that the port monitor is not to be restarted if it fails.
0	
STATUS	Indicates the current status of the port monitor.
STARTING	
COMMAND	Identifies the command used to start the port monitor.
<code>/usr/lib/saf ...</code>	
<code>#TTY Ports a & b</code>	Identifies any comment used to describe the port monitor.

▼ How to Stop a ttymon Port Monitor

To kill a ttymon port monitor, type:

```
# sacadm -k -p mbmon
```

- k The *kill* port monitor status flag
- p Specifies the *pmtag* mbmon as the port monitor tag

▼ How to Start a ttymon Port Monitor

To start a killed ttymon port monitor, type:

```
# sacadm -s -p mbmon
```

- s The *start* port monitor status flag
- p Specifies the *pmtag* mbmon as the port monitor tag

▼ How to Disable a ttymon Port Monitor

Disabling a port monitor prevents new services from starting, without affecting existing services.

To disable a ttymon port monitor, type:

```
# sacadm -d -p mbmon
```

- d The *disable* port monitor status flag
- p Specifies the *pmtag* mbmon as the port monitor tag

▼ How to Enable a ttymon Port Monitor

Enabling a ttymon port monitor allows it to service new requests.

To enable a `ttymon` port monitor, type:

```
# sacadm -e -p mbmon
```

- e The *enable* port monitor status flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag

▼ How to Remove a `ttymon` Port Monitor

To remove a `ttymon` port monitor, type:

```
# sacadm -r -p mbmon
```

- r The *remove* port monitor status flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag

Note - Removing a port monitor deletes all the configuration files associated with it. Port monitor configuration files cannot be updated or changed using `sacadm`. To reconfigure a port monitor, *remove* it and *add* a new one.

Administering `ttymon` Services

Use `pmadm` to add services, list the services of one or more ports associated with a port monitor, and enable or disable a service.

Note - You must be superuser to perform the following procedures.

▼ How to Add a Service

To add a standard terminal service to the `mbmon` port monitor, type:

```
# pmadm -a -p mbmon -s a -i root -v `ttyadm -V` -m "`ttyadm -i 'Terminal disabled'
-l contty -m ldterm,ttcompat -s y -d /dev/term/a -s /usr/bin/login`"
```

Note - In this example, the input wraps to the next line. Do not put a Return or line feed after `contty`.

- a The *add* port monitor status flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag
- s Specifies the *svctag* `a` as the port monitor *service* tag
- i Specifies the *identity* to be assigned to *svctag* when it runs
- v Specifies the *version* number of the port monitor
- m Specifies the *ttymon*-specific configuration data formatted by `tttyadm`

The above `pmadm` command contains an embedded `tttyadm` command. The options in this embedded command are as follows:

- b The *bidirectional* port flag
- i Specifies the *inactive* (disabled) response message
- l Specifies which TTY *label* in `/etc/ttydefs` to use
- m Specifies the STREAMS *modules* to push before invoking this service
- d Specifies the full path name to the *device* to use for the TTY port
- s Specifies the full path name of the *service* to invoke when a connection request is received; if arguments are required, enclose the command and its arguments in quotation marks ("")

▼ How to View the Status of a TTY Port Service

Use the `pmadm` command as shown to list the status of a TTY port, or all the ports associated with a port monitor.

Listing One Service

To list one service of a port monitor, type:

```
# pmadm -l -p mbmon -s a
```

- l Lists service information
- p Specifies the *pmtag* `mbmon` as the port monitor tag
- s Specifies the *svctag* `a` as the port monitor *service* tag

Listing All Services of All Port Monitors

To list all services of all port monitors, type:

```
# pmadm -l
```

- l Lists service information

Listing All Services of a Port Monitor

To list all services of a port monitor, type:

```
# pmadm -l -p mbmon
```

- l Lists service information
- p Specifies the *pmtag* `mbmon` as the port monitor tag

Example—Viewing the Status of a TTY Port Monitor Service

```
# pmadm -l -p mbmon
PMTAG  PMTYPE  SVCTAG  FLAGS  ID      <PMSPECIFIC>
mbmon  ttymon   a        -      root   /dev/term/a - - /usr/bin/login - contty
ldterm,ttcompat login: Terminal disabled - y #
```

mbmon	Identifies the port monitor name, mbmon, set by using the pmadm -p command.
ttymon	Identifies the port monitor type, ttymon.
a	Indicates the service tag value set by using the pmadm -s command.
-	Identifies whether the following flags are set by using the pmadm -f command: x, which means do not enable the service; u, which means create a utmp entry for the service. No flags are set in this example.
root	Identifies the ID assigned to the service when its started. This value is set by using the pmadm -i command.
<PMSPECIFIC>	<i>Information</i>
/dev/term/a	Indicates the TTY port pathname set by using the ttyadm -d command.
-	Indicates whether the following flags are set by using the ttadm -c -b -h -I -r command: c, sets the connect on carrier flag for the port b, sets the port as bidirectional, allowing both incoming and outgoing traffic h, suppresses an automatic hangup immediately after an incoming call is received I, initializes the port r, forces ttymon to wait until it receives a character from the port before it prints the login: message.

-	Indicates a value set by using the <code>ttynam -r</code> option. This option determines when <code>ttynam</code> displays a prompt after receiving data from a port. If count is 0, <code>ttynam</code> will wait until it receives any character. If count is greater than 0, <code>ttynam</code> will wait until count new lines have been received. No value is set in this example.
<code>/usr/bin/login</code>	Identifies the full pathname of the service to be invoked when a connected is received. This value is set by using <code>ttynam -s</code> command.
-	Identifies the <code>ttynam -t</code> command's (timeout) value. This option specifies that <code>ttynam</code> should close a port if the open on the port succeeds, and no input data is received in timeout seconds. There is no timeout value in this example.
<code>contty</code>	Identifies the TTY label in the <code>/etc/ttydefs</code> file. This value is set by using the <code>ttynam -l</code> command.
<code>ldterm,ttcompat</code>	Identifies the STREAMS modules to be pushed. These modules are set by using the <code>ttynam -m</code> command.
<code>login: Terminal disabled</code>	Identifies an inactive message to be displayed when the port is disabled. This message is set by using the <code>ttynam -i</code> command.
<code>tvi925</code>	Identifies the terminal type, if set, by using the <code>ttynam -T</code> command. The terminal type is <code>tvi925</code> in this example .
<code>y</code>	Identifies the software carrier value set by using the <code>ttynam -S</code> command; <code>n</code> will turn software carrier off, <code>y</code> will turn software carrier on. Software carrier is turned on in this example.
<code>#</code>	Identifies any comment specified with the <code>pmadm -y</code> command. (There is no comment in this example).

▼ How to Enable a Port Monitor Service

To enable a disabled port monitor service, type:

```
# pmadm -e -p mbmon -s a
```

- e The *enable* flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag
- s Specifies the *svctag* `a` as the port monitor *service* tag

▼ How to Disable a Port Monitor Service

To disable a port monitor service, type:

```
# pmadm -d -p mbmon -s a
```

- d The *disable* flag
- p Specifies the *pmtag* `mbmon` as the port monitor tag
- s Specifies the *svctag* `a` as the port monitor *service* tag

Reference Material for Service Access Facility Administration

Files Associated With SAF

SAF uses configuration files which can be modified by using the `sacadm` and `pmadm` commands. You should not need to edit them manually.

File Name	Description
<code>/etc/saf/_sysconfig</code>	Per-system configuration script
<code>/etc/saf/_sactab</code>	SAC's administrative file; contains configuration data for the port monitors that the SAC controls
<code>/etc/saf/pmtag</code>	Home directory for port monitor <i>pmtag</i>

File Name	Description
<code>/etc/saf/pmtag/_config</code>	Per-port monitor configuration script for port monitor <i>pmtag</i> if it exists
<code>/etc/saf/pmtag/_pmtab</code>	Port monitor <i>pmtag</i> 's administrative file; contains port monitor-specific configuration data for the services <i>pmtag</i> provides
<code>/etc/saf/pmtag/svctag</code>	Per-service configuration script for service <i>svctag</i>
<code>/var/saf/log</code>	SAC's log file
<code>/var/saf/pmtag</code>	Directory for files created by <i>pmtag</i> , for example, log files

The `/etc/saf/_sactab` File

The `/etc/saf/_sactab` looks like this:

```
# VERSION=1
zsmon:ttymon::0:/usr/lib/saf/ttymon #
```

<code># VERSION=1</code>	Indicates the Service Access Facility version number.
<code>zsmon</code>	Is the name of the port monitor.
<code>ttymon</code>	Is the type of port monitor.
<code>::</code>	Indicates whether the following two flags are set: <code>d</code> , do not enable the port monitor <code>x</code> , do not start the port monitor. No flags are set in this example.
<code>0</code>	Indicates the return code value. A return count of 0 indicates that the port monitor is not be restarted if it fails.
<code>/usr/lib/saf/ttymon</code>	Indicates the port monitor pathname

The `/etc/saf/pmtab/_pmtab` File

The `/etc/saf/pmtab/_pmtab` file, such as `/etc/saf/zsmon/_pmtab`, looks like this:

```
# VERSION=1
ttya:u:root:reserved:reserved:reserved:/dev/term/a:I::/usr/bin/login::9600:ldterm,
ttcompat:ttya login\ : :tvi925:y:#
```

<code># VERSION=1</code>	Indicates the Service Access Facility version number.
<code>ttya</code>	Indicates the service tag.
<code>x,u</code>	Identifies whether the following flags are set: <code>x</code> , which means do not enable the service <code>u</code> , which means create a <code>utmp</code> entry for the service
<code>root</code>	Indicates the identity assigned to the service tag.
<code>reserved</code>	This field is reserved.
<code>reserved</code>	This field is reserved.
<code>reserved</code>	This field is reserved.
<code>/dev/term/a</code>	Indicates the TTY port pathname.
<code>/usr/bin/login</code>	Identifies the full pathname of the service to be invoked when a connection is received.
<code>:c,b,h,I,r:</code>	Indicates whether the following flags are set <code>c</code> , sets the connect on carrier flag for the port <code>b</code> , sets the port as bidirectional, allowing both incoming and outgoing traffic <code>h</code> , supresses an automatic hangup immediately after an incoming call is received <code>I</code> , initializes the port <code>r</code> , forces <code>ttymon</code> to wait until it receives a character from the port before it prints the <code>login:</code> message.
<code>9600</code>	Identifies the TTY label defined in <code>/etc/ttydefs</code> file

ldterm,ttcompat	Identifies the STREAMS modules to be pushed
ttya login\:	Identifies the prompt to be displayed
:y/n:	
message	Identifies any inactive (disabled) response message
tvi925	Identifies the terminal type.
y	Indicates whether software carrier is set (y/n).

Service States

The `sacadm` command controls the states of services. The possible states are shown below.

State	Notes
Enabled	<i>Default state</i> – When the port monitor is added, the service operates.
Disabled	<i>Default state</i> – When the port monitor is removed, the service stops.

To determine the state of any particular service, use the following:

```
# pmadm -l -p portmon_name -s svctag
```

Port Monitor States

The `sacadm` command controls the states of `ttymon` and `listen` port monitors. The possible states are shown below.

State	Notes
Started	<i>Default state</i> – When the port monitor is added, it is automatically started.
Enabled	<i>Default state</i> – When the port monitor is added, it is automatically ready to accept requests for service.
Stopped	<i>Default state</i> – When the port monitor is removed, it is automatically stopped.

State	Notes
Disabled	<i>Default state</i> – When the port monitor is removed, it automatically continues existing services and refuses to add new services.
Starting	<i>Intermediate state</i> – The port monitor is in the process of starting.
Stopping	<i>Intermediate state</i> – The port monitor has been manually terminated, but it has not completed its shutdown procedure. It is on the way to becoming stopped.
Notrunning	<i>Inactive state</i> – The port monitor has been killed. All ports previously monitored are inaccessible. An external user cannot tell whether a port is disabled or notrunning.
Failed	<i>Inactive state</i> – The port monitor is unable to start and remain running.

To determine the state of any particular port monitor, use the following:

```
# sacadm -l -p portmon_name
```

Port States

Ports may be enabled or disabled depending on the state of the port monitor that controls them.

State	Notes
Serial (ttymon) Port States	
Enabled	The <code>ttymon</code> port monitor sends a prompt message to the port and provides login service to it.
Disabled	Default state of all ports if <code>ttymon</code> is killed or disabled. If you specify this state, <code>ttymon</code> will send out the <code>disabled</code> message when it receives a connection request.

PART **IV** Managing System Security

This part provides instructions for managing system security in the Solaris 7 environment. This part contains these chapters.

Chapter 12	Provides overview information about file, system, and network security.
Chapter 13	Provides step-by-step instructions to display file information, change file ownership and permissions, and set special permissions.
Chapter 14	Provides step-by-step instructions to check login status, set up dial-up passwords, restrict root access, and monitor root access and <code>su</code> attempts.
Chapter 15	Provides step-by-step instructions for setting up Kerberos login authentication and Pluggable Authentication Module (PAM).
Chapter 16	Provides overview information about Automated Security Enhancement Tool (ASET) and step-by-step instructions to run ASET interactively or periodically (by using a <code>cron</code> job). It also includes information about collecting client ASET reports on a server.



Managing System Security (Overview)

Keeping a system's information secure is an important system administration responsibility. This chapter provides overview information about managing system security at the file, system, and network level.

This is a list of the overview information in this chapter.

- “Where to Find System Security Tasks” on page 247
- “Granting Access to a Computer System” on page 248
- “File Security” on page 251
- “System Security” on page 252
- “Network Security” on page 256

At the file level, the SunOS 5.7 operating system provides some standard security features that you can use to protect files, directories, and devices. At the system and network levels, the security issues are mostly the same. In the workplace, a number of systems connected to a server can be thought of as one large multifaceted system. The system administrator is responsible for the security of this larger system or network. Not only is it important to defend the network from outsiders trying to gain access to the network, but it is also important to ensure the integrity of the data on the systems within the network.

Where to Find System Security Tasks

Use these references to find step-by-step instructions for setting up system security.

- Chapter 13
- Chapter 14

- Chapter 15
- Chapter 16

Granting Access to a Computer System

The first line of security defense is to control access to your system. You can control and monitor system access by:

- Maintaining physical site security
- Maintaining login control
- Restricting access to data in files
- Maintaining network control
- Monitoring system usage
- Setting the path variable correctly
- Securing files
- Tracking superuser (root) login
- Installing a firewall
- Using Automated Security Enhancement Tool (ASET)

Maintaining Physical Site Security

To control access to your system, you must maintain the physical security of your computer environment. For instance, if a system is logged in and left unattended, anyone who can use that system can gain access to the operating system and the network. You need to be aware of your computer's surroundings and physically protect it from unauthorized access.

Maintaining Login and Access Control

You also must restrict unauthorized logins to a system or the network, which you can do through password and login control. All accounts on a system should have a password. An account without a password makes your entire network accessible to anyone who can guess a user name.

Solaris 7 system software restricts control of certain system devices to the user login account. Only a process running as superuser or console user can access a system mouse, keyboard, frame buffer, or audio device unless `/etc/logindevperm` is edited. See `logindevperm(4)` for more information.

Restricting Access to Data in Files

After you have established login restrictions, you can control access to the data on your system. You may want to allow some people to read some files, and give other people permission to change or delete some files. You may have some data that you do not want anyone else to see. Chapter 13 discusses how to set file permissions.

Maintaining Network Control

Computers are often part of a configuration of systems called a *network*. A network allows connected systems to exchange information and access data and other resources available from systems connected to the network. Networking has created a powerful and sophisticated way of computing. However, networking has also jeopardized computer security.

For instance, within a network of computers, individual systems are open to allow sharing of information. Also, because many people have access to the network, there is more chance for allowing unwanted access, especially through user error (for example, through a poor use of passwords).

Monitoring System Usage

As system administrator, you need to monitor system activity, being aware of all aspects of your systems, including the following:

- What is the normal load?
- Who has access to the system?
- When do individuals access the system?

With this kind of knowledge, you can use the available tools to audit system use and monitor the activities of individual users. Monitoring is very useful when there is a suspected breach in security.

Setting the Correct Path

It is important to set your path variable correctly; otherwise, you may accidentally run a program introduced by someone else that harms your data or your system. This kind of program, which creates a security hazard, is referred to as a “Trojan horse.” For example, a substitute `su` program could be placed in a public directory where you, as system administrator, might run it. Such a script would look just like the regular `su` command; since it removes itself after execution, it is hard to tell that you have actually run a Trojan horse.

The path variable is automatically set at login time through the startup files: `.login`, `.profile`, and `.cshrc`. Setting up the user search path so that the current directory (`.`) comes last prevents you or your users from running this type of Trojan horse. The path variable for superuser should not include the current directory at all. The ASET utility examines the startup files to ensure that the path variable is set up correctly and that it does not contain a dot (`.`) entry.

Securing Files

Since the SunOS 5.7 operating system is a multiuser system, file system security is the most basic, and important, security risks on a system. You can use both the traditional UNIX file protection or the more secure access control lists (ACLs) to protect your files.

Also, many executable programs have to be run as root (that is, as superuser) to work properly. These executables run with the user ID set to 0 (`setuid=0`). Anyone running these programs runs them with the root ID, which creates a potential security problem if the programs are not written with security in mind.

Except for the executables shipped with `setuid` to root, you should disallow the use of `setuid` programs, or at least restrict and keep them to a minimum.

Installing a Firewall

Another way to protect your network is to use a firewall or secure gateway system. A firewall is a dedicated system separating two networks, each of which approaches the other as untrusted. You should consider this setup as mandatory between your internal network and any external networks, such as Internet, with which you want internal network users to communicate.

A firewall can also be useful between some internal networks. For example, the firewall or secure gateway computer will not send a packet between two networks unless the gateway computer is the origin or the destination address of the packet. A firewall should also be set up to forward packets for particular protocols only. For example, you may allow packets for transferring mail, but not those for `telnet` or `rlogin`. The ASET utility, when run at high security, disables the forwarding of Internet Protocol (IP) packets.

Reporting Security Problems

If you experience a suspected security breach, you can contact the Computer Emergency Response Team/Coordination Center (CERT/CC), which is a Defense Advanced Research Projects Agency (DARPA) funded project located at the Software Engineering Institute at Carnegie Mellon University. It can assist you with any

security problems you are having. It can also direct you to other Computer Emergency Response Teams that may be more appropriate to your particular needs. You can call CERT/CC at its 24-hour hotline: (412) 268-7090, or contact the team via email to `cert@cert.sei.cmu.edu`.

File Security

The SunOS 5.7 operating system is a multiuser system, which means that all the users logged in to a system can read and use files belonging to one another, as long as they have permission to do so. Table 12-1 describes file system administration commands. See Chapter 13 for step-by-step instructions on securing files.

File Administration Commands

Table 12-1 lists the file administration commands that you can use on files or directories.

TABLE 12-1 File Administration Commands

Command	Description
<code>ls(1)</code>	Lists the files in a directory and information about them.
<code>chown(1)</code>	Changes the ownership of a file.
<code>chgrp(1)</code>	Changes the group ownership of a file.
<code>chmod(1)</code>	Changes permissions on a file. You can use either symbolic mode (letters and symbols) or absolute mode (octal numbers) to change permissions on a file.

File Encryption

Placing a sensitive file into an inaccessible directory (700 mode) and making the file unreadable by others (600 mode) will keep it secure in most cases. However, someone who guesses your password or the root password can read and write to

that file. Also, the sensitive file is preserved on backup tapes every time you back up the system files to tape.

Fortunately, an additional layer of security is available to all SunOS 5.7 system software users in the United States—the optional file encryption kit. The encryption kit includes the `crypt(1)` command which scrambles the data to disguise the text.

Access Control Lists (ACLs)

ACLs (ACLs, pronounced “ackkls”) can provide greater control over file permissions when the traditional UNIX file protection in the SunOS operating system is not enough. The traditional UNIX file protection provides read, write, and execute permissions for the three user classes: owner, group, and other. An ACL provides better file security by enabling you to define file permissions for the owner, owner’s group, others, specific users and groups, and default permissions for each of those categories. See “Using Access Control Lists (ACLs)” on page 280 for step-by-step instructions on using ACLs.

Table 12-2 lists the ACL commands that you can use on files or directories.

TABLE 12-2 ACL Commands

Command	Description
<code>setfacl(1)</code>	Sets, adds, modifies, and deletes ACL entries
<code>getfacl(1)</code>	Displays ACL entries

System Security

This section describes how to safeguard your system against unauthorized access, such as how to prevent an intruder from logging in to your system, how to maintain the password files, and how to prevent unauthorized superuser access to sensitive system files and programs.

You can set up two security barriers on a system. The first security barrier is the login program. To cross this barrier and gain access to a system, a user must supply a user name and a corresponding password known by the local system or by the name service (NIS or NIS+).

The second security barrier is ensuring that the system files and programs can be changed or removed by superuser only. A would-be superuser must supply the root user name and its correct password.

Login Access Restrictions

When a user logs in to a system, the login program consults the appropriate database according to the information listed in the `/etc/nsswitch.conf` file. The entries in this file can include `files` (designating the `/etc` files), `nis` (designating the NIS database), and `nisplus` (designating the NIS+ database). See the *Solaris Naming Administration Guide* or `nsswitch.conf(4)` for a description of this file.

The login program verifies the user name and password entered. If the user name is not in the password file or the password is not correct for the user name, the login program denies access to the system. When the user supplies a name from the password file and the correct password for the name, the system grants the user access to the system.

Special Logins

There are two common ways to access a system—by using a conventional user login or by using the root login. In addition, a number of special *system* logins allow a user to perform administrative commands without using the root account. The administrator assigns password to these login accounts.

Table 12-3 lists the system login accounts and their uses. The system logins perform special functions, and each has its own group identifier number (GID). Each of these logins should have its own password, which should be distributed on a need-to-know basis.

TABLE 12-3 System Logins

Login Account	GID	Use
root	0	Has almost no restrictions and overrides all other logins, protections, and permissions. The root account has access to the entire system. The password for the root login should be very carefully protected.
daemon	1	Controls background processing.
bin	2	Owns most of the commands.
sys	3	Owns many system files.
adm	4	Owns certain administrative files.
lp	71	Owns the object and spooled data files for the printer.
uucp	5	Owns the object and spooled data files for UUCP, the UNIX-to-UNIX copy program.
nuucp	9	Is used by remote systems to log in to the system and start file transfers.

You should also set the security of the `eeeprom` command to require a password. See `eeeprom(1M)` for more information.

Managing Password Information

When logging in to a system, users must enter both a user name and a password. Although logins are publicly known, passwords must be kept secret, and known only to users. You should ask your users to choose their passwords carefully, and change them often.

Passwords are initially created when you set up a user account. To maintain security on user accounts, you can set up password aging to force users to routinely change their passwords, and you can also disable a user account by locking the password. See “Managing User Accounts and Groups (Overview)” in *System Administration Guide, Volume I* for detailed information about setting up and maintaining passwords.

NIS+ Password File

If your network uses NIS+, the password information is kept in the NIS+ database. Information in the NIS+ database can be protected by restricting access to authorized users. You can use Solstice User Manager or the `passwd(1)` command to change a user's NIS+ password.

NIS Password File

If your network uses NIS, the password information is kept in the NIS password map. NIS does not support password aging. You can use Solstice™ User Manager or the `passwd(1)` command to change a user's NIS password.

/etc Files

If your network uses `/etc` files, the password information is kept in the system's `/etc/passwd` and `/etc/shadow` files. The user name and other information are kept in the password file `/etc/passwd`, while the encrypted password itself is kept in a separate *shadow* file, `/etc/shadow`. This is a security measure that prevents a user from gaining access to the encrypted passwords. While the `/etc/passwd` file is available to anyone who can log in to a machine, only superuser can read the `/etc/shadow` file. You can use Solstice AdminSuite's User Manager, Admintool, or the `passwd(1)` command to change a user's password on a local system.

Using the Restricted Shell

The standard shell allows a user to open files, execute commands, and so on. The restricted shell can be used to limit the ability of a user to change directories, and execute commands. The restricted shell (`rsh`) is located in the `/usr/lib` directory. (Note that this is not the remote shell, which is `/usr/sbin/rsh`.) The restricted shell differs from the normal shell in these ways:

- The user is limited to the home directory (can't use `cd` to change directories).
- The user can use only commands in the `PATH` set by the system administrator (can't change the `PATH` variable).
- The user can access only files in the home directory and its subdirectories (can't name commands or files using a complete path name).
- The user cannot redirect output with `>` or `>>`.

The restricted shell allows the system administrator to limit a user's ability to stray into the system files, and is intended mainly to set up a user who needs to perform specific tasks. The `rsh` is not completely secure, however, and is only intended to keep unskilled users from getting into (or causing) trouble.

See `sh(1)` for information about the restricted shell.

Tracking Superuser (Root) Login

Your system requires a root password for superuser mode. In the default configuration, a user cannot remotely log in to a system as root. When logging in remotely, a user must log in as himself and then use the `su` command to become root. This enables you to track who is using superuser privileges on your system.

Monitoring Who is Becoming Superuser or Other Users

You have to use the `su` command to change to another user, for example, if you want to become superuser. For security reasons, you may want to monitor who has been using the `su` command, especially those user's who are trying to gain superuser access.

See "How to Monitor Who Is Using the `su` Command" on page 301 for detailed instructions.

Network Security

The more available access is across a network, the more advantageous it is for networked systems. However, free access and sharing of data and resources create security problems. Network security is usually based on limiting or blocking operations from remote systems. Figure 12-1 describes the security restrictions you can impose on remote operations.

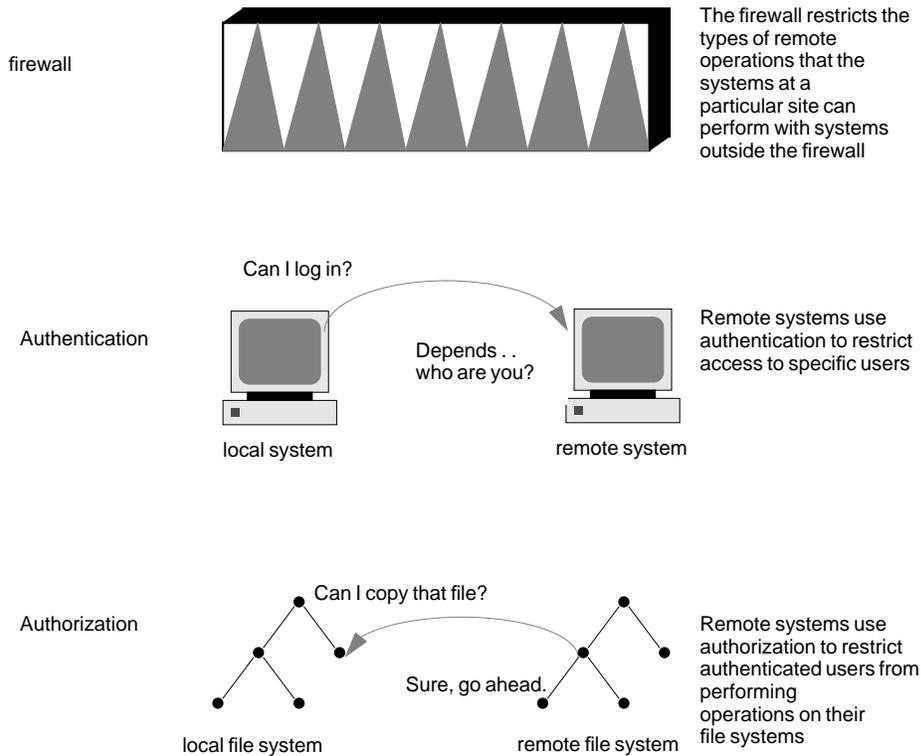


Figure 12-1 Security Restrictions for Remote Operations

Firewall Systems

You can set up a firewall system to protect the resources in your network from outside access. A *firewall system* is a secure host that acts as a barrier between your internal network and outside networks.

The firewall has two functions. It acts as a gateway which passes data between the networks, and it acts as a barrier which blocks the free passage of data to and from the network. The firewall requires a user on the internal network to log in to the firewall system to access hosts on remote networks. Similarly, a user on an outside network must log in to the firewall system before being granted access to a host on the internal network.

In addition, all electronic mail sent from the internal network is sent to the firewall system for transfer to a host on an external network. The firewall system receives all incoming electronic mail, and distributes it to the hosts on the internal network.



Caution - A firewall prevents unauthorized users from accessing hosts on your network. You should maintain strict and rigidly enforced security on the firewall, but security on other hosts on the network can be more relaxed. However, an intruder who can break into your firewall system can then gain access to all the other hosts on the internal network.

A firewall system should not have any *trusted hosts*. (A trusted host is one from which a user can log in without being required to type in a password.) It should not share any of its file systems, or mount any file systems from other servers.

ASET can be used to make a system into a firewall, and to enforce high security on a firewall system, as described in Chapter 16.

Packet Smashing

Most local-area networks transmit data between computers in blocks called packets. Through a procedure called *packet smashing*, unauthorized users can harm or destroy data. Packet smashing involves capturing packets before they reach their destination, injecting arbitrary data into the contents, then sending the packets back on their original course. On a local-area network, packet smashing is impossible because packets reach all systems, including the server, at the same time. Packet smashing is possible on a gateway, however, so make sure all gateways on the network are protected.

The most dangerous attacks are those that affect the integrity of the data. Such attacks involve changing the contents of the packets or impersonating a user. Attacks that involve eavesdropping—recording conversations and replaying them later without impersonating a user—do not compromise data integrity. These attacks do affect privacy, however. You can protect the privacy of sensitive information by encrypting data that goes over the network.

Authentication and Authorization

Authentication is a way to restrict access to specific users when accessing a remote system, which can be set up at both the system or network level. Once a user gains access to a remote system, *authorization* is a way to restrict operations that the user can perform on the remote system. Table 12-4 lists the types of authentications and authorizations that can help protect your systems on the network against unauthorized use.

TABLE 12-4 Types of Authentication and Authorization

Type	Description	Where to Find Information
NIS+	The NIS+ name service can provide both authentication and authorization at the network level.	<i>Solaris Naming Administration Guide</i>
Remote Login Programs	The remote login programs (<code>rlogin</code> , <code>rsh</code> , <code>rftp</code>) enable users to log in to a remote system over the network and use its resources. If you are a “trusted host,” authentication is automatic; otherwise, you are asked to authenticate yourself.	Chapter 8
Secure RPC	Secure RPC improves the security of network environments by authenticating users who make requests on remote systems. You can use either the UNIX, DES, or Kerberos authentication system for Secure RPC.	<i>NFS Administration Guide</i>
	Secure RPC can also be used to provide additional security to the NFS [™] environment, called Secure NFS.	“NFS Services and Secure RPC” on page 304
DES Encryption	The Data Encryption Standard (DES) encryption functions use a 56-bit key to encrypt a secret key.	“DES Encryption” on page 304
Diffie-Hellman Authentication	This authentication method is based on the ability of the sending system to use the common key to encrypt the current time, which the receiving system can decrypt and check against its current time.	“Diffie-Hellman Authentication” on page 305
Kerberos Version 4	Kerberos uses DES encryption to authenticate a user when logging in to the system.	“Kerberos Version 4” on page 308
Solstice AdminSuite	The Solstice AdminSuite product provides authentication and authorization mechanisms to remotely manage systems with the AdminSuite tools.	<i>Solstice AdminSuite 2.3 Administration Guide</i>

Sharing Files

A network file server can control which files are available for sharing. It can also control which clients have access to the files, and what type of access is permitted to those clients. In general, the file server can grant read/write or read-only access either to all clients or to specific clients. Access control is specified when resources are made available with the `share` command.

A server can use the `/etc/dfs/dfstab` file to list the file systems it makes available to clients on the network. See the *NFS Administration Guide* for more information about sharing files.

Restricting Superuser (Root) Access

In general, superuser is not allowed root access to file systems shared across the network. Unless the server specifically grants superuser privileges, a user who is logged in as superuser on a client cannot gain root access to files that are remotely mounted on the client. The NFS system implements this by changing the user ID of the requester to the user ID of the user name, `nobody`; this is generally `60001`. The access rights of user `nobody` are the same as those given to the public (or a user without credentials) for a particular file. For example, if the public has only execute permission for a file, then user `nobody` can only execute that file.

An NFS server can grant superuser privileges on a shared file system on a per-host basis, using the `root=hostname` option to the `share` command.

Using Privileged Ports

If you do not want to run Secure RPC, a possible substitute is the Solaris “privileged port” mechanism. A privileged port is built up by the superuser with a port number of less than 1024. After a client system has authenticated the client’s credential, it builds a connection to the server via the privileged port. The server then verifies the client credential by examining the connection’s port number.

Non-Solaris clients however may not be able to communicate via the privileged port. If they cannot, you will see error messages such as these:

```
''Weak Authentication
NFS request from unprivileged port''
```

Using Automated Security Enhancement Tool (ASET)

The ASET security package provides automated administration tools that enable you to control and monitor your system's security. You specify a security level—low, medium, or high—at which ASET will run. At each higher level, ASET's file-control functions increase to reduce file access and tighten your system security.

See Chapter 16 for more information.

Securing Files (Tasks)

This chapter describes the procedures for securing files. This is a list of the step-by-step instructions in this chapter.

- “How to Display File Information” on page 267
- “How to Change the Owner of a File” on page 269
- “How to Change Group Ownership of a File” on page 270
- “How to Change Permissions in Absolute Mode” on page 274
- “How to Change Permissions in Symbolic Mode” on page 276
- “How to Change Special Permissions in Absolute Mode” on page 275
- “How to Find Files With `setuid` Permissions” on page 277
- “How to Set an ACL on a File” on page 283
- “How to Disable Programs From Using Executable Stacks” on page 279
- “How to Check If a File Has an ACL” on page 285
- “How to Modify ACL Entries on a File” on page 286
- “How to Delete ACL Entries From a File” on page 287
- “How to Display ACL Entries for a File” on page 288

File Security Features

This section describes the features that constitute a file’s security.

User Classes

For each file, there are three classes of users that specify the levels of security:

- The file or directory owner—usually the user who created the file. The owner of a file can decide who has the right to read it, to write to it (make changes to it), or, if it is a command, to execute it.
- Members of a group.
- All others who are not the file or group owner.

Only the owner of the file or root can assign or modify file permissions.

File Permissions

Table 13-1 lists and describes the permissions you can give to each user class for a file.

TABLE 13-1 File Permissions

Symbol	Permission	Means Designated Users ...
r	Read	Can open and read the contents of a file.
w	Write	Can write to the file (modify its contents), add to it, or delete it.
x	Execute	Can execute the file (if it is a program or shell script), or run it with one of the <code>exec(1)</code> system calls.
-	Denied	Cannot read, write, or execute the file.

These file permissions apply to special files such as devices, sockets, and named pipes (FIFOs), as they do to regular files.

For a symbolic link, the permissions that apply are those of the file the link points to.

Directory Permissions

Table 13-2 lists and describes the permissions you can give to each user class for a directory.

TABLE 13-2 Directory Permissions

Symbol	Permission	Means Designated Users Can ...
r	Read	List files in the directory.
w	Write	Add or remove files or links in the directory.
x	Execute	Open or execute files in the directory. Also can make the directory and the directories beneath it current.

You can protect the files in a directory (and in its subdirectories) by disallowing access to that directory. Note, however, that superuser has access to all files and directories on the system.

Special File Permissions (setuid, setgid and Sticky Bit)

Three special types of permissions are available for executable files and public directories. When these permissions are set, any user who runs that executable file assumes the user ID of the owner (or group) of the executable file.

You must be extremely careful when setting special permissions, because special permissions constitute a security risk. For example, a user can gain superuser permission by executing a program that sets the user ID to root. Also, all users can set special permissions for files they own, which constitutes another security concern.

You should monitor your system for any unauthorized use of the `setuid` and `setgid` permissions to gain superuser privileges. See “How to Find Files With `setuid` Permissions” on page 277 to search for the file systems and print out a list of all programs using these permissions. A suspicious listing would be one that grants ownership of such a program to a user rather than to `bin` or `sys`.

setuid Permission

When set-user identification (`setuid`) permission is set on an executable file, a process that runs this file is granted access based on the owner of the file (usually root), rather than the user who is running the executable file. This allows a user to access files and directories that are normally only available to the owner. For example, the `setuid` permission on the `passwd` command makes it possible for a user to change passwords, assuming the permissions of the root ID:

```
-r-sr-sr-x 1 root sys 10332 May  3 08:23 /usr/bin/passwd
```

This presents a security risk, because some determined users can find a way to maintain the permissions granted to them by the `setuid` process even after the process has finished executing.

Note - Using `setuid` permissions with the reserved UIDs (0-99) from a program may not set the effective UID correctly. Use a shell script instead or avoid using the reserved UIDs with `setuid` permissions.

setgid Permission

The set-group identification (`setgid`) permission is similar to `setuid`, except that the process's effective group ID (GID) is changed to the group owner of the file, and a user is granted access based on permissions granted to that group. The `/usr/bin/mail` program has `setgid` permissions:

```
-r-x--s--x 1 bin mail 62504 May  3 07:58 /usr/bin/mail
```

When `setgid` permission is applied to a directory, files created in this directory belong to the group the directory belongs to, not the group the creating process belongs to. Any user who has write and execute permissions in the directory can create a file there—however, the file will not belong to the group of the user, but will belong to the group of the directory.

You should monitor your system for any unauthorized use of the `setuid` and `setgid` permissions to gain superuser privileges. See “How to Find Files With `setuid` Permissions” on page 277 to search for the file systems and print out a list of all programs using these permissions. A suspicious listing would be one that grants ownership of such a program to a user rather than to `bin` or `sys`.

Sticky Bit

The *sticky bit* is a permission bit that protects the files within a directory. If the directory has the sticky bit set, a file can be deleted only by the owner of the file, the owner of the directory, or by root. This prevents a user from deleting other users' files from public directories such as `/tmp`:

```
drwxrwxrwt 7 sys sys 517 Mar  6 02:01 tmp
```

Be sure to set the sticky bit manually when you set up a public directory on a TMPFS file system.

Default umask

When you create a file or directory, it has a default set of permissions. These default permissions are determined by the value of `umask(1)` in the system file `/etc/profile`, or in your `.cshrc` or `.login` file. By default, the system sets the permissions on a text file to `666`, granting read and write permission to user, group, and others, and to `777` on a directory or executable file.

The value assigned by `umask` is subtracted from the default. This has the effect of denying permissions in the same way that `chmod` grants them. For example, while the command `chmod 022` grants write permission to group and others, `umask 022` denies write permission for group and others.

Table 13–3 shows some typical `umask` settings, and the effect on an executable file.

TABLE 13–3 `umask` Settings for Different Security Levels

Level of Security	umask	Disallows
Permissive (744)	022	w for group and others
Moderate (740)	027	w for group, rwx for others
Moderate (741)	026	w for group, rw for others
Severe (700)	077	rwx for group and others

Displaying File Information

This section describes how to display file information.

▼ How to Display File Information

Display information about all the files in a directory by using the `ls` command.

```
$ ls -la
```

- l Displays the long format.
- a Displays all files, including hidden files that begin with a dot (.).

Each line in the display has the following information about a file:

- Type of file
 - A file can be one of six types. Table 13-4 lists the possible file types.

TABLE 13-4 File Types

Symbol	Type
-	Text or program
d	Directory
b	Block special file
c	Character special file
p	Named pipe (FIFO)
l	Symbolic link

- Permissions; see Table 13-1 and Table 13-2 for descriptions
- Number of hard links
- Owner of the file
- Group of the file
- Size of the file, in bytes
- Date the file was created or the last date it was changed
- Name of the file

Example—Displaying File Information

The following example displays the partial list of the files in the `/sbin` directory.

```
$ cd /sbin
$ ls -la
total 11652
drwxrwxr-x  2 root    sys      512 Jun  2 11:47 ./
drwxr-xr-x 30 root    root     512 Jun  3 14:13 ../
-r-xr-xr-x  1 bin     bin     199224 May  6 21:23 autopush*
lrwxrwxrwx  1 root    root     21 Jun  2 11:47 bpgetfile -> ...
-r-xr-xr-x  1 bin     bin     467856 May  6 21:23 dhcpageant*
-r-xr-xr-x  1 bin     bin     430172 May  6 21:23 dhcpcinfo*
-r-xr-xr-x  1 bin     bin     251500 May  6 21:23 fdisk*
-r-xr-xr-x  1 bin     bin     762136 May  6 21:29 hostconfig*
-r-xr-xr-x  1 bin     bin     533272 May  6 21:30 ifconfig*
-r-xr-xr-x  1 root    sys     515296 May  6 21:25 init*
-r-xr-xr-x  2 bin     root    256272 May  6 21:27 jsh*
-r-xr-xr-x  1 bin     bin     223448 May  7 20:06 mount*
-r-xr-xr-x  1 root    sys     6935 Jan  1 1970 mountall*
.
.
.
```

Changing File Ownership

This section describes how to change the ownership of a file.

▼ How to Change the Owner of a File

1. Become superuser.

By default, the owner cannot use the `chown` command to change the owner of a file or directory. However, you can enable the owner to use `chown` by adding the following line to the system's `/etc/system` file and rebooting the system.

```
set rstchown = 0
```

See `chown(1)` for more details. Also, be aware that there may be other restrictions on changing ownership on NFS-mounted file systems.

2. Change the owner of a file by using the `chown` command.

```
# chown newowner filename
```

<i>newowner</i>	Specifies the user name or UID of the new owner of the file or directory.
<i>filename</i>	Specifies the file or directory.

3. Verify the owner of the file is changed.

```
# ls -l filename
```

Example—Changing the Owner of a File

The following example sets the ownership on `myfile` to the user `rimmer`.

```
# chown rimmer myfile
# ls -l myfile
-rw-r--r-- 1 rimmer  scifi  112640 May 24 10:49 myfile
```

▼ How to Change Group Ownership of a File

1. Become superuser.

By default, the owner can only use the `chgrp` command to change the group of a file to a group in which the owner belongs. For example, if the owner of a file only belongs to the `staff` and `sysadm` groups, the owner can only change the group of a file to `staff` or `sysadm` group.

However, you can enable the owner to change the group of a file to a group in which the owner doesn't belong by adding the following line to the system's `/etc/system` file and rebooting the system.

```
set rstchown = 0
```

See `chgrp(1)` for more details. Also, be aware that there may be other restrictions on changing groups on NFS-mounted file systems.

2. Change the group owner of a file by using the `chgrp` command.

```
$ chgrp group filename
```

<i>group</i>	Specifies the group name or GID of the new group of the file or directory.
<i>filename</i>	Specifies the file or directory.

See Chapter 13 for information about how to edit group accounts.

3. Verify the group owner of the file is changed.

```
$ ls -l filename
```

Example—Changing Group Ownership of a File

The following example sets the group ownership on `myfile` to the group `scifi`.

```
$ chgrp scifi myfile
$ ls -l myfile
-rwxr-- 1 rimmer scifi 12985 Nov 12 16:28 myfile
```

Changing File Permissions

The `chmod` command enables you to change the permissions on a file. You must be superuser or the owner of a file or directory to change its permissions.

You can use the `chmod` command to set permissions in either of two modes:

- **Absolute Mode** - Use numbers to represent file permissions (the method most commonly used to set permissions). When you change permissions by using the absolute mode, represent permissions for each triplet by an octal mode number.
- **Symbolic Mode** - Use combinations of letters and symbols to add or remove permissions.

Table 13-5 lists the octal values for setting file permissions in absolute mode. You use these numbers in sets of three to set permissions for owner, group, and other (in that order). For example, the value `644` sets read/write permissions for owner, and read-only permissions for group and other.

TABLE 13-5 Setting File Permissions in Absolute Mode

Octal Value	File Permissions Set	Permissions Description
0	---	No permissions
1	--x	Execute permission only
2	-w-	Write permission only
3	-wx	Write and execute permissions
4	r--	Read permission only
5	r-x	Read and execute permissions
6	rw-	Read and write permissions
7	rxw	Read, write, and execute permissions

You can set special permissions on a file in absolute or symbolic modes. In absolute mode, you set special permissions by adding a new octal value to the left of the permission triplet. Table 13-6 lists the octal values to set special permissions on a file.

TABLE 13-6 Setting Special Permissions in Absolute Mode

Octal Value	Special Permissions Set
1	Sticky bit
2	setguid
4	setuid

Table 13-7 lists the symbols for setting file permissions in symbolic mode. Symbols can specify whose permissions are to be set or changed, the operation to be performed, or the permissions being assigned or changed.

TABLE 13-7 Setting File Permissions in Symbolic Mode

Symbol	Function	Description
u	Who	User (owner)
g	Who	Group
o	Who	Others
a	Who	All
=	Operation	Assign
+	Operation	Add
-	Operation	Remove
r	Permission	Read
w	Permission	Write
x	Permission	Execute
l	Permission	Mandatory locking, <code>setgid</code> bit is on, group execution bit is off
s	Permission	<code>setuid</code> or <code>setgid</code> bit is on
S	Permission	<code>suid</code> bit is on, user execution bit is off
t	Permission	Sticky bit is on, execution bit for others is on
T	Permission	Sticky bit is on, execution bit for others is off

The *who operator permission* designations in the function column specifies the symbols that change the permissions on the file or directory.

<i>who</i>	Specifies whose permissions are changed.
<i>operator</i>	Specifies the operation to perform.
<i>permissions</i>	Specifies what permissions are changed.

▼ How to Change Permissions in Absolute Mode

1. If you are not the owner of the file or directory, become superuser.

Only the current owner or superuser can use the `chmod` command to change file permissions on a file or directory.

2. Change permissions in absolute mode by using the `chmod` command.

```
$ chmod nnn filename
```

nnn Specifies the octal values that represent the permissions for the file owner, file group, and others, in that order. See Table 13-5 for the list of valid octal values.

filename Specifies the file or directory.

Note - If you use `chmod` to change the file group permissions on a file with ACL entries, both the file group permissions and the ACL mask are changed to the new permissions. Be aware that the new ACL mask permissions may change the effective permissions for additional users and groups who have ACL entries on the file. Use the `getfacl(1)` command to make sure the appropriate permissions are set for all ACL entries.

3. Verify the permissions of the file have changed.

```
$ ls -l filename
```

Example—Changing Permissions in Absolute Mode

The following example shows changing the permissions of a public directory from 744 (read/write/execute, read-only, and read-only) to 755 (read/write/execute, read/execute, and read/execute).

```
$ ls -ld public_dir
drwxr--r-- 1 ignatz  staff   6023 Aug  5 12:06 public_dir
$ chmod 755 public_dir
$ ls -ld public_dir
drwxr-xr-x 1 ignatz  staff   6023 Aug  5 12:06 public_dir
```

The following example show changing the permissions of an executable shell script from read/write to read/write/execute.

```
$ ls -l my_script
-rw----- 1 ignatz  staff   6023 Aug  5 12:06 my_script
$ chmod 700 my_script
$ ls -l my_script
-rwx----- 1 ignatz  staff   6023 Aug  5 12:06 my_script
```

▼ How to Change Special Permissions in Absolute Mode

1. If you are not the owner of the file or directory, become superuser.

Only the current owner or superuser can use the `chmod` command to change the special permissions on a file or directory.

2. Change special permissions in absolute mode by using the `chmod` command.

```
$ chmod nnnn filename
```

nnnn Specifies the octal values that change the permissions on the file or directory. The first octal value on the left sets the special permissions on the file. See Table 13-6 for the list of valid octal values for the special permissions.

filename Is the file or directory.

Note - If you use `chmod` to change the file group permissions on a file with ACL entries, both the file group permissions and the ACL mask are changed to the new permissions. Be aware that the new ACL mask permissions may change the effective permissions for additional users and groups who have ACL entries on the file. Use the `getfacl(1)` command to make sure the appropriate permissions are set for all ACL entries.

3. Verify the permissions of the file have changed.

```
$ ls -l filename
```

Examples—Setting Special Permissions in Absolute Mode

The following example sets `setuid` permission on the `dbprog` file.

```
$ chmod 4555 dbprog
$ ls -l dbprog
-r-sr-xr-x  1 db      staff      12095 May  6 09:29 dbprog
```

The following example sets `setgid` permission on the `dbprog2` file.

```
$ chmod 2551 dbprog2
$ ls -l dbprog2
-r-xr-s--x  1 db      staff      24576 May  6 09:30 dbprog2
```

The following example sets sticky bit permission on the `pubdir` directory.

```
$ chmod 1777 pubdir
```

▼ How to Change Permissions in Symbolic Mode

1. If you are not the owner of the file or directory, become superuser.

Only the current owner or superuser can use the `chmod` command to change file permissions on a file or directory.

2. Change permissions in symbolic mode by using the `chmod` command.

```
$ chmod who operator permission filename
```

who operator permission *who* specifies whose permissions are changed, *operator* specifies the operation to perform, and *permission* specifies what permissions are changed.
See Table 13-7 for the list of valid symbols.

filename Is the file or directory.

3. Verify the permissions of the file have changed.

```
$ ls -l filename
```

Examples—Changing Permissions in Symbolic Mode

The following example takes away `read` permission from others.

```
$ chmod o-r filea
```

The following example adds `read` and `execute` permissions for user, group, and others.

```
$ chmod a+rx fileb
```

The following example assigns `read`, `write`, and `execute` permissions to group.

```
$ chmod g=rwx filec
```

Searching for Special Permissions

You should monitor your system for any unauthorized use of the `setuid` and `setgid` permissions to gain superuser privileges. A suspicious listing would be one that grants ownership of such a program to a user rather than to `bin` or `sys`.

▼ How to Find Files With `setuid` Permissions

1. Become superuser.

2. Find files with `setuid` permissions set by using the `find` command.

```
# find directory -user root -perm -4000 -exec ls -ldb {} \; >/tmp/filename
```

<code>find directory</code>	Checks all mounted paths starting at the specified <i>directory</i> , which can be root (/), <code>sys</code> , <code>bin</code> , or <code>mail</code> .
<code>-user root</code>	Displays files only owned by root.
<code>-perm -4000</code>	Displays files only with permissions set to 4000.
<code>-exec ls -ldb</code>	Displays the output of the <code>find</code> command in <code>ls -ldb</code> format.
<code>>/tmp/filename</code>	Writes results to this file.

3. Display the results in `/tmp/filename`.

If you need background information about `setuid` permissions, see “`setuid` Permission” on page 265.

Example—Finding Files With `setuid` Permissions

```
# find / -user root -perm -4000 -exec ls -ldb { } \; > /tmp/ckprm
# cat /tmp/ckprm
-r-sr-xr-x 1 root bin 38836 Aug 10 16:16 /usr/bin/at
-r-sr-xr-x 1 root bin 19812 Aug 10 16:16 /usr/bin/crontab
---s--x--x 1 root sys 46040 Aug 10 15:18 /usr/bin/ct
-r-sr-xr-x 1 root sys 12092 Aug 11 01:29 /usr/lib/mv_dir
-r-sr-sr-x 1 root bin 33208 Aug 10 15:55 /usr/lib/lpadmin
-r-sr-sr-x 1 root bin 38696 Aug 10 15:55 /usr/lib/lpsched
---s--x--- 1 root rar 45376 Aug 18 15:11 /usr/rar/bin/sh
-r-sr-xr-x 1 root bin 12524 Aug 11 01:27 /usr/bin/df
-rwsr-xr-x 1 root sys 21780 Aug 11 01:27 /usr/bin/newgrp
-r-sr-sr-x 1 root sys 23000 Aug 11 01:27 /usr/bin/passwd
-r-sr-xr-x 1 root sys 23824 Aug 11 01:27 /usr/bin/su
#
```

An unauthorized user (`rar`) has made a personal copy of `/usr/bin/sh`, and has set the permissions as `setuid` to root. This means that `rar` can execute `/usr/rar/bin/sh` and become the privileged user. If you want to save this output for future reference, move the file out of the `/tmp` directory.

Executable Stacks and Security

A number of security bugs are related to default executable stacks when their permissions are set to read, write and execute. While stacks with execute permissions set are mandated by the SPARC ABI and Intel ABI, most programs can function correctly without using executable stacks.

The `noexec_user_stack` variable is available starting in the Solaris 2.6 release which enables you to specify whether stack mappings are executable or not. By default, the variable is zero, which provides ABI-compliant behavior. If the variable is set to non-zero, the system will mark the stack of every process in the system as readable and writable, but not executable.

Once this variable is set, programs that attempt to execute code on their stack will be sent a `SIGSEGV` signal, which usually results in the program terminating with a core dump. Such programs also generate a warning message that includes the name of the offending program, the process ID, and real UID of the user who ran the program. For example:

```
a.out[347] attempt to execute code on stack by uid 555
```

The message is logged by the `syslogd(1M)` daemon when the `syslog` kern facility is set to `notice` level. This logging is set by default in the `syslog.conf(4)` file, which means the message is sent to both the console and to the `/var/adm/messages` file.

This message is useful both for observing potential security problems, as well as to identify valid programs that depend upon executable stacks which have been prevented from correct operation by setting this variable. If the administrator does not want any messages logged, then the `noexec_user_stack_log` variable can be set to zero to disable it in the `/etc/system` file, though the `SIGSEGV` signal may continue to cause the executing program to core dump.

You can use `mprotect(2)` if you want programs to explicitly mark their as stack executable.

Because of hardware limitations, the capability of catching and reporting executable stack problems is only available on `sun4m`, `sun4d` and `sun4u` platforms.

▼ How to Disable Programs From Using Executable Stacks

1. **Become superuser.**
2. **Edit the `/etc/system` file and add the following line.**

```
set noexec_user_stack=1
```

3. Reboot the system.

```
# init 6
```

▼ How to Disable Executable Stack Message Logging

1. Become superuser.

2. Edit the `/etc/system` file and add the following line.

```
set noexec_user_stack_log=0
```

3. Reboot the system.

```
# init 6
```

Using Access Control Lists (ACLs)

The traditional UNIX file protection provides read, write, and execute permissions for the three user classes: file owner, file group, and other. An ACL provides better file security by enabling you to define file permissions for the file owner, file group, other, specific users and groups, and default permissions for each of those categories.

For example, if you wanted everyone in a group to be able to read a file, you would simply give group read permissions on that file. Now, assume you wanted only one person in the group to be able to write to that file. Standard UNIX doesn't provide that level of file security. However, this dilemma is perfect for ACLs.

ACL entries are the way to define an ACL on a file, and they are set through the `setfacl(1)` command. ACL entries consist of the following fields separated by colons:

```
entry_type:[uid|gid]:perms
```

<i>entry_type</i>	Type of ACL entry on which to set file permissions. For example, <i>entry_type</i> can be <code>user</code> (the owner of a file) or <code>mask</code> (the ACL mask).
<i>uid</i>	User name or identification number.
<i>gid</i>	Group name or identification number.
<i>perms</i>	Represents the permissions that are set on <i>entry_type</i> . <i>perms</i> can be indicated by the symbolic characters <code>rwX</code> or a number (the same permissions numbers used with the <code>chmod</code> command).

The following example shows an ACL entry that sets read/write permissions for the user `nathan`.

```
user:nathan:rw-
```



Caution - UFS file system attributes such as ACLs are supported in UFS file systems only. This means that if you restore or copy files with ACL entries into the `/tmp` directory, which is usually mounted as a TMPFS file system, the ACL entries will be lost. Use the `/var/tmp` directory for temporary storage of UFS files.

ACL Entries for Files

Table 13-8 lists the valid ACL entries. The first three ACL entries provide the basic UNIX file protection.

TABLE 13-8 ACL Entries for Files

ACL Entry	Description
<code>u[ser]::perms</code>	File owner permissions.
<code>g[roup]::perms</code>	File group permissions.
<code>o[ther]::perms</code>	Permissions for users other than the file owner or members of file group.

TABLE 13-8 ACL Entries for Files (continued)

ACL Entry	Description
<code>m[ask]:perms</code>	<p>The ACL mask. The mask entry indicates the maximum permissions allowed for users (other than the owner) and for groups. The mask is a quick way to change permissions on all the users and groups.</p> <p>For example, the <code>mask:r--</code> mask entry indicates that users and groups cannot have more than read permissions, even though they may have write/execute permissions.</p>
<code>u[ser]:uid:perms</code>	Permissions for a specific user. For <i>uid</i> , you can specify either a user name or a numeric UID.
<code>g[roup]:gid:perms</code>	Permissions for a specific group. For <i>gid</i> , you can specify either a group name or a numeric GID.

ACL Entries for Directories

In addition to the ACL entries described in Table 13-8, you can set default ACL entries on a directory. Files or directories created in a directory that has default ACL entries will have the same ACL entries as the default ACL entries. Table 13-9 lists the default ACL entries for directories.

When you set default ACL entries for specific users and groups on a directory for the first time, you must also set default ACL entries for the file owner, file group, others, and the ACL mask (these are required and are the first four default ACL entries in Table 13-9).

TABLE 13-9 Default ACL Entries for Directories

Default ACL Entry	Description
<code>d[efault]:u[ser]::perms</code>	Default file owner permissions.
<code>d[efault]:g[roup]::perms</code>	Default file group permissions.
<code>d[efault]:o[ther]::perms</code>	Default permissions for users other than the file owner or members of the file group.

TABLE 13-9 Default ACL Entries for Directories *(continued)*

Default ACL Entry	Description
<code>d[efault]:m[ask]:perms</code>	Default ACL mask.
<code>d[efault]:u[ser]:uid:perms</code>	Default permissions for a specific user. For <i>uid</i> , you can specify either a user name or a numeric UID.
<code>d[efault]:g[roup]:gid:perms</code>	Default permissions for a specific group. For <i>gid</i> , you can specify either a group name or a numeric GID.

▼ How to Set an ACL on a File

1. Set an ACL on a file by using the `setfacl` command.

```
$ setfacl -s user::perms,group::perms,other:perms,mask:perms,acl_entry_list
filename ...
```

<code>-s</code>	Sets an ACL on the file. If a file already has an ACL, it is replaced. This option requires at least the file owner, file group, and other entries.
<code>user::perms</code>	Specifies the file owner permissions.
<code>group::perms</code>	Specifies the file group permissions.
<code>other:perms</code>	Specifies the permissions for users other than the file owner or members of the file group.
<code>mask:perms</code>	Specifies the permissions for the ACL mask. The mask indicates the maximum permissions allowed for users (other than the owner) and for groups.

<i>acl_entry_list</i>	Is the list of one or more ACL entries to set for specific users and groups on the file or directory. You can also set default ACL entries on a directory. Table 13-8 and Table 13-9 show the valid ACL entries.
<i>filename</i>	File or directory on which to set the ACL.

2. To verify that an ACL was set on the file, see “How to Check If a File Has an ACL” on page 285. To verify which ACL entries were set on the file, use the `getfacl` command.

```
$ getfacl filename
```



Caution - If an ACL already exists on the file, the `-s` option will replace the entire ACL with the new ACL.

Examples—Setting an ACL on a File

The following example sets the file owner permissions to read/write, file group permissions to read only, and other permissions to none on the `ch1.doc` file. In addition, the user `george` is given read/write permissions on the file, and the ACL mask permissions is set to read/write, which means no user or group can have execute permissions.

```
$ setfacl -s user::rw-,group::r--,other:---,mask:rw-,user:george:rw- ch1.doc
$ ls -l
total 124
-rw-r-----+ 1 nathan  sysadmin   34816 Nov 11 14:16 ch1.doc
-rw-r--r--   1 nathan  sysadmin   20167 Nov 11 14:16 ch2.doc
-rw-r--r--   1 nathan  sysadmin    8192 Nov 11 14:16 notes
$ getfacl ch1.doc
# file: ch1.doc
# owner: nathan
# group: sysadmin
user::rw-
user:george:rw-  #effective:rw-
group::r--      #effective:r--
mask:rw-
other:---
```

The following example sets the file owner permissions to read/write/execute, file group permissions to read only, other permissions to none, and the ACL mask permissions to read on the `ch2.doc` file. In addition, the user `george` is given read/write permissions; however, due to the ACL mask, the effective permissions for `george` is only read.

```
$ setfacl -s u::7,g::4,o:0,m:4,u:george:7 ch2.doc
$ getfacl ch2.doc

# file: ch2.doc
# owner: nathan
# group: sysadmin
user::rwx
user:george:rwx          #effective:r--
group:r--                #effective:r--
mask:r--
other:---
```

▼ How to Copy an ACL

Copy a file's ACL to another file by redirecting the `getfacl` output.

```
$ getfacl filename1 | setfacl --f - filename2
```

file1 Specifies the file from which to copy the ACL.

file2 Specifies the file on which to set the copied ACL.

Example—Copying an ACL

The following example copies the ACL on `ch1.doc` to `ch3.doc`.

```
$ getfacl ch2.doc | setfacl -f - ch3.doc
```

▼ How to Check If a File Has an ACL

Check if a file has an ACL by using the `ls` command.

```
$ ls -l filename
```

filename Specifies the file or directory.

A '+' to the right of the mode field indicates the file has an ACL.

Note - Unless you have added ACL entries for additional users or groups on a file, a file is considered to be a "trivial" ACL and the '+' will not display.

Example—Checking If a File Has an ACL

The following example shows that `chl.doc` has an ACL, because the listing has a '+' to the right of the mode field.

```
$ ls -l chl.doc
-rwxr-----+ 1 nathan  sysadmin    167 Nov 11 11:13 chl.doc
```

▼ How to Modify ACL Entries on a File

1. Modify ACL entries on a file by using the `setfacl` command.

```
$ setfacl -m acl_entry_list filename1 [filename2 ...]
```

`-m` Modifies the existing ACL entry.

`acl_entry_list` Specifies the list of one or more ACL entries to modify on the file or directory. You can also modify default ACL entries on a directory. Table 13-8 and Table 13-9 show the valid ACL entries.

`filename ...` Specifies the file or directory.

2. To verify that the ACL entries were modified on the file, use the `getfacl` command.

```
$ getfacl filename
```

Examples—Modifying ACL Entries on a File

The following example modifies the permissions for the user `george` to read/write.

```

$ setfacl -m user:george:6 ch3.doc
$ getfacl ch3.doc

# file: ch3.doc
# owner: nathan
# group: staff
user::rw-
user::george:rw-   #effective:r--
group::r-           #effective:r--
mask:r--
other:r-

```

The following example modifies the default permissions for the group `staff` to read and the default ACL mask permissions to read/write on the `book` directory..

```

$ setfacl -m default:group:staff:4,default:mask:6 book

```

▼ How to Delete ACL Entries From a File

1. Delete ACL entries from a file by using the `setfacl` command.

```

$ setfacl -d acl_entry_list filename1 ...

```

<code>-d</code>	Deletes the specified ACL entries.
<code>acl_entry_list</code>	Specifies the list of ACL entries (without specifying the permissions) to delete from the file or directory. You can only delete ACL entries and default ACL entries for specific users and groups. Table 13–8 and Table 13–9 show the valid ACL entries.
<code>filename ...</code>	Specifies th file or directory.

Alternately, you can use the `setfacl -s` command to delete all the ACL entries on a file and replace them with the new ACL entries specified.

2. To verify that the ACL entries were deleted from the file, use the `getfacl` command.

```

$ getfacl filename

```

Example—Deleting ACL Entries on a File

The following example deletes the user `george` from the `ch4.doc` file.

```
$ setfacl -d user:george ch4.doc
```

▼ How to Display ACL Entries for a File

Display ACL entries for a file by using the `getfacl` command.

```
$ getfacl [-a | -d] filename1 ...
```

<code>-a</code>	Displays the file name, file owner, file group, and ACL entries for the specified file or directory.
<code>-d</code>	Displays the file name, file owner, file group, and default ACL entries for the specified directory.
<code>filename ...</code>	Specifies the file or directory.

If you specify multiple file names on the command line, the ACL entries are separated by a blank line.

Examples—Displaying ACL Entries for a File

The following example shows all the ACL entries for the `ch1.doc` file. The `#effective:` note beside the user and group entries indicates what the permissions are after being modified by the ACL mask.

```
$ getfacl ch1.doc
# file: ch1.doc
# owner: nathan
# group: sysadmin
user::rw-
user:george:r--      #effective:r--
group::rw-          #effective:rw-
mask:rw-
other:---
```

The following example shows the default ACL entries for the `book` directory.

```
$ getfacl -d book

# file: book
# owner: nathan
# group: sysadmin
user::rwx
user:george:r-x          #effective:r-x
group::rwx              #effective:rwx
mask:rwx
other:---
default:user::rw-
default:user:george:r--
default:group::rw-
default:mask:rw-
default:other:---
```

Securing Systems (Tasks)

This chapter describes the procedures for securing systems. This is a list of the step-by-step instructions in this chapter.

- “How to Display a User’s Login Status” on page 291
- “How to Display Users Without Passwords” on page 293
- “How to Temporarily Disable User Logins” on page 294
- “How to Save Failed Login Attempts” on page 295
- “How to Create a Dial-Up Password” on page 298
- “How to Temporarily Disable Dial-up Logins” on page 300
- “How to Restrict Superuser (root) Login to the Console” on page 300
- “How to Monitor Who Is Using the `su` Command” on page 301
- “How to Display Superuser (root) Access Attempts to the Console” on page 302

For overview information about securing systems, see “System Security” on page 252.

Displaying Security Information

This section describes how to display user login information.

▼ How to Display a User’s Login Status

1. **Become superuser.**
2. **Display a user’s login status by using the `logins` command.**

```
# logins -x -l username
```

`-x` Displays an extended set of login status information.

`-l username` Displays login status for the specified user. *username* is a user's login name. Multiple login names must be specified as a comma-separated list.

The `logins(1M)` command uses the local `/etc/passwd` file and the NIS or NIS+ password databases to obtain a user's login status.

Example—Displaying a User's Login Status

The following example displays login status for the user `rimmer`.

```
# logins -x -l rimmer
rimmer      500      staff          10   Arnold J. Rimmer
            /export/home/rimmer
            /bin/sh
            PS 010170 10 7 -1
```

In this example,

<code>rimmer</code>	Identifies the user's login name.
<code>500</code>	Identifies the UID (user ID).
<code>staff</code>	Identifies the user's primary group.
<code>10</code>	Identifies the GID (group ID).
<code>Arnold J. Rimmer</code>	Identifies the comment.
<code>/export/home/rimmer</code>	Identifies the user's home directory.

<code>/bin/sh</code>	Identifies the login shell.
<code>PS 010170 10 7 -1</code>	Specifies the password aging information: <ul style="list-style-type: none"> • Last date password was changed • Number of days required between changes • Number of days allowed before a change is required • Warning period

▼ How to Display Users Without Passwords

You should make sure that all users have a valid password.

1. **Become superuser.**
2. **Display users who have no passwords by using the `logins` command.**

```
# logins -p
```

`-p` Displays a list of users with no passwords.

The `logins` command uses the local `/etc/passwd` file and the NIS or NIS+ password databases to obtain a user's login status.

Example—Displaying Users With No Passwords

The following example displays that the user `pmorph` does not have a password.

```
# logins -p
pmorph      501      other          1      Polly Morph
#
```

Temporarily Disabling User Logins

You can temporarily disable user logins by:

- Creating the `/etc/nologin` file.
- Bringing the system to run level 0 (single-user mode). See “Shutting Down a System (Tasks)” in *System Administration Guide, Volume I* for information on bringing the system to single-user mode.

Creating the `/etc/nologin` File

Create this file to disallow user logins and notify users when a system will be unavailable for an extended period of time due to a system shut down or routine maintenance.

If a user attempts to log in to a system where this file exists, the contents of the `nologin(4)` file is displayed, and the user login is terminated. Superuser logins are not affected.

▼ How to Temporarily Disable User Logins

1. **Become superuser.**
2. **Create the `/etc/nologin` file using an editor.**

```
# vi /etc/nologin
```

3. **Include a message regarding system availability.**
4. **Close and save the file.**

Example—Disabling User Logins

This example shows how to notify users of system unavailability.

```
# vi /etc/nologin
(Add system message here)

# cat /etc/nologin
***No logins permitted.***

***The system will be unavailable until 12 noon.***
```

Saving Failed Login Attempts

You can save failed login attempts by creating the `/var/adm/loginlog` file with read and write permission for root only. After you create the `loginlog` file, all failed login activity will be written to this file automatically after five failed attempts. See “How to Save Failed Login Attempts” on page 295 for detailed instructions.

The `loginlog` file contains one entry for each failed attempt. Each entry contains the user’s login name, tty device, and time of the failed attempt. If a person makes fewer than five unsuccessful attempts, none of the attempts are logged.

The `loginlog` file may grow quickly. To use the information in this file and to prevent the file from getting too large, you must check and clear its contents occasionally. If this file shows a lot of activity, it may suggest an attempt to break into the computer system. For more information about this file, see `loginlog(4)`.

▼ How to Save Failed Login Attempts

1. **Become superuser.**
2. **Create the `loginlog` file in the `/var/adm` directory.**

```
# touch /var/adm/loginlog
```

3. **Set read and write permissions for root on the `loginlog` file.**

```
# chmod 600 /var/adm/loginlog
```

4. **Change group membership to `sys` on the `loginlog` file.**

```
# chgrp sys /var/adm/loginlog
```

5. **Make sure the log works by attempting to log into the system five times with the wrong password after the `loginlog` file is created. Then display the `/var/adm/loginlog` file.**

```
# more /var/adm/loginlog
pmorph:/dev/pts/4:Mon Jun  8 11:08:27 1998
pmorph:/dev/pts/4:Mon Jun  8 11:08:49 1998
pmorph:/dev/pts/4:Mon Jun  8 11:09:03 1998
pmorph:/dev/pts/4:Mon Jun  8 11:09:22 1998
pmorph:/dev/pts/4:Mon Jun  8 11:09:36 1998
#
```

Password Protection Using Dial-Up Passwords

You can add a layer of security to your password mechanism by requiring a *dial-up password* for users who access a system through a modem or dial-up port. A dial-up password is an additional password that a user must enter before being granted access to the system.

Only superuser can create or change a dial-up password. To ensure the integrity of the system, the password should be changed about once a month. The most effective use of this mechanism is to require a dial-up password to gain access to a gateway system.

Two files are involved in creating a dial-up password, `/etc/dialups` and `/etc/d_passwd`. The first contains a list of ports that require a dial-up password, and the second contains a list of shell programs that require an encrypted password as the additional dial-up password.

The `dialups(4)` file is a list of terminal devices, for example:

```
/dev/term/a  
/dev/term/b
```

The `d_passwd(4)` file has two fields. The first is the login shell that will require a password, and the second is the encrypted password. The `/etc/dialups` and `/etc/d_passwd` files work like this:

When a user attempts to log in on any of the ports listed in `/etc/dialups`, the login program looks at the user's login entry stored in `/etc/passwd`, and compares the login shell to the entries in `/etc/d_passwd`. These entries determine whether the user will be required to supply the dial-up password.

```
/usr/lib/uucp/uucico: encrypted_password:  
/usr/bin/csh: encrypted_password:  
/usr/bin/ksh: encrypted_password:  
/usr/bin/sh: encrypted_password:
```

The basic dial-up password sequence is shown in Figure 14-1.

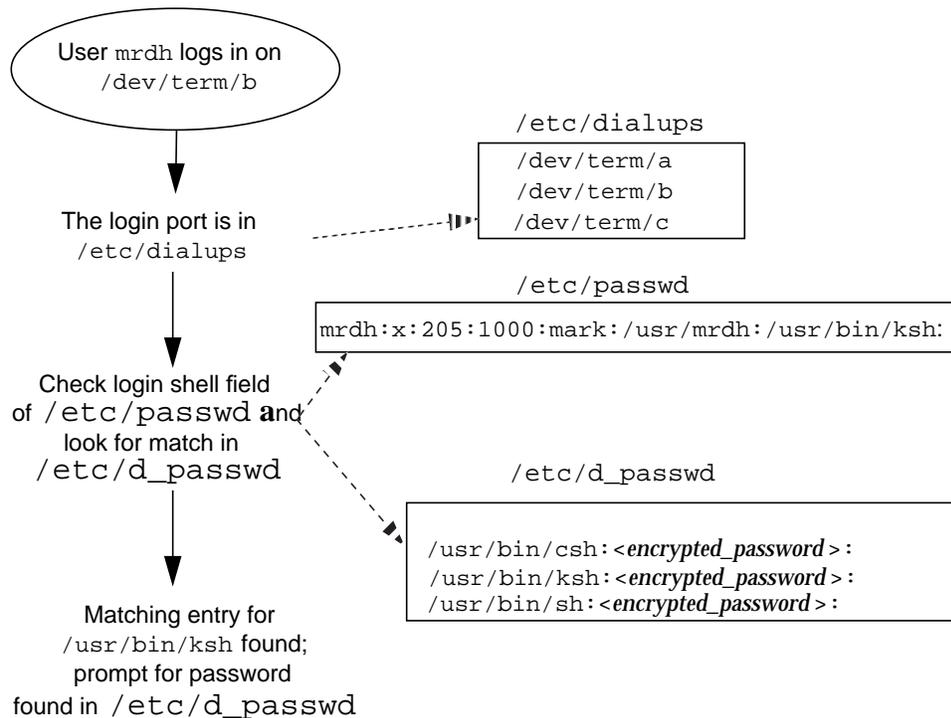


Figure 14-1 Basic Dial-Up Password Sequence

The `/etc/d_passwd` File

Because most users will be running a shell when they log in, all shell programs should have entries in `/etc/d_passwd`. Such programs include `uucico`, `sh`, `ksh`, and `csch`. If some users run something else as their login shell, include that login shell in the file, too.

If the user's login program (as specified in `/etc/passwd`) is not found in `/etc/d_passwd`, or if the login shell field in `/etc/passwd` is null, the password entry for `/usr/bin/sh` is used.

- If the user's login shell in `/etc/passwd` matches an entry in `/etc/d_passwd`, the user must supply a dial-up password.
- If the user's login shell in `/etc/passwd` is not found in `/etc/d_passwd`, the user must supply the default password. The default password is the entry for `/usr/bin/sh`.
- If the login shell field in `/etc/passwd` is empty, the user must supply the default password (the entry for `/usr/bin/sh`).
- If `/etc/d_passwd` has no entry for `/usr/bin/sh`, then those users whose login shell field in `/etc/passwd` is empty or does not match any entry in `/etc/d_passwd` will not be prompted for a dial-up password.

- Dial-up logins are disabled if `/etc/d_passwd` has only the following entry:
`/usr/bin/sh:*`

▼ How to Create a Dial-Up Password



Caution - When you first establish a dial-up password, be sure to remain logged in on at least one terminal while testing the password on a different terminal. If you make a mistake while installing the extra password and log off to test the new password, you might not be able to log back on. If you are still logged in on another terminal, you can go back and fix your mistake.

1. **Become superuser.**
2. **Create an `/etc/dialups` file containing a list of terminal devices, including all the ports that will require dial-up password protection.**

The `/etc/dialups` file should look like this:

```
/dev/term/a  
  
/dev/term/b  
  
/dev/term/c
```

3. **Create an `/etc/d_passwd` file containing the login programs that will require a dial-up password, and the encrypted dial-up password.**

Include shell programs that a user could be running at login, for example, `uucico`, `sh`, `ksh`, and `csh`. The `/etc/d_passwd` file should look like this:

```
/usr/lib/uucp/uucico:encrypted_password:  
  
/usr/bin/csh:encrypted_password:  
  
/usr/bin/ksh:encrypted_password:  
  
/usr/bin/sh:encrypted_password:
```

4. **Set ownership to `root` on the two files.**

```
# chown root /etc/dialups /etc/d_passwd
```

5. Set group ownership to `root` on the two files.

```
# chgrp root /etc/dialups /etc/d_passwd
```

6. Set read and write permissions for `root` on the two files.

```
# chmod 600 /etc/dialups /etc/d_passwd
```

7. Create the encrypted passwords.

- a. Create a temporary user.

```
# useradd user-name
```

- b. Create a password for the temporary user.

```
# passwd user-name
```

- c. Capture the encrypted password.

```
# grep user-name /etc/shadow > user-name.temp
```

- d. Edit the `user-name.temp` file.

Delete all fields except the encrypted password (the second field).
For example, in the following line, the encrypted password is
`U9gp9SyA/JlSk`.

```
temp:U9gp9SyA/JlSk:7967:::::7988:
```

- e. Delete the temporary user.

```
# userdel user-name
```

8. Copy the encrypted password from `user-name.temp` file into the `/etc/d_passwd` file.

You can create a different password for each login shell, or use the same one for each.

▼ How to Temporarily Disable Dial-up Logins

1. **Become superuser.**
2. **Put the following entry by itself into the `/etc/d_passwd` file:**

```
/usr/bin/sh:*:
```

Restricting Superuser (root) Access on the Console

The superuser account is used by the operating system to accomplish basic functions, and has wide-ranging control over the entire operating system. It has access to and can execute essential system programs. For this reason, there are almost no security restraints for any program that is run by superuser.

You can protect the superuser account on a system by restricting access to a specific device through the `/etc/default/login` file. For example, if superuser access is restricted to the console, you can log in to a system as superuser only from the console. If anybody remotely logs in to the system to perform an administrative function, they must first log in with their user login and then use the `su(1M)` command to become superuser. See “How to Restrict Superuser (root) Login to the Console” on page 300 for detailed instructions.

Note - Restricting superuser login to the console is set up by default when you install a system.

▼ How to Restrict Superuser (root) Login to the Console

1. **Become superuser.**
2. **Edit the `/etc/default/login` file.**
3. **Uncomment the following line.**

```
CONSOLE=/dev/console
```

Any users who try to remotely log in to this system must first log in with their user login, and then use the `su` command to become superuser.

4. **Attempt to log in remotely as superuser to this system, and verify that the operation fails.**

Monitoring Who Is Using the `su` Command

You can start monitoring `su` attempts through the `/etc/default/su` file. Through this file, you can enable the `/var/adm/sulog` file to monitor each time the `su` command is used to change to another user. See “How to Monitor Who Is Using the `su` Command” on page 301 for step-by-step instructions.

The `sulog` file lists all uses of the `su` command, not only those used to switch user to superuser. The entries show the date and time the command was entered, whether or not it was successful (+ or -), the port from which the command was issued, and finally, the name of the user and the switched identity.

Through the `/etc/default/su` file, you can also set up the system to display on the console each time an attempt is made to use the `su` command to gain superuser access from a remote system. This is a good way to immediately detect someone trying to gain superuser access on the system you are currently working on. See “How to Display Superuser (`root`) Access Attempts to the Console” on page 302 for detailed instructions.

▼ How to Monitor Who Is Using the `su` Command

1. **Become superuser.**
2. **Edit the `/etc/default/su` file.**
3. **Uncomment the following line.**

```
SULOG=/var/adm/sulog
```

4. **After modifying the `/etc/default/su` file, use the `su` command several times and display the `/var/adm/sulog` file. You should see an entry for each time you used the `su` command.**

```
# more /var/adm/sulog
SU 12/20 16:26 + pts/0 nathan-root
SU 12/21 10:59 + pts/0 nathan-root
SU 01/12 11:11 + pts/0 root-joebob
SU 01/12 14:56 + pts/0 pmorph-root
SU 01/12 14:57 + pts/0 pmorph-root
```

▼ How to Display Superuser (root) Access Attempts to the Console

1. **Become superuser.**
2. **Edit the `/etc/default/su` file.**
3. **Uncomment the following line.**

```
CONSOLE=/dev/console
```

4. **Use the `su` command to become root, and verify that a message is printed on the system console.**

Using Authentication Services (Tasks)

The first section of this chapter provides information about the authentication mechanisms that may be used with Secure RPC. Both Diffie-Hellman and Kerberos Version 4 authentication are supported. The second section covers the Pluggable Authentication Module (PAM) framework. PAM provides a method to “plug-in” authentication services and provides support for multiple authentication services.

This is a list of the step-by-step instructions in this chapter.

- “How to Set Up NIS+ Credentials for Diffie-Hellman Authentication” on page 310
- “How to Set Up NIS Credentials with Diffie-Hellman Authentication” on page 312
- “How to Share and Mount Files With Diffie-Hellman Authentication” on page 314
- “How to Share and Mount Files With Kerberos Authentication” on page 315
- “How to Acquire a Kerberos Ticket for Superuser on a Client” on page 315
- “How to Log In to Kerberos Service” on page 316
- “How to Access a Directory With Kerberos Authentication” on page 317
- “How to Add a PAM Module” on page 329
- “How to Prevent Unauthorized Access from Remote Systems with PAM” on page 329
- “How to Initiate PAM Error Reporting” on page 329

Overview of Secure RPC

Secure RPC is a method of authentication that authenticates both the host and the user making a request. Secure RPC uses either Diffie-Hellman or Kerberos

authentication. Both of these authentication mechanisms use DES encryption. Applications that use Secure RPC include NFS and the NIS+ name service.

NFS Services and Secure RPC

The NFS software enables several hosts to share files over the network. Under the NFS system, a server holds the data and resources for several clients. The clients have access to the file systems that the server exports to the clients. Users logged in to the client machine can access the file systems by mounting them from the server. To the user on the client machine, it appears as if the files were local to the client. One of the most common uses of the NFS environment is to allow systems to be installed in offices, while keeping all user files in a central location. Some features of the NFS system, such as the `mount -nosuid` option, can be used to prohibit the opening of devices as well as file systems by unauthorized users.

The NFS environment uses Secure RPC to authenticate users who make requests over the network. This is known as Secure NFS. The authentication mechanism, `AUTH_DH`, uses DES encryption with Diffie-Hellman authentication to ensure authorized access. The `AUTH_DH` mechanism has also been called `AUTH_DES`. The `AUTH_KERB4` mechanism uses DES encryption with Kerberos authentication. This mechanism is has also been called `AUTH_KERB`.

The *NFS Administration Guide* describes how to set up and administer Secure NFS. Setting up the NIS+ tables and entering names in the `cred` table are discussed in *Solaris Naming Administration Guide*. See “Implementation of Diffie-Hellman Authentication” on page 305 for an outline of the steps involved in RPC authentication.

DES Encryption

The Data Encryption Standard (DES) encryption functions use a 56-bit key to encrypt a secret key. If two credential users (or principals) know the same DES key, they can communicate in private, using the key to encipher and decipher text. DES is a relatively fast encryption mechanism. A DES chip makes the encryption even faster; but if the chip is not present, a software implementation is substituted.

The risk of using just the DES key is that, with enough time, an intruder can collect enough cipher-text messages encrypted with the same key to be able to discover the key and decipher the messages. For this reason, security systems such as Secure NFS change the keys frequently.

Diffie-Hellman Authentication

The Diffie-Hellman method of authenticating a user is non-trivial for an intruder to crack. The client and the server each has its own private key (sometimes called a secret key) which they use together with the public key to devise a common key. They use the common key to communicate with each other, using an agreed-upon encryption/decryption function (such as DES). This method was identified as DES authentication in previous Solaris releases.

Authentication is based on the ability of the sending system to use the common key to encrypt the current time, which the receiving system can decrypt and check against its current time. Make sure you synchronize the time on the client and the server.

The public and private keys are stored in an NIS or NIS+ database. NIS stores the keys in the `publickey` map, and NIS+ stores the keys in the `cred` table. These files contain the public key and the private key for all potential users.

The system administrator is responsible for setting up NIS or NIS+ tables and generating a public key and a private key for each user. The private key is stored encrypted with the user's password. This makes the private key known only to the user.

Implementation of Diffie-Hellman Authentication

This section describes the series of transactions in a client-server session using DH authorization (`AUTH_DH`).

Generating the Public and Secret Keys

Sometime prior to a transaction, the administrator runs either the `newkey` or `nisaddcred` commands that generates a public key and a secret key. (Each user has a unique public key and secret key.) The public key is stored in a public database; the secret key is stored in encrypted form in the same database. To change the key pair, use the `chkey` command.

Running the `keylogin` Command

Normally, the login password is identical to the secure RPC password. In this case, a `keylogin` is not required. If the passwords are different, the users have to log in, and then do a `keylogin` explicitly.

The `keylogin` program prompts the user for a secure RPC password and uses the password to decrypt the secret key. The `keylogin` program then passes the decrypted secret key to a program called the `keyserver`. (The `keyserver` is an RPC service with a local instance on every computer.) The `keyserver` saves the decrypted secret key and waits for the user to initiate a secure RPC transaction with a server.

If the passwords are the same, the login process passes the secret key to the keyserver. If the passwords are required to be different and the user must always run `keylogin`, then the `keylogin` program may be included in the user's environment configuration file, such as `~/.login`, `~/.cshrc`, or `~/.profile`, so that it runs automatically whenever the user logs in.

Generating the Conversation Key

When the user initiates a transaction with a server:

1. The keyserver randomly generates a conversation key.
2. The kernel uses the conversation key to encrypt the client's time stamp (among other things).
3. The keyserver looks up the server's public key in the public-key database (see the `publickey(4)` man page).
4. The keyserver uses the client's secret key and the server's public key to create a common key.
5. The keyserver encrypts the conversation key with the common key.

First Contact with the Server

The transmission including the encrypted time stamp and the encrypted conversation key is then sent to the server. The transmission includes a credential and a verifier. The credential contains three components:

- The client's net name
- The conversation key, encrypted with the common key
- A "window," encrypted with the conversation key

The window is the difference the client says should be allowed between the server's clock and the client's time stamp. If the difference between the server's clock and the time stamp is greater than the window, the server would reject the client's request. Under normal circumstances this will not happen because the client first synchronizes with the server before starting the RPC session.

The client's verifier contains:

- The encrypted time stamp
- An encrypted verifier of the specified window, decremented by 1

The window verifier is needed in case somebody wants to impersonate a user and writes a program that, instead of filling in the encrypted fields of the credential and verifier, just stuffs in random bits. The server will decrypt the conversation key into some random key and use it to try to decrypt the window and the time stamp. The result will be random numbers. After a few thousand trials, however, there is a good chance that the random window/time stamp pair will pass the authentication system. The window verifier makes guessing the right credential much more difficult.

Decrypting the Conversation Key

When the server receives the transmission from the client:

1. The keyserver local to the server looks up the client's public key in the publickey database.
2. The keyserver uses the client's public key and the server's secret key to deduce the common key—the same common key computed by the client. (Only the server and the client can calculate the common key because doing so requires knowing one secret key or the other.)
3. The kernel uses the common key to decrypt the conversation key.
4. The kernel calls the keyserver to decrypt the client's time stamp with the decrypted conversation key.

Storing Information on the Server

After the server decrypts the client's time stamp, it stores four items of information in a credential table:

- The client's computer name
- The conversation key
- The window
- The client's time stamp

The server stores the first three items for future use. It stores the time stamp to protect against replays. The server accepts only time stamps that are chronologically greater than the last one seen, so any replayed transactions are guaranteed to be rejected.

Note - Implicit in these procedures is the name of the caller, who must be authenticated in some manner. The keyserver cannot use DES authentication to do this because it would create a deadlock. To solve this problem, the keyserver stores the secret keys by UID and grants requests only to local root processes.

Verifier Returned to the Client

The server returns a verifier to the client, which includes:

- The index ID, which the server records in its credential cache
- The client's time stamp minus 1, encrypted by conversation key

The reason for subtracting 1 from the time stamp is to ensure that the time stamp is invalid and cannot be reused as a client verifier.

Client Authenticates the Server

The client receives the verifier and authenticates the server. The client knows that only the server could have sent the verifier because only the server knows what time stamp the client sent.

Additional Transactions

With every transaction after the first, the client returns the index ID to the server in its second transaction and sends another encrypted time stamp. The server sends back the client's time stamp minus 1, encrypted by the conversation key.

Kerberos Version 4

Kerberos is an authentication system that was developed at the Massachusetts Institute of Technology. Kerberos uses DES encryption to authenticate a user when logging in to the system. Authentication is based on the ability of the sending system to use the common key to encrypt the current time, which the receiving system can decrypt and check against its current time. Kerberos Version 4 is supported starting in the Solaris 2.6 release.

Kerberos works by authenticating the user's login password. A user enters the `kinit` command, which acquires a ticket that is valid for the time of the session (or eight hours, the default session time) from the Kerberos authentication server. When the user logs out, the ticket can be destroyed (using the `kdestroy` command).

The Kerberos software is available from MIT project Athena, and is not part of the SunOS 5.7 software. SunOS 5.7 software provides:

- Commands and APIs used by the client to create, acquire, and verify tickets
- An authentication option to Secure RPC
- A client-side daemon, `kerbd(1M)`

"Implementation of Kerberos Authentication with NFS" on page 309 gives an overview of how the Kerberos authentication procedure works.

Note - Solaris provides the ability to connect to the Kerberos functionality. It does not provide the Kerberos package. However, you can `ftp` Kerberos 4 source from `athena-dist.mit.edu` using `anonymous` as a username and your email address as a password. The source is located in the `pub/kerberos` directory.

Implementation of Kerberos Authentication with NFS

The following process assumes that the Kerberos key distribution center (KDC) is already installed on the network, using publicly available sources from MIT project Athena.

1. The `/usr/sbin/kerbd` daemon must be running on the NFS client and server.

This daemon is normally started when needed by `inetd`. The `rpcinfo` command can be used to make sure that the `kerbd` service is registered. `kerbd` is the user-mode daemon. It interfaces with the kernel RPC and the KDC. It generates and validates authentication tickets.
2. The system administrator sets up the NFS server to use Kerberos authentication.

The MIT Kerberos software is used to register the principal names in the Kerberos key distribution center (KDC) on the Kerberos server. The following entries are required:

 - `root.hostname` (required for each NFS client)
 - `nfs.hostname` (required for each NFS server)
3. The user mounts the shared file system.

The user on the client must get a ticket for `root` on the client to mount the shared file system.
4. The user logs in to the Kerberos service, using the `kinit` command.

The Kerberos authentication server authenticates the request, and grants a ticket for the ticket-granting service.
5. The user accesses the mounted directory.

The `kerbd` daemon automatically secures a ticket on behalf of the client for the NFS server exporting the file system. At this point, there are two valid tickets, the original ticket-granting ticket and one for the server.
6. The user destroys the tickets at the end of the session to prevent them from being compromised.

The `kdestroy` command destroys the user's active Kerberos authorization tickets by writing zeros to the file that contains the tickets. You can put the `kdestroy` command in your `.logout` file, so that all Kerberos tickets are automatically destroyed when you log out of the system.
7. If tickets have been destroyed before the session has finished, the user must request a new ticket with the `kinit` command.

Administering Diffie-Hellman Authentication

A system administrator can implement policies that help secure the network. The level of security required will differ with each site. This section provides instructions for some tasks associated with network security.

▼ How to Restart the Keyserver

1. **Become superuser.**
2. **Verify that the `keyserv` daemon (the keyserver) is not running.**

```
# ps -ef | grep keyserv
root 100      1   16   Apr 11 ?        0:00 /usr/sbin/keyserv
root 2215    2211   5   09:57:28 pts/0  0:00 grep keyserv
```

3. **Start the keyserver if it isn't running.**

```
# /usr/sbin/keyserv
```

▼ How to Set Up NIS+ Credentials for Diffie-Hellman Authentication

For detailed description of NIS+ security, see *Solaris Naming Administration Guide*.

To set up a new key for root on an NIS+ client:

1. **Become superuser.**
2. **Edit the `/etc/nsswitch.conf` file and add the following line:**

```
publickey: nisplus
```

3. **Initialize the NIS+ client.**

```
# nisinit -cH hostname
```

hostname is the name of a trusted NIS+ server that contains an entry in its tables for the client machine.

4. Add the client to the `cred` table by typing the following commands.

```
# nisaddcred local
# nisaddcred des
```

5. Verify the setup by using the `keylogin` command.

If you are prompted for a password, the procedure has succeeded.

Example of Setting Up a New Key for root on a NIS+ Client

The following example uses the host `pluto` to set up `earth` as an NIS+ client. You can ignore the warnings. The `keylogin` command is accepted, verifying that `earth` is correctly set up as a secure NIS+ client.

```
# nisinit -cH pluto
NIS Server/Client setup utility.
This machine is in the North.Abc.COM. directory.
Setting up NIS+ client ...
All done.
# nisaddcred local
# nisaddcred des
DES principal name : unix.earth@North.Abc.COM
Adding new key for unix.earth@North.Abc.Com (earth.North.Abc.COM.)

Network password: xxx <Press Return>
Warning, password differs from login password.
Retype password: xxx <Press Return>

# keylogin
Password:
#
```

To set up a new key for an NIS+ user:

1. Add the user to the `cred` table on the root master server by typing the following command:

```
# nisaddcred -p unix.UID@domainname -P username.domainname. des
```

Note that, in this case, the *username-domainname* must end with a dot (.)

2. **Verify the setup by logging in as the client and typing the `keylogin` command.**

Example of Setting Up a New Key for an NIS+ User

The following example gives DES security authorization to user `george`.

```
# nisaddcred -p unix.1234@North.Abc.com -P george.North.Abc.COM. des
DES principal name : unix.1234@North.Abc.COM
Adding new key for unix.1234@North.Abc.COM (george.North.Abc.COM.)

Password:
Retype password:

# rlogin rootmaster -l george
# keylogin
Password:
#
```

▼ How to Set Up NIS Credentials with Diffie-Hellman Authentication

To create a new key for sueruser on a client:

1. **Become superuser on the client.**
2. **Edit the `/etc/nsswitch.conf` file and add the following line:**

```
publickey: nis
```

3. **Create a new key pair by using the `newkey` command.**

```
# newkey -h hostname
```

hostname is the name of the client.

Example of Setting Up an NIS+ Client to Use Diffie-Hellman Security

The following example sets up `earth` as a secure NIS client.

```
# newkey -h earth
Adding new key for unix.earth@North.Abc.COM
New Password:
Retype password:
Please wait for the database to get updated...
Your new key has been successfully stored away.
#
```

To create a new key for a user:

1. Log in to the server as superuser.

Only the system administrator, logged in to the NIS+ server, can generate a new key for a user.

2. Create a new key for a user.

```
# newkey -u username
```

username is the name of the user. The system prompts for a password. The system administrator can type a generic password. The private key is stored encrypted with the generic password.

```
# newkey -u george
Adding new key for unix.12345@Abc.North.Acme.COM
New Password:
Retype password:
Please wait for the database to get updated...
Your new key has been successfully stored away.
#
```

3. Tell the user to log in and type the `chkey -p` command.

This allows the user to re-encrypt their private key with a password known only to the user.

```
earth% chkey -p
Updating nis publickey database.
Reencrypting key for unix.12345@Abc.North.Acme.COM
Please enter the Secure-RPC password for george:
Please enter the login password for george:
Sending key change request to pluto...
#
```

Note - The `chkey` command can be used to create a new key-pair for a user.

▼ How to Share and Mount Files With Diffie-Hellman Authentication

Prerequisite

The Diffie-Hellman `publickey` authentication must be enabled on the network. See “How to Set Up NIS+ Credentials for Diffie-Hellman Authentication” on page 310 and “How to Set Up NIS Credentials with Diffie-Hellman Authentication” on page 312.

To share a file system with Diffie-Hellman authentication:

1. **Become superuser.**
2. **Share the file system with Diffie-Hellman authentication.**

```
# share -F nfs -o sec=dh /filesystem
```

To mount a file system with Diffie-Hellman authentication:

1. **Become superuser.**
2. **Mount the file system with Diffie-Hellman authentication.**

```
# mount -F nfs -o sec=dh server:resource mountpoint
```

The `-o sec=dh` option mounts the file system with `AUTH_DH` authentication.

Administering Kerberos Version 4 Authentication

A system administrator can implement policies that help secure the network. The level of security required will differ with each site. This section provides instructions for some tasks associated with network security.

▼ How to Share and Mount Files With Kerberos Authentication

Prerequisite

Kerberos Version 4 authentication must be enabled on the network.

To share a file system with Kerberos authentication:

1. **Become superuser.**
2. **Share the file system with Kerberos authentication.**

```
# share -F nfs -o sec=krb4 /filesystem
```

To mount a file system with Kerberos authentication:

1. **Become superuser.**
2. **Mount the file system with Kerberos authentication.**

```
# mount -F nfs -o sec=krb4 server:resource mountpoint
```

The `-o sec=krb4` option mounts the file system with `AUTH_KERB` authentication.

▼ How to Acquire a Kerberos Ticket for Superuser on a Client

If the NFS file system that you need to access has not been mounted, you need to acquire a ticket for superuser on the client before mounting it.

To acquire a ticket for a not-yet-mounted file system:

1. **Become superuser.**
2. **Acquire a Kerberos ticket on the client.**

```
# kinit root.hostname
```

hostname is the name of the client system.

```
# kinit root.earth
Password:
#
```

To acquire a ticket for a mounted file system:

If the entry `root.hostname` for the client has been entered into the `/etc/srvtab` configuration file, you can use the `ksrvtgt` command to get a ticket for superuser. In this case, you are not required to give a superuser password. Consult the MIT documentation for information about initializing the `/etc/srvtab` file.

1. **Become superuser.**
2. **Acquire a ticket for a mounted file system.**

```
# ksrvtgt root.hostname
```

Example—Acquiring a Kerberos Ticket for Superuser on a Client

```
# ksrvtgt root.earth
#
```

▼ How to Log In to Kerberos Service

Log in to the Kerberos service by using the `kinit -l username` command.

```
earth% kinit -l username
```

The `kinit` command prompts you for the ticket lifetime (`-l` option), and your password. It prints out ticket status using the verbose mode (`-v` option).

Example of Logging In to Kerberos Service

```
earth% kinit -l jjones
SunOS (earth)
Kerberos Initialization for ``jjones``
Kerberos ticket lifetime (minutes): 480
Password:
earth%
```

▼ How to List Kerberos Tickets

```
earth% klist
```

Example of Listing Kerberos Tickets

```
earth% klist
Ticket file: /tmp/tkt8516
Principal: jjones@North.Abc.COM
   Issued           Expires           Principal
Jan 14 20:40:54   Jan
15:04:40:54   krbtgt.North.Abc.COM@North.Abc.COM
```

▼ How to Access a Directory With Kerberos Authentication

Type `cd /mountpoint`.

Access the mounted directory, just as you would any other mounted directory. You can list the files in the directory with the `ls` command, or list the Kerberos tickets with the `klist` command.

Example of Accessing a Directory With Kerberos Authentication

In the following example, user `jjones` can change to the mounted `mntkrb` directory and list the files in this directory.

The `kerbd` daemon has automatically secured a ticket on the user's behalf for the NFS server exporting the file system. At this point there are two valid tickets—the original ticket-granting ticket, and the server ticket. These two tickets are listed by `klist`.

```
earth% cd /mntkrb
earth% ls -l /mntkrb
-rw-r--r-- 1 marks  staff  29 Jul 14 12:22 sports
drwxr-xr-x 3 jjones staff 512 Sep 13 13:44 market

earth% klist
Ticket file: /tmp/tkt8516
Principal: jjones@North.Abc.COM
   Issued           Expires           Principal
Jan 14 20:40:54    Jan
15:04:40:54      krbtgt.North.Abc.COM@North.Abc.COM
Jan 14 20:43:21    Jan 15:04:43:21  nfs.pluto@North.Abc.COM
```

▼ How to Destroy a Kerberos Ticket

Enter `kdestroy`.

Destroy Kerberos tickets when the session is over, so that an unauthorized user cannot to gain access to it. If you want to reinitiate Kerberos authentication, use the `kinit` command.

Example of Destroying a Kerberos Ticket

The following example shows how to destroy the Kerberos ticket. If the user then tries to change to or list a Kerberos-protected directory, the ticket server denies access.

```
earth% kdestroy
Tickets destroyed
earth% ls /mntkrb
Can't get Kerberos key: No ticket file (tf_util)
NFS getattr failed for server pluto: RPC: Authentication error
can not access directory /mntkrb.
```

Introduction to PAM

The Pluggable Authentication Module (PAM) framework lets you “plug in” new authentication technologies without changing system entry services such as `login`,

ftp, telnet, and so on. You can also use PAM to integrate UNIX login with other security mechanisms like DCE or Kerberos. Mechanisms for account, session, and password management can also be “plugged-in” using this framework.

Benefits of Using PAM

The PAM framework allows a system administrator to choose any combination of system entry services (ftp, login, telnet, or rsh, for example) for user authentication. Some of the benefits PAM provides are:

- Flexible configuration policy
 - Per application authentication policy.
 - The ability to choose a default authentication mechanism.
 - Multiple passwords on high-security systems.
- Ease of use for the end user
 - No retyping of passwords if they are the same for different mechanisms.
 - The ability to use a single password for multiple authentication methods with the password mapping feature, even if the passwords associated with each authentication method are different.
 - The ability to prompt the user for passwords for multiple authentication methods without having the user enter multiple commands.
- The ability to pass optional parameters to the user authentication services

Overview of PAM

PAM employs run-time pluggable modules to provide authentication for system entry services. These modules are broken into four different types based on their function: authentication, account management, session management, and password management. A stacking feature is provided to let you authenticate users through multiple services, as well as a password-mapping feature to not require that users remember multiple passwords.

PAM Module Types

It is important to understand the PAM module types because the module type defines the interface to the module. These are the four types of run-time PAM modules:

- The *authentication modules* provide authentication for the users and allow for credentials to be set, refreshed, or destroyed. They provide a valuable administration tool for user identification.
- The *account modules* check for password aging, account expiration, and access hour restrictions. After the user is identified through the authentication modules, the account modules determine if the user should be given access.
- The *session modules* manage the opening and closing of an authentication session. They can log activity or provide for clean-up after the session is over.
- The *password modules* allow for changes to the actual password.

Stacking Feature

The PAM framework provides a method for authenticating users with multiple services using *stacking*. Depending on the configuration, the user can be prompted for passwords for each authentication method. The order in which the authentication services are used is determined through the PAM configuration file.

Password-Mapping Feature

The stacking method can require that a user remember several passwords. With the *password-mapping* feature, the primary password is used to decrypt the other passwords, so the user doesn't need to remember or enter multiple passwords. The other option is to synchronize the passwords across each authentication mechanism. Note that this could increase the security risk, since the security of each mechanism is limited by the least secure password method used in the stack.

PAM Functionality

The PAM software consists of a library, several modules, and a configuration file. New versions of several system entry commands or daemons which take advantage of the PAM interfaces are also included.

Figure 15-1 illustrates the relationship between the applications, the PAM library, the `pam.conf` file, and the PAM modules.

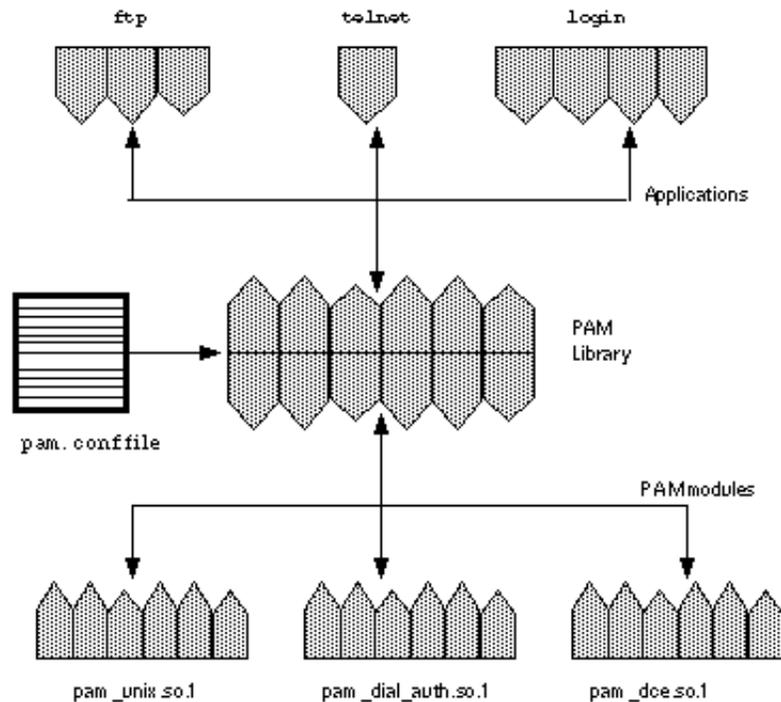


Figure 15-1 How PAM Works

The applications (`ftp`, `telnet`, and `login`) use the PAM library to access the appropriate module. The `pam.conf` file defines which modules to use, and in what order they are to be used with each application. Responses from the modules are passed back through the library to the application.

The following sections describe this relationship.

PAM Library

The PAM library, `/usr/lib/libpam`, provides the framework to load the appropriate modules and manage the stacking process. It provides a generic structure to which all of the modules can plug in.

PAM Modules

Each PAM module implements a specific mechanism. When setting up PAM authentication, you need to specify both the module and the module type, which

defines what the module will do. More than one module type (auth, account, session, or password) may be associated with each module.

The following list describes each of the PAM modules.

- The `pam_unix` module, `/usr/lib/security/pam_unix.so.1`, provides support for authentication, account management, session management, and password management. Any of the four module type definitions can be used with this module. It uses UNIX passwords for authentication. In the Solaris environment, the selection of appropriate name services to get password records is controlled through the `/etc/nsswitch.conf` file. See `pam_unix(5)` for more information
- The `dial_auth` module, `/usr/lib/security/pam_dial_auth.so.1`, can only be used for authentication. It uses data stored in the `/etc/dialups` and `/etc/d_passwd` files for authentication. This is mainly used by `login`. See `pam_dial_auth(5)` for more information.
- The `rhosts_auth` module, `/usr/lib/security/pam_rhosts_auth.so.1`, can also only be used for authentication. It uses data stored in the `~/.rhosts` and `/etc/host.equiv` files through `ruserok()`. This is mainly used by the `rlogin` and `rsh` commands. See `pam_rhosts_auth(5)` for more information.

For security reasons, these module files must be owned by root and must not be writable through `group` or `other` permissions. If the file is not owned by root, PAM will not load the module.

PAM Configuration File

The PAM configuration file, `/etc/pam.conf`, determines the authentication services to be used, and in what order they are used. This file can be edited to select authentication mechanisms for each system-entry application.

Configuration File Syntax

The PAM configuration file consists of entries with the following syntax:

```
service_name module_type control_flag module_path module_options
```

<i>service_name</i>	Name of the service (for example, ftp, login, telnet).
<i>module_type</i>	Module type for the service.
<i>control_flag</i>	Determines the continuation or failure semantics for the module.
<i>module_path</i>	Path to the library object that implements the service functionality.
<i>module_options</i>	Specific options that are passed to the service modules.

You can add comments to the `pam.conf` file by starting the line with a # (pound sign). Use white space to delimit the fields.

Note - An entry in the PAM configuration file is ignored if one of the following conditions exist: the line has less than four fields, an invalid value is given for *module_type* or *control_flag*, or the named module is not found.

Valid Service Names

Table 15-1 lists some of the valid service names, the module types that can be used with that service, and the daemon or command associated with the service name.

There are several module types that are not appropriate for each service. For example, the `password` module type is only specified to go with the `passwd` command. There is no `auth` module type associated with this command since it is not concerned with authentication.

TABLE 15-1 Valid Service Names for `/etc/pam.conf`

Service Name	Daemon or Command	Module Type
dtlogin	<code>/usr/dt/bin/dtlogin</code>	auth, account, session
ftp	<code>/usr/sbin/in.ftpd</code>	auth, account, session
init	<code>/usr/sbin/init</code>	session
login	<code>/usr/bin/login</code>	auth, account, session

TABLE 15-1 Valid Service Names for `/etc/pam.conf` (continued)

Service Name	Daemon or Command	Module Type
passwd	<code>/usr/bin/passwd</code>	password
rexcd	<code>/usr/sbin/rpc.rexd</code>	auth
rlogin	<code>/usr/sbin/in.rlogind</code>	auth, account, session
rsh	<code>/usr/sbin/in.rshd</code>	auth, account, session
sac	<code>/usr/lib/saf/sac</code>	session
su	<code>/usr/bin/su</code>	auth, account, session
telnet	<code>/usr/sbin/in.telnetd</code>	auth, account, session
ttymon	<code>/usr/lib/saf/ttymon</code>	session
uucp	<code>/usr/sbin/in.uucpd</code>	auth, account, session

Control Flags

To determine continuation or failure behavior from a module during the authentication process, you must select one of four *control flags* for each entry. The control flags indicate how a successful or a failed attempt through each module are handled. Even though these flags apply to all module types, the following explanation assumes that these flags are being used for authentication modules. The control flags are as follows:

- **required** - This module must return success in order to have the overall result be successful.

If all of the modules are labeled as `required`, then authentication through all modules must succeed for the user to be authenticated.

If some of the modules fail, then an error value from the first failed module is reported.

If a failure occurs for a module flagged as `required`, all modules in the stack are still tried but failure is returned.

If none of the modules are flagged as `required`, then at least one of the entries for that service must succeed for the user to be authenticated.

- `requisite` - This module must return success for additional authentication to occur.

If a failure occurs for a module flagged as `requisite`, an error is immediately returned to the application and no additional authentication is done. If the stack does not include prior modules labeled as `required` that failed, then the error from this module is returned. If a earlier module labeled as `required` has failed, the error message from the `required` module is returned.

- `optional` - If this module fails, the overall result can be successful if another module in this stack returns success.

The `optional` flag should be used when one success in the stack is enough for a user to be authenticated. This flag should only be used if it is not important for this particular mechanism to succeed.

If your users need to have permission associated with a specific mechanism to get their work done, then you should not label it as `optional`.

- `sufficient` - If this module is successful, skip the remaining modules in the stack, even if they are labeled as `required`.

The `sufficient` flag indicates that one successful authentication will be enough for the user to be granted access.

More information about these flags is provided in “Configuring PAM” on page 328 which describes the default `/etc/pam.conf` file.

Generic `pam.conf` File

The following is an example of a generic `pam.conf` file:

```
# PAM configuration
# Authentication management
#
login auth required /usr/lib/security/pam_unix.so.1
login auth required /usr/lib/security/pam_dial_auth.so.1
rlogin auth sufficient /usr/lib/security/pam_rhost_auth.so.1
rlogin auth required /usr/lib/security/pam_unix.so.1
dtlogin auth required /usr/lib/security/pam_unix.so.1
telnet auth required /usr/lib/security/pam_unix.so.1
su auth required /usr/lib/security/pam_unix.so.1
ftp auth required /usr/lib/security/pam_unix.so.1
uucp auth required /usr/lib/security/pam_unix.so.1
rsh auth required /usr/lib/security/pam_rhost_auth.so.1
OTHER auth required /usr/lib/security/pam_unix.so.1
#
# Account management
#
```

(continued)

(Continuation)

```
login account required /usr/lib/security/pam_unix.so.1
rlogin account required /usr/lib/security/pam_unix.so.1
dtlogin account required /usr/lib/security/pam_unix.so.1
telnet account required /usr/lib/security/pam_unix.so.1
ftp account required /usr/lib/security/pam_unix.so.1
OTHER account required /usr/lib/security/pam_unix.so.1
#
# Session management
#
login session required /usr/lib/security/pam_unix.so.1
rlogin session required /usr/lib/security/pam_unix.so.1
dtlogin session required /usr/lib/security/pam_unix.so.1
telnet session required /usr/lib/security/pam_unix.so.1
uucp session required /usr/lib/security/pam_unix.so.1
OTHER session required /usr/lib/security/pam_unix.so.1
#
# Password management
#
passwd password required /usr/lib/security/pam_unix.so.1
OTHER password required /usr/lib/security/pam_unix.so.1
```

This generic `pam.conf` file specifies:

1. When running `login`, authentication must succeed for both the `pam_unix` and the `pam_dial_auth` modules.
2. For `rlogin`, authentication through the `pam_unix` module must succeed, if authentication through `pam_rhost_auth` fails.
3. The sufficient control flag indicates that for `rlogin` the successful authentication provided by the `pam_rhost_auth` module is sufficient and the next entry will be ignored.
4. Most of the other commands requiring authentication require successful authentication through the `pam_unix` module.
5. Authentication for `rsh` must succeed through the `pam_rhost_auth` module.

The `OTHER` service name allows a default to be set for any other commands requiring authentication that are not included in the file. The `OTHER` option makes it easier to administer the file, since many commands that are using the same module can be covered using only one entry. Also, the `OTHER` service name, when used as a “catch-all,” can ensure that each access is covered by one module. By convention, the `OTHER` entry is included at the bottom of the section for each module type.

The rest of the entries in the file control the account, session and password management.

With the use of the default service name, `OTHER`, the generic PAM configuration file is simplified to:

```

# PAM configuration
#
# Authentication management
#
login auth required /usr/lib/security/pam_unix.so.1
login auth required /usr/lib/scurty/pam_dial_auth.so.1
rlogin auth sufficient /usr/lib/security/pam_unix.so.1
rlogin auth required /usr/lib/security/pam_rhost_auth.so.1
rsh auth required /usr/lib/security/pam_rhost_auth.so.1
OTHER auth required /usr/lib/security/pam_unix.so.1
#
# Account management
#
OTHER account required /usr/lib/security/pam_unix.so.1
#
# Session management
#
OTHER session required /usr/lib/security/pam_unix.so.1
#
# Password management
#
OTHER password required /usr/lib/security/pam_unix.so.1

```

Normally, the entry for the *module_path* is “root-relative.” If the filename you enter for *module_path* does not begin with a slash (/), the path `/usr/lib/security/` is prepended to the filename. A full pathname must be used for modules located in other directories.

The values for the *module_options* can be found in the man pages for the module. (For example, `pam_unix(5)`).

The `use_first_pass` and `try_first_pass` options, which are supported by the `pam_unix` module, let users reuse the same password for authentication without retyping it.

If `login` specifies authentication through both `pam_local` and `pam_unix`, then the user is prompted to enter a password for each module. In situations where the passwords are the same, the `use_first_pass` module option prompts for only one password and uses that password to authenticate the user for both modules. If the passwords are different, the authentication fails. In general, this option should be used with an optional control flag, as shown below, to make sure that the user can still log in.

```

# Authentication management
#
login auth required /usr/lib/security/pam_unix.so.1
login auth optional /usr/lib/security/pam_local.so.1 use_first_pass

```

If the `try_first_pass` module option is used instead, the local module prompts for a second password if the passwords do not match or if an error is made. If both methods of authentication are necessary for a user to get access to all the tools they

need, using this option could cause some confusion for the user since the user could get access with only one type of authentication.

Configuring PAM

The section below discusses some of the tasks that may be required to make the PAM framework fully functional. In particular, you should be aware of some of the security issues associated with the PAM configuration file.

Planning for PAM

When deciding how best to employ PAM in your environment, start by focusing on these issues:

- Determine what your needs are, especially which modules you should select.
- Identify the services that need special attention; use `OTHER` if appropriate.
- Decide on the order in which the modules should be run.
- Select the control flag for that module.
- Choose any options necessary for the module.

Here are some suggestions to consider before changing the configuration file:

- Use the `OTHER` entry for each module type so that every application does not have to be included.
- Make sure to consider the security implications of the `sufficient` and `optional` control flags.
- Review the man pages associated with the modules to understand how each module will function, what options are available, and the interactions between stacked modules.



Warning - If the PAM configuration file is misconfigured or gets corrupted, it is possible that even the superuser would be unable to log in. Since `sulogin` does not use PAM, the superuser would then be required to boot the machine into single user mode and fix the problem.

After changing the `/etc/pam.conf` file, review it as much as possible while still logged in as superuser. Test all of the commands that might have been affected by your changes. For example, if you added a new module to the `telnet` service, use the `telnet` command and verify that the changes you made behave as expected.

▼ How to Add a PAM Module

1. **Become superuser.**
2. **Determine which control flags and other options should be used.**
Refer to “PAM Modules” on page 321 information on the module.
3. **Copy the new module to `/usr/lib/security`.**
4. **Set the permissions so that the module file is owned by root and permissions are 555.**
5. **Edit the PAM configuration file, `/etc/pam.conf`, and add this module to the appropriate services.**

Verification

It is very important to do some testing *before* the system is rebooted in case the configuration file is misconfigured. Run `rlogin`, `su`, and `telnet` before rebooting the system. If the service is a daemon spawned only once when the system is booted, it may be necessary to reboot the system before you can verify that the module has been added.

▼ How to Prevent Unauthorized Access from Remote Systems with PAM

Remove the `rlogin auth rhosts_auth.so.1` entry from the PAM configuration file. This prevents reading the `~/.rhosts` files during an `rlogin` session and therefore prevents unauthenticated access to the local system from remote systems. All `rlogin` access requires a password, regardless of the presence or contents of any `~/.rhosts` or `/etc/hosts.equiv` files.

Note - To prevent other unauthenticated access to the `~/.rhosts` files, remember to disable the `rsh` service. The best way to disable a service is to remove the service entry from `/etc/inetd.conf`. Changing the PAM configuration file does not prevent the service from being started.

▼ How to Initiate PAM Error Reporting

1. **Edit the `/etc/syslog.conf` to add any of the following PAM error reporting entries:**
 - `auth.alert` — messages about conditions that should be fixed immediately
 - `auth.crit` — critical messages

- `auth.err` — error messages
- `auth.info` — informational messages
- `auth.debug` — debugging messages

2. **Restart the `syslog` daemon or send a `SIGHUP` signal to it to activate the PAM error reporting.**

Example—Initiating PAM Error Reporting

The example below displays all alert messages on the console. Critical messages are mailed to root. Informational and debug messages are added to the `/var/log/pamlog` file.

```
auth.alert /dev/console
auth.crit 'root'
auth.info;auth.debug /var/log/pamlog
```

Each line in the log contains a time stamp, the name of the system that generated the message, and the message itself. The `pamlog` file is capable of logging a large amount of information.

Using Automated Security Enhancement Tool (Tasks)

This chapter describes how to use the Automated Security Enhancement Tool (ASET) to monitor or restrict access to system files and directories.

This is a list of step-by-step instructions in this chapter.

- “How to Run ASET Interactively” on page 350
- “How to Run ASET Periodically” on page 351
- “How to Stop Running ASET Periodically” on page 352
- “How to Collect Reports on a Server” on page 352

Automated Security Enhancement Tool (ASET)

SunOS 5.7 system software includes the Automated Security Enhancement Tool (ASET). ASET helps you monitor and control system security by automatically performing tasks that you would otherwise do manually.

The ASET security package provides automated administration tools that enable you to control and monitor your system’s security. You specify a security level—low, medium, or high—at which ASET will run. At each higher level, ASET’s file-control functions increase to reduce file access and tighten your system security.

There are seven tasks involved with ASET, each performing specific checks and adjustments to system files. The ASET tasks tighten file permissions, check the contents of critical system files for security weaknesses, and monitor crucial areas. ASET can safeguard a network by applying the basic requirements of a firewall

system to a system that serves as a gateway system. (See “Firewall Setup” on page 598.)

ASET uses master files for configuration. Master files, reports, and other ASET files are in the `/usr/aset` directory. These files can be changed to suit the particular requirements of your site.

Each task generates a report noting detected security weaknesses and changes the task has made to the system files. When run at the highest security level, ASET will attempt to modify all system security weaknesses. If it cannot correct a potential security problem, ASET reports the existence of the problem.

You can initiate an ASET session by using the `/usr/aset` command interactively, or you can also set up ASET to run periodically by putting an entry into the `crontab` file.

ASET tasks are disk-intensive and can interfere with regular activities. To minimize the impact on system performance, schedule ASET to run when system activity level is lowest, for example, once every 24 or 48 hours at midnight.

ASET Security Levels

ASET can be set to operate at one of three security levels: low, medium, or high. At each higher level, ASET’s file-control functions increase to reduce file access and heighten system security. These functions range from monitoring system security without limiting users’ file access, to increasingly tightening access permissions until the system is fully secured.

The three levels are outlined below:

- *Low security* – This level ensures that attributes of system files are set to standard release values. ASET performs several checks and reports potential security weaknesses. At this level, ASET takes no action and does not affect system services.
- *Medium security* – This level provides adequate security control for most environments. ASET modifies some of the settings of system files and parameters, restricting system access to reduce the risks from security attacks. ASET reports security weaknesses and any modifications it makes to restrict access. At this level, ASET does not affect system services.
- *High security* – This level renders a highly secure system. ASET adjusts many system files and parameter settings to minimum access permissions. Most system applications and commands continue to function normally, but at this level, security considerations take precedence over other system behavior.

Note - ASET does not change the permissions of a file to make it less secure, unless you downgrade the security level or intentionally revert the system to the settings that existed prior to running ASET.

ASET Tasks

This section discusses what ASET does. You should understand each ASET task—what its objectives are, what operations it performs, and what system components it affects—to interpret and use the reports effectively.

ASET report files contain messages that describe as specifically as possible any problems discovered by each ASET task. These messages can help you diagnose and correct these problems. However, successful use of ASET assumes that you possess a general understanding of system administration and system components. If you are a new administrator, you can refer to other SunOS 5.7 system administration documentation and related manual pages to prepare yourself for ASET administration.

The `taskstat` utility identifies the tasks that have been completed and the ones that are still running. Each completed task produces a report file. For a complete description of the `taskstat` utility, refer to `taskstat(1M)`.

System Files Permissions Verification

This task sets the permissions on system files to the security level you designate. It is run when the system is installed. If you decide later to alter the previously established levels, run this task again. At low security, the permissions are set to values that are appropriate for an open information-sharing environment. At medium security, the permissions are tightened to produce adequate security for most environments. At high security, they are tightened to severely restrict access.

Any modifications that this task makes to system files permissions or parameter settings are reported in the `tune.rpt` file. “Tune Files” on page 348 shows an example of the files that ASET consults when setting permissions.

System Files Checks

This task examines system files and compares each one with a description of that file listed in a master file. The master file is created the first time ASET runs this task. The master file contains the system file settings enforced by `checklist` for the specified security level.

A list of directories whose files are to be checked is defined for each security level. You can use the default list, or you can modify it, specifying different directories for each level.

For each file, the following criteria are checked:

- Owner and group
- Permission bits
- Size and checksum
- Number of links

- Last modification time

Any discrepancies found are reported in the `cklist.rpt` file. This file contains the results of comparing system file size, permission, and checksum values to the master file.

User/Group Checks

This task checks the consistency and integrity of user accounts and groups as defined in the `passwd` and `group` files. It checks the local, and NIS or NIS+ password files. NIS+ password file problems are reported but not corrected. This task checks for the following violations:

- Duplicate names or IDs
- Entries in incorrect format
- Accounts without a password
- Invalid login directories
- The `nobody` account
- Null group password
- A plus sign (+) in the `/etc/passwd` file on an NIS (or NIS+) server

Discrepancies are reported in the `usrgrp.rpt` file.

System Configuration Files Check

During this task, ASET checks various system tables, most of which are in the `/etc` directory. These files are:

- `/etc/default/login`
- `/etc/hosts.equiv`
- `/etc/inetd.conf`
- `/etc/aliases`
- `/var/adm/utmp`
- `/var/adm/utmpx`
- `/.rhosts`
- `/etc/vfstab`
- `/etc/dfs/dfstab`
- `/etc/ftpusers`

ASET performs various checks and modifications on these files, and reports all problems in the `sysconf.rpt` file.

Environment Check

This task checks how the `PATH` and `UMASK` environment variables are set for root, and other users, in the `/.profile`, `/.login`, and `/.cshrc` files.

The results of checking the environment for security are reported in the `env.rpt` file.

EEPROM Check

This task checks the value of the `EEPROM` security parameter to ensure that it is set to the appropriate security level. You can set the `EEPROM` security parameter to `none`, `command`, or `full`.

ASET does not change this setting, but reports its recommendations in the `EEPROM.rpt` file.

Firewall Setup

This task ensures that the system can be safely used as a network relay. It protects an internal network from external public networks by setting up a dedicated system as a firewall, which is described in “Firewall Systems” on page 257. The firewall system separates two networks, each of which approaches the other as untrusted. The firewall setup task disables the forwarding of Internet Protocol (IP) packets and hides routing information from the external network.

The firewall task runs at all security levels, but takes action only at the highest level. If you want to run ASET at high security, but find that your system does not require firewall protection, you can eliminate the firewall task by editing the `asetenv` file.

Any changes made are reported in the `firewall.rpt` file.

ASET Execution Log

ASET generates an execution log whether it runs interactively or in the background. By default, ASET generates the log file on standard output. The execution log confirms that ASET ran at the designated time, and also contains any execution error messages. The `aset -n` command directs the log to be delivered by electronic mail to a designated user. For a complete list of ASET options, refer to `aset(1M)`.

Example of an Execution Log File

```
ASET running at security level low
Machine=example; Current time = 0325_08:00
```

```
aset: Using /usr/aset as working directory

Executing task list...
    firewall
    env
    sysconfig
    usrgrp
    tune
    cklist
    eeprom
All tasks executed. Some background tasks may still be running.

Run /usr/aset/util/taskstat to check their status:
    $/usr/aset/util/taskstat    aset_dir
Where aset_dir is ASET's operating directory, currently=/usr/aset

When the tasks complete, the reports can be found in:
    /usr/aset/reports/latest/*.rpt
You can view them by:
more /usr/aset/reports/latest/*.rpt
```

The log first shows the system and time that ASET was run. Then it lists each task as it is started.

ASET invokes a background process for each of these tasks, which are described in “ASET Tasks” on page 333. The task is listed in the execution log when it starts; this does not indicate that it has been completed. To check the status of the background tasks, use the `taskstat` utility.

ASET Reports

All report files generated from ASET tasks are in subdirectories under the `/usr/aset/reports` directory. This section describes the structure of the `/usr/aset/reports` directory, and provides guidelines on managing the report files.

ASET places the report files in subdirectories that are named to reflect the time and date when the reports are generated. This enables you to keep an orderly trail of records documenting the system status as it varies between ASET executions. You can monitor and compare these reports to determine the soundness of your system's security.

Figure 16-1 shows an example of the `reports` directory structure.

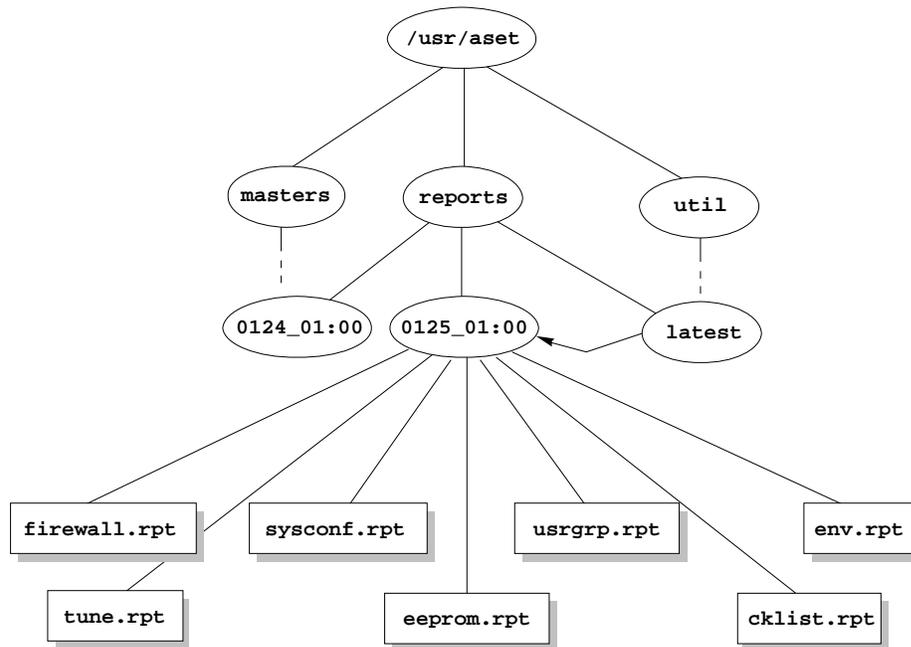


Figure 16-1 reports Directory Structure

Two report subdirectories are shown in this example:

- 0124_01:00
- 0125_01:00

The subdirectory names indicate the date and time the reports were generated. Each report subdirectory name has the following format:

monthdate_hour:minute

where *month*, *date*, *hour*, and *minute* are all two-digit numbers. For example, 0125_01:00 represents January 25, at 1 a.m.

Each of the two report subdirectories contains a collection of reports generated from one execution of ASET.

The `latest` directory is a symbolic link that always points to the subdirectory that contains the latest reports. Therefore, to look at the latest reports that ASET has generated, you can go to the `/usr/aset/reports/latest` directory. There is a report file in this directory for each task that ASET performed during its most recent execution.

Format of Report Files

Each report file is named after the task that generates it. See Table 16-1 for a list of tasks and their reports.

TABLE 16-1 ASET Tasks and Resulting Reports

Tasks	Report
System file permissions tuning (tune)	tune.rpt
System files checklist (cklist)	cklist.rpt
User/group checks (usrgrp)	usrgrp.rpt
System configuration files check (sysconf)	sysconf.rpt
Environment check (env)	env.rpt
EEPROM check (eeprom)	eeprom.rpt
Firewall setup (firewall)	firewall.rpt

Within each report file, messages are bracketed by a beginning and an ending banner line. Sometimes a task terminates prematurely; for example, when a component of ASET is accidentally removed or damaged. In most cases, the report file will contain a message near the end that indicates the reason for the premature exit.

The following is a sample report file, `usrgrp.rpt`.

```
*** Begin User and Group Checking ***  
  
Checking /etc/passwd ...  
Warning! Password file, line 10, no passwd  
:sync::1:1:/:bin/sync  
..end user check; starting group check ...  
Checking /etc/group...  
*** End User And group Checking ***
```

Examining Report Files

After initially running or reconfiguring ASET, you should examine the report files closely. (Reconfiguration includes modifying the `asetenv` file or the master files in the `masters` subdirectory, or changing the security level at which ASET operates.) The reports record any errors introduced when you reconfigured. By watching the reports closely, you can react to, and solve, problems as they arise.

Comparing Report Files

After you monitor the report files for a period during which there are no configuration changes or system updates, you may find that the content of the reports begin to stabilize and that it contains little, if any, unexpected information. You can use the `diff` utility to compare reports.

ASET Master Files

ASET's master files, `tune.high`, `tune.low`, `tune.med`, and `uid_aliases`, are located in the `/usr/aset/masters` directory. ASET uses the master files to define security levels.

Tune Files

The `tune.low`, `tune.med`, and `tune.high` master files define the available ASET security levels. They specify the attributes of system files at each level and are used for comparison and reference purposes.

The `uid_aliases` File

The `uid_aliases` file contains a list of multiple user accounts sharing the same ID. Normally, ASET warns about such multiple user accounts because this practice lessens accountability. You can allow for exceptions to this rule by listing the exceptions in the `uid_aliases` file. ASET does not report entries in the `passwd` file with duplicate user IDs if these entries are specified in the `uid_aliases` file.

Avoid having multiple user accounts (password entries) share the same user ID. You should consider other methods of achieving your objective. For example, if you intend for several users to share a set of permissions, you could create a group account. Sharing user IDs should be your last resort, used only when absolutely necessary and when other methods will not accomplish your objectives.

You can use the `UID_ALIASES` environment variable to specify an alternate aliases file. The default is `/usr/aset/masters/uid_aliases`.

The Checklist Files

The master files used by the systems files checklist are generated when you first execute ASET, or when you run ASET after you change the security level.

The files checked by this task are defined by the following environment variables:

- `CKLISTPATH_LOW`
- `CKLISTPATH_MED`

- CKLISTPATH_HIGH

ASET Environment File (`asetenv`)

The environment file, `asetenv`, contains a list of variables that affect ASET tasks. These variables can be changed to modify ASET operation.

Configuring ASET

This section discusses how ASET is configured and the environment under which it operates.

ASET requires minimum administration and configuration, and in most cases, you can run it with the default values. You can, however, fine-tune some of the parameters that affect the operation and behavior of ASET to maximize its benefit. Before changing the default values, you should understand how ASET works, and how it affects the components of your system.

ASET relies on four configuration files to control behavior of its tasks:

- `/usr/aset/asetenv`
- `/usr/aset/masters/tune.low`
- `/usr/aset/masters/tune.med`
- `/usr/aset/masters/tune.high`

Modifying the Environment File (`asetenv`)

The `/usr/aset/asetenv` file has two main sections:

- A user-configurable parameters section
- An internal environment variables section

You can alter the user-configurable parameters section. However, the settings in the internal environment variables section are for internal use only and should not be modified.

You can edit the entries in the user-configurable parameters section to:

- Choose which tasks to run
- Specify directories for checklist task
- Schedule ASET execution
- Specify an aliases file
- Extend checks to NIS+ tables

Choose Which Tasks to Run: TASKS

Each of the tasks ASET performs monitors a particular area of system security. In most system environments, all the tasks are necessary to provide balanced security coverage. However, you may decide to eliminate one or more of the tasks.

For example, the firewall task runs at all security levels, but takes action only at the high security level. You may want to run ASET at the high-security level, but do not require firewall protection.

It's possible to set up ASET to run at the high level without the firewall feature by editing the `TASKS` list of environment variables in the `asetenv` file. By default, the `TASKS` list contains all of the ASET tasks. (An example is shown below). To delete a task, remove the task setting from the file. In this case, you would delete the `firewall` environment variable from the list. The next time ASET runs, the excluded task will not be performed.

```
TASKS='env sysconfig usrgroup tune cklist eeprom firewall'
```

Specify Directories for Checklist Task: CKLISTPATH

The system files check checks attributes of files in selected system directories. You define which directories to check by using these checklist path environment variables:

- `CKLISTPATH_LOW`
- `CKLISTPATH_MED`
- `CKLISTPATH_HIGH`

The `CKLISTPATH_LOW` variable defines the directories to be checked at the low security level. `CKLISTPATH_MED` and `CKLISTPATH_HIGH` environment variables function similarly for the medium and high security levels.

The directory list defined by a variable at a lower security level should be a subset of the directory list defined at the next higher level. For example, all directories specified for `CKLISTPATH_LOW` should be included in `CKLISTPATH_MED`, and all the directories specified for `CKLISTPATH_MED` should be included in `CKLISTPATH_HIGH`.

Checks performed on these directories are not recursive; ASET only checks those directories explicitly listed in the variable. It does not check their subdirectories.

You can edit these variable definitions to add or delete directories that you want ASET to check. Note that these checklists are useful only for system files that do not normally change from day to day. A user's home directory, for example, is generally too dynamic to be a candidate for a checklist.

Schedule ASET Execution: PERIODIC_SCHEDULE

When you start ASET, you can start it interactively, or use the `-p` option to request that the ASET tasks run at a scheduled time and period. You can run ASET periodically, at a time when system demand is light. For example, ASET consults `PERIODIC_SCHEDULE` to determine how frequently to execute the ASET tasks, and at what time to run them. For detailed instructions about setting up ASET to run periodically, see “How to Run ASET Periodically” on page 351.

The format of `PERIODIC_SCHEDULE` follows the format of `crontab` entries. See `crontab(1)` for complete information.

Specify an Aliases File: UID_ALIASES

The `UID_ALIASES` variable specifies an aliases file that lists shared user IDs. The default is `/usr/aset/masters/uid_aliases`.

Extend Checks to NIS+ Tables: YPCHECK

The `YPCHECK` environment variable specifies whether ASET should also check system configuration file tables. `YPCHECK` is a Boolean variable; you can specify only true or false for it. The default value is false, disabling NIS+ table checking.

To understand how this variable works, consider its effect on the `passwd` file. When this variable is set to false, ASET checks the local `passwd` file. When it is set to true, the task also checks the NIS+ `passwd` file for the domain of the system.

Note - Although ASET automatically repairs the local tables, it only reports potential problems in the NIS+ tables; it does not change them.

Modifying the Tune Files

ASET uses the three master tune files, `tune.low`, `tune.med`, and `tune.high`, are used by ASET to ease or tighten access to critical system files. These master files are located in the `/usr/aset/masters` directory, and they can be modified to suit your environment. For additional information, see “Tune Files” on page 348.

The `tune.low` file sets permissions to values appropriate for default system settings. The `tune.med` file further restricts these permissions and includes entries not present in `tune.low`. The `tune.high` file restricts permissions even further.

Note - Modify settings in the tune file by adding or deleting file entries. Setting a permission to a less restrictive value than the current setting has no effect; the ASET tasks do not relax permissions unless you downgrade your system security to a lower level.

Restoring System Files Modified by ASET

When ASET is executed for the first time, it saves and archives the original system files. The `aset.restore` utility reinstates these files. It also deschedules ASET, if it is currently scheduled for periodic execution. The `aset.restore` utility is located in `/usr/aset`, the ASET operating directory.

Changes made to system files are lost when you run `aset.restore`.

You should use `aset.restore`:

- When you want to remove ASET changes and restore the original system. If you want to deactivate ASET permanently, you can remove it from `cron` scheduling if the `aset` command had been added to root's `crontab` previously. For directions on how to use `cron` to remove automatic execution, see “How to Stop Running ASET Periodically” on page 352.
- After a brief period of experimenting with ASET, to restore the original system state.
- When some major system functionality is not working properly and you suspect that ASET is causing the problem.

Network Operation Using the NFS System

Generally, ASET is used in standalone mode, even on a system that is part of a network. As system administrator for your standalone system, you are responsible for the security of your system and for running and managing ASET to protect your system.

You can also use ASET in the NFS distributed environment. As a network administrator, you are responsible for installing, running, and managing various administrative tasks for all of your clients. To facilitate ASET management across several client systems, you can make configuration changes that are applied globally to all clients, eliminating the need for you to log in to each system to repeat the process.

When deciding how to set up ASET on your networked systems, you should consider how much you want users to control security on their own systems, and how much you want to centralize responsibility for security control.

Providing a Global Configuration for Each Security Level

A case might arise where you want to set up more than one network configuration. For example, you may want to set up one configuration for clients that are designated with low security level, another configuration for those with medium level, and yet another one with high level.

If you need to create a separate ASET network configuration for each security level, you can create three ASET configurations on the server—one for each level. You would export each configuration to the clients with the appropriate security level. Some ASET components that are common to all three configurations could be shared using links.

Collecting ASET Reports

Not only can you centralize the ASET components on a server to be accessed by clients with or without superuser privilege, but you can also set up a central directory on a server to collect all reports produced by tasks running on various clients. For instructions on setting up a collection mechanism, see “How to Collect Reports on a Server” on page 352.

Setting up the collection of reports on a server allows you to review reports for all clients from one location. You can use this method whether a client has superuser privilege or not. Alternatively, you can leave the reports directory on the local system when you want users to monitor their own ASET reports.

Environment Variables

Table 16-2 lists the ASET environment variables and the values that they specify.

TABLE 16-2 Environment Variables and Their Meanings

Environment Variable	Specifies ...
ASETDIR (See below)	ASET working directory
ASETSECLEVEL (See below)	Security level
PERIOD_SCHEDULE	Periodic schedule
TASKS	Tasks to run
UID_ALIASES	Aliases file
YPCHECK	Extends check to NIS and NIS+
CKLISTPATH_LOW	Directory lists for low security

TABLE 16-2 Environment Variables and Their Meanings *(continued)*

Environment Variable	Specifies ...
CKLISTPATH_MED	Directory list for medium security
CKLISTPATH_HIGH	Directory list for high security

The environment variables listed below are found in the `/usr/aset/asetenv` file. The `ASETDIR` and `ASETSECLEVEL` variables are optional and can be set only through the shell by using the `aset` command. The other environment variables can be set by editing the file. The variables are described below.

ASETDIR Variable

`ASETDIR` specifies an ASET working directory.

From the C shell, type:

```
% setenv ASETDIR pathname
```

From the Bourne shell or the Korn shell, type:

```
$ ASETDIR=pathname  
$ export ASETDIR
```

Set *pathname* to the full path name of the ASET working directory.

ASETSECLEVEL Variable

The `ASETSECLEVEL` variable specifies a security level at which ASET tasks are executed.

From the C shell, type:

```
% setenv ASETSECLEVEL level
```

From the Bourne shell or the Korn shell, type:

```
$ ASETSECLEVEL=level
export ASETSECLEVEL
```

In the above commands, *level* can be set to one of the following:

low	Low security level
med	Medium security level
high	High security level

PERIODIC_SCHEDULE Variable

The value of PERIODIC_SCHEDULE follows the same format as the crontab file. Specify the variable value as a string of five fields enclosed in double quotation marks, each field separated by a space:

```
"minutes hours day-of-month month day-of-week"
```

TABLE 16-3 Periodic_Schedule Variable Values

Variable	Value
<i>minutes hours</i>	Specifies start time in number of minutes after the hour (0-59) and the hour (0-23)
<i>day-of-month</i>	Specifies the day of the month when ASET should be run, using values from 1 through 31
<i>month</i>	Specifies the month of the year when ASET should be run, using values from 1 through 12
<i>day-of-week</i>	Specifies the day of the week when ASET should be run, using values from 0 through 6; Sunday is day 0 in this scheme

The following rules apply:

- You can specify a list of values, each delimited by a comma, for any field.

- You can specify a value as a number, or you can specify it as a range; that is, a pair of numbers joined by a hyphen. A range states that the ASET tasks should be executed for every time included in the range.
- You can specify an asterisk (*) as the value of any field. An asterisk specifies all possible values of the field, inclusive.

The default entry for `PERIODIC_SCHEDULE` variable causes ASET to execute at 12:00 midnight every day:

```
PERIODIC_SCHEDULE='0 0 * * *'
```

TASKS Variable

The `TASKS` variable lists the tasks that ASET performs. The default is to list all seven tasks:

```
TASKS='env sysconfig usrgrp tune cklst eeprom firewall'
```

UID_ALIASES Variable

The `UID_ALIASES` variable specifies an aliases file. If present, ASET consults this file for a list of permitted multiple aliases. The format is `UID_ALIASES=pathname`. *pathname* is the full path name of the aliases file.

The default is:

```
UID_ALIASES=${ASETDIR}/masters/uid_aliases
```

YPCHECK Variable

The `YPCHECK` variable extends the task of checking system tables to include NIS or NIS+ tables. It is a Boolean variable, which can be set to either true or false.

The default is false, confining checking to local system tables:

```
YPCHECK=false
```

CKLISTPATH_level Variable

The three checklist path variables list the directories to be checked by the checklist task. The following definitions of the variables are set by default; they illustrate the relationship between the variables at different levels:

```
CKLISTPATH_LOW=${ASETDIR}/tasks:${ASETDIR}/util:${ASETDIR}/masters:
/etc
CKLISTPATH_MED=${CKLISTPATH_LOW}:/usr/bin:/usr/ucb
CKLISTPATH_HIGH=${CKLISTPATH_MED}:/usr/lib:/sbin:/usr/sbin:/usr/ucblib
```

The values for the checklist path environment variables are similar to those of the shell path variables, in that they are lists of directory names separated by colons (:). You use an equal sign (=) to connect the variable name to its value.

ASET File Examples

This section has examples of some of the ASET files, including the tune files and the aliases file.

Tune Files

ASET maintains three tune files. The entry format in all three tune files are described in Table 16-4.

TABLE 16-4 Tune File Entry Format

Entry	Description
<i>pathname</i>	The full path name of the file
<i>mode</i>	A five-digit number that represents the permission setting
<i>owner</i>	The owner of the file
<i>group</i>	The group owner of the file
<i>type</i>	The type of the file

The following rules apply:

- You can use regular shell wildcard characters, such as an asterisk (*) and a question mark (?), in the path name for multiple references. See `sh(1)` for more information.
- *mode* represents the least restrictive value. If the current setting is already more restrictive than the specified value, ASET does not loosen the permission settings. For example, if the specified value is 00777, the permission will remain unchanged, because 00777 is always less restrictive than whatever the current setting is.

This is how ASET handles mode setting, unless the security level is being downgraded or you are removing ASET. When you decrease the security level from what it was for the previous execution, or when you want to restore the

system files to the state they were in before ASET was first executed, ASET recognizes what you are doing and decreases the protection level.

- You must use names for *owner* and *group* instead of numeric IDs.
- You can use a question mark (?) in place of *owner*, *group*, and *type* to prevent ASET from changing the existing values of these parameters.
- *type* can be `symlink` (symbolic link), `directory`, or `file` (everything else).
- Higher security level tune files reset file permissions to be at least as restrictive as they are at lower levels. Also, at higher levels, additional files are added to the list.
- A file can match more than one tune file entry. For example, `etc/passwd` matches `etc/pass*` and `/etc/*` entries.
- Where two entries have different permissions, the file permission is set to the most restrictive value. In the following example, the permission of `/etc/passwd` will be set to `00755`, which is the more restrictive of `00755` and `00770`.

```
/etc/pass* 00755 ?? file
/etc/*     00770 ? ? file
```

- If two entries have different *owner* or *group* designations, the last entry takes precedence. The following example shows the first few lines of the `tune.low` file.

```
/ 02755 root root directory
/bin 00777 root bin symlink
/sbin 02775 root sys directory
/usr/sbin 02775 root bin directory
/etc 02755 root sys directory
/etc/chroot 00777 bin bin symlink
```

Aliases File

An aliases file contains a list of aliases that share the same user ID.

Each entry is in this form:

```
uid=alias1=alias2=alias3= . . .
```

uid Shared user ID.

aliasn User account sharing the user ID.

For example, the following entry lists the user ID 0 being shared by `sysadm` and `root`:

```
0=root=sysadm
```

Running ASET

This section describes how to run ASET either interactively or periodically.

▼ How to Run ASET Interactively

1. **Become superuser.**
2. **Run ASET interactively by using the `aset` command.**

```
# /usr/aset/aset -l level -d pathname
```

level Specifies the level of security. Valid values are `low`, `medium`, or `high`. The default setting is `low`. See “ASET Security Levels” on page 332 for detailed information about security levels.

pathname Specifies the working directory for ASET. The default is `/usr/aset`.

3. **Verify ASET is running by viewing the ASET execution log that is displayed on the screen.**

The execution log message identifies which tasks are being run.

Example—Running ASET Interactively

The following example runs ASET at low security with the default working directory.

```
# /usr/aset/aset -l low
===== ASET Execution Log =====

ASET running at security level low

Machine = jupiter; Current time = 0111_09:26

aset: Using /usr/aset as working directory

Executing task list ...
  firewall
  env
  sysconf
  usrgrp
```

(continued)

(Continuation)

```
tune
cklist
eeprom
```

All tasks executed. Some background tasks may still be running.

Run `/usr/aset/util/taskstat` to check their status:
`/usr/aset/util/taskstat [aset_dir]`

where `aset_dir` is ASET's operating directory, currently `/usr/aset`.

When the tasks complete, the reports can be found in:
`/usr/aset/reports/latest/*.rpt`

You can view them by:
`more /usr/aset/reports/latest/*.rpt`

▼ How to Run ASET Periodically

1. Become superuser.

2. If necessary, set up the time when you want ASET to run periodically.

You should have ASET run when system demand is light. The `PERIODIC_SCHEDULE` environment variable in the `/usr/aset/asetenv` file is used to set up the time for ASET to run periodically. By default, the time is set for midnight every 24 hours.

If you want to set up a different time, edit the `PERIODIC_SCHEDULE` variable in the `/usr/aset/asetenv` file. See “`PERIODIC_SCHEDULE` Variable” on page 346 for detailed information about setting the `PERIODIC_SCHEDULE` variable.

3. Add an entry to the crontab file using the `aset` command.

```
# /usr/aset/aset -p
```

-p

Inserts a line in the `crontab` file that starts ASET running at the time determined by the `PERIODIC_SCHEDULE` environment variable in the `/usr/aset/asetenv` file.

4. Display the `crontab` entry to verify when ASET will run.

```
# crontab -l root
```

▼ How to Stop Running ASET Periodically

1. **Become superuser.**
2. **Edit the `crontab` file.**

```
# crontab -e root
```

3. **Delete the ASET entry.**
4. **Save the changes and exit.**
5. **Display the `crontab` entry to verify the ASET entry is deleted.**

```
# crontab -l root
```

▼ How to Collect Reports on a Server

1. **Become superuser.**
2. **Set up a directory on the server:**
 - a. **Change to the `/usr/aset` directory.**

```
mars# cd /usr/aset
```

- b. **Create a `rptdir` directory.**

```
mars# mkdir rptdir
```

- c. **Change to the `rptdir` directory and create a `client_rpt` directory.**

```
mars# cd rptdir
mars# mkdir client_rpt
```

- d. This creates a subdirectory (*client_rpt*) for a client. Repeat this step for each client whose reports you need to collect.

The following example creates the directory `all_reports`, and the subdirectories `pluto_rpt` and `neptune_rpt`.

```
mars# cd /usr/aset
mars# mkdir all_reports
mars# cd all_reports
mars# mkdir pluto_rpt
mars# mkdir neptune_rpt
```

3. Add the *client_rpt* directories to the `/etc/dfs/dfstab` file.

The directories should have read/write options.

For example, the following entries in `dfstab` are shared with read/write permissions.

```
share -F nfs -o rw=pluto /usr/aset/all_reports/pluto_rpt
share -F nfs -o rw=neptune /usr/aset/all_reports/neptune_rpt
```

4. Make the resources in the `dfstab` file available to the clients.

```
# shareall
```

5. On each client, mount the client subdirectory from the server at the mount point, `/usr/aset/masters/reports`

```
# mount server:/usr/aset/client_rpt /usr/aset/masters/reports
```

6. Edit the `/etc/vfstab` file to mount the directory automatically at boot time.

The following sample entry in `/etc/vfstab` on `neptune` lists the directory to be mounted from `mars`, `/usr/aset/all_reports/neptune_rpt`, and the mount point on `neptune`, `/usr/aset/reports`. At boot time, the directories listed in `vfstab` are automatically mounted.

```
mars:/usr/aset/all_reports/neptune.rpt /usr/aset/reports nfs - yes
hard
```

Troubleshooting ASET Problems

This section documents the error messages generated by ASET.

ASET Error Messages

```
ASET failed: no mail program found.
```

Reason Error Occurred	How to Fix the Problem
ASET is directed to send the execution log to a user, but no mail program can be found.	Install a mail program.

```
Usage: aset [-n user[@host]] in /bin/mail or /usr/ucb/mail.
Cannot decide current and previous security levels.
```

Reason Error Occurred

ASET cannot determine what the security levels are for the current and previous invocations.

How to Fix the Problem

Ensure the current security level is set either through the command line option or the `ASETSECLEVEL` environment variable. Also, ensure that the last line of `ASETDIR/archives/asetseclevel.arch` correctly reflects the previous security level. If these values are not set or are incorrect, specify them correctly.

```
ASET working directory undefined.  
To specify, set ASETDIR environment variable or use command line  
option -d.  
ASET startup unsuccessful.
```

Reason Error Occurred

The ASET working (operating) directory is not defined, or defined incorrectly.

How to Fix the Problem

Use the `ASETDIR` environment variable or the `-d` command line option to specify it correctly, and restart ASET.

```
ASET working directory $ASETDIR missing.  
ASET startup unsuccessful.
```

Reason Error Occurred

The ASET working (operating) directory is not defined, or it is defined incorrectly. This may be because the `ASETDIR` variable or the `-d` command line option refers to a nonexistent directory.

How to Fix the Problem

Ensure that the correct directory—that is, the directory containing the ASET directory hierarchy—is referred to correctly.

```
Cannot expand $ASETDIR to full pathname.
```

Reason Error Occurred

ASET cannot expand the directory name given by the ASETDIR variable or the -d command line option to a full path name.

How to Fix the Problem

Ensure that the directory name is given correctly, and that it refers to an existing directory to which the user has access.

```
aset: invalid/undefined security level.  
To specify, set ASETSECLEVEL environment variable or use command  
line option -l, with argument= low/med/high.
```

Reason Error Occurred

The security level is not defined or it is defined incorrectly. Only the values low, med, or high are acceptable.

How to Fix the Problem

Use the ASETSECLEVEL variable or the -l command line option to specify one of the three values.

```
ASET environment file asetenv not found in $ASETDIR.  
ASET startup unsuccessful.
```

Reason Error Occurred

ASET cannot locate an asetenv file in its working directory.

How to Fix the Problem

Ensure there is an asetenv file in ASET's working directory. See **asetenv(4)** for the details about this file.

```
filename doesn't exist or is not readable.
```

Reason Error Occurred

The file referred to by *filename* doesn't exist or is not readable. This can specifically occur when using the -u option where you can specify a file that contains a list of users whom you want to check.

How to Fix the Problem

Ensure the argument to the -u option exists and is readable.

```
ASET task list TASKLIST undefined.
```

Reason Error Occurred

The ASET task list, which should be defined in the `asetenv` file, is not defined. This can mean that your `asetenv` file is bad.

How to Fix the Problem

Examine your `asetenv` file. Ensure the task list is defined in the `User Configurable` section. Also check other parts of the file to ensure the file is intact. See `asetenv(4)` for the content of a good `asetenv` file.

```
ASET task list $TASKLIST missing.  
ASET startup unsuccessful.
```

Reason Error Occurred

The ASET task list, which should be defined in the `asetenv` file, is not defined. This can mean that your `asetenv` file is bad.

How to Fix the Problem

Examine your `asetenv` file. Ensure the task list is defined in the `User Configurable` section. Also check other parts of the file to ensure the file is intact. See `asetenv(4)` for the content of a good `asetenv` file.

```
Schedule undefined for periodic invocation.  
No tasks executed or scheduled. Check asetenv file.
```

Reason Error Occurred

ASET scheduling is requested using the `-p` option, but the variable `PERIODIC_SCHEDULE` is undefined in the `asetenv` file.

How to Fix the Problem

Check the `User Configurable` section of the `asetenv` file to ensure the variable is defined and is in proper format.

```
Warning! Duplicate ASET execution scheduled.  
Check crontab file.
```

Reason Error Occurred

ASET is scheduled more than once. In other words, scheduling is requested while a schedule is already in effect. This is not necessarily an error if more than one schedule is indeed desired, just a warning that normally this is unnecessary since you should use the `crontab(1)` scheduling format if you want more than one schedule.

How to Fix the Problem

Verify, through the `crontab(1)` command interface, that the correct schedule is in effect. Ensure that no unnecessary `crontab` entries for ASET are in place.

PART **V** Managing System Resources

This part provides instructions for managing system resources in the Solaris environment. This part contains these chapters.

Chapter 17	Provides overview information about Solaris commands and utilities that help you manage system resources by using disk quotas, accounting programs, and <code>cron</code> and <code>at</code> commands.
Chapter 18	Provides step-by-step instructions for examining and changing system information.
Chapter 19	Provides step-by-step instructions for optimizing disk space by locating unused files and large directories.
Chapter 20	Provides step-by-step instructions for setting up and administering disk quotas.
Chapter 21	Provides step-by-step instructions for scheduling routine or one-time system events using <code>crontab</code> and <code>at</code> features.
Chapter 22	Provides step-by-step instructions for setting up and maintaining system accounting.
Chapter 23	Provides reference information for system accounting software.



Managing System Resources (Overview)

This chapter contains overview information about miscellaneous features offered by UNIX software and the Solaris operating environment to help you manage system resources by using disk quotas, accounting programs, and `crontab` and `at` commands that automatically run routine commands.

This is a list of the overview information in this chapter.

- “What Are Quotas?” on page 362
- “Executing Routine Tasks Automatically” on page 362
- “What is System Accounting?” on page 364

Where to Find System Resource Tasks

Use these references to find step-by-step instructions for managing system resources.

- Chapter 18
- Chapter 19
- Chapter 20
- Chapter 21
- Chapter 22

What Are Quotas?

Quotas enable system administrators to control the size of UFS file systems by limiting the amount of disk space and the number of inodes (which roughly corresponds to the number of files) that individual users can acquire. For this reason, quotas are especially useful on the file systems where user home directories reside. (As a rule, public and `/tmp` file systems probably wouldn't benefit as much from the establishment of quotas.)

Setting up quotas involves these general steps:

1. A series of commands prepares a file system to accept quotas, ensuring that quotas will be enforced each time the system is rebooted and the file system is mounted. Entries must be added to the `/etc/vfstab` file, and a `quotas` file must be created in the top-level directory of the file system.
2. After a quota is created for one user, it can be copied as a prototype to set up other user quotas.
3. Before quotas are actually turned on, another command checks for consistency by comparing the proposed quotas to the current disk usage making sure there are no conflicts.
4. Finally, a command turns the quotas on for one or more entire file systems.

These steps ensure that quotas are automatically activated on a file system each time it is mounted. See Chapter 20 for specific information about these procedures.

Once they are in place, quotas can be changed to adjust the amount of disk space or number of inodes that users can consume. Additionally, quotas can be added or removed as system needs change. See “Changing and Removing Quotas” on page 406 for instructions on how to change quotas, disable individual quotas, or remove quotas from file systems.

In addition, quota status can be monitored. Quota commands enable administrators to display information about quotas on a file system, or search for users who have exceeded their quotas. For procedures that describe how to use these commands, see “Checking Quotas” on page 403.

Executing Routine Tasks Automatically

Many routine system events can be set up to execute automatically. Some of these tasks should occur repetitively, at regular intervals. Other tasks need to run only once, perhaps during off hours such as evenings or weekends.

This section contains overview information about two commands, `crontab` and `at`, which enable you to schedule routine commands to execute automatically, avoiding peak hours or repeating commands according to a fixed schedule. `crontab` schedules repetitive commands, while `at` schedules commands that execute once.

Scheduling Repetitive Jobs: `crontab`

You can schedule routine system administration commands to execute daily, weekly, or monthly by using the `crontab` commands.

Daily `crontab` system administration tasks might include:

- Removing junk files more than a few days old from temporary directories
- Executing accounting summary commands
- Taking snapshots of the system by using `df` and `ps` commands
- Performing daily security monitoring
- Running system backups

Weekly `crontab` system administration tasks might include:

- Rebuilding the `catman` database for use by `man -k`
- Running `fsck -n` to list any disk problems

Monthly `crontab` system administration tasks might include:

- Listing files not used that month
- Producing monthly accounting reports

Additionally, users can schedule `crontab` commands to execute other routine system tasks, such as sending reminders and removing backup files.

Scheduling a Single Job: `at`

The `at` command allows you to schedule a job for execution at a later time. The job may consist of a single command or a script.

Like `crontab`, `at` allows you to schedule the automatic completion of routine commands. However, unlike `crontab` files, `at` files execute their commands once, and then are removed from their directory. Therefore, `at` is most useful for running simple commands or scripts that direct output into separate files for later examination.

Submitting an `at` job involves entering a command, following the `at` command syntax to specify options to schedule the time your job will be executed. For more information about submitting `at` jobs, see “`at` Command Description” on page 425.

The `at` command stores the command or script you entered, along with a copy of your current environment variables in either `/usr/spool/cron/atjobs` or `/var/spool/cron/atjobs`. As a file name, your `at` job file is given a long number specifying its location in the `at` queue, followed by the `.a` extension, such as `793962000.a`.

The `cron` daemon periodically executes the `atrun` program, usually at 15-minute intervals. `atrun` then executes `at` jobs at their scheduled times. After your `at` job has been executed, its file is removed from the `atjobs` directory.

What is System Accounting?

The SunOS 5.7 system accounting software is a set of programs that enables you to collect and record data about user connect time, CPU time charged to processes, and disk usage. Once this data is collected, you can generate reports and charge fees for system usage.

The accounting programs can be used for:

- Monitoring system usage
- Troubleshooting
- Locating and correcting performance problems
- Maintaining system security

After they're set up, the system accounting programs run mostly on their own.

Accounting Components

The accounting software provides C language programs and shell scripts that organize data into summary files and reports. These programs reside in the `/usr/adm/acct` and `/usr/lib/acct` directories.

Daily accounting can help you do four types of auditing:

- Connect
- Process
- Disk
- Fee calculations

How Accounting Works

Setting up automatic accounting involves putting the accounting startup script into `crontab` files so they can be started automatically by `cron`.

The following is an overview of how accounting works.

1. Between system startup and shutdown, raw data about system use (such as user logins, running processes, and data storage) are collected in accounting files.
2. Periodically (usually once a day), the `/usr/lib/acct/runacct` program processes the various accounting files and produces both cumulative summary files and daily accounting reports. The daily reports are printed by the `/usr/lib/acct/prdaily` program.
3. Monthly, the administrator can process and print the cumulative summary files generated by `runacct` by executing the `monacct` program. The summary reports produced by `monacct` provide an efficient means for billing users on a monthly or other fiscal basis.

See Chapter 22 for instructions on setting up the accounting software. See Chapter 23 for reference information about the different accounting features.

Examining and Changing System Information (Tasks)

This chapter describes tasks required to examine and change the most common system information. This is a list of the step-by-step instructions in this chapter.

- “How to Display General System Information (uname)” on page 369
- “How to Display a System’s Host ID Number ” on page 369
- “How to Display a System’s Installed Memory” on page 370
- “How to Display the Date and Time” on page 370
- “How to Synchronize Date and Time From Another System” on page 373
- “How to Set a System’s Date and Time Manually” on page 373
- “How to Set Up a Message of the Day” on page 374
- “How to Set the Number of Processes per User” on page 375
- “How to Increase the Number of Pseudo-ttys” on page 376
- “How to Increase Shared Memory Segments” on page 377

Using Commands to Display System Information

Table 18-1 describes commands that enable you to display general system information.

TABLE 18-1 Commands for Displaying System Information

Command	Enables You to Display a System's ...
<code>showrev(1M)</code>	Hostname, host identification number, release, kernel architecture, application architecture, hardware provider, domain, and kernel version
<code>uname(1)</code>	Operating system name, release, and version; node name; hardware name; processor type
<code>hostid(1)</code>	Host ID number
<code>prtconf(1M)</code>	Installed memory
<code>date(1)</code>	Date and time

▼ How to Display System and Software Release Information

To display specific system and software release information, use the `showrev` command.

```
$ showrev [-a]
```

-a

Displays all system release information available.

Example—Displaying System and Software Release Information

The following example shows `showrev` command output.

```
$ showrev -a
Hostname: pluto
Hostid: 5721864d
Release: 5.7
Kernel architecture: sun4m
Application architecture: sparc
Hardware provider: Sun_Microsystems
Domain: solar.com
Kernel version: SunOS 5.7 Generic September 1998
```

(continued)

(Continuation)

```
OpenWindows version:  
OpenWindows Version 3.7, 3 February 1998  
No patches are installed  
$
```

▼ How to Display General System Information (uname)

To display system information, use the `uname` command.

```
$ uname[-a]
```

`-a` Displays the operating system name as well as the system node name, operating system release, operating system version, hardware name, and processor type.

Example—Displaying General System Information

The following example shows `uname` command output.

```
$ uname  
SunOS  
$ uname -a  
SunOS pluto 5.7 Generic sun4m sparc SUNW,SPARCstation-5  
$
```

▼ How to Display a System's Host ID Number

To display the host identification number in hexadecimal format, use the `hostid` command.

```
$ hostid
```

Example—Displaying a System's Host ID Number

The following example shows sample output from the `hostid` command.

```
$ hostid
7725ac42
```

▼ How to Display a System's Installed Memory

To display the amount of memory installed on your system, use the `prtconf` command.

```
$ prtconf [| grep Memory]
```

`grep Memory`

Focuses output from this command to display memory information only.

Example—Displaying a System's Installed Memory

The following example shows sample output from the `prtconf` command.

```
# prtconf | grep Memory
Memory size: 56 Megabytes
```

▼ How to Display the Date and Time

To display the current date and time according to your system clock, use the `date` command.

```
$ date
```

Example—Displaying the Date and Time

The following example shows sample output from the `date` command.

```
$ date
Thu Feb 26 10:19:19 MST 1998
$
```

Using Commands to Change System Information

Table 18–2 shows man page references and descriptions for some commands that enable you to change general system information.

TABLE 18–2 Commands for Changing System Information

Command	Enables You to Change a System's ...
<code>rdate(1M)</code>	Date and time to match those of another system
<code>date(1)</code>	Date and time to match your specifications

Using these commands, you can set a system's date and time to synchronize with the date and time of another system, such as a server. Or you can change a system's date and time by specifying new information.

The message of the day (MOTD) facility, located in `/etc/motd`, enables you to send announcements or inquiries to all users of a system when they log in. Use this facility sparingly, and edit this file regularly to remove obsolete messages.

By editing the `/etc/system` file, you can:

- Change the number of processes per user
- Increase the number of pseudo-`ttys` to 256
- Increase the number of lock requests
- Increase shared memory segments

Using Network Time Protocol (NTP) in Your Network

The Network Time Protocol (NTP) public domain software from the University of Delaware is included in the Solaris software starting with the Solaris 2.6 release.

NTP enables you to manage precise time and/or network clock synchronization in a network environment. The `xntpd` daemon sets and maintains a Unix system time-of-day in agreement with Internet standard time servers. The `xntpd` daemon is

a complete implementation of the Network Time Protocol version 3 standard, as defined by RFC 1305.

The `xntpd` daemon reads the `/etc/inet/ntp.conf` file at system startup. See `xntpd(1M)` for information about configuration options. See the following section for instructions on setting up an NTP server and clients.

Keep the following in mind when using NTP in your network:

- The `xntpd` daemon takes up minimal system resources.
- An NTP client synchronizes automatically when it boots, and if it gets out of sync, it will resync again when it sees a time server.

▼ How to Set Up a Network Time (NTP) Server

1. **Become superuser.**
2. **Change to the `/etc/inet` directory.**
3. **Copy the `ntp.server` file to the `ntp.conf` file.**

```
# cp ntp.server ntp.conf
```

4. **Change to the `/etc/init.d` directory.**
5. **Start the `xntpd` daemon.**

```
# ./xntpd start
```

▼ How to Set Up a Network Time (NTP) Client

1. **Become superuser.**
2. **Change to the `/etc/inet` directory.**
3. **Copy the `ntp.client` file to the `ntp.conf` file.**

```
# cp ntp.client ntp.conf
```

4. **Change to the `/etc/init.d` directory.**
5. **Start the `xntpd` daemon.**

```
# ./xntpd start
```

▼ How to Synchronize Date and Time From Another System

1. Become superuser.
2. To reset the date and time to synchronize with another system, use the `rdate` command.

```
# rdate other-system-name
```

other-system-name Name of another system.

3. Verify that you have reset your system's date correctly by checking your system's date and time using the `date` command.

The output should show a date and time that matches that of the other system.

Example—Synchronizing Date and Time From Another System

The following example shows how to use `rdate` to synchronize the date and time of one system with another. In this example, the system `neptune`, running several hours behind, is reset to match the date and time of the server `pluto`.

```
neptune$ date
Thu Feb 26 10:20:54 MST 1998
neptune# rdate pluto
Thu Feb 26 10:20:54 MST 1998
neptune$ date
Thu Feb 26 10:20:56 MST 1998
```

▼ How to Set a System's Date and Time Manually

1. Become superuser.
2. Enter the new date and time.

```
# date mmddHHMM[[cc]yy]
```

<i>mm</i>	Month, using two digits.
<i>dd</i>	Day of the month, using two digits.
<i>HH</i>	Hour, using two digits and a 24-hour clock.
<i>MM</i>	Minutes, using two digits.
<i>cc</i>	Century, using two digits.
<i>yy</i>	Year, using two digits.

3. **Verify that you have reset your system's date correctly by checking your system's date and time using the `date` command with no options.**
The output should show a date and time that matches that of the other system.

Example—Setting a System's Date and Time Manually

The following example shows how to use `date` to manually set a system's date and time.

```
# date
Thu Feb 26 10:20:56 MST 1998
# date 022610221998
```

▼ How to Set Up a Message of the Day

1. **Become superuser.**
2. **Open the `/etc/motd` file, using the editor of your choice.**
3. **Edit the text to include the message that will be displayed as part of the user login process, including spaces, Tabs, and Returns.**
4. **Exit the file, saving your changes.**

5. Verify the changes by displaying the contents of the `/etc/motd`.

```
$ cat /etc/motd
Welcome to the UNIX Universe. Have a nice day.
```

Example—Setting Up a Message of the Day

The default message of the day, provided when you install Solaris software, contains SunOS version information:

```
$ cat /etc/motd
Sun Microsystems Inc   SunOS 5.7   Generic   September 1998
```

The following example shows an edited `/etc/motd` file that provides information about system availability to each user who logs in.

```
$ cat /etc/motd
The system will be down from 7:00 a.m to 2:00 p.m.on
Saturday, February 28, for upgrades and maintenance.
Do not try to access the system during those hours.
Thank you...
```

▼ How to Set the Number of Processes per User

- 1. Open the `/etc/system` file, using the editor of your choice.**
- 2. Add the following line to the file.**

```
set maxuprc=value
```

value Number of processes a user can run at once.

- 3. Exit the file, saving changes.**
- 4. Verify the `maxuprc` value change.**

```
# grep maxuprc /etc/system
set maxuprc=100
```

5. Reboot the system.

Example—Setting the Number of Processes per User

The following example shows the line you would add to the `/etc/system` file to allow users to run 100 processes each.

```
set maxuprc=100
```

▼ How to Increase the Number of Pseudo-ttys

1. Open the `/etc/system` file, using the editor of your choice.
2. Add the following line to the file.

```
set pt_cnt=value
set npty=same_value_as_pt_cnt
set sad_cnt=2_times_pt_cnt value
set nautopush=same_value_as_pt_cnt
```

<code>set pt_cnt</code>	Sets the number of System V ptys.
<code>set npty</code>	Sets the number of BSD ptys.
<code>set sad_cnt</code>	Sets the number of STREAMS addressable devices.
<code>set nautopush</code>	Sets the number of STREAMS autopush entries and should be two times the value of <code>sadcnt</code> .

3. Exit the file, saving changes.
4. Verify the `pt_cnt` value change.

```
# grep pt_cnt /etc/system
set pt_cnt=256
```

5. Instruct the system to reconfigure upon rebooting.

```
$ touch /reconfigure
```

6. Reboot the system.

Example—Increasing the Number of Pseudo-ttys

The following example increases the number of ptys to 128.

```
set pt_cnt=128
set npty=128
set sad_cnt=256
set nautopush=128
```

▼ How to Increase Shared Memory Segments

- 1. Open the `/etc/system` file, using the editor of your choice.**
- 2. Add the following variables to increase shared memory segments.**

```
set shmsys:shminfo_shmmax=value
set shmsys:shminfo_shmmin=value
set shmsys:shminfo_shmmni=value
set shmsys:shminfo_shmseg=value
set semsys:seminfo_semmmap=value
set semsys:seminfo_semmni=value
set semsys:seminfo_semmns=value
set semsys:seminfo_semmsl=value
set semsys:seminfo_semmnu=value
set semsys:seminfo_semume=value
```

<code>shmsys:shminfo_shmmax</code>	Maximum shared memory segment size
<code>shmsys:shminfo_shmmin</code>	Minimum shared memory segment size
<code>shmsys:shminfo_shmmni</code>	Number of shared memory identifiers
<code>shmsys:shminfo_shmseg</code>	Number of segments, per process
<code>semsys:seminfo_semap</code>	Number of entries in the semaphore map
<code>semsys:seminfo_semmni</code>	Number of semaphore identifiers
<code>semsys:seminfo_semms</code>	Number of semaphores in the system
<code>semsys:seminfo_semmsl</code>	Maximum number of semaphores, per id
<code>semsys:seminfo_semnu</code>	Number of processes using the <code>undo</code> facility
<code>semsys:seminfo_semume</code>	Maximum number of <code>undo</code> structures per process

3. Exit the file, saving changes.

4. Verify the shared memory value changes.

```
# grep shmsys /etc/system
```

5. Reboot the system.

Example—Increasing Shared Memory Segments

The following shared memory values accommodate a system with a large amount of memory (for example, 128 MBytes) that is running a large database application.

```
set shmsys:shminfo_shmmax=268435456
set shmsys:shminfo_shmmin=200
set shmsys:shminfo_shmmni=200
set shmsys:shminfo_shmseg=200
set semsys:seminfo_semap=250
set semsys:seminfo_semmni=500
set semsys:seminfo_semms=500
set semsys:seminfo_semmsl=500
```

(continued)

(Continuation)

```
set semsys:seminfo_semmnu=500  
set semsys:seminfo_semume=100
```


Managing Disk Use (Tasks)

This chapter describes how to optimize disk space by locating unused files and large directories. This is a list of the step-by-step instructions in this chapter.

- “How to Display Information About Blocks, Files, and Disk Space” on page 381
- “How to Display the Size of Files” on page 384
- “How to Find Large Files” on page 385
- “How to Find Files That Exceed a Given Size Limit” on page 386
- “How to Display the Size of Directories, Subdirectories, and Files” on page 387
- “How to Display the User Allocation of Local UFS File System” on page 388
- “How to List the Newest Files” on page 390
- “How to Find and Remove Old or Inactive Files ” on page 390
- “How to Clear Out Temporary Directories” on page 392
- “How to Find and Delete `core` Files” on page 393
- “How to Delete Crash Dump Files” on page 393

Displaying Blocks and Files Used

Use the `df` command and its options to report the number of free disk blocks and files. For more information, see `df(1M)`.

▼ How to Display Information About Blocks, Files, and Disk Space

Display information about how disk space is used by using the `df` command.

```
$ df [directory] [-F fstype] [-g] [-k] [-t]
```

<code>df</code>	With no options, lists all mounted file systems and their device names, the number of total 512-byte blocks used, and the number of files.
<code>directory</code>	Directory whose file system you want to check. The device name, blocks used, and number of files are displayed.
<code>-F fstype</code>	Displays a list of unmounted file systems, their device names, the number of 512-byte blocks used, and the number of files on file systems of type <code>fstype</code> .
<code>-g</code>	Displays the <code>statvfs</code> structure for all mounted file systems.
<code>-k</code>	Displays a list of file systems, kilobytes used, free kilobytes, percent capacity used, and mount points.
<code>-t</code>	Displays total blocks as well as blocks used for all mounted file systems.

Note - For remotely mounted file systems, ``-1 files`` is displayed instead of the number of files.

Examples—Displaying Information About Blocks, Files, and Disk Space

In the following example, all the file systems listed are locally mounted except for `/usr/local`, which is mounted remotely from the system `mars`, and does not use local disk resources.

```
$ df
/          (/dev/dsk/c0t3d0s0 ): 30374 blocks 14002 files
/usr       (/dev/dsk/c0t3d0s6 ): 40714 blocks 80522 files
/proc     (/proc              ): 0 blocks 429 files
/dev/fd   (fd                 ): 0 blocks 0 files
/export/home (/dev/dsk/c0t3d0s7 ): 10712 blocks 10564 files
/export/root (/dev/dsk/c0t3d0s3 ): 69180 blocks 18812 files
/export/swap (/dev/dsk/c0t3d0s4 ): 61804 blocks 29563 files
/opt      (/dev/dsk/c0t3d0s5 ): 15722 blocks 13147 files
/tmp      (swap               ): 57104 blocks 5653 files
/usr/local (mars:/usr/local   ): 435040 blocks -1 files
$
```

In the following example, the file system, total Kbytes, used Kbytes, available Kbytes, percent of capacity used, and mount point are displayed.

```
$ df -k
Filesystem          kbytes  used  avail capacity  Mounted on
/dev/dsk/c0t3d0s0    30991  15812  12089    57%      /
/dev/dsk/c0t3d0s6   185303 164946   1827    99%     /usr
/proc                0        0        0     0%     /proc
fd                   0        0        0     0%     /dev/fd
/dev/dsk/c0t3d0s7   19095  13739   3456    80%     /export/home
/dev/dsk/c0t3d0s3   34599      9   31140    1%     /export/root
/dev/dsk/c0t3d0s4   55511  24609  25352    50%     /export/swap
/dev/dsk/c0t3d0s5   23063  15202   5561    74%     /opt
swap                29564   976   28588    4%     /tmp
mars:/usr/local     5353093 5135591 163972    97%     /usr/local
$
```

The following example shows information about the same system as the previous example, but only UFS file system information is displayed.

```
$ df -F ufs
/                (/dev/dsk/c0t3d0s0 ): 30358 blocks 14002 files
/usr             (/dev/dsk/c0t3d0s6 ): 40714 blocks 80522 files
/export/home    (/dev/dsk/c0t3d0s7 ): 10712 blocks 10564 files
/export/root    (/dev/dsk/c0t3d0s3 ): 69180 blocks 18812 files
/export/swap    (/dev/dsk/c0t3d0s4 ): 61804 blocks 29563 files
/opt            (/dev/dsk/c0t3d0s5 ): 15722 blocks 13147 files
$
```

Note - Although `/proc` and `/tmp` are local file systems, they are not UFS file systems (`/proc` is a PROCFS file system, and `/tmp` is a TMPFS file system).

The following example shows a list of all mounted file systems, device names, total 512-byte blocks used, and number of files. The second line of each two-line entry displays the total number of blocks and files allocated for the file system.

```
$ df -t
/                (/dev/dsk/c0t3d0s0 ): 30358 blocks 14002 files
                  total: 61982 blocks 16128 files
/usr             (/dev/dsk/c0t3d0s6 ): 40714 blocks 80522 files
                  total: 370606 blocks 94080 files
/proc           (/proc                ): 0 blocks 429 files
                  total: 0 blocks 492 files
/dev/fd         (fd                    ): 0 blocks 0 files
                  total: 0 blocks 26 files
/export/home    (/dev/dsk/c0t3d0s7 ): 10712 blocks 10564 files
                  total: 38190 blocks 10752 files
/export/root    (/dev/dsk/c0t3d0s3 ): 69180 blocks 18812 files
```

(continued)

(Continuation)

```
total:      69198 blocks      18816 files
/export/swap (/dev/dsk/c0t3d0s4 ): 61804 blocks      29563 files
total:      111022 blocks     29568 files
/opt         (/dev/dsk/c0t3d0s5 ): 15722 blocks     13147 files
total:      46126 blocks     13440 files
/tmp        (swap                ): 57144 blocks     5653 files
total:      59096 blocks     5768 files
/usr/local  (mars:/usr/local    ): 435008 blocks    -1 files
total:     10706186 blocks    -1 files
$
```

Checking the Size of Files

You can check the size of files and sort them by using the `ls` command. You can find files that exceed a size limit by using the `find` command. For more information, see `ls(1)` and `find(1)`.

▼ How to Display the Size of Files

1. Change the directory to where the files you want to check are located.
2. Display the size of the files.

```
$ ls [-l] [-s]
```

<code>-l</code>	Displays a list of files and directories in long format, showing the sizes in bytes.
<code>-s</code>	Displays a list of the files and directories, showing the sizes in blocks.

Examples—Displaying the Size of Files

The following example shows that `lastlog`, `wtmp`, and `wtmpx` are substantially larger than the other files in the `/var/adm` directory.

```

venus% cd /var/adm
venus% ls -l
total 434
-r--r--r-- 1 root  other  585872 Jan 28 14:53 lastlog
drwxrwxr-x 2 adm  adm    512 Dec  1 16:35 log
-rw-r--r-- 1 root  other  408 Jan 28 14:15 messages
-rw-r--r-- 1 root  other  177 Jan 24 16:56 messages.0
-rw-r--r-- 1 root  other  177 Jan 17 16:13 messages.1
-rw-r--r-- 1 root  other   0 Jan  4 04:05 messages.2
-rw-r--r-- 1 root  other  562 Jan  2 13:13 messages.3
drwxrwxr-x 2 adm  adm    512 Dec  1 16:35 passwd
drwxrwxr-x 2 adm  sys    512 Jan 28 11:38 sa
-rw-rw-rw- 1 bin  bin     0 Nov 26 10:56 spellhist
-rw----- 1 root  root  1319 Jan 28 14:58 sulog
-rw-r--r-- 1 root  bin   288 Jan 28 14:53 utmp
-rw-r--r-- 1 root  bin  2976 Jan 28 14:53 utmpx
-rw-rw-r-- 1 adm  adm  12168 Jan 28 14:53 wtmp
-rw-rw-r-- 1 adm  adm  125736 Jan 28 14:53 wtmpx

```

The following example shows that `lpsched-2` uses two blocks.

```

% cd /var/lp/logs
% ls -s
total 2          0 lpsched          0 lpsched.1        2 lpsched.2%

```

▼ How to Find Large Files

1. Change directory to the location where you want to search.
2. Display the size of files in blocks from largest to smallest.

```
$ ls -s | sort -nr | more
```

```
sort -nr
```

Sorts the list of files by block size from smallest to largest.

Example—Finding Large Files

In the following example, `wtmpx` and `lastlog` are the largest files in the `/var/adm` directory.

```
$ cd /var/adm
$ ls -s | sort -nr | more
320 wtmpx
128 lastlog
 74 pacct
 56 messages
 30 wtmp
  6 utmpx
  2 utmp
  2 sulog
  2 sa
  2 passwd
  2 log
  0 spellhist
total 624
```

▼ How to Find Files That Exceed a Given Size Limit

To locate and display the names of files that exceed a specified size, use the `find` command.

```
$ find directory -size +nnn
```

directory

Directory you want to search.

`-size +nnn`

Is a number of 512-byte blocks. Files that exceed the size indicated are listed.

Example—Finding Files That Exceed a Given Size Limit

The following example shows how to find files with more than 400 blocks in the current working directory.

```
$ find . -size +400 -print
./Howto/howto.doc
./Howto/howto.doc.backup
./Howto/howtotest.doc
./Routine/routineBackupconcepts.doc
./Routine/routineIntro.doc
./Routine/routineTroublefsck.doc
./.record
./Mail/pagination
./Config/configPrintadmin.doc
./Config/configPrintsetup.doc
./Config/configMailappx.doc
./Config/configMailconcepts.doc
```

(continued)

(Continuation)

```
./snapshot.rs
```

Checking the Size of Directories

You can display the size of directories by using the `du` command and its options. Additionally, you can find the amount of disk space taken up by user accounts on local UFS file systems by using the `quot` command. For more information about these commands, see `du(1M)` and `quot(1M)`.

▼ How to Display the Size of Directories, Subdirectories, and Files

Display the size of one or more directories, subdirectories, and files by using the `du` command. Sizes are displayed in 512-byte blocks.

```
$ du [-as] [directory ...]
```

<code>du</code>	Displays the size of each directory you specify, including each subdirectory beneath it.
<code>-a</code>	Displays the size of each file and subdirectory, and the total number of blocks contained in the specified directory.
<code>-s</code>	Displays only the total number of blocks contained in the specified directory.
<code>directory ...</code>	Specifies one or more directories you want to check.

Examples—Displaying the Size of Directories, Subdirectories, and Files

The following example displays the sizes of two directories and all the subdirectories they contain.

```
$ du /var/log /var/cron
4      /var/log
3250   /var/cron
```

The following example displays the sizes of two directories, all of the subdirectories and files they contain, and the total number of blocks contained in each directory.

```
$ du -a /var/log /var/cron
0      /var/log/authlog
0      /var/log/syslog
2      /var/log/sysidconfig.log
4      /var/log
3248   /var/cron/log
3250   /var/cron
```

The following example displays the total sizes of two directories.

```
$ du -s /var/log /var/cron
4      /var/log
3250   /var/cron
```

▼ How to Display the User Allocation of Local UFS File System

1. **Become superuser.**
2. **Display users, directories, or file systems, and the number of 1024-byte blocks used.**

```
# quot [-a] [filesystem]
```

-a Lists all users of each mounted UFS file system and the number of 1024-byte blocks used.

filesystem Is a UFS file system. Users and the number of blocks used are displayed.

Note - The `quot` command works only on local UFS file systems.

Example—Displaying the User Allocation of Local UFS File Systems

In the following example, users of the root (/) file system are displayed, then users of all mounted UFS file systems are displayed.

```
# quot /
/dev/rdisk/c0t0d0s0:
35400 bin
 183 adm
  49 lp
  47 uucp
  37 bob
  28 sys
   2 mary
# quot -a
/dev/rdisk/c0t0d0s0 (/):
35400 bin
 183 adm
  49 lp
  47 uucp
  37 bob
  28 sys
   2 mary
/dev/rdisk/c0t0d0s6 (/usr):
56567 bin
2000 lp
 698 uucp
   1 adm
/dev/rdisk/c0t0d0s7 (/export/home):
 617 ken
```

Finding and Removing Old and Inactive Files

Part of the job of cleaning up heavily loaded file systems involves locating and removing files that have not been used recently. You can locate unused files using the `ls` or `find` commands. For more information, see `ls(1)` and `find(1)`.

Other ways to conserve disk space include emptying temporary directories such as the ones located in `/var/tmp` or `/var/spool`, and deleting `core` and crash dump files. For more information about these files, refer to Chapter 31.

▼ How to List the Newest Files

List files, displaying the most recently created or changed files first, by using the `ls -t` command.

```
$ ls -t [directory]
```

`-t` Sorts listings by latest time stamp first.

`directory` Directory you want to search.

Example—Listing the Newest Files

The following example shows how to use `ls -t` to locate the most recent files within the `/var/adm` directory. `sudo`, `messages`, `utmpx`, `wtmpx`, `utmp`, and `lastlog` were created or edited most recently. This is verified using output from `ls -l`, which shows that these three files were created or edited in March, while the other files in `/var/spool` were created or edited earlier.

```
$ ls -t /var/adm
sudo      wtmpx
messages  utmp
utmpx     lastlog
messages.0  messages.3  acct      passwd
total 686
drwxr-xr-x 5 adm      adm      512 Feb 13 16:20 acct
-rw----- 1 uucp     bin      0 Feb 13 16:04 aculog
-r--r--r-- 1 root     other    8456 Mar 27 10:34 lastlog
drwxr-xr-x 2 adm      adm      512 Feb 13 16:36 log
-rw-r--r-- 1 root     other    117376 Mar 27 13:11 messages
-rw-r--r-- 1 root     other    4620 Jan 30 08:30 messages.0
-rw-r--r-- 1 root     other    11176 Jan 23 04:30 messages.1
-rw-r--r-- 1 root     other    60 Jan 13 09:45 messages.2
-rw-r--r-- 1 root     other    0 Jan 31 04:05 messages.3
drwxr-xr-x 2 adm      adm      512 Feb 13 16:03 passwd
drwxr-xr-x 2 adm      sys      512 Mar 20 06:59 sa
-rw-rw-rw- 1 bin      bin      0 Feb 13 16:04 spellhist
-rw----- 1 root     root     1647 Mar 27 13:28 sudo
-rw-r--r-- 1 root     bin      504 Mar 27 10:34 utmp
-rw-r--r-- 1 root     bin      5208 Mar 27 10:34 utmpx
-rw-rw-rw- 1 root     root     500 Jan 11 14:40 vold.log
-rw-rw-r-- 1 adm      adm      14724 Mar 27 10:34 wtmp
-rw-rw-r-- 1 adm      adm      151404 Mar 27 10:34 wtmpx
```

▼ How to Find and Remove Old or Inactive Files

1. Become superuser.

2. Find files that have not been accessed for a specified number of days and list them in a file.

```
# find directory -type f [-atime + nnn][-mtime + nnn]-print > filename
```

<i>directory</i>	Directory you want to check. Directories below this also will be checked.
<code>-atime +<i>nnn</i></code>	Finds files that have not been accessed within the number of days you specify.
<code>-mtime +<i>nnn</i></code>	Finds files that have not been modified within the number of days you specify.
<i>filename</i>	File containing the list of inactive files.

3. Remove the inactive files that you listed in the previous step.

```
# rm `cat filename`
```

<i>filename</i>	File created by this command which contains the list of inactive files.
-----------------	---

Example—Finding and Removing Old or Inactive Files

The following example locates regular files in `/var/adm` and its directories that have not been accessed in the last 60 days and saves the list of inactive files in `/var/tmp/deadfiles`. These files are then removed with the `rm` command.

```
# find /var/adm -type f -atime +60 -print > /var/tmp/deadfiles &
# more /var/tmp/deadfiles
/var/adm/log/asppp.log
/var/adm/aculog
/var/adm/spellhist
/var/adm/wtmp
/var/adm/wtmpx
/var/adm/sa/sa13
/var/adm/sa/sa27
/var/adm/sa/sa11
/var/adm/sa/sa23
/var/adm/sulog
/var/adm/vold.log
```

(continued)

(Continuation)

```
/var/adm/messages.1  
/var/adm/messages.2  
/var/adm/messages.3  
# rm `cat /var/tmp/deadfiles`
```

▼ How to Clear Out Temporary Directories

1. Become superuser.
2. Change to the `/var/tmp` directory.

```
# cd /var/tmp
```



Caution - Be sure you are in the right directory before completing the following step. The next step deletes all files in the current directory.

3. Delete the files and subdirectories in the current directory.

```
# rm -r *
```

4. Change to other directories containing temporary or obsolete subdirectories and files (for example, `mail`, `lost+found`, or `quotas`), and delete them by repeating Step 3 above.

Example—Clearing Out Temporary Directories

The following example shows how to clear out the `/var/tmp` directory, and verifies that all files and subdirectories were removed.

```
# cd /var/tmp  
# ls  
deadfiles          wxconAAAa0003r:0.0  wxconAAAa000NA:0.0  
test_dir           wxconAAAa0003u:0.0  wxconAAAa000cc:0.0  
wxconAAAa000zs:0.0
```

(continued)

(Continuation)

```
# rm -r *  
# ls  
#
```

▼ How to Find and Delete `core` Files

1. Become superuser.
2. Change the directory to where you want to start the search.
3. Find and remove any `core` files in this directory and its subdirectories.

```
# find . -name core -exec rm {} \;
```

Example—Finding and Deleting `core` Files

The following example shows how to find and remove `core` files from the user account belonging to `jones` using the `find` command.

```
# cd /home/jones  
# find . -name core -exec rm {} \;
```

▼ How to Delete Crash Dump Files

Crash dump files can be very large, so if you have enabled your system to store these files, do not retain them for longer than necessary.

1. Become superuser.
2. Change to the directory where crash dump files are stored.

```
# cd /var/crash/system
```

system

System that created the crash dump files.



Caution - Be sure you are in the right directory before completing the following step. The next step deletes all files in the current directory.

3. Remove the crash dump files.

```
# rm *
```

4. Verify the crash dump files are removed.

```
# ls
```

Example—Deleting Crash Dump Files

The following example shows how to remove crash dump files from the system `venus`, and how to verify that the crash dump files were removed.

```
# cd /var/crash/venus  
# rm *  
# ls
```

Managing Quotas (Tasks)

This chapter describes how to set up and administer quotas for disk space and inodes. This is a list of the step-by-step instructions in this chapter.

- “How to Configure File Systems for Quotas” on page 399
- “How to Set Up Quotas for a User” on page 400
- “How to Set Up Quotas for Multiple Users” on page 401
- “How to Check Quota Consistency” on page 402
- “How to Turn Quotas On” on page 402
- “How to Check for Exceeded Quotas” on page 404
- “How to Check Quotas on a File System” on page 405
- “How to Change the Soft Time Limit Default” on page 407
- “How to Change Quotas for a User” on page 408
- “How to Disable Quotas for a User” on page 409
- “How to Turn Quotas Off” on page 410

Using Quotas

Using quotas enable system administrators to control the size of UFS file systems by limiting the amount of disk space and the number of inodes (which roughly corresponds to the number of files) that individual users can acquire. For this reason, quotas are especially useful on the file systems where user home directories reside.

Once they are in place, quotas can be changed to adjust the amount of disk space or number of inodes that users can consume. Additionally, quotas can be added or

removed as system needs change. See “Changing and Removing Quotas” on page 406 for instructions on changing quotas or the amount of time that quotas can be exceeded, disabling individual quotas, or removing quotas from file systems.

In addition, quota status can be monitored. Quota commands enable administrators to display information about quotas on a file system, or search for users who have exceeded their quotas. For procedures that describe how to use these commands, see “Checking Quotas” on page 403.

Soft Limits vs. Hard Limits

You can set both soft and hard limits. The system will not allow a user to exceed his or her hard limit. However, a system administrator may set a soft limit (sometimes referred to as a quota) which can be temporarily exceeded by the user. The soft limit must be less than the hard limit.

Once the user exceeds the soft limit a timer begins. While the timer is ticking, the user is allowed to operate above the soft limit but cannot exceed the hard limit. Once the user goes below the soft limit, the timer gets reset. However, if the user’s usage remains above the soft limit when the timer expires, the soft limit is enforced as a hard limit. By default, the soft limit timer is seven days.

The value of the timer is shown by the `timeleft` field in the `repquota` and `quota` commands.

For example, let’s say a user has a soft limit of 10,000 blocks and a hard limit of 12,000 blocks. If the user’s block usage exceeds 10,000 blocks and the timer is also exceeded (more than seven days), the user will not be able to allocate more disk blocks on that file system until his or her usage drops below the soft limit.

Difference Between Disk Block and File Limits

There are two resources that a file system provides to the user: blocks (for data) and inodes (for files). Each file consumes one inode. File data is stored in data blocks (usually made of up 1 kilobyte blocks.)

Assuming there are no directories, it is possible for a user to exceed his or her inode quota without using any blocks by creating all empty files. It is also possible for a user to use only one inode yet exceed his or her block quota by simply creating one file large enough to consume all the data blocks in the user’s quota.

Setting Up Quotas

You can set up quotas to limit the amount of disk space and number of inodes (roughly equivalent to the number of files) available to users. These quotas are activated automatically each time a file system is mounted. This section describes how to configure file systems for quotas, and how to set up and activate quotas.

Setting up quotas involves these general steps:

1. A series of commands prepares a file system to accept quotas, ensuring that quotas will be enforced each time the system is rebooted and the file system is mounted. Entries must be added to the `/etc/vfstab` file, and a `quotas` file must be created in the top-level directory of the file system.
2. After a quota is created for one user, it can be copied as a prototype to set up other user quotas.
3. Before quotas are actually turned on, another command checks for consistency by comparing the proposed quotas with the current disk usage to make sure that there are no conflicts.
4. Finally, a command turns the quotas on for one or more entire file systems.

These steps ensure that quotas are automatically activated on a file system each time it is mounted. For specific information about these procedures, see “Setting Up Quotas Task Map” on page 398.

Table 20–1 describes the commands you use to set up disk quotas.

TABLE 20–1 Commands for Setting Up Quotas

Command	Enables You To ...
<code>edquota(1M)</code>	Set the hard and soft limits on the number of inodes and disk space for each user.
<code>quotacheck(1M)</code>	Examine each mounted UFS file system, comparing against information stored in the file system’s disk quota file, and resolve inconsistencies.
<code>quotaon(1M)</code>	Activate the quotas for the specified file systems.
<code>quota(1M)</code>	Display user’s quotas on mounted file systems to verify that quotas have been correctly set up.

Guidelines for Setting Up Quotas

Before you set up quotas, you need to determine how much space and how many inodes to allocate to each user. If you want to be sure the total file system space is never exceeded, you can divide the total size of the file system between the number of users. For example, if three users share a 100-Mbyte slice and have equal disk space needs, you could allocate 33 Mbytes to each. In environments where not all users are likely to push their limits, you may want to set individual quotas so that they add up to more than the total size of the file system. For example, if three users share a 100-Mbyte slice, you could allocate 40 Mbytes to each.

When you have established a quota for one user by using the `edquota` command, you can use this quota as a prototype to set the same quota for other users on the same file system.

After you have configured UFS file systems for quotas and established quotas for each user, run the `quotacheck` command to check consistency between current disk usage and quota files before you actually turn quotas on. Also, if systems are rebooted infrequently, it is a good idea to periodically run `quotacheck`.

The quotas you set up with `edquota` are not enforced until you turn them on by using the `quotaon` command. If you have properly configured the quota files, quotas will be turned on automatically each time a system is rebooted and the file system is mounted.

Setting Up Quotas Task Map

TABLE 20-2 Setting Up Quotas Task Map

Task	Description	For Instructions, Go To
1. Configure a File System for Quotas	Edit <code>/etc/vfstab</code> so that quotas are activated each time the file system is mounted, and create a <code>quotas</code> file.	"How to Configure File Systems for Quotas" on page 399
2. Set Up Quotas for a User	Use the <code>edquota</code> command to create disk and inode quotas for a single user account.	"How to Set Up Quotas for a User" on page 400
3. Set Up Quotas for Multiple Users	<i>Optional.</i> Use <code>edquota</code> to apply prototype quotas to other user accounts.	"How to Set Up Quotas for Multiple Users" on page 401

TABLE 20-2 Setting Up Quotas Task Map (continued)

Task	Description	For Instructions, Go To
4. Check for Consistency	Use the <code>quotacheck</code> command to compare quotas to current disk usage for consistency on one or more file systems.	“How to Check Quota Consistency” on page 402
5. Turn Quotas On	Use the <code>quotaon</code> command to initiate quotas on one or more file systems.	“How to Turn Quotas On” on page 402

▼ How to Configure File Systems for Quotas

1. **Become superuser.**
2. **Edit the `/etc/vfstab` file by using the editor of your choice. Add `rq` to the `mount options` field for each UFS file system that will have quotas.**
3. **Exit the file, saving the changes.**
4. **Change directory to the top of the file system that will have quotas.**
5. **Create a file named `quotas`.**

```
# touch quotas
```

6. **Change permissions to read/write for root only.**

```
# chmod 600 quotas
```

Examples—Configuring File Systems for Quotas

The following example from `/etc/vfstab` shows that the `/export/home` directory from the system `pluto` is mounted as an NFS file system on the local system with quotas enabled.

```
#device          device  mount      FS   fsck  mount  mount
#to mount        to fsck  point     type pass  at boot options
#
```

(continued)

(Continuation)

```
pluto:/export/home - /export/home nfs - yes rq
```

The following example line from `/etc/vfstab` shows that the local (UFS)/`work` directory is mounted with quotas enabled.

```
#device          device          mount FS   fsck mount  mount
#to mount        to fsck         point type pass at boot options
#
/dev/dsk/c0t4d0s0 /dev/rdisk/c0t4d0s0 /work ufs 3   yes   rq
```

▼ How to Set Up Quotas for a User

1. Become superuser.
2. Use the quota editor to create a temporary file containing one line of quota information for each mounted UFS file system that has a `quotas` file in its top-level directory.

```
# edquota username
```

username User for whom you want to set up quotas.

3. Change the number of 1-Kbyte disk blocks, both soft and hard, and the number of inodes, both soft and hard, from 0 (the default) to the quotas you specify for each file system.
4. Exit the editor, saving your changes.
5. Verify the user's quota by using the `quota` command.

```
# quota -v username
```

<code>-v</code>	Display's user's quota information on all mounted file systems where quotas exist.
<code>username</code>	Specifies user name to view quota limits.

Examples—Setting Up Quotas for a User

The following example shows the contents of the temporary file opened by `edquota` on a system where `/files` is the only mounted file system containing a `quotas` file in its top-level directory.

```
fs /files blocks (soft = 0, hard = 0) inodes (soft = 0, hard = 0)
```

The following example shows the same line in the temporary file after quotas have been set up.

```
fs /files blocks (soft = 50, hard = 60) inodes (soft = 90, hard = 100)
```

▼ How to Set Up Quotas for Multiple Users

1. **Become superuser.**
2. **Use the quota editor to apply the quotas you already established for a prototype user to the additional users you specify.**

```
# edquota -p prototype-user username ...
```

<code>prototype-user</code>	User name of the account for which you have set up quotas.
<code>username ...</code>	Specifies one or more user names of additional accounts.

Example—Setting Up Prototype Quotas for Multiple Users

The following example applies the quotas established for user `bob` to users `mary` and `john`.

```
# edquota -p bob mary john
```

▼ How to Check Quota Consistency

Note - To ensure accurate disk data, the file systems being checked should be quiescent when you run the `quotacheck` command manually. The `quotacheck` command is run automatically when a system is rebooted.

1. **Become superuser.**
2. **Run a consistency check on UFS file systems. See the `quotacheck`.**

```
# quotacheck [ -v ] -a | filesystem
```

<code>-v</code>	(Optional) Identifies the disk quotas for each user on a particular file system.
<code>-a</code>	Checks all file systems with an <code>rq</code> entry in the <code>/etc/vfstab</code> file.
<code>filesystem</code>	Specifies a file system to check.

Example—Checking Quota Consistency

The following example checks quotas for the `/export/home` file system on the `/dev/rdisk/c0t0d0s7` slice. The `/export/home` file system is the only file system with an `rq` entry in the `/etc/vfstab` file.

```
# quotacheck -va
*** Checking quotas for /dev/rdisk/c0t0d0s7 (/export/home)
```

▼ How to Turn Quotas On

1. **Become superuser.**
2. **Turn file system quotas on by using the `quotaon` command.**

```
# quotaon [-v] -a | filesystem ...]
```

<code>-v</code>	(Optional) Verbose option.
<code>-a</code>	Turns quotas on for all file systems with an <code>rq</code> entry in the <code>/etc/vfstab</code> file.
<code>filesystem ...</code>	Turns quotas on for one or more file systems that you specify.

Example—Turning Quotas On

The following example turns quotas on for the file systems on the `/dev/dsk/c0t4d0s2` and `/dev/dsk/c0t3d0s2` slices.

```
# quotaon -v /dev/dsk/c0t4d0s2 /dev/dsk/c0t3d0s2
/dev/dsk/c0t4d0s2: quotas turned on
/dev/dsk/c0t3d0s2: quotas turned on
```

Checking Quotas

After you have set up and turned on disk and inode quotas, you can check for users who exceed their quotas. In addition, you can check quota information for entire file systems.

Table 20–3 describes the commands you use to check quotas.

TABLE 20–3 Commands for Checking Quotas

Command	Task
<code>quota(1M)</code>	Display user quotas and current disk use, and information about users who are exceeding their quotas.
<code>repquota(1M)</code>	Display quotas, files, and amount of space owned for specified file systems.

▼ How to Check for Exceeded Quotas

You can display the quotas and disk use for individual users on file systems on which quotas have been activated by using the `quota` command.

1. **Become superuser.**
2. **Display user quotas for mounted file systems where quotas are enabled.**

```
# quota [-v] username
```

`-v` (Optional) Displays users' quotas on all mounted file systems that have quotas.

`username` Is the login name or UID of a user's account.

Example—Checking for Exceeded Quotas

The following example shows that the user account identified by UID 301 has a quota of one Kbyte but has not used any disk space.

```
# quota -v 301
Disk quotas for bob (uid 301):
Filesystem usage  quota limit timeleft files  quota  limit timeleft
/export/home  0      1    2          0      2     3
```

<code>Filesystem</code>	Is the mount point for the file system
<code>usage</code>	Is the current block usage
<code>quota</code>	Is the soft block limit
<code>limit</code>	Is the hard block limit
<code>timeleft</code>	Is the amount of time (in days) left on the quota timer
<code>files</code>	Is the current inode usage
<code>quota</code>	Is the soft inode limit

<code>limit</code>	Is the hard inode limit
<code>timeleft</code>	Is the amount time (in days) left on the quota timer.

▼ How to Check Quotas on a File System

Display the quotas and disk use for all users on one or more file systems by using the `repquota` command.

1. **Become superuser.**
2. **Display all quotas for one or all file systems, even if there is no usage.**

```
# repquota [-v] -a | filesystem
```

<code>-v</code>	(Optional) Reports on quotas for all users—even those who do not consume resources. (Verbose mode).
<code>-a</code>	Reports on all file systems.
<code>filesystem</code>	(Reports on the specified file system.

Example—Checking Quotas on a File System

The following example shows output from the `repquota` command on a system that has quotas enabled on only one file system (`/export/home`).

```
# repquota -va
/dev/dsk/c0t3d0s7 (/export/home):
      Block limits                File limits
User   used  soft  hard  timeleft  used  soft  hard  timeleft
#301  --    0    1    2.0 days    0    2    3
#341  --    57   50   60   7.0 days    2    90   100
```

Block Limits

<code>used</code>	Is the current block usage
<code>soft</code>	Is the soft block limit
<code>hard</code>	Is the hard block limit
<code>timeleft</code>	Is the amount of time (in days) left on the quota timer

File Limits

<code>used</code>	Is the current inode usage
<code>soft</code>	Is the soft inode limit
<code>hard</code>	Is the hard inode limit
<code>timeleft</code>	Is the amount of time (in days) left on the quota timer

Changing and Removing Quotas

You can change quotas to adjust the amount of disk space or number of inodes users can consume. You can also remove quotas for individual users or from entire file systems as needed.

Table 20-4 describes the commands you use to change or remove quotas.

TABLE 20-4 Commands for Changing and Removing Quotas

Command	Task
<code>edquota(1M)</code>	Change the hard and soft limits on the number of inodes or disk space for each user. Also, change the soft quota time limit for each file system with a quota.
<code>quotaoff(1M)</code>	Turn off quotas for specified file systems.

▼ How to Change the Soft Time Limit Default

Users can exceed the soft time limits for their quotas for one week, by default. This means that after a week of repeated violations of the soft time limits of either disk space or inode quotas, the system prevents users from using any more inodes or disk blocks.

You can change the length of time that users may exceed their disk space or inode quotas by using the `edquota` command.

1. **Become superuser.**
2. **Use the quota editor to create a temporary file containing soft time limits.**

```
# edquota -t
```

3. **Change the time limits from 0 (the default) to the time limits you specify by numbers and the keywords month, week, day, hour, min, or sec.**
4. **Exit the editor, saving your changes.**

Note - This procedure doesn't affect current quota violators.

Examples—Changing the Soft Time Limit Default

The following example shows the contents of the temporary file opened by `edquota` on a system where `/export/home` is the only mounted file system with quotas. The 0 (default) value means that the default time limit of one week is used.

```
fs /export/home blocks time limit = 0 (default), files time limit = 0 (default)
```

The following example shows the same temporary file after the time limit for exceeding the blocks quota has been changed to one week, and the time limit for exceeding the number of files has been changed to ten days.

```
fs /export/home blocks time limit = 2 weeks, files time limit = 16 days
```

▼ How to Change Quotas for a User

1. **Become superuser.**
2. **Use the quota editor to open a temporary file containing one line for each mounted file system that has a `quotas` file in its top-level directory.**

```
# edquota username
```

username User name whose quota will be modified.



Caution - Although you can specify multiple users as arguments to the `edquota` command, the information displayed does not show which user it belongs to, which could create some confusion.

3. **Enter the number of 1-Kbyte disk blocks, both soft and hard, and the number of inodes, both soft and hard.**
4. **Exit the editor, saving your changes.**
5. **Verify that a user's quota has been correctly changed by using the `quota` command.**

```
# quota -v username
```

`-v` Displays user quota information on all mounted file systems with quotas enabled.

username User name whose quota you want to check.

Examples—Changing Quotas for a User

The following example shows the contents of the temporary file opened by `edquota` on a system where `/files` is the only mounted file system containing a `quotas` file in its top-level directory.

```
fs /files blocks (soft = 0, hard = 0) inodes (soft = 0, hard = 0)
```

The following example shows the same temporary file after quotas have been changed.

```
fs /files blocks (soft = 0, hard = 500) inodes (soft = 0, hard = 100)
```

The following example shows how to verify that the hard quotas for user `smith` have been changed to 500 1-Kbyte blocks, and 100 inodes.

```
# quota -v smith
Disk quotas for smith (uid 12):
Filesystem  usage  quota  limit  timeleft  files  quota  limit  timeleft
/files      1      0      500           1      0      100
```

▼ How to Disable Quotas for a User

1. Become superuser.
2. Use the quota editor to create a temporary file containing one line for each mounted file system that has a `quotas` file in its top-level directory.

```
# edquota username
```

username User name whose quota will be disabled.



Caution - Although you can specify multiple users as arguments to the `edquota` command, the information displayed does not show which user it belongs with, which could create some confusion.

3. Change the number of 1-Kbyte disk blocks, both soft and hard, and the number of inodes, both soft and hard, to 0 (zero).

Note - Be sure you change the values to zero. Do *not* delete the line from the text file.

4. Exit the editor, saving your changes.
5. Verify that you have disabled a user's quota by using the `quota` command.

```
# quota -v username
```

`-v`

Displays user quota information on all mounted file systems with quotas enabled.

`username`

User name (UID) whose quota you want to check.

Examples—Disabling Quotas for a User

The following example shows the contents of the temporary file opened by `edquota` on a system where `/files` is the only mounted file system containing a `quotas` file in its top-level directory.

```
fs /files blocks (soft = 50, hard = 60) inodes (soft = 90, hard = 100)
```

The following example shows the same temporary file after quotas have been disabled.

```
fs /files blocks (soft = 0, hard = 0) inodes (soft = 0, hard = 10)
```

▼ How to Turn Quotas Off

1. Become superuser.
2. Turn file system quotas off.

```
# quotaoff [ -v ] -a | filesystem ...
```

<code>-v</code>	(Optional) Verbose option.
<code>-a</code>	Turns quotas off for all file systems.
<code>filesystem1, 2, 3 ...</code>	Turns quotas off for one or more file systems you specify.

Example—Turning Quotas Off

The following example turns the quotas off for the `/export/home` file system.

```
# quotaoff -v /export/home
/export/home: quotas turned off
```


Scheduling System Events (Tasks)

This chapter describes how to schedule routine or one-time system events by using the `crontab` and `at` commands. It also explains how to control access to these commands by using `cron.deny`, `cron.allow`, and `at.deny` files.

This is a list of the step-by-step instructions in this chapter.

- “How to Create or Edit a `crontab` File” on page 417
- “How to Display a `crontab` File” on page 419
- “How to Remove a `crontab` File” on page 420
- “How to Deny `crontab` Access” on page 422
- “How to Limit `crontab` Access to Specified Users” on page 423
- “How to Create an `at` Job” on page 426
- “How to Display the `at` Queue” on page 427
- “How to Display `at` Jobs” on page 427
- “How to Remove `at` Jobs” on page 428
- “How to Deny `at` Access” on page 429

Commands for Scheduling System Events

You can schedule system events to execute repetitively, at regular intervals, by using the `crontab` command. You can schedule a single system event for execution at a specified time by using the `at` command. Table 21-1 summarizes `crontab` and `at`, as well as the files that enable you to control access to these commands.

TABLE 21-1 Command Summary: Scheduling System Events

Command	What It Schedules	Location of Files	Files That Control Access
crontab	Multiple system events at regular intervals	/var/spool/cron/crontabs	/etc/cron.d/cron.allow and /etc/cron.d/cron.deny
at	A single system event	/var/spool/cron/atjobs	/etc/cron.d/at.deny

Scheduling a Repetitive System Event (cron)

The following sections describe how to create, edit, display, and remove crontab files, as well as how to control access to them.

Inside a crontab File

The cron daemon schedules system events according to commands found within each crontab file. A crontab file consists of commands, one per line, that will be executed at regular intervals. The beginning of each line contains date and time information that tells the cron daemon when to execute the command.

For example, a crontab file named root is supplied during SunOS software installation. Its contents include these command lines:

```
10 3 * * 0,4 /etc/cron.d/logchecker
10 3 * * 0 /usr/lib/newsyslog
15 3 * * 0 /usr/lib/fs/nfs/nfsfind
1 2 * * * [ -x /usr/sbin/rtc ] && /usr/sbin/rtc -c > /dev/null 2>&1
```

The first command line instructs the system to run logchecker at 3:10 on Sundays and Thursdays nights. The second command line schedules the system to run newsyslog at 3:10 every Sunday morning. The third command line orders the system to execute nfsfind daily at 3:15 in the morning. The fourth command line

instructs the system to check for daylight savings time and makes corrections if necessary. If there is no RTC time zone nor an `/etc/rtc_config` file, this entry will do nothing.

For more information about the syntax of lines within a `crontab` file, see “Syntax of `crontab` File Entries” on page 416.

The `crontab` files are stored in `/var/spool/cron/crontabs`. Several `crontab` files besides `root` are provided during SunOS software installation (see Table 21-2).

TABLE 21-2 Default `crontab` Files

<code>crontab</code> File	Function
<code>adm</code>	Accounting
<code>lp</code>	Printing
<code>root</code>	General system functions and file system cleanup
<code>sys</code>	Performance collection
<code>uucp</code>	General <code>uucp</code> cleanup

Other `crontab` files are named after the user accounts in which they are created, such as `bob`, `mary`, `smith`, or `jones`.

Besides the default `crontab` file, users can create `crontab` files to schedule their own system events. To access `crontab` files belonging to `root` or other users, superuser privileges are required.

Procedures explaining how to create, edit, display, and remove `crontab` files are described in “Commands for Scheduling System Events” on page 413.

How the `cron` Daemon Handles Scheduling

The `cron` daemon handles the automatic scheduling of `crontab` commands. Its function is to check the `/var/spool/cron/crontab` directory for the presence of `crontab` files, normally every 15 minutes. It checks for new `crontab` files or changes to existing ones, reads the execution times listed within the files, and submits the commands for execution at the proper times.

In much the same way, the `cron` daemon controls the scheduling of `at` files, which are stored in the `/var/spool/cron/atjobs` directory.

Syntax of crontab File Entries

A `crontab` file consists of commands, one per line, that execute automatically at the time specified by the first five fields at the beginning of each command line. These first five fields, described in Table 21-3, are separated by spaces. They indicate when the command will be executed.

TABLE 21-3 Values for `crontab` Time Fields

Time Field	Values
Minute	0-59
Hour	0-23
Day of month	1-31
Month	1-12
Day of week	0-6 (0=Sunday)

Follow these guidelines to use special characters in `crontab` time fields:

- Use a space to separate each field.
- Use a comma to separate multiple values.
- Use a hyphen to designate a range of values.
- Use an asterisk as a wildcard to include all possible values.
- Use a comment mark (#) at the beginning of a line to indicate a comment or a blank line.

For example, the following sample `crontab` command entry displays a reminder in the user's console window at 4 p.m. on the first and fifteenth of every month.

```
0 16 1,15 * * echo Timesheets Due > /dev/console
```

Each command within a `crontab` file must consist of one line, even if it is very long, because `crontab` does not recognize extra carriage returns. For more detailed information about `crontab` entries and command options, refer to `crontab(1)`.

Creating and Editing crontab Files

The simplest way to create a crontab file is to use the `crontab -e` command to invoke the text editor set up for your system environment, defined by the `EDITOR` environment variable. If this variable has not been set, `crontab` uses the default editor `ed`. Define your `EDITOR` environment to be an editor you are familiar with. The following example shows how to check to see whether an editor has been defined, and how to set up `vi` as the default.

```
$ which $EDITOR
$
$ EDITOR=vi
$ export EDITOR
```

When you create a crontab file, it is automatically placed in the `/var/spool/cron/crontabs` directory and is given your user name. You can create or edit a crontab file for another user, or root, if you have superuser privileges.

Enter `crontab` command entries as described in “Syntax of crontab File Entries” on page 416.

▼ How to Create or Edit a crontab File

1. Be sure that you have access to the editor of your choice.
2. (Optional) To create or edit a crontab file belonging to root or another user, become superuser.
3. Create a new crontab file, or edit an existing one.

```
$ crontab -e [username]
```

username

Name of another user’s account, and requires root privileges to create or edit.



Caution - If you accidentally enter the `crontab` command with no option, press the interrupt character for your editor. This allows you to quit without saving changes. Exiting the file and saving changes at this point would overwrite an existing `crontab` file with an empty file.

4. **Add command lines to the file, following the syntax described in “Syntax of `crontab` File Entries” on page 416.**
5. **Exit the file, saving the changes.**
The `crontab` file will be placed in `/var/spool/cron/crontabs`.
6. **Verify the `crontab` file by using the `crontab -l` command.**

```
# crontab -l [username]
```

Example—Creating or Editing a `crontab` File

The following example shows how to create a `crontab` file for another user.

```
# crontab -e jones
```

The following command entry added to a new `crontab` file will automatically remove any log files from the user’s home directory at 1 every Sunday morning. Because the command entry does not redirect output, redirect characters are added to the command line after `*.log` to make sure that the command executes properly.

```
# This command helps clean up user accounts.  
1 0 * * 0 rm /home/jones/*.log > /dev/null 2>&1
```

▼ How to Verify a `crontab` File

To verify that a `crontab` file exists for a user, use the `ls -l` command in the `/var/spool/cron/crontabs` directory. For example, the following display shows that `crontab` files exist for users `smith` and `jones`.

```
$ ls -l /var/spool/cron/crontabs
-rw-r--r-- 1 root sys 190 Feb 26 16:23 adm
-rw----- 1 root staff 225 Mar 1 9:19 jones
-rw-r--r-- 1 root root 1063 Feb 26 16:23 lp
-rw-r--r-- 1 root sys 441 Feb 26 16:25 root
-rw----- 1 root staff 60 Mar 1 9:15 smith
-rw-r--r-- 1 root sys 308 Feb 26 16:23 sys
```

Verify the contents of user's crontab file by using `crontab -l` as described in "How to Display a crontab File" on page 419.

Displaying crontab Files

The `crontab -l` command displays the contents of your crontab file much the way the `cat` command displays the contents of other types of files. You do not have to change directories to `/var/spool/cron/crontabs` (where crontab files are located) to use this command.

By default, the `crontab -l` command displays your own crontab file. To display crontab files belonging to other users, you must be superuser.

▼ How to Display a crontab File

1. (Optional) To display a crontab file belonging to root or another user, become superuser.
2. Display the crontab file.

```
$ crontab -l [username]
```

username

Name of another user's account, and requires superuser privileges to create or edit.



Caution - If you accidentally enter the `crontab` command with no option, press the interrupt character for your editor. This allows you to quit without saving changes. Exiting the file and saving changes at this point would overwrite an existing crontab file with an empty file.

Example—Displaying a crontab File

The following example shows how to use `crontab -l` to display the contents of the default user's crontab file, the default root crontab file, and the crontab file belonging to another user.

```
$ crontab -l
13 13 * * * chmod g+w /usr/documents/*.book > /dev/null 2>&1
$ su
Password:
# crontab -l
#ident "@(#)root      1.16      98/04/28 SMI"      /* SVr4.0 1.1.3.1      */
#
# The root crontab should be used to perform accounting data collection.
#
# The rtc command is run to adjust the real time clock if and when
# daylight savings time changes.
#
10 3 * * 0,4 /etc/cron.d/logchecker
10 3 * * 0   /usr/lib/newsyslog
15 3 * * 0   /usr/lib/fs/nfs/nfsfind
1 2 * * * [ -x /usr/sbin/rtc ] && /usr/sbin/rtc -c > /dev/null 2>&1
# crontab -l jones
13 13 * * * cp /home/jones/work_files /usr/backup/. > /dev/null
2>&1
```

Removing crontab Files

By default, crontab file protections are set up so that you cannot inadvertently delete a crontab file by using the `rm` command. Instead, use the `crontab -r` command to remove crontab files.

By default, `crontab -r` removes your own crontab file. You must be superuser to remove crontab files belonging to superuser or other users.

You do not have to change directories to `/var/spool/cron/crontabs` (where crontab files are located) to use this command.

▼ How to Remove a crontab File

1. (Optional) To remove a crontab file belonging to root or another user, become superuser.
2. Remove the crontab file.

```
$ crontab -r [username]
```

username

Name of another user's account, and requires superuser privileges to create or edit.



Caution - If you accidentally enter the `crontab` command with no option, press the interrupt character for your editor. This allows you to quit without saving changes. Exiting the file and saving changes at this point would overwrite an existing `crontab` file with an empty file.

3. Verify the `crontab` file is removed.

```
# ls /var/spool/cron/crontabs
```

Example—Removing a `crontab` File

The following example shows how user `smith` uses the `crontab -r` command to remove his `crontab` file.

```
$ ls /var/spool/cron/crontabs
adm   jones   lp      root    smith   sys     uucp
$ crontab -r
$ ls /var/spool/cron/crontabs
adm   jones   lp      root    sys     uucp
```

Controlling Access to `crontab`

You can control access to `crontab` by using two files in the `/etc/cron.d` directory: `cron.deny` and `cron.allow`. These files permit only specified users to perform `crontab` tasks such as creating, editing, displaying, or removing their own `crontab` files.

The `cron.deny` and `cron.allow` files consist of a list of user names, one per line. These access control files work together like this:

- If `cron.allow` exists, only the users listed in this file can create, edit, display, or remove `crontab` files.

- If `cron.allow` doesn't exist, all users may submit `crontab` files, except for users listed in `cron.deny`.
- If neither `cron.allow` nor `cron.deny` exists, superuser privileges are required to run `crontab`.

Superuser privileges are required to edit or create `cron.deny` and `cron.allow`.

During Solaris software installation, a default `cron.deny` file is provided:

```
$ cat /etc/cron.d/cron.deny
daemon
bin
smtp
nuucp
listen
nobody
noaccess
```

None of these user names can access `crontab` commands. You can edit this file to add other user names who will be denied access to the `crontab` command.

No default `cron.allow` file is supplied. This means that, after Solaris software installation, all users (except the ones listed in the default `cron.deny` file) can access `crontab`. If you create a `cron.allow` file, only these users can access `crontab` commands.

▼ How to Deny `crontab` Access

1. **Become superuser.**
2. **Using the editor of your choice, edit the `/etc/cron.d/cron.deny` file to add user names, one per line, who will be prevented from using `crontab` commands.**

```
daemon
bin
smtp
nuucp
listen
nobody
noaccess
username1
username2
username3
.
.
```

(continued)

(Continuation)

```
.
```

3. Exit the file, saving the changes.
4. Verify the `/etc/cron.d/cron.deny` file.

```
# cat /etc/cron.d/cron.deny
```

▼ How to Limit `crontab` Access to Specified Users

1. Become superuser.
2. Use the editor of your choice to create a file named `/etc/cron.d/cron.allow`.
3. Enter the user names, one per line, who will be allowed to use `crontab` commands.

```
root
username1
username2
username3
.
.
.
```

Be sure to add `root` to this list. If you do not, superuser access to `crontab` commands will be denied.

4. Exit the file, saving the changes.

Examples—Limiting crontab Access to Specified Users

The following example shows a `cron.deny` file that prevents user names `visitor`, `jones`, and `temp` from accessing `crontab`.

```
$ cat /etc/cron.d/cron.deny
daemon
bin
smtp
nuucp
listen
nobody
noaccess
jones
temp
visitor
```

The following example shows a `cron.allow` file. The users `smith`, `jones`, `lp`, and `root` are the only ones who may access `crontab`.

```
$ cat /etc/cron.d/cron.allow
root
jones
lp
smith
```

▼ How to Verify Limited crontab Access

To verify whether or not a specific user can access `crontab`, use the `crontab -l` command while logged into the user account.

```
$ crontab -l
```

If the user can access `crontab`, and already has created a `crontab` file, it will be displayed. Otherwise, if the user can access `crontab` but no `crontab` file exists, a message like the following will be displayed:

```
crontab: can't open your crontab file
```

This user either is listed in `cron.allow` (if it exists), or is not listed in `cron.deny`.

If the user cannot access `crontab`, the following message is displayed whether or not a previous `crontab` file exists:

```
crontab: you are not authorized to use cron. Sorry.
```

This means either that the user is not listed in `cron.allow` (if it exists), or the user is listed in `cron.deny`.

Scheduling a Single System Event (at)

The following sections describe how to use `at(1)` to schedule jobs (commands and scripts) for execution at a later time, how to display and remove these jobs, and how to control access to the `at` command.

By default, users can create, display, and remove their own `at` job files. To access `at` files belonging to root or other users, you must have superuser privileges.

When you submit an `at` job, it is assigned a job identification number along with the `.a` extension that becomes its file name.

at Command Description

Submitting an `at` job file includes:

1. Invoking the `at` utility, specifying a command execution time.
2. Entering a command or script to execute later.

Note - If output from this command or script is important, be sure to direct it to a file for later examination.

For example, the following `at` job removes `core` files from the user account belonging to Smith near midnight on the last day of January.

```
$ at 11:45pm June 11
at> rm /home/smith/*core*
at> Press Control-d
job 897543900.a at Wed Jun 10 23:45:00 1998
```

at Command Security

You can set up a file to control access to the `at` command, permitting only specified users to create, remove, or display queue information about their `at` jobs. The file that controls access to `at`, `/etc/cron.d/at.deny`, consists of a list of user names, one per line. The users listed in this file cannot access `at` commands.

The `at.deny` file, created during SunOS software installation, contains the following user names:

```
daemon
bin
smtp
nuucp
listen
nobody
noaccess
```

With superuser privileges, you can edit this file to add other user names whose `at` access you want to restrict.

▼ How to Create an `at` Job

1. Enter the `at` facility, specifying the time you want your job executed, and press Return.

```
$ at [-m] time [date]
```

<code>-m</code>	Sends you mail after the job is completed.
<code>time</code>	Hour that you want to schedule the job. Add <code>am</code> or <code>pm</code> if you do not specify the hours according to a 24-hour clock. <code>midnight</code> , <code>noon</code> , and <code>now</code> are acceptable keywords. Minutes are optional.
<code>date</code>	First three or more letters of a month, a day of the week, or the keywords <code>today</code> or <code>tomorrow</code> .

2. At the `at` prompt, enter the commands or scripts you want to execute, one per line. You may enter more than one command by pressing Return at the end of each line.
3. Exit the `at` utility and save the `at` job by pressing Control-d.
Your `at` job is assigned a queue number, which is also its file name. This number is displayed when you exit the `at` utility.

Examples—Creating an `at` Job

The following example shows the `at` job that user `jones` created to remove her backup files at 7:30 at night. She used the `-m` option so that she would receive a mail message after her job completed.

```
$ at -m 1930
at> rm /home/jones/*.backup
at> Press Control-d
job 897355800.a at Mon Jun 8 19:30:00 1998
```

She received a mail message which confirmed the execution of her at job.

```
Your ``at`` job ``rm /home/jones/*.backup``
completed.
```

The following example shows how Jones scheduled a large at job for 4:00 Saturday morning. The output of which was directed to big.file.

```
$ at 4 am Saturday
at> sort -r /usr/dict/words > /export/home/jones/big.file
```

▼ How to Display the at Queue

To check your jobs that are waiting in the at queue, use the atq command. This command displays status information about the at jobs that you created.

```
$ atq
```

▼ How to Verify an at Job

To verify that you have created an at job, use the atq command. The atq command confirms that at jobs belonging to jones have been submitted to the queue.

```
$ atq
Rank  Execution Date      Owner      Job              Queue  Job Name
1st   Jun  8, 1998 19:30   jones  897355800.a     a      stdin
2nd   Jun 10, 1998 23:45   jones  897543900.a     a      stdin
3rd   Jun 13, 1998 04:00   jones  897732000.a     a      stdin
```

▼ How to Display at Jobs

To display information about the execution times of your at jobs, use the at -l command.

```
$ at -l [job-id]
```

`-l job-id`

Identification number of the job whose status you want to examine.

Example—Displaying `at` Jobs

The following example shows output from the `at -l` command, used to get status information on all jobs submitted by a user.

```
$ at -l
897543900.a Wed Jun 10 23:45:00 1998
897355800.a Mon Jun 8 19:30:00 1998
897732000.a Sat Jun 13 04:00:00 1998
```

The following example shows output displayed when a single job is specified with the `at -l` command.

```
$ at -l 897732000.a
```

▼ How to Remove `at` Jobs

1. (Optional) To remove an `at` job belonging to root or another user, become superuser.
2. Remove the `at` job from the queue before it is executed.

```
$ at -r [job-id]
```

`-r job-id`

Identification number of the job you want to remove.

3. Verify the `at` job is removed by using the `at -l` (or the `atq`) command to display the jobs remaining in the `at` queue. The job whose identification number you specified should not appear.

```
$ at -l [job-id]
```

Example—Removing `at` Jobs

In the following example, a user wants to remove an `at` job that was scheduled to execute at noon on March 1. First, the user displays the `at` queue to locate the job

identification number. Next, the user removes this job from the `at` queue. Finally, the user verifies that this job has been removed from the queue.

```
$ at -l
897543900.a Wed Jun 10 23:45:00 1998
897355800.a Mon Jun  8 19:30:00 1998
897732000.a Sat Jun 13 04:00:00 1998
$ at -r 897732000.a
$ at -l 897732000.a
at: 858142000.a: No such file or directory
```

Controlling Access to `at`

Users listed in the `at.deny` file cannot use `at` to schedule jobs or to check the `at` queue status.

The `at.deny` file is placed in the `/etc/cron.d` directory during Solaris software installation. At that time, the same users are listed in both this file and the default `cron.deny` file.

```
daemon
bin
smtp
nuucp
listen
nobody
noaccess
```

Root permissions are required to edit this file.

▼ How to Deny `at` Access

1. **Become superuser.**
2. **Using the editor of your choice, open the `/etc/cron.d/at.deny` file.**
3. **Add the names of users, one per line, who will be prevented from using `at` commands.**

```
daemon
bin
smtp
nuucp
listen
nobody
noaccess
username1
username2
username3
.
.
.
```

4. Exit the file, saving your changes.

Example—Denying at Access

The following example shows an `at.deny` file that has been edited so that the users Smith and Jones may not access `at`.

```
$ cat at.deny
daemon
bin
smtp
nuucp
listen
nobody
noaccess
jones
smith
```

▼ How to Verify at Access Is Denied

To verify whether or not a user's name was added correctly to `/etc/cron.d/at.deny`, use the `at -l` command while logged in as the user. If the user cannot access `at` commands, the following message is displayed.

```
# su smith
Password:
$ at -l
at: you are not authorized to use at. Sorry.
```

Likewise, if the user tries to submit an `at` job, the following message is displayed:

```
$ at 2:30pm
at: you are not authorized to use at. Sorry.
```

This confirms that the user is listed in the `at.deny` file.

Managing System Accounting (Tasks)

This section contains some simple procedures for setting up and maintaining system accounting.

This is a list of the step-by-step instructions in this chapter.

- “How to Set Up System Accounting” on page 434
- “How to Bill Users” on page 437
- “How to Fix a `wtmp` File” on page 438
- “How to Fix `tacct` Errors” on page 439
- “How to Restart `runacct`” on page 440
- “How to Set Up System Accounting” on page 434
- “How to Permanently Disable System Accounting” on page 441

Setting Up System Accounting

You can set up system accounting to run while the system is in multiuser mode (system state 2). Generally, this involves:

1. Creating `/etc/rc0.d/K22acct` and `/etc/rc2.d/S22acct`.
2. Modifying `/var/spool/cron/crontabs/adm`
and `/var/spool/cron/crontabs/root`.

Most of the accounting scripts are added to the `/var/spool/cron/crontabs/adm` database file. Table 22-1 describes the default accounting scripts.

TABLE 22-1 Default Accounting Scripts

Accounting Script ...	Is Used To ...	And Runs ...
<code>ckpacct(1M)</code>	Check the size of the <code>/usr/adm/pacct</code> log file	Periodically
<code>runacct(1M)</code>	Process connect, process, disk, and fee accounting information	Daily
<code>monacct(1M)</code>	Generate fiscal reports and is run once per period	On a fiscal basis

You can change these defaults. After these entries have been added to the database and the accounting programs have been installed, accounting should run automatically.

▼ How to Set Up System Accounting

1. **Become superuser.**
2. **If necessary, install the `SUNWaccr` and `SUNWaccu` packages on your system by using the `pkgadd` or `admintool` command.**
3. **Install `/etc/init.d/acct` as the startup script for Run Level 2.**

```
# ln /etc/init.d/acct /etc/rc2.d/S22acct
```

4. **Install `/etc/init.d/acct` as the stop script for Run Level 0.**

```
# ln /etc/init.d/acct /etc/rc0.d/K22acct
```

5. **Modify the `admcrontab` file to start the `ckpacct`, `runacct`, and `monacct` programs automatically.**

```
# EDITOR=vi; export EDITOR
# crontab -e adm
0 * * * * /usr/lib/acct/ckpacct
30 2 * * * /usr/lib/acct/runacct 2> /var/adm/acct/nite/fd2log
```

(continued)

(Continuation)

```
30 7 1 * * /usr/lib/acct/monacct
```

6. Modify the root crontab file to start the `dodisk` program automatically.

```
# crontab -e
30 22 * * 4 /usr/lib/acct/dodisk
```

7. Edit `/etc/acct/holidays` to include national and local holidays, by using the editor of your choice.

8. Reboot the system, or type

```
# /etc/init.d/acct start
```

Examples—Setting Up Accounting

The following example shows how the crontab entries that run `/usr/lib/acct/ckpacct`, `/usr/lib/acct/runacct`, and `/usr/lib/acct/monacct` have been added to `/var/spool/cron/crontabs/adm`.

```
#ident "@(#)adm 1.5 92/07/14 SMI" /* SVr4.0 1.2 */
#
# The adm crontab file should contain startup of performance
# collection if the profiling and performance feature has been
# installed.
0 * * * * /usr/lib/acct/ckpacct
30 2 * * * /usr/lib/acct/runacct 2> /var/adm/acct/nite/fd2log
30 7 1 * * /usr/lib/acct/monacct
```

The following example shows how the crontab entry that runs `/usr/lib/acct/dodisk` has been added to `/var/spool/cron/crontabs/root`.

```

#ident "@(#)root      1.16    98/04/28 SMI" /* SVr4.0 1.1.3.1 */
#
# The root crontab should be used to perform accounting data collection.
#
# The rtc command is run to adjust the real time clock if and when
# daylight savings time changes.
#
10 3 * * 0,4 /etc/cron.d/logchecker
10 3 * * 0 /usr/lib/newsyslog
15 3 * * 0 /usr/lib/fs/nfs/nfsfind
1 2 * * * [ -x /usr/sbin/rtc ] && /usr/sbin/rtc -c > /dev/null 2>&1
30 22 * * 4 /usr/lib/acct/dodisk

```

The following example shows a sample `/etc/acct/holidays` file.

```

* @(#)holidays  January 1, 1998
*
* Prime/Nonprime Table for UNIX Accounting System
*
* Curr  Prime  Non-Prime
* Year  Start  Start
*
  1997  0800   1800
*
* only the first column (month/day) is significant.
*
* month/day      Company
*                Holiday
*
1/1              New Years Day
1/20             Martin Luther King's Day
2/17             President's Day
5/26             Memorial Day
7/3              Day before Indep. Day
7/4              Indep. Day
9/1              Labor Day
11/27            Thanksgiving
11/28            Day after Thanksgiving
12/25            Christmas
12/26            Winter Break
12/29            Winter Break
12/30            Winter Break
12/31            Winter Break

```

Billing Users

If you provide special user services on a request basis, such as restoring files or remote printing, you may want to bill users by running a utility called **chargefee(1M)**. `chargefee` records charges in the file `/var/adm/fee` and each time the `runacct` utility is executed, new entries are merged into the total accounting records.

▼ How to Bill Users

1. Become superuser.
2. Charge a user for special services.

```
# chargefee username amount
```

username User account you want to bill.

amount Number of units to bill the user.

Example—Billing Users

The following example charges the user `print_customer` 10 units.

```
# chargefee print_customer 10
```

Maintaining Accounting Information

This section describes how to maintain accounting information.

Fixing Corrupted Files and `wtmp` Errors

Unfortunately, the UNIX accounting system is not foolproof. Occasionally, a file will become corrupted or lost. Some of the files can simply be ignored or restored from backup. However, certain files must be fixed to maintain the integrity of the accounting system.

The `wtmp(4)` files seem to cause the most problems in the day-to-day operation of the accounting system. When the date is changed and the system is in multiuser mode, a set of date change records is written into `/var/adm/wtmp`. The `wtmpfix(1M)` utility is designed to adjust the time stamps in the `wtmp` records when a date change is encountered. However, some combinations of date changes and reboots will slip through `wtmpfix` and cause `acctcon` to fail. For instructions on correcting `wtmp` problems, see “How to Fix a `wtmp` File” on page 438.

▼ How to Fix a `wtmp` File

1. Become superuser.
2. Change to the `/var/adm/acct/nite` directory.
3. Convert the binary file `wtmp.MMDD` into the ASCII file `xwtmp`.

```
# fwtmp wtmp.MMDD xwtmp
```

`MMDD` Pair of two-digit numbers representing the month and day.

4. Edit `xwtmp`. Delete the corrupted files, or delete all records from the beginning up to the date change.
5. Convert the ASCII file `xwtmp` to a binary file, overwriting the corrupted file.

```
# fwtmp -ic xwtmp wtmp.MMDD
```

Fixing `tacct` Errors

The integrity of `/var/adm/acct/sum/tacct` is important if you are charging users for system resources. Occasionally, mysterious `tacct` records appear with negative numbers, duplicate user IDs, or a user ID of 65535. First, check `/var/adm/acct/sum/tacctprev`, using `prtacct` to print it. If the contents look all right, patch the latest `/var/adm/acct/sum/tacct.MMDD` file, then recreate

the `/var/adm/acct/sum/tacct` file. The following steps outline a simple patch procedure.

▼ How to Fix `tacct` Errors

1. **Become superuser.**
2. **Change to the `/var/adm/acct/sum` directory.**
3. **Convert the contents of `tacct.MMDD` from binary to ASCII format.**

```
# acctmrg -v tacct.MMDD xtacct
```

`MMDD` Month and day specified by two-digit numbers.

4. **Edit the `xtacct` file, removing bad records and writing duplicate records to another file.**
5. **Convert the `xtacct` file from ASCII format to binary.**

```
# acctmrg -i xtacct tacct.MMDD
```

`MMDD` Month and day specified by two-digit numbers.

6. **Merge the files `tacct.prv` and `tacct.MMDD` into the file `tacct`.**

```
# acctmrg tacctprv tacct.MMDD tacct
```

Restarting `runacct`

The `runacct` program can fail for a variety of reasons, the most common being a system crash, `/var` running out of space, or a corrupted `wtmp` file. If the `activeMMDD` file exists, check it first for error messages. If the `active` and `lock` files exist, check `fd2log` for any mysterious messages.

Called without arguments, `runacct` assumes that this is the first invocation of the day. The argument `MMDD` is necessary if `runacct` is being restarted and specifies the month and day for which `runacct` will rerun the accounting. The entry point

for processing is based on the contents of `statefile`. To override `statefile`, include the desired state on the command line.



Caution - When running the `runacct` program manually, be sure to run it as user `adm`.

▼ How to Restart `runacct`

1. Remove the `lastdate` file and any `lock*` files, if any.

```
$ cd /var/adm/acct/nite
$ rm lastdate lock*
```

2. Restart the `runacct` program.

```
$ runacct MMDD [state] 2> /var/adm/acct/nite/fd2log &
```

<i>MMDD</i>	Month and day specified by two-digit numbers.
<i>state</i>	Specifies a state, or starting point, where <code>runacct</code> processing should begin.

Stopping and Disabling System Accounting

You can temporarily stop system accounting or disable it permanently.

▼ How to Temporarily Stop System Accounting

1. Become superuser.

2. **Modify the adm crontab file to stop the ckpacct, runacct, and monacct programs from running by commenting out the appropriate lines.**

```
# EDITOR=vi; export EDITOR
# crontab -e adm
#0 * * * * /usr/lib/acct/ckpacct
#30 2 * * * /usr/lib/acct/runacct 2> /var/adm/acct/nite/fd2log
#30 7 1 * * /usr/lib/acct/monacct
```

3. **Modify the crontab file for user root in order to stop the dodisk program from running by commenting out the appropriate line.**

```
# crontab -e
#30 22 * * 4 /usr/lib/acct/dodisk
```

4. **Stop accounting.**

```
# /etc/init.d/acct stop
```

To re-enable system accounting, remove the newly added comment symbols from the crontab files and restart accounting.

```
# /etc/init.d/acct start
```

▼ How to Permanently Disable System Accounting

1. **Become superuser.**
2. **Modify the adm crontab file and delete the entries for the ckpacct, runacct, and monacct programs.**

```
# EDITOR=vi; export EDITOR
# crontab -e adm
```

3. Modify the root crontab file and delete the entries for the dodisk program.

```
# crontab -e
```

4. Remove the startup script for Run Level 2.

```
# unlink /etc/rc2.d/S22acct
```

5. Remove the stop script for Run Level 0.

```
# unlink /etc/rc0.d/K22acct
```

6. Stop accounting.

```
# /etc/init.d/acct stop
```

System Accounting (Reference)

This is a list of reference information in this chapter.

- “Daily Accounting” on page 443
- “Connect Accounting ” on page 443
- “Process Accounting ” on page 444
- “Disk Accounting ” on page 444
- “Calculating User Fees” on page 445
- “How Daily Accounting Works” on page 445
- “Daily Accounting Reports ” on page 447
- “The runacct Program” on page 456
- “Accounting Reports” on page 447
- “Accounting Files” on page 458

Daily Accounting

Daily accounting can help you track four types of accounting: *connect accounting*, *process accounting*, *disk accounting*, and *fee calculations*.

Connect Accounting

Connect accounting enables you to determine the following:

- The length of time a user was logged in

- How the `tty` lines are being used
- The number of reboots on your system
- The frequency with which the accounting software was turned off and on

To provide this information, the system stores records of time adjustments, boot times, times the accounting software was turned off and on, changes in run levels, the creation of user processes (`login` processes and `init` processes), and the deaths of processes. These records (produced from the output of system programs such as `date`, `init`, `login`, `ttymon`, and `acctwtmp`) are stored in the `/var/adm/wtmp` file. Entries in the `wtmp` file may contain the following information: a user's login name, a device name, a process ID, the type of entry, and a time stamp denoting when the entry was made.

Process Accounting

Process accounting enables you to keep track of the following data about each process run on your system:

- User and group IDs of those using the process
- Beginning and elapsed times of the process
- CPU time for the process (user time and system time)
- Amount of memory used
- Commands run
- The `tty` controlling the process

Every time a process dies, the `exit` program collects this data and writes it to `/var/adm/pacct`.

Disk Accounting

Disk accounting enables you to gather and format the following data about the files each user has on disks:

- Name and ID of the user
- Number of blocks used by the user's files

This data is collected by the shell script `/usr/lib/acct/dodisk` at intervals determined by the entry you add to the `/var/spool/cron/crontabs/root` file. In turn, `dodisk` invokes the commands `acctdusg` and `diskusg`, which gather disk usage by login.

See “How to Set Up System Accounting” on page 434 for more information about setting up `dodisk`.



The `acctdusg(1M)` command gathers all the disk accounting information. Each time it is invoked, this command can process a maximum of 3000 users.

Caution - Information gathered by running `dodisk(1M)` is stored in the `/var/adm/acct/nite/disktacct` file. This information is overwritten the next time `dodisk` is run. Therefore, avoid running `dodisk` twice in the same day.

The `diskusg` command may overcharge for files that are written in random access fashion, which may create holes in the files. This is because `diskusg` does not read the indirect blocks of a file when determining its size. Rather, `diskusg` determines the size of a file by looking at the `di_size` value of the inode.

Calculating User Fees

The `chargefee` utility stores charges for special services provided to a user, such as file restoration, in the file `/var/adm/fee`. Each entry in the file consists of a user's login name, user ID, and the fee. This file is checked by the `runacct` program every day and new entries are merged into the total accounting records. For instructions on running `chargefee` to bill users, see “How to Bill Users” on page 437.

How Daily Accounting Works

Here is a step-by-step summary of how daily accounting works:

1. When the system is switched into multiuser mode, the `/usr/lib/acct/startup` program is executed. The `startup` program executes several other programs that invoke accounting.
2. The `acctwtmp` program adds a “boot” record to `/var/adm/wtmp`. In this record, the system name is shown as the login name in the `wtmp` record. Table 23-1 summarizes how the raw accounting data is gathered and where it is stored.

TABLE 23-1 Raw Accounting Data

File in <code>/var/adm</code>	Information	Written By	Format
<code>wtmp</code>	Connect sessions	<code>login, init</code>	<code>utmp.h</code>
	Changes	<code>date</code>	
	Reboots	<code>acctwtmp</code>	

TABLE 23-1 Raw Accounting Data (continued)

File in /var/adm	Information	Written By	Format
	Shutdowns	shutacct shell	
pacctn	Processes	Kernel (when the process ends)	acct.h
		turnacct switch (creates a new file when the old one reaches 500 blocks)	
fee	Special charges	chargefee	acct.h
acct/nite/diskacct	Disk space used	dodisk	tacct.h

3. The `turnacct` program, invoked with the `-on` option, begins process accounting. Specifically, `turnacct` executes the `accton` program with the `/var/adm/pacct` argument.
4. The remove shell script “cleans up” the saved `pacct` and `wtmp` files left in the `sum` directory by `runacct`.
5. The `login` and `init` programs record connect sessions by writing records into `/var/adm/wtmp`. Any date changes (using `date` with an argument) are also written to `/var/adm/wtmp`. Reboots and shutdowns using `acctwtmp` are also recorded in `/var/adm/wtmp`.
6. When a process ends, the kernel writes one record per process, using `acct.h` format, in the `/var/adm/pacct` file.
 Every hour, `cron` executes the `ckpacct` program to check the size of `/var/adm/pacct`. If the file grows past 500 blocks (default), the `turnacct` switch is executed. (The program moves the `pacct` file and creates a new one.) The advantage of having several smaller `pacct` files becomes apparent when trying to restart `runacct` if a failure occurs when processing these records.
7. `runacct` is executed by `cron` each night. `runacct` processes the accounting files: `/var/adm/pacctn`, `/var/adm/wtmp`, `/var/adm/fee`, and `/var/adm/acct/nite/diskacct`, to produce command summaries and usage summaries by `login`.
8. The `/usr/lib/acct/prdaily` program is executed on a daily basis by `runacct` to write the daily accounting information collected by `runacct` (in ASCII format) in `/var/adm/acct/sum/rprt.MMDD`.

9. The `monacct` program should be executed on a monthly basis (or at intervals determined by you, such as the end of every fiscal period). The `monacct` program creates a report based on data stored in the `sum` directory that has been updated daily by `runacct`. After creating the report, `monacct` “cleans up” the `sum` directory to prepare the directory’s files for the new `runacct` data.

What Happens if the System Shuts Down

If the system is shut down using `shutdown`, the `shutacct` program is executed automatically. The `shutacct` program writes a reason record into `/var/adm/wtmp` and turns off process accounting.

Accounting Reports

This section describes the various reports generated by the accounting software.

Daily Accounting Reports

The `runacct(1M)` shell script generates four basic reports upon each invocation. These reports cover the areas of connect accounting, usage by login on a daily basis, command usage reported by daily and monthly totals, and a report of the last time users were logged in. Table 23-2 describes the four basic reports generated.

TABLE 23-2 Daily Accounting Reports

Report Type	Description
Daily Report	Shows line utilization by <code>tty</code> number.
Daily Usage Report	Indicates usage of system resources by users (listed in order of UID).
Daily Command Summary	Indicates usage of system resources by commands, listed in descending order of use of memory (in other words, the command that used the most memory is listed first). This same information is reported for the month with the monthly total command summary.
Last Login	Shows the last time each user logged in (arranged in chronological order).

Daily Report

This report gives information about each terminal line used. A sample daily report appears below.

```
Jun 11 02:30:02 1998  DAILY REPORT FOR mercury Page 1

from Wed Jun 10 02:30:02 1998
to   Thu Jun 11 02:30:02 1998
1    system boot
1    run-level 3
1    acctg on
1    runacct
1    acctcon

TOTAL DURATION IS 1384 MINUTES
LINE      MINUTES  PERCENT  # SESS  # ON  # OFF
/dev/pts/5  0         0         0       0     0
/dev/pts/6  0         0         0       0     1
/dev/pts/7  0         0         0       0     0
console    1337      97        1       1     1
pts/3      0         0         0       0     1
pts/4      0         0         0       0     1
pts/5      3         0         2       2     3
pts/6     232      17        5       5     5
pts/7      54        4         1       1     2
pts/8      0         0         0       0     1
pts/9      0         0         0       0     1
TOTALS    1625     --        9       9    16
```

The `from` and `to` lines specify the time period reflected in the report—the period from the time the last accounting report was generated until the time the current accounting report was generated. It is followed by a log of system reboots, shutdowns, power failure recoveries, and any other record dumped into `/var/adm/wtmp` by the `acctwtmp` program. For more information, see `acct(1M)`.

The second part of the report is a breakdown of line utilization. The `TOTAL DURATION` tells how long the system was in multiuser state (accessible through the terminal lines). The columns are described in Table 23-3.

TABLE 23-3 Daily Report Data

Column	Description
LINE	The terminal line or access port.
MINUTES	The total number of minutes that the line was in use during the accounting period.

TABLE 23-3 Daily Report Data (continued)

Column	Description
PERCENT	The total number of MINUTES the line was in use, divided into the TOTAL DURATION.
# SESS	The number of times this port was accessed for a login session.
# ON	Identical to SESS. (This column does not have much meaning anymore. Previously, it listed the number of times that a port was used to log in a user.)
# OFF	This column reflects the number of times a user logs out and any interrupts that occur on that line. Generally, interrupts occur on a port when ttymon is first invoked after the system is brought to multiuser state. If the # OFF exceeds the # ON by a large factor, the multiplexer, modem, or cable is probably going bad, or there is a bad connection somewhere. The most common cause of this is an unconnected cable dangling from the multiplexer.

During real time, you should monitor `/var/adm/wtmp` because it is the file from which the connect accounting is geared. If the `wtmp` file grows rapidly, execute `acctcon -l file < /var/adm/wtmp` to see which `tty` line is the noisiest. If interruption is occurring frequently, general system performance will be affected. Additionally, `wtmp` may become corrupted. To correct this, see "How to Fix a `wtmp` File" on page 438.

Daily Usage Report

The daily usage report gives a breakdown of system resource utilization by user. A sample of this type of report appears below.

```

Jun 11 02:30:02 1998  DAILY USAGE REPORT FOR mercury Page 1

  LOGIN      CPU (MINS)  KCORE-MINS  CONNECT (MINS)  DISK  # OF  # OF  # DISK  FEE
UID  NAME      PRIME NPRIME PRIME NPRIME PRIME NPRIME  BLOCKS  PROCS  SESS  SAMPLES
0    TOTAL    1      1      2017  717    785   840    660361  1067  9     7     20
0    root     1      1      1833  499    550   840    400443  408   2     1     0
1    daemon  0      0      0      0      0     0     400    0     0     1     0
2    bin      0      0      0      0      0     0    253942  0     0     1     0
3    sys      0      0      0      0      0     0     2      0     0     1     0
4    adm      0      0      46    83     0     0    104    280  0     1     0
5    uucp     0      0      74    133    0     0    1672   316  0     1     0
71   lp       0      0      0      2      0     0    3798   1     0     1     0
8198 ksm      0      0      8     0      0     0     0      6     1     0     0

```

(continued)

(Continuation)

52171	pjm	0	0	56	0	234	0	0	56	6	0	20
-------	-----	---	---	----	---	-----	---	---	----	---	---	----

The data provided in the daily usage report is described in Table 23-4.

TABLE 23-4 Daily Usage Report Data

Column	Description
UID	User identification number.
LOGIN NAME	Login name of the user. Identifies a user who has multiple login names.
CPU-MINS	Amount of time, in minutes, that the user's process used the central processing unit. Divided into PRIME and NPRIME (non-prime) utilization. The accounting system's version of this data is located in the <code>/etc/acct/holidays</code> file.
KCORE-MINS	A cumulative measure of the amount of memory in kbyte segments per minute that a process uses while running. Divided into PRIME and NPRIME utilization.
CONNECT-MINS	Amount of time a user was logged into the system, or "real time." Divided into PRIME and NPRIME use. If these numbers are high while the # OF PROCS is low, you can conclude that the user logs in first thing in the morning and hardly touches the terminal the rest of the day.
DISK BLOCKS	Output from the <code>acctdusg</code> program, which runs and merges disk accounting programs and total accounting record (<code>daytacct</code>). (For accounting purposes, a block is 512 bytes.)
# OF PROCS	Number of processes invoked by the user. If large numbers appear, a user may have a shell procedure that has run out of control.
# OF SESS	Number of times a user logged on to the system.
# DISK SAMPLES	Number of times disk accounting was run to obtain the average number of DISK BLOCKS.
FEE	Often unused field that represents the total accumulation of units charged against the user by <code>chargefee</code> .

Daily Command Summary

The daily command summary report shows the system resource use by command. With this report, you can identify the most heavily used commands and, based on how those commands use system resources, gain insight on how best to tune the system. The format of the daily and monthly reports are virtually the same; however, the daily summary reports only on the current accounting period while the monthly summary reports on the start of the fiscal period to the current date. In other words, the monthly report reflects the data accumulated since the last invocation of `monacct`.

These reports are sorted by `TOTAL KCOREMIN`, which is an arbitrary gauge but often a good one for calculating drain on a system.

A sample daily command summary appears below.

```

Jun 11 02:30:02 1998  DAILY COMMAND SUMMARY Page 1

```

COMMAND NAME	NUMBER CMDS	TOTAL COMMAND SUMMARY							
		TOTAL KCOREMIN	TOTAL CPU-MIN	TOTAL REAL-MIN	MEAN SIZE-K	MEAN CPU-MIN	HOG FACTOR	CHARS TRNSFD	BLOCKS READ
TOTALS	1067	2730.99	2.01	1649.38	1361.41	0.00	0.00	6253571	2305
sendmail	28	1085.87	0.05	0.24	23865.20	0.00	0.19	101544	39
admintoo	3	397.68	0.12	1132.96	3443.12	0.04	0.00	680220	83
sh	166	204.78	0.31	161.13	651.80	0.00	0.00	598158	20
nroff	12	167.17	0.14	0.24	1205.55	0.01	0.59	709048	22
find	10	151.27	0.27	2.72	563.40	0.03	0.10	877971	1580
acctdusg	3	87.40	0.13	2.74	698.29	0.04	0.05	883845	203
lp	10	74.29	0.05	0.22	1397.38	0.01	0.24	136460	57
expr	20	67.48	0.02	0.06	3213.24	0.00	0.34	6380	1
mail.loc	3	65.83	0.01	0.04	11285.60	0.00	0.15	24709	15
cmdtool	1	37.65	0.02	20.13	2091.56	0.02	0.00	151296	1
uudemon.	105	37.38	0.09	0.32	435.46	0.00	0.27	62130	17
csch	6	35.17	0.05	57.28	756.30	0.01	0.00	209560	13
col	12	31.12	0.06	0.26	523.00	0.00	0.23	309932	0
ntpdate	22	27.55	0.05	11.18	599.00	0.00	0.00	22419	0
uuxqt	44	18.66	0.04	0.06	417.79	0.00	0.74	32604	3
man	12	15.11	0.03	7.05	503.67	0.00	0.00	85266	47
.									
.									
.									

The data provided, by column, in the daily command summary is described in Table 23-5.

TABLE 23-5 Daily Command Summary

Column	Description
COMMAND NAME	Name of the command. Unfortunately, all shell procedures are lumped together under the name <code>sh</code> because only object modules are reported by the process accounting system. It's a good idea to monitor the frequency of programs called <code>a.out</code> or <code>core</code> or any other unexpected name. <code>acctcom</code> can be used to determine who executed an oddly named command and if superuser privileges were used.
NUMBER CMDS	Total number of invocations of this particular command during prime time.
TOTAL KCOREMIN	Total cumulative measurement of the Kbyte segments of memory used by a process per minute of run time.
TOTAL CPU-MIN:	Total processing time this program has accumulated during prime time.
TOTAL REAL-MIN	Total real-time (wall-clock) minutes this program has accumulated.
MEAN SIZE-K	Mean of the <code>TOTAL KCOREMIN</code> over the number of invocations reflected by <code>NUMBER CMDS</code> .
MEAN CPU-MIN	Mean derived between the <code>NUMBER CMDS</code> and <code>TOTAL CPU-MIN</code> .
HOG FACTOR	Total CPU time divided by elapsed time. Shows the ratio of system availability to system use, providing a relative measure of total available CPU time consumed by the process during its execution.
CHARS TRNSFD	Total count of the number of characters pushed around by the read and write system calls. May be negative due to overflow.
BLOCKS READ	Total count of the physical block reads and writes that a process performed.

Monthly Command Summary

The monthly command summary is similar to the daily command summary. The only difference is that the monthly command summary shows totals accumulated since the last invocation of `monacct`. A sample report appears below.

Jun 9 02:30:03 1998 MONTHLY TOTAL COMMAND SUMMARY Page 1

TOTAL COMMAND SUMMARY									
COMMAND NAME	NUMBER CMDS	TOTAL KCOREMIN	TOTAL CPU-MIN	TOTAL REAL-MIN	MEAN SIZE-K	MEAN CPU-MIN	HOG FACTOR	CHARS TRNSFD	BLOCKS READ
TOTALS	771	483.70	0.94	8984.09	515.12	0.00	0.00	2248299	179
sh	105	155.41	0.23	429.58	667.94	0.00	0.00	491870	1
uudemon.	85	29.39	0.07	0.29	434.28	0.00	0.23	49630	14
acctcms	5	27.21	0.04	0.04	752.41	0.01	0.90	218880	1
ntpdate	17	21.30	0.04	14.10	605.73	0.00	0.00	18192	0
dtpad	1	19.69	0.01	10.87	2072.70	0.01	0.00	46992	8
sendmail	17	16.75	0.02	0.02	859.04	0.00	0.91	1965	0
acctprc	1	14.92	0.03	0.03	552.69	0.03	0.95	115584	0
uuxqt	34	14.78	0.03	0.04	426.29	0.00	0.92	25194	0
uusched	34	10.96	0.03	0.03	363.25	0.00	0.91	25194	0
sed	40	10.15	0.03	0.09	315.50	0.00	0.36	64162	2
man	5	10.08	0.02	57.58	555.05	0.00	0.00	25773	2
getent	1	7.68	0.01	0.02	921.60	0.01	0.40	20136	0
in.rlogi	5	7.65	0.01	4331.67	611.73	0.00	0.00	87440	0
cp	37	7.28	0.03	0.05	280.08	0.00	0.50	1739	36
date	27	7.24	0.02	0.03	329.12	0.00	0.65	23443	1
ls	15	7.05	0.01	0.02	503.33	0.00	0.79	14123	0
awk	19	6.94	0.02	0.06	372.04	0.00	0.32	666	0
rm	29	6.83	0.02	0.04	301.32	0.00	0.60	2348	17

See "Daily Command Summary" on page 451 for a description of the data.

Last Login Report

This report gives the date when a particular login was last used. You can use this information to find unused logins and login directories that may be archived and deleted. A sample report appears below.

```
Jun 9 02:30:03 1998 LAST LOGIN Page 1
.
.
.
00-00-00 arimmer 00-00-00 lister 97-02-27 pjm
00-00-00 reception 00-00-00 smithey 97-02-27 ksm
00-00-00 release 00-00-00 smsc 97-02-27 root
00-00-00 resch 00-00-00 datab
```

Looking at the pacct File With acctcom

At any time, you can examine the contents of the `/var/adm/pacctn` files, or any file with records in the `acct.h` format, by using the `acctcom` program. If you don't specify any files and don't provide any standard input when you run this command, `acctcom` reads the `pacct` file. Each record read by `acctcom` represents information

about a dead process (active processes may be examined by running the `ps` command). The default output of `acctcom` provides the following information:

- Command name (pound (#) sign if it was executed with superuser privileges)
- User
- `tty` name (listed as ? if unknown)
- Starting time
- Ending time
- Real time (in seconds)
- CPU time (in seconds)
- Mean size (in Kbytes)

The following information can be obtained by using options to `acctcom`:

- State of the `fork/exec` flag (1 for `fork` without `exec`)
- System exit status
- Hog factor
- Total `kcore` minutes
- CPU factor
- Characters transferred
- Blocks read

Table 23-6 describes the `acctcom` options.

TABLE 23-6 `acctcom` Options

Option	Description
-a	Show some average statistics about the processes selected. (The statistics are printed after the output is recorded.)
-b	Read the files backward, showing latest commands first. (This has no effect if reading standard input.)
-f	Print the <code>fork/exec</code> flag and system exit status columns. (The output is an octal number.)
-h	Instead of mean memory size, show the hog factor, which is the fraction of total available CPU time consumed by the process during its execution. Hog factor = $total_CPU_time/elapsed_time$.
-i	Print columns containing the I/O counts in the output.

TABLE 23-6 `acctcom` Options (continued)

Option	Description
<code>-k</code>	Show total <code>kcore</code> minutes instead of memory size.
<code>-m</code>	Show mean core size (this is the default).
<code>-q</code>	Don't print output records, just print average statistics.
<code>-r</code>	Show CPU factor: $user_time / (system_time + user_time)$.
<code>-t</code>	Show separate system and user CPU times.
<code>-v</code>	Exclude column headings from the output.
<code>-C sec</code>	Show only processes with total CPU time (system plus user) exceeding <code>sec</code> seconds.
<code>-e time</code>	Show processes existing at or before time, given in the format <code>hr[:min[:sec]]</code> .
<code>-E time</code>	Show processes starting at or before time, given in the format <code>hr[:min[:sec]]</code> . Using the same time for both <code>-S</code> and <code>-E</code> , show processes that existed at the time.
<code>-g group</code>	Show only processes belonging to group.
<code>-H factor</code>	Show only processes that exceed factor, where factor is the "hog factor" (see the <code>-h</code> option).
<code>-I chars</code>	Show only processes transferring more characters than the cutoff number specified by <code>chars</code> .
<code>-l line</code>	Show only processes belonging to the terminal <code>/dev/line</code> .
<code>-n pattern</code>	Show only commands matching pattern (a regular expression except that "+" means one or more occurrences).
<code>-o ofile</code>	Instead of printing the records, copy them in <code>acct.h</code> format to <code>ofile</code> .
<code>-O sec</code>	Show only processes with CPU system time exceeding <code>sec</code> seconds.

TABLE 23-6 acctcom Options (continued)

Option	Description
<code>-s time</code>	Show processes existing at or after time, given in the format <code>hr[:min[:sec]]</code> .
<code>-S time</code>	Show processes starting at or after time, given in the format <code>hr[:min[:sec]]</code> .
<code>-u user</code>	Show only processes belonging to user.

The runacct Program

The main daily accounting shell script, `runacct`, is normally invoked by `cron` outside of prime time hours. The `runacct` shell script processes connect, fee, disk, and process accounting files. It also prepares daily and cumulative summary files for use by `prdaily` and `monacct` for billing purposes.

The `runacct` shell script takes care not to damage files if errors occur. A series of protection mechanisms are used that attempt to recognize an error, provide intelligent diagnostics, and complete processing in such a way that `runacct` can be restarted with minimal intervention. It records its progress by writing descriptive messages into the file `active`. (Files used by `runacct` are assumed to be in the `/var/adm/acct/nite` directory, unless otherwise noted.) All diagnostic output during the execution of `runacct` is written into `fd2log`.

When `runacct` is invoked, it creates the files `lock` and `lock1`. These files are used to prevent simultaneous execution of `runacct`. The `runacct` program prints an error message if these files exist when it is invoked. The `lastdate` file contains the month and day `runacct` was last invoked, and is used to prevent more than one execution per day. If `runacct` detects an error, a message is written to the console, mail is sent to `root` and `adm`, locks may be removed, diagnostic files are saved, and execution is ended. For instructions on how to start `runacct` again, see “How to Restart `runacct`” on page 440.

To allow `runacct` to be restartable, processing is broken down into separate re-entrant states. The file `statefile` is used to keep track of the last state completed. When each state is completed, `statefile` is updated to reflect the next state. After processing for the state is complete, `statefile` is read and the next state is processed. When `runacct` reaches the `CLEANUP` state, it removes the locks and ends. States are executed as shown in Table 23-7.

TABLE 23-7 runacct States

State	Description
SETUP	The command <code>turnacct</code> switch is executed to create a new <code>pacct</code> file. The process accounting files in <code>/var/adm/pacctn</code> (except for the <code>pacct</code> file) are moved to <code>/var/adm/Spacctn.MMDD</code> . The <code>/var/adm/wtmp</code> file is moved to <code>/var/adm/acct/nite/wtmp.MMDD</code> (with the current time record added on the end) and a new <code>/var/adm/wtmp</code> is created. <code>closewtmp</code> and <code>utmp2wtmp</code> add records to <code>wtmp.MMDD</code> and the new <code>wtmp</code> to account for users currently logged in.
WTMPFIX	The <code>wtmpfix</code> program checks the <code>wtmp.MMDD</code> file in the <code>nite</code> directory for accuracy. Because some date changes will cause <code>acctcon</code> to fail, <code>wtmpfix</code> attempts to adjust the time stamps in the <code>wtmp</code> file if a record of a date change appears. It also deletes any corrupted entries from the <code>wtmp</code> file. The fixed version of <code>wtmp.MMDD</code> is written to <code>tmpwtmp</code> .
CONNECT	The <code>acctcon</code> program is used to record connect accounting records in the file <code>ctacct.MMDD</code> . These records are in <code>tacct.h</code> format. In addition, <code>acctcon</code> creates the <code>lineuse</code> and <code>reboots</code> files. The <code>reboots</code> file records all the boot records found in the <code>wtmp</code> file.
PROCESS	The <code>acctprc</code> program is used to convert the process accounting files, <code>/var/adm/Spacctn.MMDD</code> , into total accounting records in <code>ptacctn.MMDD</code> . The <code>Spacct</code> and <code>ptacct</code> files are correlated by number so that if <code>runacct</code> fails, the <code>Spacct</code> files will not be processed.
MERGE	The <code>MERGE</code> program merges the process accounting records with the connect accounting records to form <code>daytacct</code> .
FEEES	The <code>MERGE</code> program merges ASCII <code>tacct</code> records from the <code>fee</code> file into <code>daytacct</code> .
DISK	If the <code>dodisk</code> procedure has been run, producing the <code>disktacct</code> file, the <code>DISK</code> program merges the file into <code>daytacct</code> and moves <code>disktacct</code> to <code>/tmp/disktacct.MMDD</code> .
MERGETACCT	The <code>MERGETACCT</code> merges <code>daytacct</code> with <code>sum/tacct</code> , the cumulative total accounting file. Each day, <code>daytacct</code> is saved in <code>sum/tacct.MMDD</code> , so that <code>sum/tacct</code> can be recreated if it is corrupted or lost.

TABLE 23-7 runacct States (continued)

State	Description
CMS	The acctcms program is run several times. acctcms is first run to generate the command summary using the Spacctn files and write it to sum/daycms. The acctcms program is then run to merge sum/daycms with the cumulative command summary file sum/cms. Finally, acctcms is run to produce the ASCII command summary files, nite/daycms and nite/cms, from the sum/daycms and sum/cms files, respectively. The lastlogin program is used to create the /var/adm/acct/sum/loginlog log file, the report of when each user last logged in. (If runacct is run after midnight, the dates showing the time last logged in by some users will be incorrect by one day.)
USEREXIT	Any installation-dependent (local) accounting program can be included at this point. runacct expects it to be called /usr/lib/acct/runacct.local.
CLEANUP	Cleans up temporary files, runs prdaily and saves its output in sum/rpt.MMDD, removes the locks, then exits.



Caution - When restarting runacct in the CLEANUP state, remove the last ptacct file because it will not be complete.

Accounting Files

The /var/adm directory structure contains the active data collection files and is owned by the adm login (currently user ID of 4).

TABLE 23-8 Files in /var/adm Directory

File	Description
dtmp	Output from the acctdusg program
fee	Output from the chargefee program, ASCII tacct records
pacct	Active process accounting file

TABLE 23-8 Files in `/var/adm` Directory (continued)

File	Description
<code>pacctn</code>	Process accounting files switched using <code>turnacct</code>
<code>Spacctn.MMDD</code>	Process accounting files for <code>MMDD</code> during execution of <code>runacct</code>

The `/var/adm/acct` directory contains the `nite`, `sum`, and `fiscal` directories, which contain the actual data collection files. For example, the `nite` directory contains files that are reused daily by the `runacct` procedure. A brief summary of the files in the `/var/adm/acct/nite` directory follows.

TABLE 23-9 Files in the `/var/adm/acct/nite` Directory

File	Description
<code>active</code>	Used by <code>runacct</code> to record progress and print warning and error messages
<code>activeMMDD</code>	Same as <code>active</code> after <code>runacct</code> detects an error
<code>cms</code>	ASCII total command summary used by <code>prdaily</code>
<code>ctacct.MMDD</code>	Connect accounting records in <code>tacct.h</code> format
<code>ctmp</code>	Output of <code>acctcon1</code> program, connect session records in <code>ctmp.h</code> format (<code>acctcon1</code> and <code>acctcon2</code> are provided for compatibility purposes)
<code>daycms</code>	ASCII daily command summary used by <code>prdaily</code>
<code>daytacct</code>	Total accounting records for one day in <code>tacct.h</code> format
<code>disktacct</code>	Disk accounting records in <code>tacct.h</code> format, created by the <code>dodisk</code> procedure
<code>fd2log</code>	Diagnostic output during execution of <code>runacct</code>
<code>lastdate</code>	Last day <code>runacct</code> executed (in <code>date +%m%d</code> format)
<code>lock</code>	Used to control serial use of <code>runacct</code>
<code>lineuse</code>	<code>tty</code> line usage report used by <code>prdaily</code>

TABLE 23-9 Files in the `/var/adm/acct/nite` Directory (continued)

File	Description
<code>log</code>	Diagnostic output from <code>acctcon</code>
<code>log.MMDD</code>	Same as <code>log</code> after <code>runacct</code> detects an error
<code>owtmp</code>	Previous day's <code>wtmp</code> file
<code>reboots</code>	Beginning and ending dates from <code>wtmp</code> and a listing of reboots
<code>statefile</code>	Used to record current state during execution of <code>runacct</code>
<code>tmpwtmp</code>	<code>wtmp</code> file corrected by <code>wtmpfix</code>
<code>wtmperror</code>	Place for <code>wtmpfix</code> error messages
<code>wtmperror.MMDD</code>	Same as <code>wtmperror</code> after <code>runacct</code> detects an error
<code>wtmp.MMDD</code>	<code>runacct</code> 's copy of the <code>wtmp</code> file

The `sum` directory contains the cumulative summary files updated by `runacct` and used by `monacct`. A brief summary of the files in the `/var/adm/acct/sum` directory is in Table 23-10.

TABLE 23-10 Files in the `/var/adm/acct/sum` Directory

File	Description
<code>cms</code>	Total command summary file for current fiscal period in internal summary format
<code>cmsprev</code>	Command summary file without latest update
<code>daycms</code>	Command summary file for the day's usage in internal summary format
<code>loginlog</code>	Record of last date each user logged on; created by <code>lastlogin</code> and used in the <code>prdaily</code> program
<code>rppt.MMDD</code>	Saved output of <code>prdaily</code> program
<code>tacct</code>	Cumulative total accounting file for current fiscal period

TABLE 23-10 Files in the `/var/adm/acct/sum` Directory (continued)

File	Description
<code>tacctprev</code>	Same as <code>tacct</code> without latest update
<code>tacct.MMDD</code>	Total accounting file for <code>MMDD</code>

The fiscal directory contains periodic summary files created by `monacct`. A brief description of the files in the `/var/adm/acct/fiscal` directory is in Table 23-11.

TABLE 23-11 Files in the `/var/adm/acct/fiscal` Directory

File	Description
<code>cmsn</code>	Total command summary file for fiscal period <code>n</code> in internal summary format
<code>fiscrptn</code>	Report similar to <code>rprtn</code> for fiscal period <code>n</code>
<code>tacctn</code>	Total accounting file for fiscal period <code>n</code>

Files Produced by `runacct`

The most useful files produced by `runacct` (found in `/var/adm/acct`) are shown in Table 23-12.

TABLE 23-12 Files Produced by `runacct`

File	Description
<code>nite/lineuse</code>	<code>runacct</code> calls <code>acctcon</code> to gather data on terminal line usage from <code>/var/adm/acct/nite/tmpwtmp</code> and writes the data to <code>/var/adm/acct/nite/lineuse</code> . <code>prdaily</code> uses this data to report line usage. This report is especially useful for detecting bad lines. If the ratio between the number of logouts to logins is greater than about three to one, there is a good possibility that the line is failing.
<code>nite/daytacct</code>	This file is the total accounting file for the day in <code>tacct.h</code> format.
<code>sum/tacct</code>	This file is the accumulation of each day's <code>nite/daytacct</code> and can be used for billing purposes. It is restarted each month or fiscal period by the <code>monacct</code> procedure.
<code>sum/daycms</code>	<code>runacct</code> calls <code>acctcms</code> to process the data about the commands used during the day. This information is stored in <code>/var/adm/acct/sum/daycms</code> . It contains the daily command summary. The ASCII version of this file is <code>/var/adm/acct/nite/daycms</code> .
<code>sum/cms</code>	This file is the accumulation of each day's command summaries. It is restarted by the execution of <code>monacct</code> . The ASCII version is <code>nite/cms</code> .
<code>sum/loginlog</code>	<code>runacct</code> calls <code>lastlogin</code> to update the last date logged in for the logins in <code>/var/adm/acct/sum/loginlog</code> . <code>lastlogin</code> also removes from this file logins that are no longer valid.
<code>sum/rprt.MMDD</code>	Each execution of <code>runacct</code> saves a copy of the daily report that was printed by <code>prdaily</code> .

PART VI Managing System Performance

This part provides instructions for managing system performance. This part contains these chapters.

Chapter 24	Provides overview information about performance topics.
Chapter 25	Provides step-by-step instructions for using process commands to enhance system performance.
Chapter 26	Provides step-by-step instructions for using <code>vmstat</code> , <code>sar</code> , and disk utilization commands to monitor performance.
Chapter 27	Provides step-by-step instructions for monitoring network performance.
Chapter 28	Provides step-by-step instructions for tuning selected kernel parameters.
Chapter 29	Provides overview information about the SunOS 5.7 scheduler.



System Performance (Overview)

Getting good performance from a computer or network is an important part of system administration. This chapter is an overview of some of the factors that contribute to maintaining and managing the performance of the computer systems in your care.

This is a list of the overview information in this chapter.

- “Where to Find System Performance Tasks” on page 467
- “System Performance and System Resources” on page 467
- “Processes and System Performance” on page 468
- “Disk I/O and System Performance” on page 473
- “Memory and System Performance” on page 475
- “Kernel Parameters and System Performance” on page 476
- “About Monitoring Performance” on page 477

What’s New in Managing System Performance?

This section describes new Solaris 7 features in the area of managing system performance.

The `pgrep` and `pkill` Commands

The `pgrep` and `pkill` commands replace the combination of the `ps`, `grep`, `egrep`, `awk`, and `kill` commands that were used to manage processes in previous Solaris releases.

The `pgrep` command looks at the active processes on the system and displays the process IDs of the processes whose attributes match the specified criteria on the command line.

The `pkill` command works the same way as the `pgrep` command except that each matching process ID is signaled by `kill(2)` instead of having the process ID displayed.

Highlights of the command usage are:

- Processes can be matched by their real or effective user IDs, group IDs, or their parent process ID or process group ID, etc.
- Each process ID is displayed as a decimal value and is separated from the next process ID by a new line. You can override the new line display between each process by specifying your own delimiter with the `-d` option.
- Multiple options can be specified on one command line by separating each one with a comma.
- Defunct processes are never matched by either the `pgrep` or `pkill` commands.
- The current `pgrep` or `pkill` process will never consider itself a potential match.
- You can use `pkill -signal` to specify a signal value, such as `HUP (1)` or `KILL (9)`, as either the symbolic or numeric value. If you specify a signal value, it must be the first option on the command line. The `SIGTERM` signal is sent by default.

Examples—Using the `pgrep` and `pkill` Commands

The following example illustrates how to use the `pgrep` command to exactly match the user `kryten` as the owner of the specified process `dtmail`, and then terminate the process with the `pkill` command.

```
$ pgrep -u kryten -x dtmail
14206
$ pkill -u kryten -x dtmail
$
```

Using the `-u` option prevents you from accidentally terminating a process called `dtmail` owned by another user, if you executed the `pkill` command as superuser.

This example terminates the most recently created `shelltool` process owned by the user `pmorph`:

```
% pkill -u pmorph -n shelltool
```

This example uses the `pwdx` command, one of the `proc(1)` tools, as input to the `pgrep` command to display the current working directory of the user `rimmer`'s Korn shells:

```
$ pgrep -u rimmer -x ksh | xargs /usr/proc/bin/pwdx
4748: /home/rimmer
11395: /home/rimmer/src/command
6010: /datab/files/file1
```

See `pgrep(1)` for more information.

Where to Find System Performance Tasks

Use these references to find step-by-step instructions for monitoring system performance.

- Chapter 25
- Chapter 26
- Chapter 27
- Chapter 28

System Performance and System Resources

The performance of a computer system depends upon how the system uses and allocates its resources. It is important to monitor your system's performance on a regularly so that you know how it behaves under normal conditions. You should have a good idea of what to expect, and be able to recognize a problem when it occurs.

System resources that affect performance include:

- *Central processing unit (CPU)* – The CPU processes instructions, fetching instructions from memory and executing them.

- *Input/output (I/O) devices* – I/O devices transfer information into and out of the computer. Such a device could be a terminal and keyboard, a disk drive, or a printer.
- *Memory* – Physical (or main) memory is the amount of memory (RAM) on the system.

Chapter 26 describes the tools that display statistics about the activity and the performance of the computer system.

Other Sources of Information

Performance is a broad subject that can't be adequately covered in these chapters. There are several books available that cover various aspects of improving performance and tuning your system or network. Three useful books are:

- *Sun Performance and Tuning: SPARC and Solaris*, by Adrian Cockcroft, SunSoft Press/PRT Prentice Hall, ISBN 0-13-149642-3
- *System Performance Tuning*, by Mike Loukides, O'Reilly & Associates, Inc.
- *Managing NFS and NIS*, by Hal Stern, O'Reilly & Associates, Inc.

Processes and System Performance

Terms related to processes are described in Table 24-1.

TABLE 24-1 Process Terminology

Term	Description
Process	An instance of program in execution.
Lightweight process (LWP)	Is a virtual CPU or execution resource. LWPs are scheduled by the kernel to use available CPU resources based on their scheduling class and priority. LWPs include a kernel thread, which contains information that has to be in memory all the time and an LWP, which contains information that is swappable.
Application thread	A series of instructions with a separate stack that can execute independently in a user's address space. They can be multiplexed on top of LWPs.

A process can consist of multiple LWPs and multiple application threads. The kernel schedules a kernel-thread structure, which is the scheduling entity in the SunOS 5.7 environment. Various process structures are described in Table 24-2.

TABLE 24-2 Process Structures

Structure	Description
<code>proc</code>	Contains information that pertains to the whole process and has to be in main memory all the time.
<code>kthread</code>	Contains information that pertains to one LWP and has to be in main memory all the time.
<code>user</code>	Contains the per process information that is swappable.
<code>klwp</code>	Contains the per LWP process information that is swappable.

Figure 24-1 illustrates the relationship of these structures.

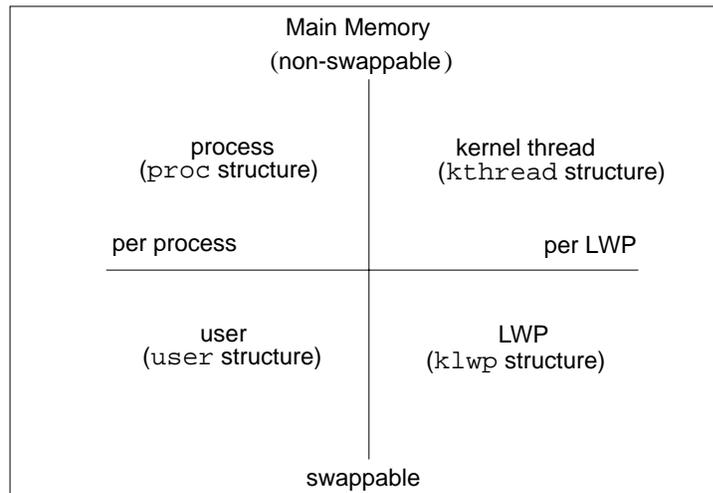


Figure 24-1 Process Structures

Most process resources are accessible to all the threads in the process. Almost all process virtual memory is shared. A change in shared data by one thread is available to the other threads in the process.

Commands for Managing Processes

Table 24-3 describes commands for managing processes.

TABLE 24-3 Commands for Managing Processes

Use This Command ...	To ...
<code>ps</code>	Check the status of active processes on a system, as well as display detailed information about the processes
<code>dispadmin</code>	List default scheduling policies
<code>priocntl</code>	Assign processes to a priority class and manage process priorities
<code>nice</code>	Change the priority of a timesharing process

Another feature enables the control of process groups over processor sets. Using processor sets means process groups can bind to a group of processors rather than to just a single processor. The `/usr/sbin/psrset` command gives a system administrator control over the creation and management of processor sets. See `psrset(1M)` for more information.

See Chapter 25 for more information about commands for managing processes.

The `/proc` File System and Commands

In addition, process tools are available in the `/usr/proc/bin` directory that display highly detailed information about the processes listed in the `/proc` directory, also known as the process file system (PROCFS). Images of active processes are stored here by their process ID number.

The process tools are similar to some options of the `ps` command, except that the output provided by the tools is more detailed. In general, the process tools:

- Display more details about processes, such as `fstat` and `fcntl` information, working directories, and trees of parent and child processes
- Provide control over processes, allowing users to stop or resume them

The new `/usr/proc/bin` utilities are summarized in Table 24-4.

TABLE 24-4 Process Tools

Tools That Control Processes	What the Tools Do
<code>/usr/proc/bin/pstop <i>pid</i></code>	Stops the process
<code>/usr/proc/bin/prun <i>pid</i></code>	Restarts the process
<code>/usr/proc/bin/ptime <i>pid</i></code>	Times the process using microstate accounting
<code>/usr/proc/bin/pwait [-v] <i>pid</i></code>	Waits for specified processes to terminate
Tools That Display Process Details	What the Tools Display
<code>/usr/proc/bin/pcred <i>pid</i></code>	Credentials
<code>/usr/proc/bin/pfiles <i>pid</i></code>	<code>fstat</code> and <code>fcntl</code> information for open files
<code>/usr/proc/bin/pflags <i>pid</i></code>	<code>/proc</code> tracing flags, pending and held signals, and other status information for each <code>lwp</code>
<code>/usr/proc/bin/pldd <i>pid</i></code>	Dynamic libraries linked into each process
<code>/usr/proc/bin/pmap <i>pid</i></code>	Address space map
<code>/usr/proc/bin/psig <i>pid</i></code>	Signal actions
<code>/usr/proc/bin/pstack <i>pid</i></code>	Hex+symbolic stack trace for each <code>lwp</code>
<code>/usr/proc/bin/ptree <i>pid</i></code>	Process trees containing specified <code>pids</code>
<code>/usr/proc/bin/pwdx <i>pid</i></code>	Current working directory

In these commands, *pid* is a process identification number. You can obtain this number by using the `ps -ef` command.

Chapter 25 describes how to use the process tool commands to perform selected system administration tasks, such as displaying details about processes, and starting

and stopping them. A more detailed description of the process tools can be found in `proc(1)`.

If a process becomes trapped in an endless loop, or if it takes too long to execute, you may want to stop (kill) the process. See Chapter 25 for more information about stopping processes using the `pkill` command.

The previous flat `/proc` file system has been restructured into a directory hierarchy that contains additional sub-directories for state information and control functions.

It also provides a watchpoint facility that is used to remap read/write permissions on the individual pages of a process's address space. This facility has no restrictions and is MT-safe.

The new `/proc` file structure provides complete binary compatibility with the old `/proc` interface except that the new watchpoint facility cannot be used with the old interface.

Debugging tools have been modified to use `/proc`'s new watchpoint facility, which means the entire watchpoint process is faster.

The following restrictions have been removed when setting watchpoints using the `dbx` debugging tool:

- Setting watchpoints on local variables on the stack due to SPARC register windows
- Setting watchpoints on multi-threaded processes

See `proc(4)`, `core(4)`, and `adb(1)` for more information.

Process Scheduling Classes and Priority Levels

A process is allocated CPU time according to its scheduling class and its priority level. By default, the Solaris operating environment has four process scheduling classes: *real-time*, *system*, *timesharing* and *interactive*.

- Real-time processes have the highest priority. This class includes processes that must respond to external events as they happen. For example, a process that collects data from a sensing device may need to process the data and respond immediately. In most cases, a real-time process requires a dedicated system. No other processes can be serviced while a real-time process has control of the CPU. By default, the range of priorities is 100-159.
- System processes have the middle priorities. This class is made up of those processes that are automatically run by the kernel, such as the swapper and the paging daemon. By default, the range of priorities is 60-99.
- Timesharing processes have the lowest priority. This class includes the standard UNIX processes. Normally, all user processes are timesharing processes. They are subject to a scheduling policy that attempts to distribute processing time fairly, giving interactive applications quick response time and maintaining good throughput for computations. By default, the range of priorities is 0-59.

- Interactive processes were introduced in the SunOS 5.4 environment. The priorities range from 0-59. All processes started under OpenWindows are placed in the interactive class and those processes with keyboard focus get higher priorities.

The scheduling priority determines the order in which processes will be run.

Real-time processes have fixed priorities. If a real-time process is ready to run, no system process or timesharing process can run.

System processes have fixed priorities that are established by the kernel when they are started. The processes in the system class are controlled by the kernel, and cannot be changed.

Timesharing and interactive processes are controlled by the scheduler, which dynamically assigns their priorities. You can manipulate the priorities of the processes within this class.

Disk I/O and System Performance

The disk is used to store data and instructions used by your computer system. You can examine how efficiently the system is accessing data on the disk by looking at the disk access activity and terminal activity. See Chapter 26 for a discussion of the `iostat` and `sar` commands, which report statistics on disk activity. Managing and allocating disk space and dividing your disk into slices are discussed in “Disk Management (Overview)” in *System Administration Guide, Volume I*.

If the CPU spends much of its time waiting for I/O completions, there is a problem with disk slowdown. Some ways to prevent disk slowdowns are:

- Keep disk space with 10% free so file systems are not full. If a disk becomes full, back up and restore the file systems to prevent disk fragmentation. Consider purchasing products that resolve disk fragmentation.
- Organize the file system to minimize disk activity. If you have two disks, distribute the file system for a more balanced load. Using Sun’s Solstice DiskSuite™ product provides more efficient disk usage.
- Add more memory. Additional memory reduces swapping and paging traffic, and allows an expanded buffer pool (reducing the number of user-level reads and writes that need to go out to disk).
- Add a disk and balance the most active file systems across the disks.

UFS Direct Input/Output (I/O)

Direct I/O is intended to boost bulk I/O operations. Bulk I/O operations use large buffer sizes to transfer large files (files larger than physical memory).

An example of a bulk I/O operation is downloading satellite data, which writes large amounts of data to a file. Direct I/O data is read or written into memory without using the overhead of the operating system's page caching mechanism.

There is a potential penalty on direct I/O startup. If a file requested for I/O is already mapped by another application, the pages will have to be flushed out of memory before the direct I/O operation can begin.

See `directio(3C)` for more information.

Direct I/O can also be enabled on a file system by using the `forcedirectio` option to the `mount` command. Enabling direct I/O is a performance benefit only when a file system is transferring large amounts of sequential data.

When a file system is mounted with this option, data is transferred directly between a user's address space and the disk. When forced direct I/O is not enabled for a file system, data transferred between a user's address space and the disk is first buffered in the kernel address space.

The default behavior is no forced direct I/O on a UFS file system. See `mount_ufs(1M)` for more information.

▼ How to Enable Forced Direct I/O on a UFS File System

1. **Become superuser.**
2. **Mount a file system with the `forcedirectio` mount option.**

```
# mount -F ufs -o forcedirectio /dev/dsk/c0t3d0s7 /datab
```

3. **Verify the mounted file system has forced direct I/O enabled.**

```
# mount
      .
      .
      .
/export/home on /dev/dsk/c0t3d0s7 forcedirectio/setuid/read/write/
largefiles on Tue Jun 16 10:25:05 1998
```

Memory and System Performance

Performance suffers when the programs running on the system require more physical memory than is available. When this happens, the operating system begins paging and swapping, which is costly in both disk and CPU overhead.

Paging involves moving pages that have not been recently referenced to a free list of available memory pages. Most of the kernel resides in main memory and is not pageable.

Swapping occurs if the page daemon cannot keep up with the demand for memory. The swapper will attempt to swap out sleeping or stopped lightweight processes (LWPs). If there are no sleeping or stopped LWPs, the swapper will swap out a runnable process. The swapper will swap LWPs back in based on their priority. It will attempt to swap in processes that are runnable.

Swap Space

Swap areas are really file systems used for swapping. Swap areas should be sized based on the requirements of your applications. Check with your vendor to identify application requirements.

Table 24-5 describes the formula used to size default swap areas by the Solaris installation program. These default swap sizes are a good place to start if you are not sure how to size your swap areas.

TABLE 24-5 Default Swap Sizes

If Your Physical Memory Size Is ...	Your Default Swap Size Is ...
16-64 Mbytes	32 Mbytes
64-128 Mbytes	64 Mbytes
128-512 Mbytes	128 Mbytes
greater than 512 Mbytes	256 Mbytes

See “Configuring Additional Swap Space (Tasks)” in *System Administration Guide, Volume I* for information about managing swap space.

Buffer Resources

The buffer cache for `read` and `write` system calls uses a range of virtual addresses in the kernel address space. A page of data is mapped into the kernel address space and the amount of data requested by the process is then physically copied to the process' address space. The page is then unmapped in the kernel. The physical page will remain in memory until the page is freed up by the page daemon.

This means a few I/O-intensive processes can monopolize or force other processes out of main memory. To prevent monopolization of main memory, balance the running of I/O-intensive processes serially in a script or with the `at(1)` command. Programmers can use `mmap(2)` and `madvise(3)` to ensure that their programs free memory when they are not using it.

Kernel Parameters and System Performance

Many basic parameters (or tables) within the kernel are calculated from the value of the `maxusers` parameter. Tables are allocated space dynamically. However, you can set maximums for these tables to ensure that applications won't take up large amounts of memory.

By default, `maxusers` is approximately set to the number of Mbytes of physical memory on the system. However, the system will never set `maxusers` higher than 1024. The maximum value of `maxusers` is 2048, which can be set by modifying the `/etc/system` file.

See Chapter 28 and `system(3S)` for details on kernel parameters.

In addition to `maxusers`, a number of kernel parameters are allocated dynamically based on the amount of physical memory on the system, as shown in Table 24-6 below.

TABLE 24-6 Kernel Parameters

Kernel Parameter	Description
<code>ufs_ninode</code>	The maximum size of the inode table
<code>ncsize</code>	The size of the directory name lookup cache
<code>max_nprocs</code>	The maximum size of the process

TABLE 24-6 Kernel Parameters (continued)

Kernel Parameter	Description
ndquot	The number of disk quota structures
maxuprc	The maximum number of user processes per user-ID

Table 24-7 lists the default settings for kernel parameters affected by the value assigned to `maxusers`.

TABLE 24-7 Default Settings for Kernel Parameters

Kernel Table	Variable	Default Setting
Inode	<code>ufs_ninode</code>	$max_nprocs + 16 + maxusers + 64$
Name cache	<code>ncsize</code>	$max_nprocs + 16 + maxusers + 64$
Process	<code>max_nprocs</code>	$10 + 16 * maxusers$
Quota table	<code>ndquot</code>	$(maxusers * NMOUNT) / 4 + max_nprocs$
User process	<code>maxuprc</code>	$max_nprocs - 5$

See Chapter 28 for a description of the kernel parameters and how to change the default values.

About Monitoring Performance

While your computer is running, counters in the operating system are incremented to keep track of various system activities. System activities that are tracked are:

- Central processing unit (CPU) utilization
- Buffer usage
- Disk and tape input/output (I/O) activity
- Terminal device activity

- System call activity
- Context switching
- File access
- Queue activity
- Kernel tables
- Interprocess communication
- Paging
- Free memory and swap space
- Kernel Memory Allocation (KMA)

Monitoring Tools

The Solaris 7 system software provides several tools to help you keep track of how your system is performing. These include:

TABLE 24-8 Performance Monitoring Tools

The ...	Enable(s) You To ...	For More Information, See ...
<code>sar</code> and <code>sadc</code> utilities	Collect and report on system activity data	Chapter 26
<code>ps</code> command	Display information about active processes	Chapter 25
Performance meter	Display graphical representation of the status of systems on the network	Chapter 26
<code>vmstat</code> and <code>iostat</code> commands	Summarize system activity data, such as virtual memory statistics, disk usage, and CPU activity	Chapter 26
<code>swap</code> command	Display information about available swap space on your system	“Configuring Additional Swap Space (Tasks)” in <i>System Administration Guide, Volume I</i>

TABLE 24-8 Performance Monitoring Tools *(continued)*

The ...	Enable(s) You To ...	For More Information, See ...
<code>netstat</code> and <code>nfsstat</code> commands	Display information about network performance	Chapter 27
Solstice System Monitor (SyMON)	Collect system activity data on Ultra™ Enterprise™ 3000, 4000, 5000, and 6000 systems	<i>Solstice SyMON 1.5 User's Guide</i>

Managing Processes (Tasks)

This chapter describes the procedures for managing system processes. This is a list of the step-by-step instructions in this chapter.

- “How to List Processes” on page 483
- “How to Display Information About Processes” on page 485
- “How to Control Processes” on page 487
- “How to Kill a Process” on page 489
- “How to Display Basic Information About Process Classes” on page 490
- “How to Display the Global Priority of a Process” on page 491
- “How to Designate a Process Priority” on page 491
- “How to Change Scheduling Parameters of a Timeshare Process” on page 492
- “How to Change the Class of a Process” on page 493
- “How to Change the Priority of a Process” on page 495

Displaying Information About Processes

This section describes commands used to manage process information.

The `ps` Command

The `ps` command enables you to check the status of active processes on a system, as well as display technical information about the processes. This data is useful for such administrative tasks as determining how to set process priorities.

Depending on which options you use, `ps` reports the following information:

- Current status of the process
- Process ID
- Parent process ID
- User ID
- Scheduling class
- Priority
- Address of the process
- Memory used
- CPU time used

Table 25-1 describes some of the fields reported by the `ps` command. The fields displayed depend on which option you choose. See `ps(1)` for a description of all available options.

TABLE 25-1 Summary of Fields in `ps` Reports

Field	Description
UID	The effective user ID of the process's owner.
PID	The process ID.
PPID	The parent process's ID.
C	The processor utilization for scheduling. This field is not displayed when the <code>-c</code> option is used.
CLS	The scheduling class to which the process belongs: real-time, system, or timesharing. This field is included only with the <code>-c</code> option.
PRI	The kernel thread's scheduling priority. Higher numbers mean higher priority.
NI	The process's nice number, which contributes to its scheduling priority. Making a process "nicer" means lowering its priority.
ADDR	The address of the <code>proc</code> structure.

TABLE 25-1 Summary of Fields in `ps` Reports *(continued)*

Field	Description
SZ	The virtual address size of the process.
WCHAN	The address of an event or lock for which the process is sleeping.
STIME	The starting time of the process (in hours, minutes, and seconds).
TTY	The terminal from which the process (or its parent) was started. A question mark indicates there is no controlling terminal.
TIME	The total amount of CPU time used by the process since it began.
CMD	The command that generated the process.

▼ How to List Processes

To list all the processes being executed on a system, use the `ps` command.

```
$ ps [-ef]
```

<code>ps</code>	Displays only the processes associated with your login session.
<code>-ef</code>	Displays full information about all the processes being executed on the system.

Example—Listing Processes

The following example shows output from the `ps` command when no options are used.

```
$ ps
  PID TTY          TIME CMD
 1664 pts/4        0:06 csh
 2081 pts/4        0:00 ps
```

The following example shows output from `ps -ef`. This shows that the first process executed when the system boots is `sched` (the swapper) followed by the `init` process, `pageout`, and so on.

```

$ ps -ef
  UID  PID  PPID  C   STIME TTY      TIME CMD
  root    0    0  0   May 05 ?        0:04 sched
  root    1    0  0   May 05 ?       10:48 /etc/init -
  root    2    0  0   May 05 ?        0:00 pageout
  root    3    0  0   May 05 ?       43:21 fsflush
  root   238    1  0   May 05 ?        0:00 /usr/lib/saf/saf/sac -t 300
  root   115    1  0   May 05 ?        0:10 /usr/sbin/rpcbind
  root   158    1  0   May 05 ?        0:00 /usr/lib/autofs/autom...
  root   134    1  0   May 05 ?        0:12 /usr/sbin/inetd -s
  root   107    1  0   May 05 ?       11:49 /usr/sbin/in.routed -q
  root   117    1  5   May 05 ?     899:32 /usr/sbin/keyserv
  root   125    1  0   May 05 ?        0:00 /usr/sbin/kerbd
  root   123    1  0   May 05 ?        4:17 /usr/sbin/nis_cachemgr
  root   137    1  0   May 05 ?        0:00 /usr/lib/nfs/statd
  root   139    1  0   May 05 ?        0:02 /usr/lib/nfs/lockd
  root   159    1  50  May 05 ?     8243:36 /usr/sbin/automount
  root   162    1  0   May 05 ?        0:07 /usr/sbin/syslogd
  root   181    1  0   May 05 ?        0:03 /usr/sbin/nscd...
  root   169    1  0   May 05 ?        5:09 /usr/sbin/cron
  root   191    1  0   May 05 ?        0:00 /usr/lib/lpsched
  root   210    1  0   May 05 ?        0:01 /usr/sbin/vold
  root   200    1  0   May 05 ?        0:08 /usr/lib/sendmail -bd -qlh
  root  4942    1  0   May 17 console 0:00 /usr/lib/saf/ttymon...
  root   208    1  0   May 05 ?        0:00 /usr/lib/utmpd
  root   241   238  0   May 05 ?        0:00 /usr/lib/saf/ttymon
  root  5748   134  0  17:09:49 ?        0:01 in.rlogind
  root  5750  5748  0  17:09:52 pts/0    0:00 -sh
  root  5770  5750  2  17:23:39 pts/0    0:00 ps -ef

```

Displaying Information About Processes (/proc Tools)

You can display detailed, technical information about active processes by using some of the process tool commands contained in `/usr/proc/bin`. Table 25-2 lists these process tools. Refer to `proc(1)` for more information.

TABLE 25-2 `/usr/proc/bin` Process Tools That Display Information

Process Tool	What It Displays
<code>pcrd</code>	Credentials
<code>pfiles</code>	<code>fstat</code> and <code>fcntl</code> information for open files in a process

TABLE 25-2 /usr/proc/bin Process Tools That Display Information (continued)

Process Tool	What It Displays
pflags	/proc tracing flags, pending and held signals, and other status information
pldd	Dynamic libraries linked into a process
pmap	Address space map
psig	Signal actions
pstack	Hex+symbolic stack trace
ptime	Process time using microstate accounting
ptree	Process trees that contain the process
pwait	Status information after a process terminates
pwdx	Current working directory for a process

Note - To avoid typing long command names, add the process tool directory to your PATH variable. This enables you to run process tools by entering only the last part of each file name (for example, pwdx instead of /usr/proc/bin/pwdx).

▼ How to Display Information About Processes

1. (Optional) Use output from the ps command to obtain the identification number of the process you want to display more information about.

```
# ps -e | grep process
```

process Name of the process you want to display more information about.

The process identification number is in the first column of the output.

2. Use the appropriate /usr/bin/proc command to display the information you need.

```
# /usr/proc/bin/pcommand pid
```

pcommand Process tool command you want to run. Table 25-2 lists these commands.

pid Identification number of a process.

Examples—Displaying Information About Processes

The following example shows how to use process tool commands to display more information about an `lpsched` process. First the `/usr/proc/bin` path is defined to avoid typing long process tool commands. Next, the identification number for `lpsched` is obtained. Finally, output from three process tool commands is shown.

```
1 # PATH=$PATH:/usr/proc/bin
2 # export PATH
3 # ps -e | grep lpsched
   191 ?          0:00 /usr/lib/lpsched
4 # pwdx 191
   191: /
5 # ptree 191
   183 /usr/lib/lpsched
6 # pfiles 191
   210: /usr/lib/lpsched
      Current rlimit: 1024 file descriptors
      0: S_IFIFO mode:0000 dev:165,0 ino:83 uid:0 gid:0 size:0
         O_RDWR
      1: S_IFIFO mode:0000 dev:165,0 ino:83 uid:0 gid:0 size:0
         O_RDWR
      3: S_IFCHR mode:0666 dev:32,24 ino:34307 uid:0 gid:3 rdev:21,0
         O_WRONLY FD_CLOEXEC
      4: S_IFDOOR mode:0444 dev:171,0 ino:4124226512 uid:0 gid:0
         size:0
         O_RDONLY|O_LARGEFILE FD_CLOEXEC door to nscd[200]
      5: S_IFREG mode:0664 dev:32,24 ino:311 uid:71 gid:8 size:0
         O_WRONLY
```

The following example shows output from the `pwait` command, which waits until a process terminates, then displays information about what happened. The following

1. Adds the `/usr/proc/bin` directory to the `PATH` variable.
2. Obtains the process identification number for `lpsched`.
3. Displays the current working directory for `lpsched`.
4. Displays the process tree containing `lpsched`.
5. Displays `fstat` and `fcntl` information.

example shows output from the `pwait` command after a Command Tool window was exited.

```
$ ps -e | grep cmdtool
273 console 0:01 cmdtool
277 console 0:01 cmdtool
281 console 0:01 cmdtool
$ pwait -v 281
281: terminated, wait status 0x0000
```

Controlling Processes (/proc Tools)

You can control some aspects of processes by using some of the process tools contained in `/usr/proc/bin`. Table 25-3 lists these process tools. Refer to `proc(1)` for detailed information about process tools.

TABLE 25-3 /usr/proc/bin Process Tools That Provide Control

Process Tool	What it Does
<code>pstop</code>	Stops a process
<code>prun</code>	Restarts a process

Note - To avoid typing long command names, add the process tool directory to your `PATH` variable. This allows you to run process tools by entering only the last part of each file name (for example, `prun` instead of `/usr/proc/bin/prun`).

▼ How to Control Processes

1. (Optional) Use output from the `ps` command to obtain the identification number of the process you want to display more information about.

```
# ps -e | grep process
```

process Name of the process you want to display more information about.

The process identification number is in the first column of the output.

2. Use the appropriate `/usr/proc/bin` command to control the process.

```
# /usr/proc/bin/pcommand PID
```

pcommand Process tool command you want to run. Table 25-3 lists these commands.

PID Identification number of a process.

3. Verify the process status using the `ps` command.

```
# ps | grep PID
```

Example—Controlling Processes

The following example shows how to use process tools to stop and restart Print Tool.

```
6 # PATH=$PATH:/usr/proc/bin
7 # export PATH
8 # ps -e | grep print*
264 console 0:03 printtool
9 # pstop 264
# prun 264
# ps | grep 264
264 console 0:03 printtool
#
```

-
- 6. Adds the `/usr/proc/bin` directory to the `PATH` variable.
 - 7. Obtains the process identification number for Print Tool.
 - 8. Stops the Print Tool process.
 - 9. Restarts the Print Tool process.

Killing a Process (`pkill`)

Sometimes it is necessary to stop (kill) a process. The process may be in an endless loop, or you may have started a large job that you want to stop before it is completed. You can kill any process that you own, and superuser can kill any processes in the system except for those with process IDs 0, 1, 2, 3, and 4.

Refer to `pkill(1)` for more detailed information.

▼ How to Kill a Process

1. (Optional) To kill a process belonging to another user, become superuser.
2. (Optional) Use output from the `pgrep` command to obtain the identification number of the process you want to display more information about.

```
$ pgrep process
```

process Name of the process you want to display more information about.

The process identification number is in the first column of the output.

3. Use the `pkill` command to stop the process.

```
$ pkill [-9] PID ...
```

-9 Ensures that the process terminates promptly.

PID ... ID of the process or processes to stop.

4. Use the `pgrep` command to verify that the process has been stopped.

```
$ pgrep PID ...
```

Managing Process Class Information

The listing below shows which classes are configured on your system, and the user priority range for the timesharing class. The possible classes are:

- System (SYS)
- Interactive (IA)
- Real-time (RT)
- Timesharing (TS)
 - The user-supplied priority ranges from -20 to +20.
 - The priority of a process is inherited from the parent process. This is referred to as the *user-mode* priority.
 - The system looks up the user-mode priority in the timesharing dispatch parameter table and adds in any `nice` or `priocntl` (user-supplied) priority and ensures a 0-59 range to create a *global* priority.

Changing the Scheduling Priority of Processes With `priocntl`

The scheduling priority of a process is the priority it is assigned by the process scheduler, according to scheduling policies. The `dispadmin` command lists the default scheduling policies. See “Scheduler Configuration” on page 554 for information on the `dispadmin` command.

The `priocntl(1)` command can be used to assign processes to a priority class and to manage process priorities. See the section called “How to Designate a Process Priority” on page 491 for instructions on using the `priocntl` command to manage processes.

▼ How to Display Basic Information About Process Classes

You can display process class and scheduling parameters with the `priocntl -l` command.

```
$ priocntl -l
```

Example—Getting Basic Information About Process Classes

The following example shows output from the `priocntl -l` command.

```

$ priocntl -l
CONFIGURED CLASSES
=====

SYS (System Class)

TS (Time Sharing)
  Configured TS User Priority Range: -20 through 20

```

▼ How to Display the Global Priority of a Process

You can display the global priority of a process by using the `ps` command.

```
$ ps -ecl
```

The global priority is listed under the `PRI` column.

Example—Displaying the Global Priority of a Process

The following example shows output from `ps -ecl`. Data in the `PRI` column show that `pageout` has the highest priority, while `sh` has the lowest.

```

$ ps -ecl
 F S UID PID  PPID CLS PRI  ADDR      SZ  WCHAN    TTY      TIME  COMD
19 T 0  0    0    SYS 96  f00d05a8  0   ?         ?        0:03  sched
 8 S 0  1    0    TS 50  ff0f4678 185  ff0f4848 ?        36:51  init
19 S 0  2    0    SYS 98  ff0f4018  0   f00c645c ?        0:01  pageout
19 S 0  3    0    SYS 60  ff0f5998  0   f00d0c68 ?        241:01 fsflush
 8 S 0 269  1    TS 58  ff0f5338 303  ff49837e ?        0:07   sac
 8 S 0 204  1    TS 43  ff2f6008  50   ff2f606e console 0:02   sh

```

▼ How to Designate a Process Priority

1. Become superuser.
2. Start a process with a designated priority.

```
# priocntl -e -c class -m userlimit -p pri command_name
```

<code>-e</code>	Executes the command.
<code>-c class</code>	Specifies the class within which to run the process. The default classes are <code>TS</code> (timesharing) or <code>RT</code> (real-time).
<code>-m userlimit</code>	Specifies the maximum amount you can raise or lower your priority, when using the <code>-p</code> option.
<code>-p pri command_name</code>	Lets you specify the relative priority in the <code>RT</code> class, for a real-time thread. For a timesharing process, the <code>-p</code> option lets you specify the user-supplied priority which ranges from <code>-20</code> to <code>+20</code> .

3. Verify the process status by using the `ps -ecl` command.

```
# ps -ecl | grep command_name
```

Example—Designating a Priority

The following example starts the `find` command with the highest possible user-supplied priority.

```
# prctl -e -c TS -m 20 -p 20 find . -name core -print
# ps -ecl | grep find
```

▼ How to Change Scheduling Parameters of a Timeshare Process

1. Become superuser.
2. Change the scheduling parameter of a running timeshare process.

```
# prctl -s -m userlimit [-p userpriority] -i idtype idlist
```

<code>-s</code>	Lets you set the upper limit on the user priority range and change the current priority.
<code>-m userlimit</code>	Specifies the maximum amount you can raise or lower your priority, when using the <code>-p</code> option.
<code>-p userpriority</code>	Allows you to designate a priority.
<code>-i idtype idlist</code>	Uses a combination of <i>idtype</i> and <i>idlist</i> to identify the process. The <i>idtype</i> specifies the type of ID, such as PID or UID.

3. Verify the process status by using the `ps -ecl` command.

```
# ps -ecl | grep idlist
```

Example—Changing Scheduling Parameters of a Timeshare Process

The following example executes a command with a 500-millisecond time slice, a priority of 20 in the RT class, and a global priority of 120.

```
# priocntl -e -c RT -t 500 -p 20 myprog
# ps -ecl | grep myprog
```

▼ How to Change the Class of a Process

1. (Optional) Become superuser.

Note - You must be superuser or working in a real-time shell to change processes from, or to, real-time processes.

2. Change the class of a process.

```
# priocntl -s -c class -i idtype idlist
```

<code>-s</code>	Lets you set the upper limit on the user priority range and change the current priority.
<code>-c class</code>	Specifies the class, TS or RT, to which you are changing the process.
<code>-i idtype idlist</code>	Uses a combination of <i>idtype</i> and <i>idlist</i> to identify the process. The <i>idtype</i> specifies the type of ID, such as PID or UID.

3. Verify the process status by using the `ps -ecl` command.

```
# ps -ecl | grep idlist
```

Example—Changing the Class of a Process

The following example changes all the processes belonging to user 15249 to real-time processes.

```
# priocntl -s -c RT -i uid 15249
# ps -ecl | grep 15249
```

Note - If, as superuser, you change a user process to the real-time class, the user cannot subsequently change the real-time scheduling parameters (using `priocntl -s`).

Changing the Priority of a Timesharing Process With `nice`

The `nice(1)` command is only supported for backward compatibility to previous Solaris releases. The `priocntl` command provides more flexibility in managing processes.

The priority of a process is determined by the policies of its scheduling class, and by its *nice number*. Each timesharing process has a global priority which is calculated by adding the user-supplied priority, which can be influenced by the `nice` or `priocntl` commands, and the system-calculated priority.

The execution priority number of a process is assigned by the operating system, and is determined by several factors, including its schedule class, how much CPU time it has used, and (in the case of a timesharing process) its `nice` number.

Each timesharing process starts with a default `nice` number, which it inherits from its parent process. The `nice` number is shown in the `NI` column of the `ps` report.

A user can lower the priority of a process by increasing its user-supplied priority. But only the superuser can lower a `nice` number to increase the priority of a process. This is to prevent users from increasing the priorities of their own processes, thereby monopolizing a greater share of the CPU.

Nice numbers range between 0 and +40, with 0 representing the highest priority. The default value is 20. Two versions of the command are available, the standard version, `/usr/bin/nice`, and a version that is part of the C shell.

▼ How to Change the Priority of a Process

You can raise or lower the priority of a command or a process by changing the `nice` number. To lower the priority of a process:

<code>/usr/bin/nice <i>command_name</i></code>	Increase the <code>nice</code> number by four units (the default)
<code>/usr/bin/nice +4 <i>command_name</i></code>	Increase the <code>nice</code> number by four units
<code>/usr/bin/nice -10 <i>command_name</i></code>	Increase the <code>nice</code> number by ten units

The first and second commands increase the `nice` number by four units (the default); and the third command increases the `nice` by ten units, lowering the priority of the process.

The following commands raise the priority of the command by lowering the `nice` number.

To raise the priority of a process:

<code>/usr/bin/nice -10 <i>command_name</i></code>	Raises the priority of the command by lowering the <code>nice</code> number
<code>/usr/bin/nice --10 <i>command_name</i></code>	Raises the priority of the command by lowering the <code>nice</code> number. The first minus sign is the option sign, and the second minus sign indicates a negative number.

The above commands raise the priority of the command, `command_name`, by lowering the `nice` number. Note that in the second case, the two minus signs are required.

Process Troubleshooting

Here are some tips on obvious problems you may find:

- Look for several identical jobs owned by the same user. This may come as a result of running a script that starts a lot of background jobs without waiting for any of the jobs to finish.
- Look for a process that has accumulated a large amount of CPU time. You'll see this by looking at the `TIME` field. Possibly, the process is in an endless loop.
- Look for a process running with a priority that is too high. Type `ps -c` to see the `CLS` field, which displays the scheduler class of each process. A process executing as a real-time (`RT`) process can monopolize the CPU. Or look for a timeshare (`TS`) process with a high `nice` value. A user with superuser privileges may have bumped up the priorities of this process. The system administrator can lower the priority by using the `nice` command.
- Look for a runaway process—one that progressively uses more and more CPU time. You can see it happening by looking at the time when the process started (`STIME`) and by watching the cumulation of CPU time (`TIME`) for awhile.

Monitoring Performance (Tasks)

This chapter describes procedures for monitoring system performance by using the `vmstat`, `iostat`, `df`, and `sar` commands. This is a list of the step-by-step instructions in this chapter.

- “How to Display Virtual Memory Statistics (`vmstat`)” on page 498
- “How to Display System Event Information” on page 500
- “How to Display Swapping Statistics” on page 501
- “How to Display Cache Flushing Statistics ” on page 502
- “How to Display Interrupts Per Device” on page 502
- “How to Display Disk Utilization Information” on page 503
- “How to Display Extended Disk Statistics” on page 504
- “How to Display File System Information” on page 506
- “How to Check File Access (`sar`)” on page 507
- “How to Check Buffer Activity (`sar`)” on page 508
- “How to Check System Call Statistics (`sar`)” on page 510
- “How to Check Disk Activity (`sar`)” on page 511
- “How to Check Page-Out and Memory (`sar`)” on page 513
- “How to Check Kernel Memory Allocation (`sar`)” on page 515
- “How to Check Interprocess Communication (`sar`)” on page 517
- “How to Check Page-In Activity (`sar`)” on page 518
- “How to Check Queue Activity (`sar`)” on page 520
- “How to Check Unused Memory (`sar`)” on page 521
- “How to Check CPU Utilization (`sar`)” on page 522
- “How to Check System Table Status (`sar`)” on page 523

- “How to Check Swap Activity (*sar*)” on page 525
- “How to Check Terminal Activity (*sar*)” on page 526
- “How to Check Overall System Performance (*sar*)” on page 528
- “How to Set Up Automatic Data Collection ” on page 531

Displaying Virtual Memory Statistics (*vmstat*)

You can use the *vmstat* command to report virtual memory statistics and such information about system events as CPU load, paging, number of context switches, device interrupts, and system calls. The *vmstat* command can also display statistics on swapping, cache flushing, and interrupts.

Refer to *vmstat(1M)* for a more detailed description of this command.

▼ How to Display Virtual Memory Statistics (*vmstat*)

Collect virtual memory statistics using the *vmstat* command with a time interval.

```
$ vmstat n
```

n Interval in seconds between reports.

Table 26-1 describes the fields in the *vmstat* output.

TABLE 26-1 Output From the *vmstat* Command

Category	Field Name	Description
<i>procs</i>		Reports the following states:
	<i>r</i>	The number of kernel threads in the dispatch queue
	<i>b</i>	Blocked kernel threads waiting for resources
	<i>w</i>	Swapped out LWPs waiting for processing resources to finish

TABLE 26-1 Output From the `vmstat` Command *(continued)*

Category	Field Name	Description
memory		Reports on usage of real and virtual memory:
	swap	Available swap space
	free	Size of the free list
page		Reports on page faults and paging activity, in units per second:
	re	Pages reclaimed
	mf	Minor and major faults
	pi	Kbytes paged in
	po	Kbytes paged out
	fr	Kbytes freed
	de	Anticipated memory needed by recently swapped-in processes
	sr	Pages scanned by page daemon (not currently in use). If <code>sr</code> does not equal zero, the page daemon has been running.
disk		Reports the number of disk operations per second, showing data on up to four disks
faults		Reports the trap/interrupt rates (per second):
	in	Interrupts per second
	sy	System calls per second
	cs	CPU context switch rate
cpu		Reports on the use of CPU time:
	us	User time

TABLE 26-1 Output From the `vmstat` Command (continued)

Category	Field Name	Description
	<code>sy</code>	System time
	<code>id</code>	Idle time

Example—Displaying Virtual Memory Statistics

The following example shows the `vmstat` display of statistics gathered at five-second intervals.

```
$ vmstat 5
procs      memory          page          disk          faults          cpu
r  b  w  swap free re  mf  pi  po  fr de sr f0 s3 -- --  in  sy  cs us sy  id
0  0  8 28312 668 0   9   2   0   1  0  0  0  1  0  0  10  61  82  1  2  97
0  0  3 31940 248 0  10  20   0  26  0  27  0  4  0  0  53 189 191  6  6  88
0  0  3 32080 288 3  19  49   6  26  0  15  0  9  0  0  75 415 277  6 15  79
0  0  3 32080 256 0  26  20   6  21  0  12  1  6  0  0 163 110 138  1  3  96
0  1  3 32060 256 3  45  52  28  61  0  27  5 12  0  0 195 191 223  7 11  82
0  0  3 32056 260 0   1   0   0  0  0  0  0  0  0  0   4  52  84  0  1  99
```

▼ How to Display System Event Information

Run `vmstat -s` to show the total of various system events that have taken place since the system was last booted.

```
$ vmstat -s
      0 swap ins
      0 swap outs
      0 pages swapped in
      0 pages swapped out
2560974 total address trans. faults taken
  495226 page ins
   52459 page outs
1088645 pages paged in
  420615 pages paged out
   34409 total reclaims
   34104 reclaims from free list
         0 micro (hat) faults
2560974 minor (as) faults
  493981 major faults
  450203 copy-on-write faults
  609679 zero fill page faults
```

(continued)

(Continuation)

```
2669301 pages examined by the clock daemon
    195 revolutions of the clock hand
1234901 pages freed by the clock daemon
    14228 forks
    3979 vforks
    16151 execs
212282273 cpu context switches
248366049 device interrupts
    5891779 traps
529830492 system calls
    4028123 total name lookups (cache hits 95%)
        1969 toolong
    7272260 user    cpu
    3047366 system cpu
171183965 idle    cpu
    348263 wait    cpu
```

▼ How to Display Swapping Statistics

Run `vmstat -S` to show swapping statistics.

```
$ vmstat -S
procs      memory          page              disk              faults           cpu
r  b  w  swap  free  si  so pi po fr de sr f0 s3 -- --  in  sy  cs us sy id
0  0  0  5604 1860  0  0  2  0  2  0  1  0  0  0  0  36 291 116  4  2 94
```

The additional fields are described in Table 26-2.

TABLE 26-2 Output From the `vmstat -S` Command

Field Name	Description
si	Average number of LWPs swapped in per second
so	Number of whole processes swapped out

Note - The `vmstat` command truncates the output of both of these fields. Use the `sar` command to display a more accurate accounting of swap statistics.

▼ How to Display Cache Flushing Statistics

Run `vmstat -c` to show cache flushing statistics for a virtual cache.

```
$ vmstat -c
usr      ctx      rgn      seg      pag      par
  0     60714         5 134584 4486560 4718054
```

It shows the total number of cache flushes since the last boot. The cache types are described in Table 26-3.

TABLE 26-3 Output From the `vmstat -c` Command

Cache Name	Cache Type
usr	User
ctx	Context
rgn	Region
seg	Segment
pag	Page
par	Partial-page

▼ How to Display Interrupts Per Device

Run `vmstat -i` to show interrupts per device.

```
$ vmstat -i
```

Example—Displaying Interrupts Per Device

The following example shows output from the `vmstat -i` command.

```
$ vmstat -i
interrupt      total      rate
-----
clock          181871074    100
zsc0              2           0
```

(continued)

(Continuation)

zsc1	6523622	3
cgsixc0	63951	0
lec0	6433537	3
fdc0	13309	0

Total	194905495	107

Displaying Disk Utilization Information

Use the `iostat` command to report statistics about disk input and output, and produces measures of throughput, utilization, queue lengths, transaction rates, and service time. For a detailed description of this command, refer to `iostat(1M)`.

▼ How to Display Disk Utilization Information

You can display disk activity information by using the `iostat` command with a time interval.

```
$ iostat 5
      tty          fd0          sd3          nfs1          nfs31          cpu
  tin tout kps tps serv  kps tps serv  kps tps serv  kps tps serv  us sy wt id
    0   1   0   0  410    3   0  29    0   0   9    3   0  47   4  2  0 94
```

The first line of output shows the statistics since the last boot. Each subsequent line shows the interval statistics. The default is to show statistics for the terminal (`tty`), disks (`fd` and `sd`), and CPU (`cpu`).

Table 26-4 describes the fields in the `iostat` command output.

TABLE 26-4 Output From the `iostat n` Command

For Each ...	Field Name	Description
Terminal		
	<code>tin</code>	Number of characters in the terminal input queue
	<code>tout</code>	Number of characters in the terminal output queue

TABLE 26-4 Output From the `iostat n` Command (continued)

For Each ...	Field Name	Description
Disk		
	<code>bps</code>	Blocks per second
	<code>tps</code>	Transactions per second
	<code>serv</code>	Average service time, in milliseconds
CPU		
	<code>us</code>	In user mode
	<code>sy</code>	In system mode
	<code>wt</code>	Waiting for I/O
	<code>id</code>	Idle

Example—Displaying Disk Utilization Information

The following example shows disk statistics gathered every five seconds.

```

$ iostat 5
      tty          fd0          sd3          nfs1          nfs31          cpu
 tin tout kps tps serv kps tps serv kps tps serv kps tps serv us sy wt id
 0     1   0   0  410    3   0  29    0   0   9    3   0  47   4  2  0  94
 0    47   0   0   0    0   0   0    0   0   0    0   0   0   1  2  0  97
 0    16   0   0   0    0   0   0    0   0   0    0   0   0   3  3  0  93
 0    16   0   0   0    0   0   0    0   0   0    0   0   0   4  4  0  92
 0    16   0   0   0    1   0   7    0   0   0   50  2  94  50  5  0  45
 0    16   0   0   0    3   1  14    0   0   0    0   0   0   2  3  1  94
 0    16   0   0   0   24  4  58    0   0   0    0   0   0   0  2  0  97
 0    16   0   0   0    0   0   0    0   0   0    0   0   0   4  3  0  93
 0    16   0   0   0    0   0   0    0   0   0    0   0   0   3  3  0  94
 0    16   0   0   0    3   1  25    0   0   0    0   0   0   3  3  0  93
 0    16   0   0   0    0   0   0    0   0   0    1   0  27   8  4  0  88

```

▼ How to Display Extended Disk Statistics

Run `iostat -xtc` to get extended disk statistics.

```

$ iostat -xtc
                extended device statistics
device  r/s  w/s  kr/s  kw/s  wait  actv  svc_t  %w  %b  tin  tout  us  sy  wt  id
fd0     0.0  0.0   0.0   0.0  0.0  0.0  410.2  0  0   0    1  4  2  0  94
sd3     0.2  0.1   1.1   1.4  0.0  0.0   29.0  0  0
nfs1    0.0  0.0   0.0   0.0  0.0  0.0    8.6  0  0
nfs31   0.1  0.0   2.1   0.4  0.0  0.0   47.0  0  0
nfs32   0.0  0.0   0.2   0.0  0.0  0.0   29.7  0  0
nfs202  0.0  0.0   0.0   0.0  0.0  0.0  963.2  0  0
nfs216  0.2  0.0   5.3   0.0  0.0  0.0   50.9  0  1
nfs220  0.0  0.0   0.0   0.0  0.0  0.0    0.0  0  0

```

This command displays a line of output for each disk. The output fields are described in Table 26-5.

TABLE 26-5 Output From the `iostat -xtc` Command

Field Name	Description
r/s	Reads per second
w/s	Writes per second
Kr/s	Kbytes read per second
Kw/s	Kbytes written per second
wait	Average number of transactions waiting for service (queue length)
actv	Average number of transactions actively being serviced
svc_t	Average service time, in milliseconds
%w	Percentage of time the queue is not empty
%b	Percentage of time the disk is busy

Displaying Disk Usage Statistics

Use the `df` command to show the amount of free disk space on each mounted disk. The *usable* disk space reported by `df` reflects only 90% of full capacity, as the reporting statistics leave a 10% head room above the total available space. This head room normally stays empty for better performance.

The percentage of disk space actually reported by `df` is used space divided by usable space.

If the file system is above 90% capacity, transfer files to a disk that is not as full by using `cp`, or to a tape by using `tar` or `cpio`; or remove the files.

For a detailed description of this command, refer to the `df(1M)` man page.

▼ How to Display File System Information

Use the `df -k` command to display file system information in Kbytes.

```
$ df -k
Filesystem          kbytes  used  avail capacity  Mounted on
/dev/dsk/c0t3d0s0  192807  40231 133296    24%      /
```

Table 26-6 describes the `df -k` command output.

TABLE 26-6 Output From the `df -k` Command

Field Name	Description
<code>kbytes</code>	Total size of usable space in the file system
<code>used</code>	Amount of space used
<code>avail</code>	Amount of space available for use
<code>capacity</code>	Amount of space used, as a percent of the total capacity
<code>mounted on</code>	Mount point

Example—Displaying File System Information

The following example shows output of the `df -k` command.

```
$ df -k
```

Filesystem	kbytes	used	avail	capacity	Mounted on
/dev/dsk/c0t3d0s0	192807	40239	133288	24%	/
/dev/dsk/c0t3d0s6	769758	472613	243262	67%	/usr
/proc	0	0	0	0%	/proc
fd	0	0	0	0%	/dev/fd
/dev/dsk/c0t3d0s7	217191	19341	176131	10%	/export/home
/dev/dsk/c0t3d0s5	192807	7785	165742	5%	/opt
swap	161256	288	160968	1%	/tmp

Monitoring System Activities (sar)

Use the `sar` command to:

- Organize and view data about system activity
- Access system activity data on a special request basis
- Generate automatic reports to measure and monitor system performance, and special request reports to pinpoint specific performance problems. “Collecting System Activity Data Automatically (sar)” on page 528 describes these tools.

For a detailed description of this command, refer to `sar(1)`.

▼ How to Check File Access (sar)

Display file access operation statistics with the `sar -a` command.

```
$ sar -a
```

SunOS venus 5.7 Generic sun4m 06/17/98

Time	iget/s	namei/s	dirbk/s
00:00:01			
01:00:01	0	1	0
02:00:01	0	1	0
03:00:00	0	1	0
04:00:01	0	1	0
05:00:01	0	1	0
06:00:01	0	1	0
07:00:01	0	1	0
08:00:01	0	1	0
08:20:01	0	1	0
08:40:00	0	0	0
09:00:01	0	1	0

(continued)

(Continuation)

09:20:00	0	3	0
09:40:00	0	3	0
10:00:02	0	3	1
10:20:02	0	11	7
Average	0	1	0

The operating system routines reported are described in Table 26-7.

TABLE 26-7 Output from the `sar -a` Command

Field Name	Description
<code>iget/s</code>	The number of requests made for inodes that were not in the directory name lookup cache (<code>dnlc</code>).
<code>namei/s</code>	This is the number of file system path searches per second. If <code>namei</code> does not find a directory name in the <code>dnlc</code> , it calls <code>iget</code> to get the inode for either a file or directory. Hence, most <code>igets</code> are the result of <code>dnlc</code> misses.
<code>dirbk/s</code>	This is the number of directory block reads issued per second.

The larger the values reported, the more time the kernel is spending to access user files. The amount of time reflects how heavily programs and applications are using the file systems. The `-a` option is helpful for viewing how disk-dependent an application is.

▼ How to Check Buffer Activity (`sar`)

Display buffer activity statistics with the `sar -b` command.

The buffer is used to cache metadata, which includes inodes, cylinder group blocks, and indirect blocks.

```
$ sar -b
0:0:03 bread/s lread/s %rcache bwrit/s lwrit/s %wcache pread/s pwrit/s
1:0:02 0 0 100 0 0 57 0 0
```

The buffer activities displayed by the `-b` option are described in Table 26-8. The most important entries are the cache hit ratios `%rcache` and `%wcache`, which measure the

effectiveness of system buffering. If %rcache falls below 90, or if %wcache falls below 65, it may be possible to improve performance by increasing the buffer space.

TABLE 26-8 Output from the `sar -b` Command

Field Name	Description
bread/s	Average number of reads per second submitted to the buffer cache from the disk
lread/s	Average number of logical reads per second from the buffer cache
%rcache	Fraction of logical reads found in the buffer cache (100% minus the ratio of bread/s to lread/s)
bwrit/s	Average number of physical blocks (512 blocks) written from the buffer cache to disk, per second
lwrite/s	Average number of logical writes to the buffer cache, per second
%wcache	Fraction of logical writes found in the buffer cache(100% minus the ratio of bwrit/s to lwrit/s)
pread/s	Average number of physical reads, per second, using character device interfaces
pwrit/s	Average number of physical write requests, per second, using character device interfaces

Example—Checking Buffer Activity

The following example of `sar -b` output shows that the %rcache and %wcache buffers are not causing any slowdowns, because all the data is within acceptable limits.

```

$ sar -b
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01 bread/s lread/s %rcache bwrit/s lwrit/s %wcache pread/s pwrit/s
01:00:01 0 0 100 0 0 56 0 0
02:00:01 0 0 100 0 0 55 0 0
03:00:00 0 0 99 0 0 58 0 0
04:00:01 0 0 100 0 0 55 0 0
05:00:01 0 0 100 0 0 55 0 0

```

(continued)

(Continuation)

06:00:01	0	0	100	0	0	55	0	0
07:00:01	0	0	100	0	0	55	0	0
08:00:01	0	0	100	0	0	56	0	0
08:20:01	0	0	100	0	0	56	0	0
08:40:00	0	0	100	0	0	56	0	0
09:00:01	0	0	100	0	0	57	0	0
09:20:00	0	1	98	0	1	59	0	0
09:40:00	0	1	99	0	1	59	0	0
10:00:02	0	0	96	0	0	57	0	0
10:20:02	0	1	99	0	1	60	0	0
Average	0	0	99	0	0	57	0	0

▼ How to Check System Call Statistics (sar)

Display system call statistics by using the `sar -c` command.

```
$ sar -c
00:00:01 scall/s sread/s swrit/s fork/s exec/s rchar/s wchar/s
01:00:01 2071 231 230 0.01 0.00 923483 923298
```

Table 26-9 describes the following system call categories reported by the `-c` option. Typically, `reads` and `writes` account for about half of the total system calls, although the percentage varies greatly with the activities that are being performed by the system.

TABLE 26-9 Output from the `sar -c` Command

Field Name	Description
<code>scall/s</code>	All types of system calls per second (generally about 30 per second on a busy four- to six-user system)
<code>sread/s</code>	read system calls per second
<code>swrit/s</code>	write system calls per second
<code>fork/s</code>	<code>fork</code> system calls per second (about 0.5 per second on a four- to six-user system); this number will increase if shell scripts are running

TABLE 26-9 Output from the `sar -c` Command (continued)

Field Name	Description
<code>exec/d</code>	<code>exec</code> system calls per second; if <code>exec/s</code> divided by <code>fork/s</code> is greater than three, look for inefficient <code>PATH</code> variables
<code>rchar/s</code>	Characters (bytes) transferred by <code>read</code> system calls per second
<code>wchar/s</code>	Characters (bytes) transferred by <code>write</code> system calls per second

Example—Checking System Call Statistics

The following example shows output from the `sar -c` command.

```

$ sar -c
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01 scall/s sread/s swrit/s fork/s exec/s rchar/s wchar/s
01:00:01 2071 231 230 0.01 0.00 923483 923298
02:00:01 2071 231 230 0.01 0.00 923789 923603
03:00:00 2070 231 229 0.02 0.02 922355 922140
04:00:01 2073 231 230 0.01 0.00 924497 924312
05:00:01 2071 231 230 0.01 0.00 923577 923392
06:00:01 2071 231 230 0.01 0.00 923740 923554
07:00:01 2071 231 230 0.01 0.00 923545 923360
08:00:01 2074 231 230 0.01 0.00 924737 924552
08:20:01 2071 231 229 0.01 0.01 923096 922884
08:40:00 2071 231 230 0.00 0.00 923610 923438
09:00:01 2071 231 229 0.01 0.01 923343 923163
09:20:00 571 70 58 0.03 0.03 226013 218929
09:40:00 197 38 16 0.02 0.03 11321 3021
10:00:02 207 41 14 0.08 0.07 28534 5795
10:20:02 782 183 30 0.49 0.49 148126 14726

Average 1861 212 204 0.03 0.03 9691 3994

```

▼ How to Check Disk Activity (sar)

Display disk activity statistics with the `sar -d` command.

```

$ sar -d
00:00:01 device %busy avque r+w/s blks/s await aserv
01:00:01 fd0 0 0.0 0 0 0.0 0.0

```

Table 26-10 describes the disk devices activities reported by the `-d` option. Note that queue lengths and wait times are measured when there is something in the queue. If `%busy` is small, large queues and service times probably represent the periodic efforts by the system to ensure that altered blocks are written to the disk in a timely fashion.

TABLE 26-10 Output from the `sar -d` Command

Field Name	Description
<code>device</code>	Name of the disk device being monitored
<code>%busy</code>	Percentage of time the device spent servicing a transfer request
<code>avque</code>	The sum of the average wait time plus the average service time
<code>r+w/s</code>	Number of read and write transfers to the device per second
<code>blks/s</code>	Number of 512-byte blocks transferred to the device per second
<code>await</code>	Average time, in milliseconds, that transfer requests wait idly in the queue (measured only when the queue is occupied)
<code>avserv</code>	Average time, in milliseconds, for a transfer request to be completed by the device (for disks, this includes seek, rotational latency, and data transfer times)

Examples—Checking Disk Activity

These two examples illustrate the `sar -d` output. The first example is from a computer with a non-SCSI (Small Computer System Interface, pronounced “scuzzy”) integral disk; that is, a disk that does not use a SCSI interface. This example illustrates data being transferred from a hard disk (`hdsk-0`) to the floppy disk (`fdsk-0`).

```

$ sar -d
SunOS venus 5.7 Generic sun4m    06/17/98

00:00:01  device      %busy  avque  r+w/s  blks/s  await  avserv
01:00:01  fd0          0      0.0    0      0      0.0    0.0
          nfs1         0      0.0    0      0      0.0    0.0
          nfs31        0      0.0    0      0      1.4    5.5
          nfs32        0      0.0    0      0      0.0    0.0
          nfs179       0      0.0    0      0      0.0    0.0

```

(continued)

(Continuation)

nfs202	0	0.0	0	0	0.0	0.0
sd3	0	0.0	0	2	0.0	53.9
sd3,a	0	0.0	0	1	0.0	59.6
sd3,b	0	0.0	0	0	0.0	14.2
sd3,c	0	0.0	0	0	0.0	0.0
sd3,d	0	0.0	0	0	0.0	0.0
sd3,e	0	0.0	0	0	0.0	0.0
sd3,f	0	0.0	0	0	0.0	0.0
sd3,g	0	0.0	0	0	0.0	77.6
sd3,h	0	0.0	0	0	0.0	0.0

The following example is from a computer with SCSI integral disks; that is, disks that use a SCSI interface. The example illustrates data being transferred from one SCSI hard disk (sd00-0) to another SCSI integral disk (sd00-1).

```
$ sar -d
SunOS venus 5.7 Generic sun4m 06/17/98
14:16:24 device %busy avque r+w/s blks/s avwait avserv
14:16:52 sd00-0 2 1.0 1 3 0.0 17.9
sd00-1 6 1.1 3 5 2.0 23.9
14:17:21 sd00-0 2 1.0 1 2 0.0 19.6
sd00-1 6 1.1 3 5 0.2 24.3
14:17:48 sd00-0 3 1.0 1 3 0.3 18.3
sd00-1 7 1.1 3 5 1.3 25.4
14:18:15 sd00-0 3 1.0 1 3 0.0 17.2
sd00-1 5 1.0 2 5 0.0 21.6
Average sd00-0 2 1.0 1 3 0.1 18.2
sd00-1 6 1.0 3 5 0.9 23.0
```

▼ How to Check Page-Out and Memory (sar)

Use the `sar -g` option reports page-out and memory freeing activities (in averages).

```
$ sar -g
00:00:01 pgout/s ppgout/s pgfree/s pgscan/s %ufs_ipf
01:00:01 0.00 0.00 0.00 0.00 0.00
```

The output displayed by `sar -g` is a good indicator of whether more memory may be needed. Use the `ps -elf` command to show the number of cycles used by the page daemon. A high number of cycles, combined with high values for `pgfree/s` and `pgscan/s` indicates a memory shortage.

`sar -g` also shows whether inodes are being recycled too quickly, causing a loss of reusable pages.

Output from the `-g` option is described in Table 26-11.

TABLE 26-11 Output From the `sar -g` Command

Field Name	Description
<code>pgout/s</code>	The number of page-out requests per second.
<code>ppgout/s</code>	The actual number of pages that are paged-out, per second. (A single page-out request may involve paging-out multiple pages.)
<code>pgfree/s</code>	The number of pages, per second, that are placed on the free list.
<code>pgscan/s</code>	The number of pages, per second, scanned by the page daemon. If this value is high, the page daemon is spending a lot of time checking for free memory. This implies that more memory may be needed.
<code>%ufs_ipf</code>	The percentage of <code>ufs</code> inodes taken off the free list by <code>iget</code> that had reusable pages associated with them. These pages are flushed and cannot be reclaimed by processes. Thus, this is the percentage of <code>igets</code> with page flushes. A high value indicates that the free list of inodes is page-bound and the number of <code>ufs</code> inodes may need to be increased.

Example—Checking Page-Out and Memory

The following example shows output from the `sar -g` command.

```
$ sar -g
SunOS venus 5.7 Generic sun4m    06/17/98

00:00:01  pgout/s ppgout/s pgfree/s pgscan/s %ufs_ipf
01:00:01    0.00    0.00    0.00    0.00    0.00
02:00:01    0.00    0.00    0.00    0.00    0.00
03:00:00    0.00    0.00    0.00    0.00    0.00
04:00:01    0.00    0.00    0.00    0.00    0.00
05:00:01    0.00    0.00    0.00    0.00    0.00
06:00:01    0.00    0.00    0.00    0.00    0.00
07:00:01    0.00    0.00    0.00    0.00    0.00
08:00:01    0.00    0.00    0.00    0.00    0.00
08:20:01    0.00    0.00    0.00    0.00    0.00
08:40:00    0.00    0.00    0.00    0.00    0.00
09:00:01    0.00    0.00    0.00    0.00    0.00
09:20:00    0.02    0.07    0.23    6.01    0.00
09:40:00    0.06    0.58    1.57    5.83    0.00
```

(continued)

(Continuation)

10:00:02	0.58	2.49	5.72	13.69	0.00
10:20:02	0.49	4.66	14.11	31.06	0.00
Average	0.04	0.25	0.70	1.83	0.00

▼ How to Check Kernel Memory Allocation (sar)

Use the `sar -k` command to report on the following activities of the Kernel Memory Allocator (KMA).

The KMA allows a kernel subsystem to allocate and free memory as needed. Rather than statically allocating the maximum amount of memory it is expected to require under peak load, the KMA divides requests for memory into three categories: small (less than 256 bytes), large (512 to 4 Kbytes), and oversized (greater than 4 Kbytes). It keeps two pools of memory to satisfy small and large requests. The oversized requests are satisfied by allocating memory from the system page allocator.

If you are investigating a system that is being used to write drivers or STREAMS that use KMA resources, then `sar -k` will likely prove useful. Otherwise, you will probably not need the information it provides. Any driver or module that uses KMA resources, but does not specifically return the resources before it exits, can create a memory leak. A memory leak causes the amount of memory allocated by KMA to increase over time. Thus, if the `alloc` fields of `sar -k` increase steadily over time, there may be a memory leak. Another indication of a memory leak is failed requests. If this occurs, a memory leak has probably caused KMA to be unable to reserve and allocate memory.

If it appears that a memory leak has occurred, you should check any drivers or STREAMS that may have requested memory from KMA and not returned it.

```
$ sar -k
00:00:01 sml_mem  alloc  fail  lg_mem  alloc  fail  ovsz_alloc  fail
01:00:01 1949696 1444668      0 5578752 4254136      0    2826240      0
```

Output from the `-k` option is described in Table 26-12.

TABLE 26-12 Output From the `sar -k` Command

Field Name	Description
<code>sml_mem</code>	The amount of memory, in bytes, that the KMA has available in the small memory request pool (a small request is less than 256 bytes)
<code>alloc</code>	The amount of memory, in bytes, that the KMA has allocated from its small memory request pool to small memory requests
<code>fail</code>	The number of requests for small amounts of memory that failed
<code>lg_mem</code>	The amount of memory, in bytes, that the KMA has available in the large memory request pool (a large request is from 512 bytes to 4 Kbytes)
<code>alloc</code>	The amount of memory, in bytes, that the KMA has allocated from its large memory request pool to large memory requests
<code>fail</code>	The number of failed requests for large amounts of memory
<code>ovsz_alloc</code>	The amount of memory allocated for oversized requests (those greater than 4 Kbytes); these requests are satisfied by the page allocator—thus, there is no pool
<code>fail</code>	The number of failed requests for oversized amounts of memory

Example—Checking Kernel Memory Allocation (`sar`)

The following is an example of `sar -k` output.

```

$ sar -k
SunOS venus 5.7 Generic sun4m    06/17/98

00:00:01 sml_mem  alloc  fail  lg_mem  alloc  fail  ovsz_alloc  fail
01:00:01 1949696 1444668    0 5578752 4254136    0    2826240    0
02:00:01 1949696 1444800    0 5578752 4254136    0    2826240    0
03:00:00 1949696 1445144    0 5578752 4258872    0    2826240    0
04:00:01 1949696 1446208    0 5578752 4259784    0    2826240    0
05:00:01 1949696 1445528    0 5578752 4256160    0    2826240    0
06:00:01 1949696 1445488    0 5578752 4259784    0    2826240    0
07:00:01 1949696 1445460    0 5578752 4259784    0    2826240    0
08:00:01 1949696 1446308    0 5578752 4258872    0    2826240    0
08:20:01 1949696 1440708    0 5578752 4250976    0    2826240    0
08:40:00 1949696 1440664    0 5578752 4250976    0    2826240    0

```

(continued)

(Continuation)

09:00:01	1949696	1445280	0	5578752	4259784	0	2826240	0
09:20:00	1929216	1369988	0	5324800	4122928	0	2826240	0
09:40:00	1929216	1380628	0	5320704	4065992	0	2826240	0
10:00:02	1916928	1442364	0	5345280	4142184	0	2826240	0
10:20:02	1916928	1415932	0	5373952	4100360	0	2826240	0
Average	1942596	1433278	0	5515401	4216982	0	2826240	0

▼ How to Check Interprocess Communication (sar)

Use the `sar -m` command to report interprocess communication activities.

```
$ sar -m
00:00:01  msg/s  sema/s
01:00:01  0.00   0.00
```

These figures will usually be zero (0.00), unless you are running applications that use messages or semaphores.

The output from the `-m` option is described in Table 26-13.

TABLE 26-13 Output From the `sar -m` Command

Field Name	Description
<code>msg/s</code>	The number of message operations (sends and receives) per second.
<code>sema/s</code>	The number of semaphore operations per second.

Example—Checking Interprocess Communication

The following example shows output from the `sar -m` command.

```

$ sar -m
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01  msg/s  sema/s
01:00:01  0.00  0.00
02:00:01  0.00  0.00
03:00:00  0.00  0.00
04:00:01  0.00  0.00
05:00:01  0.00  0.00
06:00:01  0.00  0.00
07:00:01  0.00  0.00
08:00:01  0.00  0.00
08:20:01  0.00  0.00
08:40:00  0.00  0.00
09:00:01  0.00  0.00
09:20:00  0.00  0.00
09:40:00  0.00  0.00
10:00:02  0.00  0.00
10:20:02  0.00  0.00

Average  0.00  0.00

```

▼ How to Check Page-In Activity (sar)

Use the `sar -p` command to report page-in activity which includes protection and translation faults.

```

$ sar -p
00:00:01  atch/s  pgin/s  ppgin/s  pflt/s  vflt/s  slock/s
01:00:01  0.00    0.04    0.05     0.38    0.67    0.00

```

The reported statistics from the `-p` option are described in Table 26-14.

TABLE 26-14 Output from the `sar -p` Command

Field Name	Description
<code>atch/s</code>	The number of page faults, per second, that are satisfied by reclaiming a page currently in memory (attaches per second). Instances of this include reclaiming an invalid page from the free list and sharing a page of text currently being used by another process (for example, two or more processes accessing the same program text).
<code>pgin/s</code>	The number of times, per second, that file systems receive page-in requests.

TABLE 26-14 Output from the `sar -p` Command (continued)

Field Name	Description
<code>ppgin/s</code>	The number of pages paged in, per second. A single page-in request, such as a soft-lock request (see <code>slock/s</code>), or a large block size, may involve paging-in multiple pages.
<code>pflt/s</code>	The number of page faults from protection errors. Instances of protection faults are illegal access to a page and “copy-on-writes.” Generally, this number consists primarily of “copy-on-writes.”
<code>vflt/s</code>	The number of address translation page faults, per second. These are known as validity faults, and occur when a valid process table entry does not exist for a given virtual address.
<code>slock/s</code>	The number of faults, per second, caused by software lock requests requiring physical I/O. An example of the occurrence of a soft-lock request is the transfer of data from a disk to memory. The system locks the page that is to receive the data, so that it cannot be claimed and used by another process.

Example—Checking Page-In Activity

The following example shows output from `sar -p`.

```

$ sar -p
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01 atch/s pgin/s ppgin/s pflt/s vflt/s slock/s
01:00:01 0.00 0.04 0.05 0.38 0.67 0.00
02:00:01 0.00 0.00 0.00 0.37 0.61 0.00
03:00:00 0.00 0.05 0.07 0.99 1.70 0.00
04:00:01 0.00 0.00 0.00 0.38 0.63 0.00
05:00:01 0.00 0.00 0.00 0.36 0.60 0.00
06:00:01 0.00 0.00 0.00 0.39 0.66 0.00
07:00:01 0.00 0.00 0.00 0.38 0.63 0.00
08:00:01 0.00 0.00 0.00 0.38 0.63 0.00
08:20:01 0.00 0.00 0.00 0.76 1.35 0.00
08:40:00 0.00 0.00 0.00 0.24 0.40 0.00
09:00:01 0.00 0.00 0.00 0.48 0.77 0.00
09:20:00 0.02 3.06 6.10 1.58 8.12 0.00
09:40:00 0.19 0.65 0.98 1.36 5.26 0.00
10:00:02 0.09 1.28 3.36 3.12 9.47 0.00
10:20:02 0.60 6.52 13.52 17.00 46.08 0.00

```

(continued)

(Continuation)

Average	0.03	0.38	0.79	1.14	2.90	0.00
---------	------	------	------	------	------	------

▼ How to Check Queue Activity (sar)

Use the `sar -q` command to report the average queue length while the queue is occupied, and the percentage of time that the queue is occupied.

```
$ sar -q
00:00:01 runq-sz %runocc swpq-sz %swpocc
01:00:01      1.0      34
```

Note - The number of LWPs swapped out may be greater than zero even if the system has an abundance of free memory. This happens when a sleeping LWP is swapped out and has not been awakened (for example, a process or LWP sleeping, waiting for the keyboard or mouse input).

Output from the `-q` option is described in Table 26-15.

TABLE 26-15 Output From the `sar -q` Command

Field Name	Description
<code>runq-sz</code>	The number of kernel threads in memory waiting for a CPU to run. Typically, this value should be less than 2. Consistently higher values mean that the system may be CPU-bound.
<code>%runocc</code>	The percentage of time the dispatch queues are occupied.
<code>swpq-sz</code>	The average number of swapped out LWPs.
<code>%swpocc</code>	The percentage of time LWPs are swapped out.

Example—Checking Queue Activity

The following example shows output from the `sar -q` command. If `%runocc` is high (greater than 90 percent) and `runq-sz` is greater than 2, the CPU is heavily

loaded and response is degraded. In this case, additional CPU capacity may be required to obtain acceptable system response.

```
$ sar -q
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01 runq-sz %runocc swpq-sz %swpocc
01:00:01 1.0 34
02:00:01 1.0 34
03:00:00 1.0 34
04:00:01 1.0 35
05:00:01 1.0 35
06:00:01 1.0 35
07:00:01 1.0 34
08:00:01 1.0 35
08:20:01 1.0 36
08:40:00 1.0 32
09:00:01 1.0 36
09:20:00 1.1 9
09:40:00 1.3 3
10:00:02 1.5 4
10:20:02 1.4 11
10:40:00 1.2 4

Average 1.0 30
```

▼ How to Check Unused Memory (sar)

Use the `sar -r` command to report the number of memory pages and swap-file disk blocks that are currently unused.

```
$ sar -r
00:00:01 freemem freeswap
01:00:01 4184 320108
```

Output from the `-r` option is described in Table 26-16.

TABLE 26-16 Output From the `sar -r` Command

Field Name	Description
freemem	The average number of memory pages available to user processes over the intervals sampled by the command. Page size is machine-dependent.
freeswap	The number of 512-byte disk blocks available for page swapping.

TABLE 26-16 Output From the `sar -r` Command (continued)

Example—Checking Unused Memory

The following example shows output from the `sar -r` command.

```
$ sar -r
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01 freemem freeswap
01:00:01 4184 320108
02:00:01 4181 320120
03:00:00 4048 320077
04:00:01 3918 320144
05:00:01 3917 320131
06:00:01 3902 320103
07:00:01 3898 320113
08:00:01 3897 320124
08:20:01 3891 319641
08:40:00 3894 320036
09:00:01 3898 320214
09:20:00 3463 334610
09:40:00 436 332371
10:00:02 337 329243
10:20:02 1610 326295
10:40:00 533 326078

Average 3559 321601
```

▼ How to Check CPU Utilization (`sar`)

Display CPU utilization with the `sar -u` command.

```
$ sar -u
00:00:01 %usr %sys %wio %idle
01:00:01 67 33 0 0
```

(The `sar` command without any options is equivalent to `sar -u`.) At any given moment, the processor is either busy or idle. When busy, the processor is in either user or system mode. When idle, the processor is either waiting for I/O completion or “sitting still” with no work to do.

Output from the `-u` option is described in Table 26-17.

TABLE 26-17 Output From the `sar -u` Command

Field Name	Description
%sys	Lists the percentage of time that the processor is in system mode
%user	Lists the percentage of time that the processor is in user mode
%wio	Lists the percentage of time the processor is idle and waiting for I/O completion
%idle	Lists the percentage of time the processor is idle and is not waiting for I/O

A high %wio generally means a disk slowdown has occurred.

Example—Checking CPU Utilization

The following example shows output from the `sar -u` command.

```

$ sar -u
SunOS venus 5.7 Generic sun4m 06/17/98

00:00:01 %usr %sys %wio %idle
01:00:01 67 33 0 0
02:00:01 67 33 0 0
03:00:00 67 33 0 0
04:00:01 67 33 0 0
05:00:01 67 33 0 0
06:00:01 67 33 0 0
07:00:01 67 33 0 0
08:00:01 67 33 0 0
08:20:01 67 33 0 0
08:40:00 67 33 0 0
09:00:01 67 33 0 0
09:20:00 19 9 3 69
09:40:00 5 2 1 92
10:00:02 10 3 0 87
10:20:02 23 9 2 66
10:40:00 6 3 0 90

Average 59 28 0 13

```

▼ How to Check System Table Status (`sar`)

Use the `sar -v` command to report the status of the process table, inode table, file table, and shared memory record table.

```

$ sar -v
00:00:01 proc-sz   ov  inod-sz   ov  file-sz   ov  lock-sz
01:00:01 69/874     0 2698/4032  0 519/519   0   0/0

```

Output from the `-v` option is described in Table 26-18.

TABLE 26-18 Output From the `sar -v` Command

Field Name	Description
proc-sz	The number of process entries (proc structs) currently being used, or allocated in the kernel.
inod-sz	The total number of inodes in memory verses the maximum number of inodes allocated in the kernel. This is not a strict high water mark; it can overflow.
file-sz	The size of the open system file table. The <code>sz</code> is given as 0, since space is allocated dynamically for the file table.
ov	The number of shared memory record table entries currently being used or allocated in the kernel. The <code>sz</code> is given as 0 because space is allocated dynamically for the shared memory record table.
lock-sz	The number of shared memory record table entries currently being used or allocated in the kernel. The <code>sz</code> is given as 0 because space is allocated dynamically for the shared memory record table.

Example—Checking System Table Status

The following example shows output from the `sar -v` command. This example shows that all tables are large enough to have no overflows. These tables are all dynamically allocated based on the amount of physical memory.

```

$ sar -v
SunOS venus 5.7 Generic sun4m   06/17/98

00:00:01 proc-sz   ov  inod-sz   ov  file-sz   ov  lock-sz
01:00:01 69/874     0 2698/4032  0 519/519   0   0/0
02:00:01 69/874     0 2698/4032  0 519/519   0   0/0
03:00:00 69/874     0 2700/4032  0 519/519   0   0/0
04:00:01 69/874     0 2700/4032  0 519/519   0   0/0

```

(continued)

(Continuation)

05:00:01	68/874	0	2700/4032	0	518/518	0	0/0
06:00:01	69/874	0	2700/4032	0	519/519	0	0/0
07:00:01	69/874	0	2700/4032	0	519/519	0	0/0
08:00:01	69/874	0	2700/4032	0	519/519	0	0/0
08:20:01	66/874	0	2700/4032	0	516/516	0	0/0
08:40:00	66/874	0	2700/4032	0	516/516	0	0/0
09:00:01	69/874	0	2700/4032	0	519/519	0	0/0
09:20:00	64/874	0	2700/4032	0	515/515	0	0/0
09:40:00	66/874	0	2700/4032	0	526/526	0	0/0
10:00:02	72/874	0	2704/4032	0	538/538	0	0/0
10:20:02	65/874	0	2705/4032	0	526/526	0	0/0
10:40:00	65/874	0	2706/4032	0	524/524	0	0/0

▼ How to Check Swap Activity (sar)

Use the `sar -w` command to report swapping and switching activity.

\$ <code>sar -w</code>						
00:00:01	swpin/s	bswin/s	swpot/s	bswot/s	pswch/s	
01:00:01	0.00	0.0	0.00	0.0	479	

Target values and observations are described in Table 26-19.

TABLE 26-19 Output From the `sar -w` Command

Field Name	Description
swpin/s	The number of LWP transfers into memory per second.
bswin/s	The average number of processes swapped out of memory per second. If the number is greater than 1, you may need to increase memory.
swpot/s	The average number of processes swapped out of memory per second. If the number is greater than 1, you may need to increase memory.
bswot/s	The number of blocks transferred for swap-outs per second.
pswch/s	The number of kernel thread switches per second.

Note - All process swap-ins include process initialization.

Example—Checking Swap Activity

The following example shows output from the `sar -w` command.

```
$ sar -w
SunOS venus 5.7 Generic sun4m    06/17/98

00:00:01 swpin/s bswin/s swpot/s bswot/s pswch/s
01:00:01 0.00    0.0    0.00    0.0    479
02:00:01 0.00    0.0    0.00    0.0    479
03:00:00 0.00    0.0    0.00    0.0    478
04:00:01 0.00    0.0    0.00    0.0    479
05:00:01 0.00    0.0    0.00    0.0    479
06:00:01 0.00    0.0    0.00    0.0    479
07:00:01 0.00    0.0    0.00    0.0    479
08:00:01 0.00    0.0    0.00    0.0    479
08:20:01 0.00    0.0    0.00    0.0    479
08:40:00 0.00    0.0    0.00    0.0    479
09:00:01 0.00    0.0    0.00    0.0    479
09:20:00 0.00    0.0    0.00    0.0    153
09:40:00 0.00    0.0    0.00    0.0    68
10:00:02 0.00    0.0    0.00    0.0    70
10:20:02 0.00    0.0    0.00    0.0    147
10:40:00 0.00    0.0    0.00    0.0    112

Average 0.00    0.0    0.00    0.0    421
```

▼ How to Check Terminal Activity (`sar`)

Use the `sar -y` command to monitor terminal device activities.

```
$ sar -y
00:00:01 rawch/s canch/s outch/s rcvin/s xmtin/s madmin/s
01:00:01 0        0        0        0        0        0
```

If you have a lot of terminal I/O, you can use this report to determine if there are any bad lines. The activities recorded are defined in Table 26-20.

TABLE 26-20 Output From the `sar -y` Command

Field Name	Description
<code>rawch/s</code>	Input characters (raw queue), per second
<code>canch/s</code>	Input characters processed by canon (canonical queue) per second
<code>outch/s</code>	Output characters (output queue) per second
<code>rcvin/s</code>	Receiver hardware interrupts per second
<code>xmtin/s</code>	Transmitter hardware interrupts per second
<code>mdmin/s</code>	Modem interrupts per second

The number of modem interrupts per second (`mdmin/s`) should be close to zero, and the receive and transmit interrupts per second (`xmtin/s` and `rcvin/s`) should be less than or equal to the number of incoming or outgoing characters, respectively. If this is not the case, check for bad lines.

Example—Checking Terminal Activity

The following example shows output from the `sar -y` command.

```

$ sar -y
SunOS venus 5.7 Generic sun4m    06/17/98

00:00:01 rawch/s canch/s outch/s rcvin/s xmtin/s mdmin/s
01:00:01      0      0      0      0      0      0
02:00:01      0      0      0      0      0      0
03:00:00      0      0      0      0      0      0
04:00:01      0      0      0      0      0      0
05:00:01      0      0      0      0      0      0
06:00:01      0      0      0      0      0      0
07:00:01      0      0      0      0      0      0
08:00:01      0      0      0      0      0      0
08:20:01      0      0      0      0      0      0
08:40:00      0      0      0      0      0      0
09:00:01      0      0      0      0      0      0
09:20:00      0      0      6      0      0      0
09:40:00      0      0     15      0      0      0
10:00:02      0      0      5      0      0      0
10:20:02      0      0     10      0      0      0
10:40:00      0      0     21      0      0      0

```

(continued)

(Continuation)

Average	0	0	2	0	0	0
---------	---	---	---	---	---	---

▼ How to Check Overall System Performance (sar)

Use the `sar -A` command to display a view of overall system performance.

This provides a more global perspective. If data from more than one time segment is shown, the report includes averages.

Collecting System Activity Data Automatically (sar)

Three commands are involved in automatic system activity data collection: `sadc`, `sa1`, and `sa2`.

The `sadc` data collection utility periodically collects data on system activity and saves it in a file in binary format—one file for each 24-hour period. You can set up `sadc` to run periodically (usually once each hour), and whenever the system boots to multiuser mode. The data files are placed in the directory `/usr/adm/sa`. Each file is named `sadd`, where `dd` is the current date. The format of the command is as follows:

```
/usr/lib/sa/sadc [t n] [ofile]
```

The command samples `n` times with an interval of `t` seconds (`t` should be greater than 5 seconds) between samples. It then writes, in binary format, to the file `ofile`, or to standard output. If `t` and `n` are omitted, a special file is written once.

Running `sadc` When Booting

The `sadc` command should be run at system boot time in order to record the statistics from when the counters are reset to zero. To make sure that `sadc` is run at boot time, the `/etc/init.d/perf` file must contain a command line that writes a record to the daily data file.

The command entry has the following format:

```
su sys -c "/usr/lib/sa/sadc /usr/adm/sa/sa`date +5d`"
```

Running `sadc` Periodically With `sa1`

To generate periodic records, you need to run `sadc` regularly. The simplest way to do this is by putting a line into the `/var/spool/cron/sys` file, which calls the shell script, `sa1`. This script invokes `sadc` and writes to the daily data files, `/var/adm/sa/sadd`. It has the following format:

```
/usr/lib/sa/sa1 [t n]
```

The arguments *t* and *n* cause records to be written *n* times at an interval of *t* seconds. If these arguments are omitted, the records are written only one time.

Producing Reports With `sa2`

Another shell script, `sa2`, produces reports rather than binary data files. The `sa2` command invokes the `sar` command and writes the ASCII output to a report file.

Collecting System Activity Data (`sar`)

The `sar` command can be used either to gather system activity data itself or to report what has been collected in the daily activity files created by `sadc`.

The `sar` command has the following formats:

```
sar [-aAbcdgkmpqruvw] [-o file] t [n]
```

```
sar [-aAbcdgkmpqruvw] [-s time] [-e time] [-i sec] [-f file]
```

The `sar` command below samples cumulative activity counters in the operating system every *t* seconds, *n* times. (*t* should be 5 seconds or greater; otherwise, the command itself may affect the sample.) You must specify a time interval between which to take the samples; otherwise, the command operates according to the second format. The default value of *n* is 1. The following example takes two samples separated by 10 seconds. If the `-o` option is specified, samples are saved in *file* in binary format.

```
$ sar -u 10 2
```

Other important information about the `sar` command:

- With no sampling interval or number of samples specified, `sar` extracts data from a previously recorded file, either the one specified by the `-f` option or, by default, the standard daily activity file, `/var/adm/sa/sadd`, for the most recent day.
- The `-s` and `-e` options define the starting and ending times for the report. Starting and ending times are of the form `hh[:mm[:ss]]` (where *h*, *m*, and *s* represent hours, minutes, and seconds).
- The `-i` option specifies, in seconds, the intervals between record selection. If the `-i` option is not included, all intervals found in the daily activity file are reported.

Table 26-21 lists the `sar` options and their actions.

TABLE 26-21 Options for `sar` Command

Option	Actions
<code>-a</code>	Checks file access operations
<code>-b</code>	Checks buffer activity
<code>-c</code>	Checks system calls
<code>-d</code>	Checks activity for each block device
<code>-g</code>	Checks page-out and memory freeing
<code>-k</code>	Checks kernel memory allocation
<code>-m</code>	Checks interprocess communication
<code>-p</code>	Checks swap and dispatch activity
<code>-q</code>	Checks queue activity
<code>-r</code>	Checks unused memory
<code>-u</code>	Checks CPU utilization
<code>-nv</code>	Checks system table status
<code>-w</code>	Checks swapping and switching volume
<code>-y</code>	Checks terminal activity
<code>-A</code>	Reports overall system performance (same as entering all options)

TABLE 26-21 Options for `sar` Command (continued)

If no option is used, it is equivalent to calling the command with the `-u` option.

▼ How to Set Up Automatic Data Collection

1. Become superuser.
2. Using the editor of your choice, open the `/etc/init.d/perf` file, which contains the `sadc` start-up instructions. Verify that the following lines are uncommented:

```
MATCH=`who -r|grep -c ``[234][ ]*0[ ]*[S1]`` if [ ${MATCH} -eq 1 ]
then su sys -c ``/usr/lib/sa/sadc /var/adm/sa/sa`date +%d`` fi
```

This version of the `sadc` command writes a special record that marks the time when the counters are reset to zero (boot time). The `sadc` output is put into the file `sadd` (where `dd` is the current date), which acts as the daily system activity record.

3. Using the editor of your choice, open the `/var/spool/cron/crontabs/sys` file (the system crontab file). Uncomment the following lines:

```
# 0 * * * 0-6 /usr/lib/sa/sal
# 20,40 8-17 * * 1-5 /usr/lib/sa/sal
```

The first entry writes a record to `/var/adm/sa/sadd` on the hour, every hour, seven days a week.

The second entry writes a record to `/var/adm/sa/sadd` twice each hour during peak working hours: at 20 minutes and 40 minutes past the hour, from 8 a.m. to 5 p.m., Monday through Friday.

Thus, these two `crontab` entries cause a record to be written to `/var/adm/sa/sadd` every 20 minutes from 8 a.m. to 5 p.m., Monday through Friday, and every hour on the hour otherwise. You can change these defaults to meet your needs.

Monitoring Network Performance (Tasks)

This chapter describes the how to monitor network performance. This is a list of the step-by-step instructions in this chapter.

- “How to Check the Response of Hosts on the Network” on page 534
- “How to Send Packets to Hosts on the Network” on page 535
- “How to Capture Packets From the Network” on page 536
- “How to Check the Network Status” on page 536
- “How to Display NFS Server and Client Statistics” on page 539

Monitoring Network Performance

Table 27-1 describes the commands available for monitoring network performance.

TABLE 27-1 Network Monitoring Commands

Command	Use This Command To ...
ping	Look at the response of hosts on the network.
spray	Test the reliability of your packet sizes. It can tell you whether packets are being delayed or dropped.
snoop	Capture packets from the network and trace the calls from each client to each server.

TABLE 27-1 Network Monitoring Commands (continued)

Command	Use This Command To ...
<code>netstat</code>	Display network status, including state of the interfaces used for TCP/IP traffic, the IP routing table, and the per-protocol statistics for UDP, TCP, ICMP, and IGMP.
<code>nfsstat</code>	Display a summary of server and client statistics that can be used to identify NFS problems.

▼ How to Check the Response of Hosts on the Network

Check the response of hosts on the network with the `ping` command.

```
$ ping hostname
```

If you suspect a physical problem, you can use `ping` to find the response time of several hosts on the network. If the response from one host is not what you would expect, you can investigate that host. Physical problems could be caused by:

- Loose cables or connectors
- Improper grounding
- Missing termination
- Signal reflection

For more information about this command, see `ping(1M)`.

Examples—Checking the Response of Hosts on the Network

The simplest version of `ping` sends a single packet to a host on the network. If it receives the correct response, it prints the message `host is alive`.

```
$ ping elvis
elvis is alive
```

With the `-s` option, `ping` sends one datagram per second to a host. It then prints each response and the time it took for the round trip. For example:

```
$ ping -s pluto
64 bytes from pluto (123.456.78.90): icmp_seq=0. time=10. ms
64 bytes from pluto (123.456.78.90): icmp_seq=5. time=0. ms
64 bytes from pluto (123.456.78.90): icmp_seq=6. time=0. ms
^C
----pluto PING Statistics----
8 packets transmitted, 8 packets received, 0% packet loss
round-trip (ms) min/avg/max = 0/2/10
```

▼ How to Send Packets to Hosts on the Network

Test the reliability of your packet sizes with the `spray` command.

```
$ spray [ -c count -d interval -l packet_size] hostname
```

<code>-c count</code>	Number of packets to send.
<code>-d interval</code>	Number of microseconds to pause between sending packets. If you don't use a delay, you may run out of buffers.
<code>-l packet_size</code>	Is the packet size.
<code>hostname</code>	Is the system to send packets.

For more information about this command, see `spray(1M)`.

Example—Sending Packets to Hosts on the Network

The following example sends 100 packets to a host (`-c 100`) with each packet having a size of 2048 bytes (`-l 2048`). The packets are sent with a delay time of 20 microseconds between each burst (`-d 20`).

```
$ spray -c 100 -d 20 -l 2048 pluto
sending 100 packets of length 2048 to pluto ...
no packets dropped by pluto
279 packets/sec, 573043 bytes/sec
```

▼ How to Capture Packets From the Network

To capture packets from the network and trace the calls from each client to each server, use `snoop`. This command provides accurate time stamps that allow some network performance problems to be isolated quickly. For more information, see `snoop(1M)`.

```
# snoop
```

Dropped packets could be caused by insufficient buffer space, or an overloaded CPU.

▼ How to Check the Network Status

Display network status information, such as statistics about the state of network interfaces, routing tables, and various protocols, with the `netstat` command.

```
$ netstat [-i] [-r] [-s]
```

`-i` Displays the state of the TCP/IP interfaces.

`-r` Displays the IP routing table.

`-s` Displays statistics for the UDP, TCP, ICMP, and IGMP protocols.

For more information, see `netstat(1M)`.

Examples—Checking the Network Status

The following example shows output from the `netstat -i` command, which displays the state of the interfaces used for TCP/IP traffic.

```
$ netstat -i
Name Mtu Net/Dest Address Ipkts Ierrs Opkts Oerrs Collis Queue
lo0 8232 software localhost 1280 0 1280 0 0 0
le0 1500 loopback venus 1628480 0 347070 16 39354 0
```

This display shows how many packets a machine has transmitted and received on each interface. A machine with active network traffic should show both `Ipkts` and `Opkts` continually increasing.

Calculate the network collisions rate by dividing the number of collision counts (`Collis`) by the number of out packets (`Opkts`). In the above example, the collision

rate is 3.5 percent. A network-wide collision rate greater than 5 to 10 percent can indicate a problem.

Calculate the input packet error rate by dividing the number of input errors by the total number of input packets (I_{errs}/I_{pkts}). The output packet error rate is the number of output errors divided by the total number of output packets (O_{errs}/O_{pkts}). If the input error rate is high (over 0.25 percent), the host may be dropping packets.

The following example shows output from the `netstat -s` command, which displays the per-protocol statistics for the UDP, TCP, ICMP, and IGMP protocols.

```

UDP
  udpInDatagrams      =196543  udpInErrors          =      0
  udpOutDatagrams     =187820

TCP
  tcpRtoAlgorithm     =      4  tcpRtoMin            =     200
  tcpRtoMax           =    60000  tcpMaxConn           =      -1
  tcpActiveOpens      =    26952  tcpPassiveOpens      =     420
  tcpAttemptFails     =    1133  tcpEstabResets       =        9
  tcpCurrEstab        =      31  tcpOutSegs           =   3957636
  tcpOutDataSegs      =  2731494  tcpOutDataBytes      = 1865269594
  tcpRetransSegs      =    36186  tcpRetransBytes      =   3762520
  tcpOutAck            =  1225849  tcpOutAckDelayed     =   165044
  tcpOutUrg           =        7  tcpOutWinUpdate      =     315
  tcpOutWinProbe      =         0  tcpOutControl        =   56588
  tcpOutRsts          =     803  tcpOutFastRetrans    =     741
  tcpInSegs           =  4587678
  tcpInAckSegs        =  2087448  tcpInAckBytes        = 1865292802
  tcpInDupAck         =   109461  tcpInAckUnsent       =         0
  tcpInInorderSegs    =  3877639  tcpInInorderBytes    = -598404107
  tcpInUnorderSegs    =   14756  tcpInUnorderBytes    = 17985602
  tcpInDupSegs        =      34  tcpInDupBytes        =   32759
  tcpInPartDupSegs    =     212  tcpInPartDupBytes    =  134800
  tcpInPastWinSegs    =         0  tcpInPastWinBytes    =         0
  tcpInWinProbe       =     456  tcpInWinUpdate       =         0
  tcpInClosed         =      99  tcpRttNoUpdate       =     6862
  tcpRttUpdate        =  435097  tcpTimRetrans        =   15065
  tcpTimRetransDrop   =      67  tcpTimKeepalive      =     763
  tcpTimKeepaliveProbe=      1  tcpTimKeepaliveDrop  =         0

IP
  ipForwarding        =      2  ipDefaultTTL         =     255
  ipInReceives        = 11757234  ipInHdrErrors        =         0
  ipInAddrErrors      =         0  ipInCksumErrs       =         0
  ipForwDatagrams      =         0  ipForwProhibits     =         0
  ipInUnknownProtos   =         0  ipInDiscards        =         0
  ipInDelivers         =  4784901  ipOutRequests        =  4195180
  ipOutDiscards       =         0  ipOutNoRoutes       =         0
  ipReasmTimeout       =      60  ipReasmReqds        =     8723
  ipReasmOKs          =   7565  ipReasmFails        =    1158
  ipReasmDuplicates   =      7  ipReasmPartDups     =         0
  ipFragOKs           =   19938  ipFragFails         =         0
  ipFragCreates       =  116953  ipRoutingDiscards   =         0

```

(continued)

(Continuation)

```
tcpInErrs          = 0  udpNoPorts          =6426577
udpInCksumErrs    = 0  udpInOverflows    = 473
rawipInOverflows  = 0

ICMP
icmpInMsgs         =490338  icmpInErrors       = 0
icmpInCksumErrs   = 0  icmpInUnknowns    = 0
icmpInDestUnreachs = 618  icmpInTimeExcds   = 314
icmpInParmProbs   = 0  icmpInSrcQuenchs  = 0
icmpInRedirects   = 313  icmpInBadRedirects = 5
icmpInEchos       = 477  icmpInEchoReps    = 20
icmpInTimestamps = 0  icmpInTimestampReps = 0
icmpInAddrMasks   = 0  icmpInAddrMaskReps = 0
icmpInFragNeeded  = 0  icmpOutMsgs       = 827
icmpOutDrops      = 103  icmpOutErrors     = 0
icmpOutDestUnreachs = 94  icmpOutTimeExcds = 256
icmpOutParmProbs  = 0  icmpOutSrcQuenchs = 0
icmpOutRedirects  = 0  icmpOutEchos      = 0
icmpOutEchoReps   = 477  icmpOutTimestamps = 0
icmpOutTimestampReps = 0  icmpOutAddrMasks = 0
icmpOutAddrMaskReps = 0  icmpOutFragNeeded = 0
icmpInOverflows   = 0

IGMP:
    0 messages received
    0 messages received with too few bytes
    0 messages received with bad checksum
    0 membership queries received
    0 membership queries received with invalid field(s)
    0 membership reports received
    0 membership reports received with invalid field(s)
    0 membership reports received for groups to which we belong
    0 membership reports sent
```

The following example shows output from the `netstat -r` command, which displays the IP routing table.

```
Routing Table:
Destination      Gateway          Flags  Ref  Use  Interface
-----
localhost        localhost       UH     0   2817  lo0
earth-bb         pluto           U      3  14293  le0
224.0.0.0        pluto           U      3     0  le0
default          mars-gate       UG     0  14142
```

The fields in the `netstat -r` report are described in Table 27-2.

TABLE 27-2 Output From the `netstat -r` Command

Field Name	Description
Flags	U The route is up
	G The route is through a gateway
	H The route is to a host
	D The route was dynamically created using a redirect
Ref	Shows the current number of routes sharing the same link layer
Use	Indicates the number of packets sent out
Interface	Lists the network interface used for the route

▼ How to Display NFS Server and Client Statistics

The NFS distributed file service uses a remote procedure call (RPC) facility which translates local commands into requests for the remote host. The remote procedure calls are synchronous. That is, the client application is blocked or suspended until the server has completed the call and returned the results. One of the major factors affecting NFS performance is the retransmission rate.

If the file server cannot respond to a client's request, the client retransmits the request a specified number of times before it quits. Each retransmission imposes system overhead, and increases network traffic. Excessive retransmissions can cause network performance problems. If the retransmission rate is high, you could look for:

- Overloaded servers that take too long to complete requests
- An Ethernet interface dropping packets
- Network congestion which slows the packet transmission

Table 27-3 describes the `nfsstat` options to display client and server statistics.

TABLE 27-3 Commands for Displaying Client/Server Statistics

Use ...	To Display ...
<code>nfsstat -c</code>	Client statistics
<code>nfsstat -s</code>	Server statistics
<code>netstat -m</code>	Network statistics for each file system

Use `nfsstat -c` to show client statistics, and `nfsstat -s` to show server statistics. Use `netstat -m` to display network statistics for each file system. For more information, see `nfsstat(1M)`.

Examples—Displaying NFS Server and Client Statistics

The following example displays RPC and NFS data for the client, `pluto`.

```

$ nfsstat -c

      Client rpc:
Connection oriented:
calls   badcalls  badxids  timeouts  newcreds  badverfs  timers
1595799 1511      59       297       0         0         0
cantconn nomem    interrupts
1198   0        7
Connectionless:
calls   badcalls  retrans  badxids  timeouts  newcreds  badverfs
80785  3135     25029   193     9543     0         0
timers  nomem    cantsend
17399  0        0

Client nfs:
calls   badcalls  clgets  cltoomany
1640097 3112     1640097 0
Version 2: (46366 calls)
null    getattr  setattr  root      lookup    readlink  read
0 0%    6589 14%  2202 4%  0 0%    11506 24%  0 0%    7654 16%
wrcache write    create  remove   rename    link      symlink
0 0%    13297 28% 1081 2%  0 0%    0 0%    0 0%
mkdir  rmdir    readdir  statfs
24 0%    0 0%    906 1%  3107 6%
Version 3: (1585571 calls)
null    getattr  setattr  lookup    access    readlink  read
0 0%    508406 32% 10209 0%  263441 16% 400845 25% 3065 0%  117959 7%
write  create    mkdir    symlink   mknod    remove    rmdir
69201 4% 7615 0%  42 0%    16 0%    0 0%    7875 0%  51 0%
rename link      readdir  readdir+  fsstat   fsinfo   pathconf

```

(continued)

(Continuation)

```
929 0%   597 0%   3986 0%  185145 11%  942 0%   300 0%   583 0%
commit
4364 0%

Client nfs_acl:
Version 2: (3105 calls)
null      getacl    setacl    getattr   access
0 0%      0 0%      0 0%      3105 100% 0 0%
Version 3: (5055 calls)
null      getacl    setacl
0 0%      5055 100% 0 0%
```

The output of the `nfsstat -c` command is described in Table 27-4.

TABLE 27-4 Output From the `nfsstat -c` Command

Field	Description
<code>calls</code>	Shows the total number of calls sent.
<code>badcalls</code>	The total number of calls rejected by RPC.
<code>retrans</code>	The total number of retransmissions. For this client, the number of retransmissions is less than 1 percent (10 time-outs out of 6888 calls). These may be caused by temporary failures. Higher rates may indicate a problem.
<code>badxid</code>	The number of times that a duplicate acknowledgment was received for a single NFS request.
<code>timeout</code>	The number of calls that timed out.
<code>wait</code>	The number of times a call had to wait because no client handle was available.
<code>newcred</code>	The number of times the authentication information had to be refreshed.
<code>timers</code>	The number of times the time-out value was greater than or equal to the specified time-out value for a call.
<code>readlink</code>	The number of times a <code>read</code> was made to a symbolic link. If this number is high (over 10 percent), it could mean that there are too many symbolic links.

TABLE 27-4 Output From the `nfsstat -c` Command *(continued)*

The following example shows output from the `nfsstat -m` command.

```
pluto$ nfsstat -m
/usr/man from pluto:/export/svr4/man
Flags: vers=2,proto=udp,auth=unix,hard,intr,dynamic,
       rsize=8192, wsize=8192,retrans=5
Lookups: srtt=13 (32ms), dev=10 (50ms), cur=6 (120ms)
All:     srtt=13 (32ms), dev=10 (50ms), cur=6 (120ms)
```

This output of the `nfsstat -m` command, which is displayed in milliseconds, is described in Table 27-5.

TABLE 27-5 Output From the `nfsstat -m` Command

Field	Description
srtt	The smoothed average of the round-trip times
dev	The average deviations
cur	The current “expected” response time

If you suspect that the hardware components of your network are creating problems, you need to look carefully at the cabling and connectors.

Tuning Kernel Parameters (Tasks)

This chapter describes the procedures for tuning kernel parameters. This is a list of the step-by-step instructions in this chapter.

- “Listing the Kernel Parameters” on page 543
- “How to Change the Value of a Kernel Parameter” on page 544
- “How to Set the Value of a Kernel Module Variable” on page 544
- “How to Tune the Interprocess Communication Parameters” on page 548
- “How to Tune Memory Management Parameters” on page 549
- “How to Tune Miscellaneous Parameters” on page 550

Listing the Kernel Parameters

Display the current kernel parameters values by using the `sysdef -i` command.

```
# sysdef -i
* Hostid
  53001b80
*
* sun4m Configuration
* Devices
packages (driver not attached)
disk-label (driver not attached)
  deblocker (driver not attached)
  obp-tftp (driver not attached)
  .
  .
```

(continued)

(Continuation)

```
options, instance #0
aliases (driver not attached)
openprom (driver not attached)
iommu, instance #0
  sbus, instance #0
    espdma, instance #0
      esp, instance #0
        sd (driver not attached)
        st (driver not attached)
      .
    .
  .
```

▼ How to Change the Value of a Kernel Parameter

1. **Become superuser.**
2. **Add a line to the `/etc/system` file in the form:**

```
set parameter=value
```

3. **Verify the kernel parameter change.**

```
# grep parameter /etc/system
```

4. **Reboot the system.**

The kernel parses the `/etc/system` file during autoconfiguration and overrides the default value for the parameters specified in this file.

Example—Changing the Value of a Kernel Parameter

The following line in the `/etc/system` file sets the value of the `max_nprocs` to 500 parameter.

```
set max_nprocs=500
```

▼ How to Set the Value of a Kernel Module Variable

1. **Become superuser.**

2. Add a line to the `/etc/system` file in the form:

```
set module_name:variable=value
```

3. Verify the kernel module variable change.

```
# grep module_name /etc/system
```

4. Reboot the system.

The kernel parses the `/etc/system` file during autoconfiguration and overrides the default value for the parameters specified in this file.

Example—Setting the Value of a Kernel Module Variable

The following line in the `/etc/system` file sets the value of the `msginfo_msgmap` parameter in the `msgsys` module to 150.

```
set msgsys:msginfo_msgmap=150
```

Buffer Cache Parameters

The `bufhwm` parameter specifies the maximum size for buffer cache memory usage expressed in units of 1,000 bytes. The default is 2% of physical memory. Use `sar(1M)` to measure the buffer cache statistics.

UFS Parameters

Table 28-1 describes the tunable UFS parameters.

TABLE 28-1 Tunable UFS Parameters

Parameter	Description
<code>ufs_ninode</code>	Maximum size of the inode table (default = <code>max_nprocs + 16 + maxusers + 64</code>)
<code>ncsize</code>	Number of <code>dnlc</code> entries (default = <code>max_nprocs + 16 + maxusers + 64</code>); <code>dnlc</code> is the directory-name lookup cache.

STREAMS Parameters

Table 28-2 describes the tunable STREAMS parameters.

TABLE 28-2 Tunable STREAMS Parameters

Parameter	Default	Description
nstrpush	9	The maximum number of STREAMS pushes allowed.
strmsgsz	0	The maximum size for the STREAMS message that a user can create. A value of 0 indicates no upper bound. This parameter may disappear entirely in a future release.
strctlsz	1024	The maximum size of the <code>ctl</code> part of a message.
strthresh	0	The maximum amount of dynamic memory that the STREAMS subsystem can consume, in bytes. Once this threshold is passed, any pushes, opens, and writes on a STREAMS devices will fail for non-root processes. A value of 0 means no limit.
sadcnt	16	Number of <code>sad</code> devices.

Interprocess Communication (IPC) Parameters

Table 28-3 describes the tunable interprocess communication parameters.

TABLE 28-3 Interprocess Communication Parameters

Parameter	Default	Description
Message Queue		
msginfo_msgmap	100	Number of entries in the message map
msginfo_msgmax	2048	Maximum message size
msginfo_msgmnb	4096	Maximum bytes on queue

TABLE 28-3 Interprocess Communication Parameters *(continued)*

<code>msginfo_msgmni</code>	50	Number of message queue identifiers
<code>msginfo_msgssz</code>	8	Segment size of a message (should be a multiple of the word size)
<code>msginfo_msgtql</code>	40	Number of system message headers
<code>msginfo_msgseg</code>	1024	Number of message segments (must be < 32768)
Semaphore Facility		
<code>seminfo_semmap</code>	10	Number of entries in the semaphore map
<code>seminfo_semmni</code>	10	Number of semaphore identifiers
<code>seminfo_semmns</code>	60	Number of semaphores in the system
<code>seminfo_semmnu</code>	30	Number of processes using the <code>undo</code> facility
<code>seminfo_semmsl</code>	25	Maximum number of semaphores, per <code>id</code>
<code>seminfo_semopm</code>	10	Maximum number of operations, per semaphore call
<code>seminfo_semume</code>	10	Maximum number of <code>undo</code> structures per process
Note: The total number of <code>undo</code> structures allocated in the system is:		
<code>seminfo_semmnu * seminfo_semume</code>		
<code>seminfo_semvmx</code>	32767	Semaphore maximum value
<code>seminfo_semaem</code>	16384	Maximum value for adjustment on exit
Shared Memory		
<code>shminfo_shmmax</code>	1048576	Maximum shared memory segment size
<code>shminfo_shmmin</code>	1	Minimum shared memory segment size

TABLE 28-3 Interprocess Communication Parameters *(continued)*

shminfo_shmni	100	Number of shared memory identifiers
shminfo_shmseg	6	Segments, per process

▼ How to Tune the Interprocess Communication Parameters

1. **Become superuser.**
2. **Add a line to the `/etc/system` file using the syntax described in Table 28-4.**

TABLE 28-4 Tuning Interprocess Communication Parameters

Parameter Type	Parameter	Tuning Syntax
Message Queue	msgsys	<code>set msgsys:msginfo_variable = value</code>
Semaphore Facility	semsys	<code>set semsys:seminfo_variable=value</code>
Shared Memory	shmsys	<code>set shmsys:shminfo_variable=value</code>

3. **Verify the kernel parameter change.**

```
# grep parameter /etc/system
```

4. **Reboot the system.**

The kernel parses the `/etc/system` file during autoconfiguration and overrides the default value for the parameters specified in this file.

Memory Management Parameters

Table 28-5 describes the tunable memory management parameters.

TABLE 28-5 Memory Management Parameters

Parameter	Default	Description
lotsfree	scaled based on physical memory	If <code>freemem</code> drops below <code>lotsfree</code> , the system starts to steal pages from processes.
tune_t_fsflushr	30	Rate at which <code>fsflush</code> is run, in seconds
tune_t_minarmem	25	The minimum available resident (not swappable) memory needed to avoid deadlock, in pages
tune_t_minasmem	25	The minimum available swappable memory needed to avoid deadlock, in pages
tune_t_flckrec	512	The maximum number of active <code>frlocks</code>

Note - Since the Solaris 2.4 release, the `tune_t_gpgslo` parameter has been replaced by a more complicated criteria for swapping based on the number of runnable threads.

The `freemem` parameter is defined in pages. Utilities like `vmstat` translates `freemem` into bytes from pages.

▼ How to Tune Memory Management Parameters

1. Become superuser.
2. Add a line to the `/etc/system` file using the following syntax.

```
set tune:variable=value
```

3. Verify the kernel parameter change.

```
# grep parameter /etc/system
```

4. Reboot the system.

The kernel parses the `/etc/system` file during autoconfiguration and overrides the default value for the parameters specified in this file.

Miscellaneous Parameters

Table 28-6 describes tunable miscellaneous parameters.

TABLE 28-6 Miscellaneous Parameters

Parameter	Default	Description
<code>lwp_default_stksize</code>	8192	Size of the kernel stack for <code>lwps</code> . Do not adjust this value unless there is a kernel overflow. The value is expressed in bytes and must be a multiple of <code>PAGESIZE</code> bytes.
<code>npty</code>	48	Total number of 4.0 or 4.1 pseudo-ttys configured
<code>pt_cnt</code>	48	Total number of 5.7 pseudo-ttys configured

▼ How to Tune Miscellaneous Parameters

1. **Become superuser.**
2. **Add a line to the `/etc/system` file using the following syntax.**

```
set parameter=value
```

3. **Verify the kernel parameter change.**

```
# grep parameter /etc/system
```

4. **Reboot the system.**

If you changed device related kernel parameters, you need to use the `-r` option when booting the system. When the system boots, the kernel parses the `/etc/system` file during autoconfiguration and overrides the default value for the parameters specified in this file.

Example—Tuning Miscellaneous Parameters

The following line in the `/etc/system` file sets the value of the `pt_cnt` parameter to 200.

```
set pt_cnt=200
```

The Scheduler (Reference)

This chapter contains reference information for the SunOS 5.7 scheduler. This is a list of the overview information in this chapter.

- “About the Scheduler” on page 551
- “Scheduler Class Policies” on page 552
- “Scheduler Configuration” on page 554

About the Scheduler

The *scheduler* (or dispatcher) is the portion of the kernel that controls the allocation of the CPU to processes. It determines when processes run and for how long, depending on their assigned priorities. Priorities are based on scheduling class and process behavior. Four scheduling classes are supported by default: timesharing, system, real-time and interactive.

The scheduler has an overriding effect on the performance of a system.

Note - The fundamental scheduling entity is the kernel thread. For single-threaded processes, scheduling the kernel thread is synonymous with process scheduling.

The SunOS 5.7 scheduler controls the order in which processes run and the amount of CPU time each process may use before another process can run.

The scheduler allocates CPU time to processes according to the scheduling policies defined for each scheduling class. Associated with each scheduling class is a set of priority levels or queues. Ready-to-run processes are moved among these queues. Within a class, you can view these queues as a contiguous set of priority levels. These priority levels are mapped into a set of global scheduling priorities.

The global priority of a process determines when it runs—the scheduler runs the process with the highest global priority that is ready to run. Processes with numerically higher priorities run first, and processes with the same priority run using a round robin scheduling policy.

Once the scheduler assigns a process to a CPU, the process runs until one of the following events occur:

- The process uses up its time slice.
- The process blocks waiting for an event (for example, I/O) or a suspended lock.
- The process is preempted by a higher-priority process.

By default, all real-time processes have higher priorities than any system process, and all system processes have higher priorities than any timesharing process.

A process inherits its scheduler parameters from its parent process, including its scheduler class and its priority within that class. A process changes class only from a user request (with the `prionctl` command or system call). The system manages the priority of a process based on user requests and the policy associated with the scheduling class of the process.

Scheduler Activation

Scheduler activations provide kernel scheduling support for applications with particular scheduling needs, such as database and multithreaded applications. Multithreaded support changes for scheduler activation are implemented as a private interface between the kernel and the `libthread` library, without changing the `libthread` interface. Additionally, applications may give scheduling hints to the kernel to improve performance. See `schedctl_init(3X)` for more information.

Scheduler Class Policies

The following sections describe the scheduling policies of the three default classes: timesharing, system, and real-time.

Timesharing Class Policies

In the default configuration, the initialization process (`init`) belongs to the timesharing class. Because processes inherit their scheduler parameters, all user login shells—and consequently the processes run from those shells—begin as timesharing processes.

The goal of the timesharing policy is to provide good response time for interactive processes and good throughput for processes that use a lot of CPU time. The scheduler tries to divide the CPU's time fairly between processes, subject to the priorities associated with the processes. Those with higher priorities get more attention than those with lower priorities. However, to prevent any one job (process) from hogging the CPU, the scheduler can move jobs from high priorities to low priorities and vice versa.

The scheduler switches CPU allocation frequently enough to provide good response time, but not so frequently that it spends too much time doing the switching. Time slices are typically on the order of a few hundredths of a second.

The timesharing policy changes priorities dynamically and assigns time slices of different lengths. Once a process has started, its timesharing priority varies according to how much CPU time it's getting, how much time it's spending in queues, and other factors. The scheduler raises the priority of a process that "sleeps." (A process sleeps, for example, when it starts an I/O operation such as a terminal read or a disk read.) Entering sleep states frequently is characteristic of interactive tasks such as editing and running simple shell commands. On the other hand, the timesharing policy lowers the priority of a process that uses the CPU for long periods without sleeping.

The default timesharing policy gives larger time slices to processes with lower priorities. A process with a low priority is likely to be stuck in the CPU. Other processes get the CPU first, but when a lower-priority process finally gets the CPU, it gets a bigger chunk of time. If a higher-priority process becomes ready to run during a time slice, however, it preempts the running process.

The scheduler manages timesharing processes using parameters in the timesharing parameter table `ts_dptbl`. This table contains information specific to the timesharing class. It is automatically loaded into core memory from the `TS_DPTBL` loadable module located in the `/kernel/sched` directory.

System Class Policies

The system class uses a fixed-priority policy to run kernel processes such as servers, and housekeeping processes such as the page daemon. Their priorities are not dynamically adjusted like timesharing processes. The system class is reserved for use by the kernel, and users may neither add nor remove a process from the system class. Priorities for system-class processes are set up in the kernel code for the kernel processes, and, once established, these priorities do not change. (User processes running in kernel mode are not in the system class.)

Real-Time Class Policies

The SunOS 5.7 operating system uses a real-time scheduling policy as well as a timesharing policy. Real-time scheduling allows users to set fixed priorities on a per-process basis, so that critical processes can run in predetermined order. The real-time scheduler never moves jobs between priorities. Real-time priorities change only when a user requests a change (using the `prionctl` command). Contrast this fixed-priority policy with the timesharing policy, in which the system changes priorities to provide good interactive response time.

The user process with the highest real-time priority always gets the CPU as soon as it can be run, even if other processes are ready to run. An application can be written so that its real-time processes have a guaranteed response time from the operating system.

Note - As long as there is a real-time process ready to run, no process and no timesharing process runs. Other real-time processes can run only if they have a higher priority. Real-time processes managed carelessly can have a dramatic negative effect on the performance of timesharing processes.

The real-time policy gives higher-priority processes smaller time slices, by default. The higher priorities are allocated to real-time processes that are driven by external events. The operating system must be able to respond instantly to I/O. The lower-priority real-time processes are those that need more computation time. If a process with the highest priority uses up its time slice, it runs again because there is no process with a higher priority to pre-empt it.

The scheduler manages real-time processes by using parameters in the real-time parameter table `rt_dptbl`. This table contains information specific to the real-time class. It is automatically loaded into core from the `RT_DPTBL` loadable module located in the `/kernel/sched` directory.

Scheduler Configuration

This section describes the parameters and tables that control the scheduler configuration. A basic assumption is that your work load is reasonable for your system resources, such as CPU, memory, and I/O. If your resources are inadequate to meet the demands, reconfiguring the scheduler won't help.

You can display or change (fine tune) the scheduler parameters in a running system for both the timesharing and real-time classes by using the `dispadmin` command. Changes made by the `dispadmin` command do not survive a reboot. To make permanent changes in scheduler configuration, you must change the scheduler parameter tables in the appropriate loadable module: `TS_DPTBL` or `RT_DPTBL`

provided in the `/kernel/sched` directory. See `ts_dptbl(4)` and `rt_dptbl(4)` for instructions on replacing these modules.

The primary user command for controlling process scheduling is `prionctl(1)`. With this command, a user can start a process at a specified priority or manipulate the priorities of running processes. You can find out what classes are configured on your system with the `prionctl -l` command. The primary function call for controlling process scheduling is `prionctl(2)`.

See Chapter 25 for examples of using the `prionctl` command. See *System Interface Guide* for a detailed description of real-time programming and `dispadm(1M)` and `prionctl(1)`.

Default Global Priorities

The following table shows the scheduling order and ranges of global priorities for each scheduler class.

TABLE 29-1 Scheduling Order and Global Priorities

Scheduling Order	Global Priority	Scheduler Class
First	159	
	.	
	.	Real-Time
	.	
	100	
	99	
	.	
	.	System
	.	
	60	
	59	
	.	
	.	Timesharing

TABLE 29-1 Scheduling Order and Global Priorities (continued)

Scheduling Order	Global Priority	Scheduler Class
	.	
Last	0	

How Global Priorities Are Constructed

When your operating system is built, it constructs the global priorities from the tunable parameters and scheduler parameter tables described in the following sections. There isn't any command that will show you this complete global priority table. However, the `dispadmin` command displays the priorities (from 0 to *n*) specific to the real-time and timesharing classes. You can display the global priority of an active process with the `ps -cl` command.

Initial Global Priorities of Processes

A timesharing process inherits its scheduling class and priority from its parent process. The `init` process is the first process to enter the timesharing class.

System processes initially run with a priority that depends on the process's importance (which is programmed into the kernel). The most important system processes start with a priority at or near the top of the system class range.

Tunable Parameters

This section describes the tunable parameters that control scheduler configuration. To change any of these kernel parameters, enter a line in the `/etc/system` file with the format:

```
set parameter=value
```

See `system(4)` for more information.

The parameters described in this section control aspects of process scheduling, timesharing policy, and real-time policy.

The initial priority of a real-time process is determined when the process is put into the real-time scheduling class.

The `prionctl -p` command is used to specify the relative priority within the real-time class.

This is added to the base priority of the real-time class, which by default is 100. For example:

```
prctl -e -c RT -p 20 command
```

This command would put the *command* into execution at a real-time priority of 120.

Process Scheduling Parameters

The following kernel parameters control aspects of process scheduling:

- `maxclsypri`

`maxclsypri` is the maximum global priority of processes in the system class. When the kernel starts system processes, it assigns their priorities using the value of `maxclsypri` as a reference point. `maxclsypri` must have a value of 39 or greater, because the kernel assumes that the total range of system class priorities is at least 40.

If you change this parameter, you must rebuild the scheduling class tables with values that correspond to the maximum priorities that you assign.

- `sys_name`

`sys_name` is the character string name of the system scheduler class. The default value of `sys_name` is `SYS`.

Timesharing Policy

The following parameter is specified in the TS loadable module, which controls the timesharing policy:

- `ts_maxupri`

`ts_maxupri` specifies the range within which users may adjust the priority of a timesharing process, using the `prctl(1)` command or the `prctl(2)` system call. The valid range for the user-supplied priority in the timesharing class is from `+ts_maxupri` to `-ts_maxupri`. The default value of `ts_maxupri` is 20 (which sets the range between +20 and -20, emulating the behavior of the older, less general scheduler interfaces, `nice` and `setpriority`.)

The value of `ts_maxupri` is independent of the configured number of global timesharing priorities. In the default configuration, there are 0-59 timesharing priorities, but users may adjust their priorities only within a range of -20 to +20, relative to the system-calculated priority of the process. See “How to Designate a Process Priority” on page 491 for more information.

To change the value of this parameter, enter a line in `/etc/system` with the format:

```
set TS:ts_maxupri=value
```

Real-Time Policy

The following parameter is specified in the RT loadable module, which controls the real-time policy:

- `rt_maxpri`

`rt_maxpri` specifies the maximum priority to assign to real-time processes. The default value of `rt_maxpri` is 159.

If you change this parameter, you must rebuild the scheduling class tables with values that correspond to the maximum priorities that you assign.

To change the value of this parameter, enter a line in the `/etc/system` file with the format:

```
set RT:rt_maxupri=value
```

Scheduler Parameter Tables

The scheduler tables are described in Table 29-2.

TABLE 29-2 Scheduler Parameters

Table	Used to Manage ...
<code>rt_dptbl</code>	Real-time processes
<code>ts_dptbl</code>	Timesharing processes
<code>ts_kmdpris</code>	Sleeping timesharing processes that own critical resources

These tables define scheduling policy by setting the scheduling parameters to use for real-time and timesharing processes. The parameters specify how much CPU time processes get at different priority levels.

Default time slices for the priority levels are specified in the `ts_dptbl` and `rt_dptbl` configuration tables, which are defined in the `TS_DPTBL` and `RT_DPTBL` loadable modules. These modules are automatically loaded from the `/kernel/sched` directory into the kernel as needed.

The time slices are specified in units (quanta) with a resolution defined by a “resolution” line. The default resolution is 1000, which means the time quantum values are interpreted as milliseconds. This is derived from the reciprocal of the specified resolution in seconds. The quanta are rounded up to the next integral multiple of the system clock’s resolution in clock ticks. (The system clock ticks `HZ` times per second, where `HZ` is a hardware-dependent constant defined in the `param.h` header file.) For example, if the clock tick is 10 milliseconds, 42 quanta is rounded up to 50 milliseconds.

Timesharing Parameter Table

A default version of the `ts_dptb`, is delivered with the system in `/kernel/sched/TS_DPTBL`. The default configuration has 60 timesharing priorities.

The `dispadmin -c TS -g` command displays a sample `ts_dptbl` table.

```
$ dispadmin -c TS -g
# Time Sharing Dispatcher Configuration
RES=1000

# ts_quantum  ts_tqexp  ts_slpret  ts_maxwait ts_lwait  PRIORITY LEVEL
200           0           50         0           50         # 0
200           0           50         0           50         # 1
200           0           50         0           50         # 2
200           0           50         0           50         # 3
200           0           50         0           50         # 4
200           0           50         0           50         # 5
200           0           50         0           50         # 6
200           0           50         0           50         # 7
200           0           50         0           50         # 8
200           0           50         0           50         # 9
160           0           51         0           51         # 10
160           1           51         0           51         # 11
160           2           51         0           51         # 12
160           3           51         0           51         # 13
160           4           51         0           51         # 14
160           5           51         0           51         # 15
160           6           51         0           51         # 16
160           7           51         0           51         # 17
160           8           51         0           51         # 18
160           9           51         0           51         # 19
120          10           52         0           52         # 20
120          11           52         0           52         # 21
120          12           52         0           52         # 22
120          13           52         0           52         # 23
120          14           52         0           52         # 24
120          15           52         0           52         # 25
120          16           52         0           52         # 26
120          17           52         0           52         # 27
120          18           52         0           52         # 28
120          19           52         0           52         # 29
80           20           53         0           53         # 30
80           21           53         0           53         # 31
80           22           53         0           53         # 32
80           23           53         0           53         # 33
80           24           53         0           53         # 34
80           25           54         0           54         # 35
80           26           54         0           54         # 36
80           27           54         0           54         # 37
80           28           54         0           54         # 38
80           29           54         0           54         # 39
40           30           55         0           55         # 40
40           31           55         0           55         # 41
40           32           55         0           55         # 42
40           33           55         0           55         # 43
```

(continued)

(Continuation)

40	34	55	0	55	#	44
40	35	56	0	56	#	45
40	36	57	0	57	#	46
40	37	58	0	58	#	47
40	38	58	0	58	#	48
40	39	58	0	59	#	49
40	40	58	0	59	#	50
40	41	58	0	59	#	51
40	42	58	0	59	#	52
40	43	58	0	59	#	53
40	44	58	0	59	#	54
40	45	58	0	59	#	55
40	46	58	0	59	#	56
40	47	58	0	59	#	57
40	48	58	0	59	#	58
20	49	59	32000	59	#	59
\$						

Table 29-3 describes the fields in the `ts_dptbl` table.

TABLE 29-3 Fields in the `ts_dptbl` Table

Field Name	Description
<code>ts_quantum</code> (runtime)	Contains the time slice (in milliseconds by default) that a process at a given priority is allowed to run before the scheduler reevaluates its priority. If the process uses up its entire time slice, it is put on the expired-level (<code>ts_tqexp</code>) queue. Time slices run from 40 milliseconds for the highest priority (59) to 200 milliseconds (0) for the lowest priority.
<code>ts_tqexp</code> (expired level)	Determines the new process priority for a process whose time slice has expired. If a process uses its whole time slice without sleeping, the scheduler changes its priority to the level indicated in the <code>ts_tqexp</code> column. The expired level is lower than the prior level. For example, a process with a priority of 30 that used up its time slice (80 milliseconds) will get a new priority of 20.
<code>ts_slpret</code> (sleep level)	Determines the priority assigned to a process when it returns from sleep. A process may sleep during certain system calls or when waiting for I/O (for example, servicing a page fault or waiting for a lock). When a process returns from sleep, it is always a given a priority of 59.

TABLE 29-3 Fields in the `ts_dptbl` Table (continued)

Field Name	Description
<code>ts_maxwait</code> (wait time)	Specifies the number of seconds a process will be left on a dispatch queue without its time slice expiring. If it does not use its time slice (in <code>ts_maxwait</code> seconds), its new priority will be set to <code>ts_lwait</code> . This is used to prevent a low-priority process from being starved of CPU time.
<code>ts_lwait</code> (wait level)	Contains the new priority for a ready-to-run process that has exceeded the maximum wait time (<code>ts_maxwait</code>) without getting its full time slice.
PRIORITY LEVEL	Contains global priorities. Processes put in queues at the higher priority levels run first. The global priorities run from a high of 59 to a low of 0. This is the only column in the table that is not tunable.

Real-Time Parameter Table

A default version of `rt_dptbl` is delivered with the system in the `/kernel/sched/RT_DPTBL` loadable module.

The `dispadmin -c RT -g` command displays `rt_dptbl` information similar to the following.

```

$ dispadmin -c RT -g
# Real Time Dispatcher Configuration
RES=1000

# TIME QUANTUM          PRIORITY
# (rt_quantum)         LEVEL
    1000                #      0
    1000                #      1
    1000                #      2
    1000                #      3
    1000                #      4
    1000                #      5
    1000                #      6
    1000                #      7
    1000                #      8
    1000                #      9
     800                #     10
     800                #     11
     800                #     12
     800                #     13
     800                #     14

```

(continued)

(Continuation)

800	#	15
800	#	16
800	#	17
800	#	18
800	#	19
600	#	20
600	#	21
600	#	22
600	#	23
600	#	24
600	#	25
600	#	26
600	#	27
600	#	28
600	#	29
400	#	30
400	#	31
400	#	32
400	#	33
400	#	34
400	#	35
400	#	36
400	#	37
400	#	38
400	#	39
200	#	40
200	#	41
200	#	42
200	#	43
200	#	44
200	#	45
200	#	46
200	#	47
200	#	48
200	#	49
100	#	50
100	#	51
100	#	52
100	#	53
100	#	54
100	#	55
100	#	56
100	#	57
100	#	58
100	#	59
\$		

Table 29-4 describes the fields in the real-time parameter table.

TABLE 29-4 Fields in the `rt_dptbl` Table

Field Name	Description
<code>rt_glbpri</code>	Contains global priorities. Processes put in queues at the higher priority levels run first. Note that the <code>dispadmin</code> command, which you can use to display the table, shows only the relative priorities within the class, and not the global priorities. This column cannot be changed with <code>dispadmin</code> .
<code>rt_qntm</code>	Describes the default time slice (in milliseconds) a process with this priority (<code>rt_glbpri</code>) may run before the scheduler gives another process a chance. The time slice for a real-time process can be specified with the <code>pricntl -t</code> command.

Kernel-Mode Parameter Table

The scheduler uses the kernel-mode parameter table, `ts_kmdpris`, to manage sleeping timesharing processes. A default version of `ts_kmdpris` is delivered with the system, in the `/kernel/sched/TS_DPTBL` loadable module, and is automatically built into the kernel as part of system configuration. See `ts_dptbl(4)` for more information.

Note - The kernel assumes that it has at least 40 priorities in `ts_kmdpris`. It panics if it does not.

The kernel-mode parameter table is a one-dimensional array of global priorities from 60 through 99. If a process owns a critical resource, it is assigned a kernel priority so that it can release the resource as soon as possible. Critical resources are:

- An exclusive lock on a page
- A read lock on a readers/writer lock

Prior to the SunOS 5.3 release, processes were assigned kernel priorities while they were asleep. This ensured that the resources they were waiting for were not paged out before they had a chance to execute again.

In order to do this after the SunOS 5.3 release, processes return from sleep with the highest time-share priority (59).

PART VII Troubleshooting Solaris Software Problems

This part provides instructions for troubleshooting Solaris software problems. This part contains these chapters.

Chapter 30	Provides overview information about troubleshooting common software problems and instructions for troubleshooting a system crash.
Chapter 31	Provides step-by-step instructions for saving crash dumps and customizing system error logging.
Chapter 32	Provides problem scenarios and possible solutions for general software problems such as a hung system or a system that won't boot.
Chapter 33	Provides solutions for solving common file access problems such as incorrect command search paths and file permissions.
Chapter 34	Provides solutions for solving common printer problems such as no output or incorrect output.
Chapter 35	Provides specific <code>fsck</code> error messages and corresponding solutions for solving file system-related problems.
Chapter 36	Provides specific error messages and possible solutions for problems encountered when adding or removing software packages.



Troubleshooting Software Problems (Overview)

This chapter provides a general overview of troubleshooting software problems, including information on troubleshooting system crashes and viewing system messages.

This is a list of information in this chapter.

- “Where to Find Software Troubleshooting Tasks” on page 567
- “Troubleshooting a System Crash” on page 568
- “Troubleshooting a System Crash Checklist” on page 569
- “Viewing System Messages” on page 570
- “Customizing System Message Logging” on page 572

Where to Find Software Troubleshooting Tasks

Use these references to find step-by-step instructions for troubleshooting software problems.

- Chapter 31
- Chapter 32
- Chapter 33
- Chapter 34
- Chapter 35

Troubleshooting a System Crash

If a system running the Solaris operating environment crashes, provide your service provider with as much information as possible—including crash dump files.

What To Do if The System Crashes

The most important things are:

1. Write down the system console messages.

If a system crashes, making it run again may seem like your most pressing concern. However, before you reboot the system, examine the console screen for messages. These messages may provide some insight about what caused the crash. Even if the system reboots automatically and the console messages have disappeared from the screen, you may be able to check these messages by viewing the system error log file that is generated automatically in `/var/adm/messages` (or `/usr/adm/messages`). See “How to View System Messages” on page 571 for more information about viewing system error log files.

If you have frequent crashes and can't determine their cause, gather all the information you can from the system console or the `/var/adm/messages` files, and have it ready for a customer service representative to examine. See “Troubleshooting a System Crash” on page 568 for a complete list of troubleshooting information to gather for your service provider.

See Chapter 32 if the system fails to reboot successfully after a system crash.

2. Synchronize the disks and reboot.

```
ok sync
```

See Chapter 32 if the system fails to reboot successfully after a system crash.

3. Attempt to save the crash information written onto the swap area by running the `savecore` command.

```
# savecore
```

See Chapter 31 for information about saving crash dumps automatically.

Gathering Troubleshooting Data

Answer the following questions to help isolate the system problem. Use “Troubleshooting a System Crash Checklist” on page 569 for gathering troubleshooting data for a crashed system.

TABLE 30-1 Identifying System Crash Data

Question	Description
<i>Can you reproduce the problem?</i>	This is important because a reproducible test case is often essential for debugging really hard problems. By reproducing the problem, the service provider can build kernels with special instrumentation to trigger, diagnose, and fix the bug.
<i>Are you using any third-party drivers?</i>	Drivers run in the same address space as the kernel, with all the same privileges, so they can cause system crashes if they have bugs.
<i>What was the system doing just before it crashed?</i>	If the system was doing anything unusual like running a new stress test or experiencing higher-than-usual load, that may have led to the crash.
<i>Were there any unusual console messages right before the crash?</i>	Sometimes the system will show signs of distress before it actually crashes; this information is often useful.
<i>Did you add any tuning parameters to the <code>/etc/system</code> file?</i>	Sometimes tuning parameters, such as increasing shared memory segments so that the system tries to allocate more than it has, can cause the system to crash.
<i>Did the problem start recently?</i>	If so, did the onset of problems coincide with any changes to the system, for example, new drivers, new software, different workload, CPU upgrade, or a memory upgrade.

Troubleshooting a System Crash Checklist

Use this checklist when gathering system data for a crashed system.

Item	Your Data
Is a core file available?	
Identify the operating system release and appropriate software application release levels.	
Identify system hardware.	
Include <code>prtdiag</code> output from sun4d systems.	
Are patches installed? If so, include <code>showrev -p</code> output.	
Is the problem reproducible?	
Does the system have any third-party drivers?	
What was the system doing before it crashed?	
Were there any unusual console messages right before the system crashed?	
Did you add any parameters to the <code>/etc/system</code> file?	
Did the problem start recently?	

Viewing System Messages

When a system crashes, it may display a message on the system console like this:

```
panic: error message
```

where *error message* is one of the panic error messages described in `crash(1M)`.

Less frequently, this message may be displayed instead of the panic message:

```
Watchdog reset !
```

The error logging daemon, `syslogd`, automatically records various system warnings and errors in message files. By default, many of these system messages are displayed

on the system console and are stored in `/var/adm` (or `/usr/adm`) or `.`. You can direct where these messages are stored by setting up system logging. See “How to Customize System Message Logging” on page 574 for more information. These messages can alert you to system problems, such as a device that is about to fail.

The `/var/adm` directory contains several message files. The most recent messages are in `/var/adm/messages` (and in `messages.0`), and the oldest are in `messages.3`. After a period of time (usually every ten days), a new `messages` file is created. The `messages.0` file is renamed `messages.1`, `messages.1` is renamed `messages.2`, and `messages.2` is renamed `messages.3`. The current `/var/adm/messages.3` is deleted.

Because `/var/adm` stores large files containing messages, crash dumps, and other data, this directory can consume lots of disk space. To keep the `/var/adm` directory from growing too large, and to ensure that future crash dumps can be saved, you should remove unneeded files periodically. You can automate this task by using `crontab`. See “How to Delete Crash Dump Files” on page 393 and Chapter 21 for more information on automating this task.

▼ How to View System Messages

Display recent messages generated by a system crash or reboot by using the `dmesg` command.

```
$ dmesg
```

Or use the `more` command to display one screen of messages at a time.

```
$ more /var/adm/messages
```

For more information, refer to `dmesg(1M)`.

Example—Viewing System Messages

The following example shows output from the `dmesg` command.

```
$ dmesg
SunOS Release 5.7 Version Generic [UNIX(R) System V Release 4.0]
Copyright (c) 1983-1998, Sun Microsystems, Inc.
vac: enabled in write through mode
cpu0: FMI,MB86904 (mid 0 impl 0x0 ver 0x4 clock 110 MHz)
mem = 57344K (0x3800000)
avail mem = 53268480
Ethernet address = 8:0:20:7c:d8:60
root nexus = SUNW,SPARCstation-5
iommu0 at root: obio 0x1000000
sbus0 at iommu0: obio 0x10001000
```

(continued)

(Continuation)

```
espdma0 at sbus0: SBus slot 5 0x8400000
espdma0 is /iommu@0,10000000/sbus@0,10001000/espdma@5,8400000
esp0: esp-options=0x46
esp0 at espdma0: SBus slot 5 0x8800000 sparc ipl 4
esp0 is /iommu@0,10000000/sbus@0,10001000/espdma@5,8400000/esp@5,8800000
sd3 at esp0: target 3 lun 0
sd3 is /iommu@0,10000000/sbus@0,10001000/espdma@5,8400000/esp@5,8800000/...
  root on /iommu@0,10000000/sbus@0,10001000/espdma@5,8400000/esp@5,8800000/
  ...
obio0 at root
.
.
.
```

Customizing System Message Logging

You can capture additional error messages that are generated by various system processes by modifying the `/etc/syslog.conf` file. By default, `/etc/syslog.conf` directs many system process messages to the `/var/adm` message files. Crash and boot messages are stored here as well. To view `/var/adm` messages, see “How to View System Messages” on page 571.

The `/etc/syslog.conf` file has two columns separated by tabs:

<i>facility.level ...</i>	<i>action</i>
---------------------------	---------------

facility.level

A *facility* or system source of the message or condition. May be a comma-separated listed of facilities. Facility values are listed in Table 30-2. A *level*, indicates the severity or priority of the condition being logged. Priority levels are listed in Table 30-3.

action

The action field indicates where the messages are forwarded.

The following example shows sample lines from a default `/etc/syslog.conf` file.

```
user.err      /dev/console
user.err      /var/adm/messages
user.alert    'root, operator'
user.emerg    *
```

The most common error condition sources are shown in Table 30-2. The most common priorities are shown in Table 30-3 in order of severity.

TABLE 30-2 Source Facilities for `syslog.conf` Messages

Source	Description
kern	The kernel
auth	Authentication
daemon	All daemons
mail	Mail system
lp	Spooling system
user	User processes

Note - Starting in the Solaris 2.6 release, the number of `syslog` facilities that can be activated in the `/etc/syslog.conf` file is unlimited. In previous releases, the number of facilities was limited to 20.

TABLE 30-3 Priority Levels for `syslog.conf` Messages

Priority	Description
emerg	System emergencies
alert	Errors requiring immediate correction
crit	Critical errors
err	Other errors

TABLE 30-3 Priority Levels for `syslog.conf` Messages (continued)

Priority	Description
info	Informational messages
debug	Output used for debugging
none	This setting doesn't log output

▼ How to Customize System Message Logging

1. Become superuser.
2. Using the editor of your choice, edit the `/etc/syslog.conf` file, adding or changing message sources, priorities, and message locations according to the syntax described in `syslog.conf(4)`.
3. Exit the file, saving the changes.

Example—Customizing Message System Logging

The following `/etc/syslog.conf` lines are provided by default during the Solaris installation process.

```
user.err      /dev/console
user.err      /var/adm/messages
user.alert    'root, operator'
user.emerg    *
```

This means the following user messages are automatically logged:

- User errors are printed to the console and also are logged to the `/var/adm/messages` file.
- User messages requiring immediate action (`alert`) are sent to the root and operator users.
- User emergency messages are sent to individual users.

Managing System Crash Information

This section contains information about managing system crash information.

This is a list of the step-by-step instructions in this chapter.

- “How to Display the Current Crash Dump Configuration” on page 579
- “How to Modify a Crash Dump Configuration” on page 579
- “How to Examine a Crash Dump” on page 581
- “How to Recover From a Full Crash Dump Directory (Optional)” on page 582
- “How to Disable or Enable Saving Crash Dumps (Optional)” on page 583

What’s New in Managing System Crash Information?

This section describes the new system crash dump features available in the Solaris 7 release.

New System Crash Dump Features

The Solaris 7 system crash dump features are:

- The new `dumpadm` command, which allows system administrators to configure crash dumps of the operating system. The `dumpadm` configuration parameters include the dump content, dump device, and the directory in which crash dump files are saved. See “The `dumpadm` Command” on page 576 for more information about the `dumpadm` command.

- Dump data is now stored in compressed format on the dump device. Kernel crash dump images can be as big as 4 Gbytes or more. Compressing the data means faster dumping and less disk space needed for the dump device.
- Saving crash dump files is run in the background when a dedicated dump device—not the swap area—is part of the dump configuration. This means a booting system does not wait for the `savecore` command to complete before going to the next step. On large memory systems, the system can be available before `savecore` completes.
- System crash dump files, generated by the `savecore` command, are now saved by default.
- The `savecore -L` command is a new feature which enables you to get a crash dump of the live running Solaris operating environment. This command is intended for troubleshooting a running system by taking a snapshot of memory during some bad state—such as a transient performance problem or service outage. If the system is up and you can still run some commands, you can execute the `savecore -L` to save a snapshot of the system to the dump device, and then immediately write out the crash dump files to your `savecore` directory. Because the system is still running, you may only use `savecore -L` if you have configured a dedicated dump device.

The dumpadm Command

The `/usr/sbin/dumpadm` command manages a system's crash dump configuration parameters. The following table describes `dumpadm`'s configuration parameters.

Dump Parameter	Description
dump device	The device that stores dump data temporarily as the system crashes. When the dump device is not the swap area, <code>savecore</code> runs in the background, which speeds up the boot process.
savecore directory	The directory that stores system crash dump files.
dump content	Type of data, kernel memory or all of memory, to dump.
minimum free space	Minimum amount of free space required in the <code>savecore</code> directory after saving crash dump files. If no minimum free space has been configured, the default is one megabyte.

See `dumpadm(1M)` for more information.

The dump configuration parameters managed by the `dumpadm` command are stored in the `/etc/dumpadm.conf` file.

Note - Do not `/etc/dumpadm.conf` edit manually. This could result in an inconsistent system dump configuration.

How the `dumpadm` Command Works

During system startup, the `dumpadm` command is invoked by the `/etc/init.d/savecore` script to configure crash dumps parameters based on information in the `/etc/dumpadm.conf` file.

Specifically, it initializes the dump device and the dump content through the `/dev/dump` interface.

After the dump configuration is complete, the `savecore` script looks for the location of the crash dump file directory by parsing the content of `/etc/dumpadm.conf` file. Then, `savecore` is invoked to check for crash dumps. It will also check the content of the `minfree` file in the crash dump directory.

System Crashes

System crashes can occur due to hardware malfunctions, i/o problems, and software errors. If the system crashes, it will display an error message on the console, and then write a copy of its physical memory to the dump device. The system will then reboot automatically. When the system reboots, the `savecore` command is executed to retrieve the data from the dump device and write the saved crash dump to your `savecore` directory. The saved crash dump files provide invaluable information to your support provider to aid in diagnosing the problem.

Crash Dump Files

The `savecore` command runs automatically after a system crash to retrieve the crash dump information from the dump device and writes a pair of files called `unix.X` and `vmcore.X`, where `X` identifies the dump sequence number. Together, these files represent the saved system crash dump information. Crash dump files are sometimes confused with `core` files, which are images of user applications that are written when the application terminates abnormally.

Crash dump files are saved in a predetermined directory, which by default, is `/var/crash/hostname`. In the Solaris 2.6 release and compatible versions, crash dump files were overwritten when a system rebooted—unless you manually enabled the system to save the images of physical memory in a crash dump file. Now the saving of crash dump files is enabled by default.

Saving Crash Dumps

You can examine the control structures, active tables, memory images of a live or crashed system kernel, and other information about the operation of the kernel by using the `crash` or `adb` utilities. Using `crash` or `adb` to its full potential requires a detailed knowledge of the kernel, and is beyond the scope of this manual. See `crash(1M)` or `adb(1)` for more details on using these utilities.

Additionally, crash dumps saved by `savecore` can be useful to send to a customer service representative for analysis of why the system is crashing. If you will be sending crash dump files to a customer service representative, perform the first two tasks listed in “Managing Crash Dumps Task Map” on page 578.

Managing Crash Dumps Task Map

TABLE 31-1 Managing Crash Dumps Task Map

Task	Description	For Instructions, Go To
1. Display the Current Crash Dump Configuration	Display the current crash dump configuration by using the <code>dumppadm</code> command.	“How to Display the Current Crash Dump Configuration” on page 579
2. Modify the Crash Dump Configuration	Use the <code>dumppadm</code> command to specify the type of data to dump, whether or not the system will use a dedicated dump device, the directory for saving crash dump files, and the amount of space that must remain available after core files are written.	“How to Modify a Crash Dump Configuration” on page 579
3. Examine a Crash Dump File	Use the <code>crash</code> command to view crash dump files.	“How to Examine a Crash Dump” on page 581
4. Recover From a Full Crash Dump Directory	<i>Optional.</i> The system crashes but there is no room in the <code>savecore</code> directory, and you want to save some critical system crash dump information.	“How to Recover From a Full Crash Dump Directory (Optional)” on page 582
4. Disable or Enable the Saving of Crash Dump Files	<i>Optional.</i> Use the <code>dumppadm</code> command to disable or enable the saving the crash dump files. Saving crash dump files is enabled by default.	“How to Disable or Enable Saving Crash Dumps (Optional)” on page 583

TABLE 31-1 Managing Crash Dumps Task Map (continued)

▼ How to Display the Current Crash Dump Configuration

1. Become superuser.
2. Display the current crash dump configuration by using the `dumpadm` command without any options.

```
# dumpadm
  Dump content: kernel pages
  Dump device: /dev/dsk/c0t3d0s1 (swap)
Savecore directory: /var/pluto
Savecore enabled: yes
```

The above example output means:

- The dump content is kernel memory pages.
- Kernel memory will be dumped on a swap device, `/dev/dsk/c0t3d0s1`. You can identify all your swap areas with the `swap -l` command.
- Core files will be written in the `/var/crash/venus` directory.
- Saving core files is enabled.

▼ How to Modify a Crash Dump Configuration

1. Become superuser.
2. Identify the current crash dump configuration by using the `dumpadm` command.

```
# dumpadm
  Dump content: kernel pages
  Dump device: /dev/dsk/c0t3d0s1 (swap)
Savecore directory: /var/crash/pluto
Savecore enabled: yes
```

This is the default dump configuration for a system running the Solaris 7 release.

3. Modify the crash dump configuration by using the `dumpadm` command.

```
# dumpadm -c content -d dump-device -m nnnk | nnnm | nnn% -n -s savecore-dir
```

<code>-c content</code>	Specifies the type of data to dump: kernel memory or all of memory. The default dump content is kernel memory.
<code>-d dump-device</code>	Specifies the device that stores dump data temporarily as the system crashes. The primary swap device is the default dump device.
<code>-m nnnk nnnm nnn%</code>	Specifies the minimum free disk space for saving core files by creating a <code>minfree</code> file in the current <code>savecore</code> directory. This parameter can be specified in kilobytes (<code>nnnk</code>), megabytes (<code>nnnm</code>) or file system size percentage (<code>nnn%</code>). The <code>savecore</code> command consults this file prior to writing the crash dump files. If writing the crash dump files, based on their size, would decrease the amount of free space below the <code>minfree</code> threshold, the dump files are not written and an error message is logged. See “How to Recover From a Full Crash Dump Directory (Optional)” on page 582 for recovering from this scenario.
<code>-n</code>	Specifies that <code>savecore</code> should not be run when the system reboots. This dump configuration is not recommended. If system crash information is written to the swap device, and <code>savecore</code> is not enabled, the crash dump information will be overwritten when the system begins to swap.
<code>-s</code>	Specifies an alternate directory for storing crash dump files. The default directory is <code>/var/crash/hostname</code> where <code>hostname</code> is the output of the <code>uname -n</code> command.

Example—Modifying a Crash Dump Configuration

In this example, all of memory is dumped to the dedicated dump device, `/dev/dsk/c0t1d0s1`, and the minimum free space that must be available after the crash dump files are saved is 10% of the file system space.

```
# dumpadm
  Dump content: kernel pages
  Dump device: /dev/dsk/c0t3d0s1 (swap)
Savecore directory: /var/crash/pluto
Savecore enabled: yes
# dumpadm -c all -d /dev/dsk/c0t1d0s1 -m 10%
  Dump content: all pages
```

(continued)

(Continuation)

```
Dump device: /dev/dsk/c0t1d0s1 (dedicated)
Savecore directory: /var/crash/pluto (minfree = 77071KB)
Savecore enabled: yes
```

▼ How to Examine a Crash Dump

1. Become superuser.
2. Examine a crash dump by using the `crash` utility.

```
# /usr/sbin/crash [-d crashdump-file] [-n name-list] [-w output-file]
```

<code>-d crashdump-file</code>	Specifies a file to contain the system memory image. The default crash dump file is <code>/dev/mem</code> .
<code>-n name-list</code>	Specifies a text file to contain symbol table information if you want to examine symbolic access to the system memory image. The default file name is <code>/dev/ksyms</code> .
<code>-w output-file</code>	Specifies a file to contain output from a crash session. The default is standard output.

3. Display crash status information.

```
# /usr/sbin/crash
dumpfile = /dev/mem, namelist = /dev/ksyms, outfile = stdout
> status
.
.
.
> size buf proc queue
.
.
du .
```

Example—Examining a Crash Dump

The following example shows sample output from the `crash` utility. Information about status, and about the buffer, process, and queue size is displayed.

```
# /usr/sbin/crash
dumpfile = /dev/mem, namelist = /dev/ksyms, outfile = stdout
> status
system name:      SunOS
release:          5.7
node name:        saturn
version:          Generic
machine name:     sun4m
time of crash:    Thu Feb 26 12:17:04 1998
age of system:    19 day, 23 hr., 55 min.
panicstr:
panic registers:
    pc: 0      sp: 0
> size buf proc queue
120
1552
88
```

▼ How to Recover From a Full Crash Dump Directory (Optional)

In this scenario, the system crashes but there is no room in the `savecore` directory, and you want to save some critical system crash dump information.

1. **Log in as superuser after the system reboots.**
2. **Clear out the `savecore` directory, usually `/var/crash/hostname`, by removing existing crash dump files that have already been sent to your service provider. Or, run the `savecore` command and specify an alternate directory that has sufficient disk space. (See the next step.)**
3. **Manually run the `savecore` command and if necessary, specify an alternate `savecore` directory.**

```
# savecore [ directory ]
```

▼ How to Disable or Enable Saving Crash Dumps (Optional)

1. **Become superuser.**
2. **Disable or enable the saving of crash dumps on your system by using the `dumpadm` command.**

Example—Disabling the Saving of Crash Dumps

This example illustrates how to disable the saving of crash dumps on your system.

```
# dumpadm -n
Dump content: all pages
Dump device: /dev/dsk/c0t1d0s1 (dedicated)
Savecore directory: /var/crash/pluto (minfree = 77071KB)
Savecore enabled: no
```

Example—Enabling the Saving of Crash Dumps

This example illustrates how to enable the saving of crash dump on your system.

```
# dumpadm -y
Dump content: all pages
Dump device: /dev/dsk/c0t1d0s1 (dedicated)
Savecore directory: /var/crash/pluto (minfree = 77071KB)
Savecore enabled: yes
```


Troubleshooting Miscellaneous Software Problems

This chapter describes miscellaneous software problems that may occur occasionally and are relatively easy to fix. Troubleshooting miscellaneous software problems includes solving problems that aren't related to a specific software application or topic, such as unsuccessful reboots and full file systems. Resolving these problems are described in the following sections.

This is a list of information in this chapter.

- “What to Do If Rebooting Fails” on page 585
- “What to Do If a System Hangs” on page 586
- “What to Do If a File System Fills Up” on page 587
- “What to Do If File ACLs Are Lost After Copy or Restore” on page 588
- “Troubleshooting Backup Problems” on page 588

What to Do If Rebooting Fails

If the system does not reboot completely, or if it reboots and then crashes again, there may be a software or hardware problem that is preventing the system from booting successfully.

Problem — A System Won't Boot Because ... How to Fix the Problem

The system can't find `/platform/'uname -m'/kernel/unix`.

You may need to change the `boot-device` setting in the PROM on a SPARC system. See "Booting a SPARC System (Tasks)" in *System Administration Guide, Volume I* for information on changing the default boot device.

There is no default boot device on an x86 system. The message displayed is:

Boot the system using the Configuration Assistant/Boot diskette and select the disk from which to boot.

Not a UFS filesystem.

There's an invalid entry in the `/etc/passwd` file.

See "Shutting Down and Booting a System (Overview)" in *System Administration Guide, Volume I* for information on recovering from an invalid `passwd` file.

There's a hardware problem with a disk or another device.

Check the hardware connections:

- Make sure the equipment is plugged in.
 - Make sure all the switches are set properly.
 - Look at all the connectors and cables, including the Ethernet cables.
 - If all this fails, turn off the power to the system, wait 10 to 20 seconds, and then turn on the power again.
-

If none of the above suggestions solve the problem, contact your local service provider.

What to Do If a System Hangs

A system may freeze or hang rather than crash completely if some software process is stuck. Follow these steps to recover from a hung system.

1. Determine whether the system is running a window environment and follow the suggestions listed below. If these suggestions don't solve the problem, go to step 2.
 - Make sure the pointer is in the window where you are typing the commands
 - Press Control-q in case the user accidentally pressed Control-s, which freezes the screen. Control-s freezes only the window, not the entire screen. If a window is frozen, try using another window.

- If possible, log in remotely from another system on the network. Use the `pgrep` command to look for the hung process. If it looks like the window system is hung, identify the process and kill it.
2. Press Control-\ to force a “quit” in the running program and (probably) write out a `core` file.
 3. Press Control-c to interrupt the program that may be running.
 4. Log in remotely and attempt to identify and kill the process that is hanging the system.
 5. Log in remotely, become superuser and reboot the system.
 6. If the system still does not respond, force a crash dump and reboot. See Chapter 31 for information on forcing a crash dump and booting.
 7. If the system still does not respond, turn the power off, wait a minute or so, then turn the power back on.
 8. If you cannot get the system to respond at all, contact your local service provider for help.

What to Do If a File System Fills Up

When the root (/) file system or any other file system fills up, you will see the following message in the console window:

```
.... file system full
```

There are several reasons why a file system fills up. The following sections describe several scenarios for recovering from a full file system. See Chapter 19 for information on routinely cleaning out old and unused files to prevent full file systems.

A File System Fills Up Because a Large File or Directory Was Created

Reason Error Occurred	How to Fix the Problem
Someone accidentally copied a file or directory to the wrong location. This also happens when an application crashes and writes a large <code>core</code> file into the file system.	Log in as superuser and use the <code>ls -tl</code> command in the specific file system to identify which large file is newly created and remove it. See “How to Find and Delete <code>core</code> Files” on page 393 to remove <code>core</code> files.

The `tmpfs` File System Is Full Because the System Ran Out of Memory

Reason Error Occurred	How to Fix the Problem
This can occur if <code>tmpfs</code> is trying to write more than it is allowed or some current processes are using a lot of memory.	See <code>tmpfs(7FS)</code> for information on recovering from <code>tmpfs</code> -related error messages.

What to Do If File ACLs Are Lost After Copy or Restore

Reason Error Occurred	How to Fix the Problem
If files or directories with ACLs are copied or restored into the <code>/tmp</code> directory, the ACL attributes are lost. The <code>/tmp</code> directory is usually mounted as a temporary file system, which doesn't support UFS file system attributes such as ACLs.	Copy or restore files into the <code>/var/tmp</code> directory instead.

Troubleshooting Backup Problems

This section describes some basic troubleshooting techniques to use when backing up and restoring data.

The root (`/`) File System Fills Up After You Back Up a File System

You back up a file system, and the root (`/`) file system fills up. Nothing is written to the media, and the `ufsdump` command prompts you to insert the second volume of media.

Reason Error Occurred	How to Fix the Problem
If you used an invalid destination device name with the <code>-f</code> option, the <code>ufsdump</code> command wrote to a file in the <code>/dev</code> directory of the root (<code>/</code>) file system, filling it up. For example, if you typed <code>/dev/rmt/st0</code> instead of <code>/dev/rmt/0</code> , the backup file <code>/dev/rmt/st0</code> was created on the disk rather than being sent to the tape drive.	Use the <code>ls -tl</code> command in the <code>/dev</code> directory to identify which file is newly created and abnormally large, and remove it.

Make Sure the Backup and Restore Commands Match

You can only use `ufsrestore` to restore files backed up with `ufsdump`. If you back up with `tar`, restore with `tar`. If you use the `ufsrestore` command to restore a tape that was written with another command, an error message tells you that the tape is not in `ufsdump` format.

Check to Make Sure You Have the Right Current Directory

It is easy to restore files to the wrong location. Because the `ufsdump` command always copies files with full path names relative to the root of the file system, you should usually change to the root directory of the file system before running `ufsrestore`. If you change to a lower-level directory, after you restore the files you will see a complete file tree created under that directory.

Use the Old `restore` Command to Restore Multivolume Diskette Backups

You cannot use the `ufsrestore` command to restore files from a multivolume backup set of diskettes made with the `dump` command. You must restore the files on a SunOS 4.1 system.

Interactive Commands

When you use the interactive command, a `ufsrestore>` prompt is displayed, as shown in this example:

```
# ufsrestore ivf /dev/rmt/0
Verify volume and initialize maps
Media block size is 126
Dump   date: Tue Jun 16 10:19:36 1998
Dumped from: the epoch
Level 0 dump of / on mars:/dev/dsk/c0t3d0s0
Label: none
Extract directories from tape
Initialize symbol table.
ufsrestore >
```

At the `ufsrestore>` prompt, you can use the commands listed on “The `ufsdump` and `ufsrestore` Commands (Reference)” in *System Administration Guide, Volume I* to find files, create a list of files to be restored, and restore them.

Troubleshooting File Access Problems

This is a list of troubleshooting topics in this chapter.

- “Solving Problems With Search Paths (Command not found)” on page 591
- “Solving File Access Problems” on page 594
- “Recognizing Problems With Network Access” on page 595

Users frequently experience problems—and call on a system administrator for help—because they cannot access a program, a file, or a directory that they could previously use. Whenever you encounter such a problem, investigate one of three areas:

- The user’s search path may have been changed, or the directories in the search path may not be in the proper order.
- The file or directory may not have the proper permissions or ownership.
- The configuration of a system accessed over the network may have changed.

This chapter briefly describes how to recognize problems in each of these three areas and suggests possible solutions.

Solving Problems With Search Paths (Command not found)

A message of `Command not found` indicates one of the following:

- The command is not available on the system.
- The command directory is not in the search path.

To fix a search path problem, you need to know the pathname of the directory where the command is stored.

If the wrong version of the command is found, a directory that has a command of the same name is in the search path. In this case, the proper directory may be later in the search path or may not be present at all.

You can display your current search path by using the `echo $PATH` command.

```
$ echo $PATH
/home/kryten/bin:/sbin:/usr/sbin:/usr/openwin/bin:/usr/openwin/bin/xview:
/usr/dist/local/exe:/usr/dist/exe
```

Use the `which` command to determine whether you are running the wrong version of the command.

```
$ which maker
/usr/doctools/frame5.1/bin/maker
```

Note - The `which` command looks in the `.cshrc` file for path information. The `which` command may give misleading results if you execute it from the Bourne or Korn shell and you have a `.cshrc` file than contains aliases for the `which` command. To ensure accurate results, use the `which` command in a C shell, or, in the Korn shell, use the `whence` command.

▼ How to Diagnose and Correct Search Path Problems

1. **Display the current search path to verify that the directory for the command is not in your path or that it isn't misspelled.**

```
$ echo $PATH
```

2. **Check the following:**

- Is the search path correct?
- Is the search path listed before other search paths where another version of the command is found?
- Is the command in one of the search paths?

If the path needs correction, go to step 3. Otherwise, go to step 4.

3. **Add the path to the appropriate file, as shown in this table.**

Shell	File	Syntax	Notes
Bourne and Korn	<code>\$HOME/.profile</code>	<code>\$ PATH=\$HOME/bin:/sbin:/usr/local/bin ...</code> <code>\$ export PATH</code>	A colon separates path names.
C	<code>\$HOME/.cshrc</code> or <code>\$HOME/.login</code>	<code>hostname% set path=(~bin /sbin /usr/local/bin ...)</code>	A blank space separates path names.

4. Activate the new path as follows:

Shell	File Where Path Is Located	Activate The Path With ...
Bourne and Korn	<code>.profile</code>	<code>\$. ./profile</code>
C	<code>.cshrc</code>	<code>hostname% source .cshrc</code>
	<code>.login</code>	<code>hostname% source .login</code>

5. Verify the path using the command shown below.

```
$ which command
```

Example—Diagnosing and Correcting Search Path Problems

This example shows that the OpenWindows executable is not in any of the directories in the search path using the `which` command.

```
venus% openwin
openwin: Command not found
venus% echo $PATH
no openwin in . /home/ignatz /sbin /usr/sbin /usr/bin /etc
/home/ignatz/bin /bin /home/bin /usr/etc
```

(continued)

(Continuation)

```
venus% vi ~/.cshrc
      (Add appropriate command directory to the search path)
venus% source .cshrc
venus% openwin
```

If you cannot find a command, look at the man page for its directory path. For example, if you cannot find the `lpsched` command (the `lp` printer daemon), `lpsched(1M)` tells you the path is `/usr/lib/lp/lpsched`.

Solving File Access Problems

When users cannot access files or directories that they previously could access, the permissions or ownership of the files or directories probably has changed.

Changing File and Group Ownerships

Frequently, file and directory ownerships change because someone edited the files as superuser. When you create home directories for new users, be sure to make the user the owner of the dot (`.`) file in the home directory. When users do not own “.” they cannot create files in their own home directory.

Access problems can also arise when the group ownership changes or when a group of which a user is a member is deleted from the `/etc/group` database.

Table 33-1 for information about how to change the permissions or ownership of a file that you are having problems accessing.

TABLE 33-1 Solving File Access Problems

If You Need to Change the ...	Use the ...	For More Details, See ...
Permission on a file	<code>chmod(1)</code> command	“How to Change Permissions in Absolute Mode” on page 274
Ownership of a file	<code>chown(1)</code> command	“How to Change the Owner of a File” on page 269
Group ownership of a file	<code>chgrp(1)</code> command	“How to Change Group Ownership of a File” on page 270

Recognizing Problems With Network Access

If users have problems using the `rsh` remote copy command to copy files over the network, the directories and files on the remote system may have restricted access by setting permissions. Another possible source of trouble is that the remote system and the local system are not configured to allow access.

See *NFS Administration Guide* for information about problems with network access and problems with accessing systems through AutoFS.

Troubleshooting Printing Problems

This chapter explains how to troubleshoot printing problems that may occur when you set up or maintain printing services.

This is a list of step-by-step instructions in this chapter:

- “How to Troubleshoot No Printer Output” on page 603
- “How to Troubleshoot Incorrect Output” on page 618
- “How to Unhang the LP Print Service” on page 624
- “How to Troubleshoot an Idle (Hung) Printer” on page 625
- “How to Resolve Conflicting Printer Status Messages” on page 627

See for information about printing and the LP print service.

Tips on Troubleshooting

Sometimes after setting up a printer, you find that nothing prints. Or, you may get a little farther in the process: something prints, but it is not what you expect—the output is incorrect or illegible. Then, when you get past these problems, other problems may occur, such as:

- LP commands hanging
- Printers becoming idle
- Users getting conflicting messages

Note - Although many of the suggestions in this chapter are relevant to parallel printers, they are geared toward the more common serial printers.

Troubleshooting Adding a Printer

If you use Admintool to add access to a remote printer after installing the Solaris release, and you get the following message:

```
Admintool: Error
add remote printer failed
```

It is possible that the SunSoft Print Client software is installed in your network and the remote printer is already available to you. Use the `lpstat -t` command before adding a printer to see if the printer is available.

Troubleshooting No Output (Nothing Prints)

When nothing prints, there are three general areas to check:

- The printer hardware
- The network
- The LP print service

If you get a banner page, but nothing else, this is a special case of incorrect output. See “Troubleshooting Incorrect Output” on page 600.

Check the Hardware

The hardware is the first area to check. As obvious as it sounds, you should make sure that the printer is plugged in and turned on. In addition, you should refer to the manufacturer’s documentation for information about hardware settings. Some computers use hardware switches that change the characteristics of a printer port.

The printer hardware includes the printer, the cable that connects it to the computer, and the ports into which the cable plugs at each end. As a general approach, you should work your way from the printer to the computer. Check the printer. Check where the cable connects to the printer. Check the cable. Check where the cable connects to the computer.

Check the Network

Problems are more common with remote print requests—those going from a print client to a print server. You should make sure that network access between the print server and print clients is enabled.

If the network is running the Network Information Service Plus (NIS+), see the *Solaris Naming Administration Guide* for instructions to enable access between

systems. If the network is not running the Network Information Service (NIS) or NIS+, before you set up print servers and print clients, include the Internet address and system name for each client system in the `/etc/hosts` file on the print server. Also, the Internet address and system name for the print server must be included in the `/etc/hosts` file of each print client system.

Check the LP Print Service

For printing to work, the LP scheduler must be running on both the print server and print client. If it is not running, you need to start it using the `/usr/lib/lp/lpsched` command. If you have trouble starting the scheduler, see “How to Restart the Print Scheduler” on page 66.

In addition to the scheduler running, a printer must be enabled and accepting requests before it will produce any output. If the LP print service is not accepting requests for a printer, the submitted print requests are rejected. Usually, in that instance, the user receives a warning message after submitting a print request. If the LP print service is not enabled for a printer, print requests remain queued on the system until the printer is enabled.

In general, you should analyze a printing problem as follows:

- Follow the path of the print request step-by-step.
- Examine the status of the LP print service at each step.
 - Is the configuration correct?
 - Is the printer accepting requests?
 - Is the printer enabled to process requests?
- If the request is hanging on transmission, set up `lpr.debug` in `syslog.conf` to display the flow.
- If the request is hanging locally, examine the `lpsched` log (`/var/lp/logs/lpsched`).
- If the request is hanging locally, have notification of the printer device errors (faults) mailed to you, and re-enable the printer.

The procedures found in “Troubleshooting Printing Problems” on page 603 use this strategy to help you troubleshoot various problems with the LP print service.

If basic troubleshooting of the LP print service does not solve the problem, you need to follow the troubleshooting steps for the specific client/server case that applies:

- SunOS 5.7 or compatible print client using a SunOS 5.7 or compatible print server (for instructions, see “To check printing from a SunOS 5.7 or compatible print client to a SunOS 5.7 or compatible print server:” on page 610)
- SunOS 5.7 or compatible print client using a SunOS 4.1 print server (for instructions, see “To check printing from a SunOS 5.7 or compatible print client to a SunOS 4.1 print server:” on page 611)

- SunOS 4.1 print client using a SunOS 5.7 or compatible print server (for instructions, see “To check printing from a SunOS 4.1 client to a SunOS 5.7 or compatible print server: ” on page 614)

Troubleshooting Incorrect Output

If the printer and the print service software are not configured correctly, the printer may print, but it may provide output that is not what you expect.

Check the Printer Type and File Content Type

If you used the wrong printer type when you set up the printer with the LP print service, inappropriate printer control characters can be sent to the printer. The results are unpredictable: nothing may print, the output may be illegible, or the output may be printed in the wrong character set or font.

If you specified an incorrect file content type on a SunOS 5.7 or compatible print client or a SunOS 5.7 or compatible print server, the banner page may print, but that is all. The file content types specified for a printer indicate the types of files the printer can print directly, without filtering. When a user sends a file to the printer, the file is sent directly to the printer without any attempt to filter it. The problem occurs if the printer cannot handle the file content type.

When setting up print clients, you increase the chance for a mistake because the file content types must be correct on both the print server and the print client. If you set up the print client as recommended with `any` as the file content type, files are sent directly to the print server and the print server determines the need for filtering. Therefore, the file content types have to be specified correctly only on the server.

You can specify a file content on the print client to off-load filtering from the server to the client, but the content type must be supported on the print server.

Check the `stty` Settings

Many formatting problems can result when the default `stty` (standard terminal) settings do not match the settings required by the printer. The following sections describe what happens when some of the settings are incorrect.

Wrong Baud Settings

When the baud setting of the computer does not match the baud setting of the printer, usually you get some output, but it does not look like the file you submitted for printing. Random characters are displayed, with an unusual mixture of special characters and undesirable spacing. The default for the LP print service is 9600 baud.

Note - If a printer is connected by a parallel port, the baud setting is irrelevant.

Wrong Parity Setting

Some printers use a parity bit to ensure that data received for printing has not been garbled during transmission. The parity bit setting for the computer and the printer must match. If they do not match, some characters either will not be printed at all, or will be replaced by other characters. In this case, the output looks approximately correct; the word spacing is all right and many letters are in their correct place. The LP print service does not set the parity bit by default.

Wrong Tab Settings

If the file contains tabs, but the printer expects no tabs, the printed output may contain the complete contents of the file, but the text may be jammed against the right margin. Also, if the tab settings for the printer are incorrect, the text may not have a left margin, it may run together, it may be concentrated to a portion of the page, or it may be incorrectly double-spaced. The default is for tabs to be set every eight spaces.

Wrong Return Setting

If the output is double-spaced, but it should be single-spaced, either the tab settings for the printer are incorrect or the printer is adding a line feed after each return. The LP print service adds a return before each line feed, so the combination causes two line feeds.

If the print zigzags down the page, the `stty` option `onlcr` that sends a return before every line feed is not set. The `stty=onlcr` option is set by default, but you may have cleared it while trying to solve other printing problems.

Troubleshooting Hung LP Print Service Commands

If you type any of the LP commands (such as `lpssystem`, `lpadmin`, or `lpstat`) and nothing happens (no error message, status information, or prompt is displayed), chances are something is wrong with the LP scheduler. Such a problem can usually be resolved by stopping and restarting the LP scheduler. See “How to Stop the Print Scheduler” on page 65 and for instructions.

Troubleshooting Idle (Hung) Printers

You may find a printer that is idle, even though it has print requests queued to it. A printer may seem idle when it should not be for one of the following reasons:

- The current print request is being filtered.
- The printer has a fault.
- Networking problems may be interrupting the printing process.

Check the Print Filters

Slow print filters run in the background to avoid tying up the printer. A print request that requires filtering will not print until it has been filtered.

Check Printer Faults

When the LP print service detects a fault, printing resumes automatically, but not immediately. The LP print service waits about five minutes before trying again, and continues trying until a request is printed successfully. You can force a retry immediately by enabling the printer.

Check Network Problems

When printing files over a network, you may encounter the following types of problems:

- Requests sent to print servers may back up in the client system (local) queue.
- Requests sent to print servers may back up in the print server (remote) queue.

Print Requests Backed Up in the Local Queue

Print requests submitted to a print server may back up in the client system queue for the following reasons:

- The print server is down.
- The printer is disabled on the print server.
- The network between the print client and print server is down.
- Underlying SunOS 5.7 or compatible network software was not set up properly.

While you are tracking the source of the problem, you should stop new requests from being added to the queue. See “How to Accept or Reject Print Requests for a Printer” on page 81 for more information.

Print Requests Backed Up in the Remote Queue

If print requests back up in the print server queue, the printer has probably been disabled. When a printer is accepting requests, but not processing them, the requests are queued to print. Unless there is a further problem, once the printer is enabled, the print requests in the queue should print.

Troubleshooting Conflicting Status Messages

A user may enter a print request and be notified that the client system has accepted it, then receive mail from the print server that the print request has been rejected. These conflicting messages may occur for the following reasons:

- The print client may be accepting requests, while the print server is rejecting requests.
- The definition of the printer on the print client might not match the definition of that printer on the print server. More specifically, the definitions of the print job components, like filters, character sets, print wheels, or forms are not the same on the client and server systems.

You should check that identical definitions of these job components are registered on both the print clients and print servers so that local users can access printers on the print servers.

Troubleshooting Printing Problems

This section contains step-by-step instructions that explain:

- How to troubleshoot no output
- How to troubleshoot incorrect output
- How to unhang the LP commands
- How to troubleshoot an idle (hung) printer
- How to resolve conflicting status messages

▼ How to Troubleshoot No Printer Output

This task includes the following troubleshooting procedures to try when you submit a print request to a printer and nothing prints:

- Check the hardware (“To check the hardware:” on page 604).
- Check the network (“To check the network:” on page 605).

- Check the LP print service basic functions (“To check the basic functions of the LP print service: ” on page 606)
- Check printing from a SunOS 5.7 or compatible print client to a SunOS 5.7 or compatible print server (“To check printing from a SunOS 5.7 or compatible print client to a SunOS 5.7 or compatible print server:” on page 610).
- Check printing from a SunOS 5.7 or compatible print client to a SunOS 4.1 print server (“To check printing from a SunOS 5.7 or compatible print client to a SunOS 4.1 print server:” on page 611).
- Check printing from a SunOS 4.1 print client to a SunOS 5.7 or compatible print server (“To check printing from a SunOS 4.1 client to a SunOS 5.7 or compatible print server: ” on page 614).

Try the first three procedures in the order in which they are listed, before going to the specific print client/server case that applies. However, if the banner page prints, but nothing else does, turn to the instructions under “How to Troubleshoot Incorrect Output” on page 618.

To check the hardware:

1. **Check that the printer is plugged in and turned on.**
2. **Check that the cable is connected to the port on the printer and to the port on the system or server.**
3. **Make sure that the cable is the correct cable and that it is not defective.**

Refer to the manufacturer’s documentation. If the printer is connected to a serial port, verify that the cable supports hardware flow control; a NULL modem adapter supports this. Table 34–1 shows the pin configuration for NULL modem cables.

TABLE 34–1 Pin Configuration for NULL Modem Cables

	Host	Printer
Mini-Din-8	25-Pin D-sub	25-Pin D-sub
-	1 (FG)	1(FG)
3(TD)	2(TD)	3(RD)
5(RD)	3(RD)	2(TD)
6(RTS)	4(RTS)	5(CTS)

TABLE 34-1 Pin Configuration for NULL Modem Cables (continued)

	Host	Printer
Mini-Din-8	25-Pin D-sub	25-Pin D-sub
2(CTS)	5(CTS)	4(RTS)
4(SG)	7(SG)	7(SG)
7(DCD)	6(DSR), 8(DCD)	20(DTR)
1(DTR)	20(DTR)	6(DSR), 8(DCD)

4. **Check that any hardware switches for the ports are set properly.**
See the printer documentation for the correct settings.
5. **Check that the printer is operational.**
Use the printer's self-test feature, if the printer has one. Check the printer documentation for information about printer self-testing.
6. **Check that the baud settings for the computer and the printer are correct.**
If the baud settings are not the same for both the computer and the printer, sometimes nothing will print, but more often you get incorrect output. For instructions, see "How to Troubleshoot Incorrect Output" on page 618.

To check the network:

1. **Check that the network link between the print server and the print client is setup correctly.**

```
print_client# ping print_server
print_server is alive
print_server# ping print_client
print_client not available
```

If the message says the system is alive, you know you can reach the system, so the network is all right. The message also tells you that either a name service or the local `/etc/hosts` file has translated the host (system) name you entered into an IP address; otherwise, you would need to enter the IP address.

If you get a not available message, try to answer the following questions: How is NIS or NIS+ set up at your site? Do you need to take additional steps so that print servers and print clients can communicate with one another? If your site is not running NIS or NIS+, have you entered the IP address for the print server in each print client's `/etc/hosts` file, and entered all print client IP addresses in the `/etc/hosts` file of the print server?

2. (On a SunOS 5.0-5.1 print server only) Check that the `listen` port monitor is configured correctly.
3. (On a SunOS 5.0-5.1 print server only) Check that the network `listen` services are registered with the port monitor on the print server.

To check the basic functions of the LP print service:

This procedure uses the printer `luna` as an example of checking basic LP print service functions.

1. On both the print server and print client, make sure that the LP print service is running.
 - a. Check whether the LP scheduler is running.

```
# lpstat -r
scheduler is running
```

- b. If the scheduler is not running, become superuser or `lp`, and start the scheduler.

```
# /usr/lib/lp/lpsched
```

If you have trouble starting the scheduler, see "How to Unhang the LP Print Service" on page 624.

2. On both the print server and print client, make sure that the printer is accepting requests.
 - a. Check that the printer is accepting requests.

```
# lpstat -a
mars accepting requests since Jun 16 10:37 1998
luna not accepting requests since Jun 16 10:37 1998
unknown reason
```

This command verifies that the LP system is accepting requests for each printer configured for the system.

- b. If the printer is not accepting requests, become superuser or `lp`, and allow the printer to accept print requests.**

```
# accept luna
```

The specified printer now accepts requests.

- 3. On both the print server and print client, make sure that the printer is enabled to print submitted print requests.**

- a. Check that the printer is enabled.**

```
# lpstat -p luna
printer luna disabled since Jun 16 10:40 1998.
available.
unknown reason
```

This command displays information about printer status. You can omit the printer name to obtain information about all printers set up for the system. The following example shows a printer that is disabled.

- b. If the printer is disabled, become superuser or `lp`, and enable the printer.**

```
# enable luna
printer "luna" now enabled.
```

The specified printer is enabled to process print requests.

- 4. On the print server, make sure that the printer is connected to the correct serial port.**

- a. Check that the printer is connected to the correct serial port.**

```
# lpstat -t
scheduler is running
system default destination: luna
device for luna: /dev/term/a
```

The message `device for printer-name` shows the port address. Is the cable connected to the port to which the LP print service says is connected? If the port is correct, skip to Step 5 on page 608.

- b. Become superuser or `lp`.
- c. Change the file ownership of the device file that represents the port.

```
# chown lp device-filename
```

This command assigns the special user `lp` as the owner of the device file. In this command, *device-filename* is the name of the device file.

- d. Change the permissions on the printer port device file.

```
# chmod 600 device-filename
```

This command allows only superuser or `lp` to access the printer port device file.

5. On both the print server and print client, make sure that the printer is configured properly.
 - a. Check that the printer is configured properly.

```
# lpstat -p luna -l
printer luna is idle. enabled since Jun 16 10:38 1998. available.
Content types: postscript
Printer types: PS
```

The above example shows a PostScript printer that is configured properly, and that is available to process print requests. If the printer type and file content type are correct, skip to Step 6 on page 609.

- b. If the printer type or file content type is incorrect, try setting the print type to `unknown` and the content type to `any` on the print client.

```
# lpadmin -p printer-name -T printer-type -I file-content-type
```

6. On the print server, make sure that the printer is not faulted.

a. Check that the printer is not waiting because of a printer fault.

```
# lpadmin -p printer-name -F continue
```

This command instructs the LP print service to continue if it is waiting because of a fault.

b. Force an immediate retry by re-enabling the printer.

```
# enable printer-name
```

c. (Optional) Instruct the LP print service to enable quick notification of printer faults.

```
# lpadmin -p printer-name -A 'write root'
```

This command instructs the LP print service to set a default policy of writing root—sending the printer fault message to the terminal on which root is logged in—if the printer fails. This may help you get quick notification of faults as you try to fix the problem.

7. Make sure that the printer is not set up incorrectly as a login terminal.

Note - It is easy to mistakenly set up a printer as a login terminal, so be sure to check this possibility even if you think it does not apply.

a. Look for the printer port entry in the `ps -ef` command output.

```
# ps -ef
root 169 167 0 Apr 04 ? 0:08 /usr/lib/saf/listen tcp
root 939 1 0 19:30:47 ? 0:02 /usr/lib/lpsched
root 859 858 0 19:18:54 term/a 0:01 /bin/sh -c \ /etc/lp
/interfaces/luna
luna-294 rocket!smith ``passwd\n##
#
```

In the output from this command, look for the printer port entry. In the above example, port `/dev/term/a` is set up incorrectly as a login terminal. You can tell by the `"passwd\n##` information at the end of the line. If the port is set correctly, skip the last steps in this procedure.

b. Cancel the print request(s).

```
# cancel request-id
```

In this command, *request-id* is the request ID number for a print request to be canceled.

c. Set the printer port to be a nonlogin device.

```
# lpadmin -p printer-name -h
```

d. Check the `ps -ef` command output to verify that the printer port is no longer a login device.

If you do not find the source of the printing problem in the basic LP print service functions, continue to one of the following procedures for the specific client/server case that applies.

To check printing from a SunOS 5.7 or compatible print client to a SunOS 5.7 or compatible print server:

1. Check the basic functions of the LP print service on the print server, if you have not done so already.

For instructions on checking basic functions, see "To check the basic functions of the LP print service: " on page 606. Make sure that the printer works locally before trying to figure out why nothing prints when a request is made from a print client.

2. Check the basic functions of the LP print service on the print client, if you have not done so already.

For instructions on checking basic functions, see "To check the basic functions of the LP print service: " on page 606. On the print client, the LP scheduler has to be running, and the printer has to be enabled and accepting requests before any request from the client will print.

Note - For most of the following steps, you must be logged in as root or lp.

3. **Make sure that the print server is accessible.**
 - a. **On the print client, send an “are you there?” request to the print server.**

```
print_client# ping print_server
```

If you receive the message *print_server* not available, you may have a network problem.

4. **On SunOS 5.1 print client only, make sure that the print server is identified as type *s5* by viewing the Modify Printer window in Admintool.**
5. **Verify that the print server is operating properly.**

```
# lpstat -t luna
scheduler is running
system default destination: luna
device for luna: /dev/term/a
luna accepting requests since Jun 16 10:39 1998. available.
printer luna now printing luna-314. enabled since Jun 16 10:39 1998.
available.
luna-129          root          488    Jun 16 10:45
#
```

The above example shows a print server up and running.

6. **If the print server is not operating properly, go back to step 1.**

To check printing from a SunOS 5.7 or compatible print client to a SunOS 4.1 print server:

1. **Check the basic functions of the LP print service on the print client, if you have not done so already.**

For instructions, see “To check the basic functions of the LP print service: ” on page 606.
2. **Make sure that the print server is accessible.**
 - a. **On the print client, send an “are you there?” request to the print server.**

```
print_client# ping print_server
```

If you receive the message *print_server* not available, you may have a network problem.

3. Make sure that the `lpd` daemon on the print server is running.

a. On the print server, verify the `lpd` daemon is running.

```
$ ps -ax | grep lpd
126 ? IW 0:00 /usr/lib/lpd
200 p1 S 0:00 grep lpd
$
```

If the `lpd` daemon is running, a line is displayed, as shown in the above example. If it is not running, no process information is shown.

b. If `lpd` is not running on the print server, become superuser on the print server, and restart it.

```
# /usr/lib/lpd &
```

4. Make sure that the remote `lpd` daemon is configured properly.

a. On the print server, become superuser, and invoke the `lpc` command.

```
# /usr/etc/lpc
lpc>
```

b. Get LP status information.

```
lpc> status
luna:
queuing is enabled
printing is enabled
no entries
no daemon present
lpc>
```

Status information is displayed. In the above example, the daemon is not running and needs to be restarted.

c. If no daemon is present, restart the daemon.

```
lpc> restart luna
```

The daemon is restarted.

d. Verify that the lpd daemon has started.

```
lpc> status
```

e. Quit the lpc command.

```
lpc> quit
```

The shell prompt is redisplayed.

5. Make sure that the print client has access to the print server.

a. Check if there is an /etc/hosts.lpd file on the 4.1 print server.

On a 4.1 print server, if this file exists, it is used to determine whether an incoming print request can be accepted. If the file does not exist, all print client systems have access, so skip steps b and c.

b. If the file exists, see if the print client is listed in the file.

Requests from client systems not listed in the file are not transferred to the print server.

c. If the client is not listed, add the print client to the file.

Note - If you get this far without pinpointing the problem, the SunOS 4.1 system is probably set up and working properly.

6. Make sure that the connection to the remote `lpd` print daemon from the print client is made correctly.
 - a. On the print client, become superuser, and verify the `lpsched` daemon is running.

```
# ps -ef | grep lp
root 154 1 80 Jan 07 ? 0:02 /usr/lib/lpsched
```

The `lpsched` daemon should be running, as shown in the above example.

- b. Stop the LP print service.

```
# lpshut
```

The LP print service is stopped.

- c. Restart the LP print service.

```
# /usr/lib/lp/lpsched
```

The LP print service is restarted.

7. Make sure that the remote print server is identified correctly as a SunOS 4.1 system.

To check printing from a SunOS 4.1 client to a SunOS 5.7 or compatible print server:

1. Check the basic functions of the LP print service on the print server, if you have not done so already.

For instructions, see “To check the basic functions of the LP print service: ” on page 606. Make sure that the printer works locally before trying to figure out why nothing prints when a request is made from a print client.

Note - You should be logged in as superuser or `lp` on the system specified in the following steps.

2. Make sure that the print client is accessible.

- a. On the SunOS 5.7 or compatible print server, send an “are you there?” request to the print client.

```
print_server# ping print_client
print_client is alive
```

If you receive the message *print_client* not available, you may have a network problem.

3. On the print client, verify the printer is set up correctly.

```
# lpr -P luna /etc/fstab
lpr: cannot access luna
#
```

This command shows whether the print client is working. The above example shows that the print client is not working correctly.

4. Make sure that the `lpd` daemon is running on the print client.
 - a. Verify the `lpd` daemon is running.

```
# ps -ax | grep lpd
118 ? IW 0:02 /usr/lib/lpd
#
```

This command shows if the `lpd` daemon is running on the print client. The above example shows that the daemon is running.

- b. On the print client, start the `lpd` daemon.

```
# /usr/lib/lpd &
```

5. On the print client, make sure that there is a `printcap` entry identifying the printer.

a. Verify the printer is known.

```
# lpr -P mercury /etc/fstab
lpr: mercury: unknown printer
#
```

The above example shows that the `/etc/printcap` file does not have an entry for the specified printer.

b. If there is no entry, edit the `/etc/printcap` file and add the following information:

```
printer-name|print-server:\  
:lp=:rm=print-server:rp=printer-name:br#9600:rw:\  
:lf=/var/spool/lpd/printer-name/log:\  
:sd=/var/spool/lpd/printer-name:
```

The following example shows an entry for printer `luna` connected to print server `neptune`.

```
luna|neptune:\  
:lp=:rm=neptune:rp=luna:br#9600:rw:\  
:lf=/var/spool/lpd/luna/log:\  
:sd=/var/spool/lpd/luna:
```

c. Create a spooling directory (`/var/spool/lpd/printer-name`) for the printer.

6. Make sure that the print client `lpd` is not in a wait state by forcing a retry.

If the print server is up and responding, the print client `lpd` may be in a wait state before attempting a retry.

- a. **As superuser on the print client, invoke the `lpc` command.**

The `lpc>` prompt is displayed.

- b. **Restart the printer.**

- c. **Quit the `lpc` command.**

The shell prompt is redisplayed.

```
# lpc
lpc> restart luna
luna:
      no daemon to abort
luna:
      daemon started
# quit
$
```

7. **Check the connection to the print server.**

- a. **On the print client, become superuser, and check the printer log file.**

```
# more /var/spool/lpd/luna/log
```

Frequently, no information is displayed.

- b. **Also check the printer status log.**

```
# more /var/spool/lpd/luna/status
waiting for luna to come up
#
```

- c. **If the connection is all right, on the print server, verify the print server is setup correctly.**

```
# lpstat -t
scheduler is running
system default destination: luna
device for luna: /dev/term/a
luna accepting requests since Jun 16 10:41 1998
printer luna now printing luna-314. enabled since
Jun 16 10:41 1998. available.
luna-314          root          488   Jun 16 10:41
#
```

The above example shows a print server that is up and running.
If the print server is not running, go back to Step 1 on page 614 before continuing.

▼ How to Troubleshoot Incorrect Output

1. **Log in as superuser or lp.**
2. **Make sure that the printer type is correct.**

An incorrect printer type may cause incorrect output. For example, if you specify printer type PS and the pages print in reverse order, try printer type PSR. (These type names must be in uppercase.) Also, an incorrect printer type may cause missing text, illegible text, or text with the wrong font. To determine the printer type, examine the entries in the `terminfo` database. For information on the structure of the `terminfo` database, see “Printer Type” on page 24.

- a. **On the print server, display the printer’s characteristics.**

```
$ lpstat -p luna -l
printer luna is idle. enabled since Jun 16 10:43 1998.
available.
Form mounted:
Content types: any
Printer types: NeWSprinter20
Description:
Connection: direct
Interface: /etc/lp/interfaces/alamosa
After fault: continue
Users allowed:
(all)
Forms allowed:
(none)
Banner not required
Character sets:
```

(continued)

```

Default pitch:
Default page size: 80 wide 66 long
Default port settings:
$

```

- b. Consult the printer manufacturer's documentation to determine the printer model.
- c. If the printer type is not correct, change it with Admintool's Modify Printer option, or use the following `lpadmin` command.

```
# lpstat -p printer-name -T printer-type
```

On the print client, the printer type should be `unknown`. On the print server, the printer type must match a `terminfo` entry that is defined to support the model of printer you have. If there is no `terminfo` entry for the type of printer you have, see "How to Add a `terminfo` Entry for an Unsupported Printer" on page 127.

3. If the banner page prints, but there is no output for the body of the document, check the file content types.

File content types specified for a printer indicate the types of files the printer can print directly without filtering. An incorrect file content type causes filtering to be bypassed when it may be needed.

- a. Note the information on file content type that was supplied in the previous step by the `lpstat` command.

On the print client, the file content type should be `any`, unless you have good reason to specify one or more explicit content types. If a content is specified on the client, filtering is done on the print client, rather than the print server. In addition, content types on the client must match the content types specified on the print server, which in turn must reflect the capabilities of the printer.

- b. Consult your printer manufacturer's documentation to determine which types of files the printer can print directly.

The names you use to refer to these types of files do not have to match the names used by the manufacturer. However, the names you use must agree with the names used by the filters known to the LP print service.

- c. If the file content type is not correct, change it with Admintool's Modify Printer option, or the following `lpadmin` command.

```
# lpadmin -p printer-name -I file-content-type(s)
```

Run this command on either the print client, or print server, or both, as needed. Try `-I any` on the print client, and `-I ""` on the print server. The latter specifies a null file content type list, which means an attempt should be made to filter all files, because the printer can directly print only files that exactly match its printer type.

This combination is a good first choice when files are not printing. If it works, you may want to try specifying explicit content types on the print server to reduce unnecessary filtering. For a local PostScript printer, you should use `postscript`, or `postscript, simple`— if the printer supports these types. Be aware that `PS` and `PSR` are not file content types; they are printer types.

If you omit `-I`, the file content list defaults to `simple`. If you use the `-I` option and want to specify file content types in addition to `simple`, `simple` must be included in the list.

When specifying multiple file content types, separate the names with commas. Or you can separate names with spaces and enclose the list in quotation marks. If you specify `any` as the file content type, no filtering will be done and only file types that can be printed directly by the printer should be sent to it.

4. Check that the print request does not bypass filtering needed to download fonts.

If a user submits a print request to a PostScript printer with the command `lp -T PS`, no filtering is done. Try submitting the request with the command `lp -T postscript` to force filtering, which may result in the downloading of non-resident fonts needed by the document.

5. Make sure that the `stty` settings for the printer port are correct.

- a. Read the printer documentation to determine the correct `stty` settings for the printer port.

Note - If a printer is connected by a parallel port, the baud setting is irrelevant.

- b. Examine the current settings by using the `stty` command.

```
# stty -a < /dev/term/a
speed 9600 baud;
rows = 0; columns = 0; ypixels = 0; xpixels = 0;
```

(continued)

(Continuation)

```
eucw 1:0:0:0, scrw 1:0:0:0
intr = ^c; quit = ^|; erase = ^?; kill = ^u;
eof = ^d; eol = <undef>; eol2 = <undef>; swtch = <undef>;
start = ^q; stop = ^s; susp = ^z; dsusp = ^y;
rprnt = ^r; flush = ^o; werase = ^w; lnext = ^v;
parenb -parodd cs7 -cstopb -hupcl cread -clocal -loblk -parext
-ignbrk brkint -ignpar -parmrk -inpck istrip -inlcr -igncr icrnl -iuclc
ixon -ixany -ixoff imaxbel
isig icanon -xcase echo echoe echok -echonl -noflsh
-tostop echoctl -echoprt echoke -defecho -flusho -pendin iexten
opost -olcuc onlcr -ocrnl -onocr -onlret -ofill -ofdel tab3
#
```

This command shows the current `stty` settings for the printer port. Table 34-2 shows the default `stty` options used by the LP print service's standard printer interface program.

TABLE 34-2 Default `stty` Settings Used by the Standard Interface Program

Option	Meaning
-9600	Set baud rate to 9600
-cs8	Set 8-bit bytes
-cstopb	Send one stop bit per byte
-parity	Do not generate parity
-ixon	Enable XON/XOFF (also known as START/STOP or DC1/DC3)
-opost	Do "output post-processing" using all the settings that follow in this table
-olcuc	Do not map lowercase to uppercase
-onlcr	Change line feed to carriage return/line feed

TABLE 34-2 Default `stty` Settings Used by the Standard Interface Program *(continued)*

Option	Meaning
<code>-ocrnl</code>	Do not change carriage returns into line feeds
<code>-onocr</code>	Output carriage returns even at column 0
<code>-nl0</code>	No delay after line feeds
<code>-cr0</code>	No delay after carriage returns
<code>-tab0</code>	No delay after tabs
<code>-bs0</code>	No delay after backspaces
<code>-vt0</code>	No delay after vertical tabs
<code>-ff0</code>	No delay after form feeds

c. Change the `stty` settings.

```
# lpadmin -p printer-name -o "stty= options"
```

Use Table 34-3 to choose `stty` options to correct various problems affecting print output.

TABLE 34-3 stty Options to Correct Print Output Problems

stty Values	Result	Possible Problem From Incorrect Setting
110, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400	Sets baud rate to the specified value (enter only one baud rate)	Random characters and special characters may be printed and spacing may be inconsistent
oddp	Sets odd parity	Missing or incorrect characters appear randomly
evenp	Sets even parity	
-parity	Sets no parity	
-tabs	Sets no tabs	Text is jammed against right margin
tabs	Sets tabs every eight spaces	Text has no left margin, is run together, or is jammed together
-onlcr	Sets no carriage return at the beginning of line(s)	Incorrect double spacing
onlcr	Sets carriage return at beginning of line(s)	The print zigzags down the page

You can change more than one option setting by enclosing the list of options in single quotation marks and separating each option with spaces. For example, suppose the printer requires you to enable odd parity and set a 7-bit character size. You would type a command similar to that shown in the following example:

```
# lpadmin -p neptune -o "stty='parenb parodd cs7'"
```

The `stty` option `parenb` enables parity checking/generation, `parodd` sets odd parity generation, and `cs7` sets the character size to 7 bits.

6. Verify that the document prints correctly.

```
# lp -d printer-name filename
```

▼ How to Unhang the LP Print Service

1. Log in as superuser or lp.

2. Stop the LP print service.

```
# lpshut
```

If this command hangs, press Control-c and proceed to the next step. If this command succeeds, skip to step 4.

3. Identify the LP process IDs.

```
# ps -el | grep lp
 134 term/a  0:01 lpsched
#
```

Use the process ID numbers (PIDs) from the first column in place of the *pid* variables in the next step.

4. Stop the LP processes by using the `kill -15` command.

```
# kill -15 103 134
```

This should stop the LP print service processes. If the processes do not stop, as a last resort go to step 5.

5. As a last resort, terminate the processes abruptly.

```
# kill -9 103 134
```

All the `lp` processes are terminated.

6. Remove the `SCHEDLOCK` file so you can restart the LP print service.

```
# rm /usr/spool/lp/SCHEDLOCK
```

7. Restart the LP print service.

```
# /usr/lib/lp/lpsched
```

The LP print service should restart. If you are having trouble restarting the scheduler, see “How to Restart the Print Scheduler” on page 66.

▼ How to Troubleshoot an Idle (Hung) Printer

This task includes a number of procedures to use when a printer appears idle but it should not be. It makes sense to try the procedures in order, but the order is not mandatory.

To check that the printer is ready to print:

1. Display printer status information.

```
# lpstat -p printer-name
```

The information displayed shows you whether the printer is idle or active, enabled or disabled, or available or not accepting print requests. If everything looks all right, continue with other procedures in this section. If you cannot run the `lpstat` command, see “How to Unhang the LP Print Service” on page 624.

2. If the printer is not available (not accepting requests), allow the printer to accept requests.

```
# accept printer-name
```

The printer begins to accept requests into its print queue.

3. If the printer is disabled, re-enable it.

```
# enable printer-name
```

This command re-enables the printer so that it will act on the requests in its queue.

To check for print filtering:

Check for print filtering by using the `lpstat -o` command.

```
$ lpstat -o luna
luna-10      fred          1261   Mar 12 17:34 being filtered
luna-11      iggy          1261   Mar 12 17:36 on terra
luna-12      jack          1261   Mar 12 17:39 on terra
```

(continued)

(Continuation)

```
$
```

See if the first waiting request is being filtered. If the output looks like the above example, the file is being filtered; the printer is not hung, it just is taking a while to process the request.

To resume printing after a printer fault:

1. **Look for a message about a printer fault and try to correct the fault if there is one.**

Depending on how printer fault alerts have been specified, messages may be sent to root by email or written to a terminal on which root is logged in.

2. **Re-enable the printer.**

```
# enable printer-name
```

If a request was blocked by a printer fault, this command will force a retry. If this command does not work, continue with other procedures in this section.

To send print requests to a remote printer when they back up in the local queue:

1. **On the print client, stop further queuing of print requests to the print server.**

```
# reject printer-name
```

2. **On the print client, send an “are you there?” request to the print server.**

```
print_client# ping print_server  
print_server is alive
```

If you receive the message *print_server* not available, you may have a network problem.

3. **After you fix the above problem, allow new print requests to be queued.**

```
# accept printer-name
```

4. If necessary, re-enable the printer.

```
# enable printer-name
```

To free print requests from a print client that back up in the print server queue:

1. On the print server, stop further queuing of print requests from any print client to the print server.

```
# reject printer-name
```

2. Display the `lp sched` log file.

```
# more /var/lp/logs/lpsched
```

The information displayed may help you pinpoint what is preventing the print requests from the print client to the print server from being printed.

3. After you fix the problem, allow new print requests to be queued.

```
# accept printer-name
```

4. If necessary, re-enable the printer on the print server.

```
# enable printer-name
```

▼ How to Resolve Conflicting Printer Status Messages

1. On the print server, verify the printer is enabled and is accepting requests.

```
# lpstat -p printer-name
```

Users will see conflicting status messages when the print client is accepting requests, but the print server is rejecting requests.

2. **On the print server, check that the definition of the printer on the print client matches the definition of the printer on the print server.**

```
# lpstat -p -l printer-name
```

Look at the definitions of the print job components, like print filters, character sets, print wheels, and forms, to be sure they are the same on both the client and server systems so that local users can access printers on print server systems.

Troubleshooting File System Problems

This is a list of the information in this chapter.

- “General `fsck` Error Messages ” on page 631
- “Initialization Phase `fsck` Messages” on page 632
- “Phase 1: Check Blocks and Sizes Messages” on page 636
- “Phase 1B: Rescan for More DUPS Messages” on page 640
- “Phase 2: Check Path Names Messages” on page 641
- “Phase 3: Check Connectivity Messages” on page 650
- “Phase 4: Check Reference Counts Messages” on page 653
- “Phase 5: Check Cylinder Groups Messages” on page 657
- “Cleanup Phase Messages” on page 659

See “Checking File System Integrity” in *System Administration Guide, Volume I* for information about the `fsck` program and how to use it to check file system integrity.

Error Messages

Normally, `fsck` is run non-interactively to *preen* the file systems after an abrupt system halt in which the latest file system changes were not written to disk. Preening automatically fixes any basic file system inconsistencies and does not try to repair more serious errors. While preening a file system, `fsck` fixes the inconsistencies it expects from such an abrupt halt. For more serious conditions, the command reports the error and terminates.

When you run `fsck` interactively, `fsck` reports each inconsistency found and fixes innocuous errors. However, for more serious errors, the command reports the

inconsistency and prompts you to choose a response. When you run `fsck` using the `-y` or `-n` options, your response is predefined as yes or no to the default response suggested by `fsck` for each error condition.

Some corrective actions will result in some loss of data. The amount and severity of data loss may be determined from the `fsck` diagnostic output.

`fsck` is a multipass file system check program. Each pass invokes a different phase of the `fsck` program with different sets of messages. After initialization, `fsck` performs successive passes over each file system, checking blocks and sizes, path names, connectivity, reference counts, and the map of free blocks (possibly rebuilding it). It also performs some cleanup.

The phases (passes) performed by the UFS version of `fsck` are:

- Initialization
- Phase 1 – Check blocks and sizes
- Phase 2 – Check path names
- Phase 3 – Check connectivity
- Phase 4 – Check reference counts
- Phase 5 – Check cylinder groups

The next sections describe the error conditions that may be detected in each phase, the messages and prompts that result, and possible responses you can make.

Messages that may appear in more than one phase are described in “General `fsck` Error Messages ” on page 631. Otherwise, messages are organized alphabetically by the phases in which they occur.

Many of the messages include the abbreviations shown in Table 35-1:

TABLE 35-1 Error Message Abbreviations

Abbreviation	Meaning
BLK	Block number
DUP	Duplicate block number
DIR	Directory name
CG	Cylinder group

TABLE 35-1 Error Message Abbreviations *(continued)*

Abbreviation	Meaning
MTIME	Time file was last modified
UNREF	Unreferenced

Many of the messages also include variable fields, such as inode numbers, which are represented in this book by an italicized term, such as *inode-number*. For example, this screen message:

```
INCORRECT BLOCK COUNT I=2529
```

is shown as:

```
INCORRECT BLOCK COUNT I=inode-number
```

General `fsck` Error Messages

The error messages in this section may be displayed in any phase after initialization. Although they offer the option to continue, it is generally best to regard them as fatal. They reflect a serious system failure and should be handled immediately. When confronted with such a message, terminate the program by entering `n(o)`. If you cannot determine what caused the problem, contact your local service provider or another qualified person.

```
CANNOT SEEK: BLK block-number (CONTINUE)
```

Reason Error Occurred

A request to move to a specified block number, *block-number*, in the file system failed. This message indicates a serious problem, probably a hardware failure.

If you want to continue the file system check, `fsck` will retry the move and display a list of sector numbers that could not be moved. If the block was part of the virtual memory buffer cache, `fsck` will terminate with a fatal I/O error message.

How to Solve the Problem

If the disk is experiencing hardware problems, the problem will persist. Run `fsck` again to recheck the file system.

If the recheck fails, contact your local service provider or another qualified person.

```
CANNOT READ: BLK block-number (CONTINUE)
```

Reason Error Occurred

A request to read a specified block number, *block-number*, in the file system failed. The message indicates a serious problem, probably a hardware failure.

If you want to continue the file system check, `fsck` will retry the read and display a list of sector numbers that could not be read. If the block was part of the virtual memory buffer cache, `fsck` will terminate with a fatal I/O error message.

If `fsck` tries to write back one of the blocks on which the read failed, it will display the following message:

```
WRITING ZERO'ED BLOCK sector-numbers TO  
DISK
```

How to Solve the Problem

If the disk is experiencing hardware problems, the problem will persist. Run `fsck` again to recheck the file system.

If the recheck fails, contact your local service provider or another qualified person.

```
CANNOT WRITE: BLK block-number (CONTINUE)
```

Reason Error Occurred

A request to write a specified block number, *block-number*, in the file system failed.

If you continue the file system check, `fsck` will retry the write and display a list of sector numbers that could not be written. If the block was part of the virtual memory buffer cache, `fsck` will terminate with a fatal I/O error message.

How to Solve the Problem

The disk may be write-protected. Check the write-protect lock on the drive.

If the disk has hardware problems, the problem will persist. Run `fsck` again to recheck the file system.

If the write-protect is not the problem or the recheck fails, contact your local service provider or another qualified person.

Initialization Phase `fsck` Messages

In the initialization phase, command-line syntax is checked. Before the file system check can be performed, `fsck` sets up tables and opens files.

The messages in this section relate to error conditions resulting from command-line options, memory requests, the opening of files, the status of files, file system size checks, and the creation of the scratch file. All such initialization errors terminate `fsck` when it is preening the file system.

```
bad inode number inode-number to ginode
```

Reason Error Occurred

An internal error occurred because of a nonexistent inode *inode-number*. `fsck` exits.

How to Solve the Problem

Contact your local service provider or another qualified person.

```
cannot alloc size-of-block map bytes for blockmap  
cannot alloc size-of-free map bytes for freemap  
cannot alloc size-of-state map bytes for statemap  
cannot alloc size-of-lncntp bytes for lncntp
```

Reason Error Occurred

Request for memory for its internal tables failed. `fsck` terminates. This message indicates a serious system failure that should be handled immediately. This condition may occur if other processes are using a very large amount of system resources.

How to Solve the Problem

Killing other processes may solve the problem. If not, contact your local service provider or another qualified person.

```
Can't open checklist file: filename
```

Reason Error Occurred

The file system checklist file *filename* (usually `/etc/vfstab`) cannot be opened for reading. `fsck` terminates.

How to Solve the Problem

Check if the file exists and if its access modes permit read access.

```
Can't open filename
```

Reason Error Occurred

`fsck` cannot open file system *filename*. When running interactively, `fsck` ignores this file system and continues checking the next file system given.

How to Solve the Problem

Check to see if read and write access to the raw device file for the file system is permitted.

```
Can't stat root
```

Reason Error Occurred

`fsck` request for statistics about the root directory failed. `fsck` terminates.

How to Solve the Problem

This message indicates a serious system failure. Contact your local service provider or another qualified person.

```
Can't stat filename
Can't make sense out of name filename
```

Reason Error Occurred

`fsck` request for statistics about the file system *filename* failed. When running interactively, `fsck` ignores this file system and continues checking the next file system given.

How to Solve the Problem

Check if the file system exists and check its access modes.

```
filename: (NO WRITE)
```

Reason Error Occurred

Either the `-n` option was specified or `fsck` could not open the file system *filename* for writing. When `fsck` is running in no-write mode, all diagnostic messages are displayed, but `fsck` does not attempt to fix anything.

How to Solve the Problem

If `-n` was not specified, check the type of the file specified. It may be the name of a regular file.

```
IMPOSSIBLE MINFREE=percent IN SUPERBLOCK (SET TO DEFAULT)
```

Reason Error Occurred

The superblock minimum space percentage is greater than 99 percent or less than 0 percent.

How to Solve the Problem

To set the `minfree` parameter to the default 10 percent, type `y` at the default prompt. To ignore the error condition, type `n` at the default prompt.

```
filename: BAD SUPER BLOCK: message
USE AN ALTERNATE SUPER-BLOCK TO SUPPLY NEEDED INFORMATION;
e.g., fsck[-f ufs] -o b=# [special ...]
where # is the alternate superblock. See fsck_ufs(1M)
```

Reason Error Occurred

fsck has had an internal error, whose message is *message*.

How to Solve the Problem

If one of the following messages are displayed, contact your local service provider or another qualified person:

```
CPG OUT OF RANGE
FRAGS PER BLOCK OR FRAGSIZE WRONG
INODES PER GROUP OUT OF RANGE
INOPB NONSENSICAL RELATIVE TO BSIZE
MAGIC NUMBER WRONG
NCG OUT OF RANGE
NCYL IS INCONSISTENT WITH NCG*CPG
NUMBER OF DATA BLOCKS OUT OF RANGE
NUMBER OF DIRECTORIES OUT OF RANGE
ROTATIONAL POSITION TABLE SIZE OUT OF RANGE
SIZE OF CYLINDER GROUP SUMMARY AREA WRONG
SIZE TOO LARGE
BAD VALUES IN SUPERBLOCK
```

Reason Error Occurred

The superblock has been corrupted.

How to Solve the Problem

Use an alternative superblock to supply needed information. Specifying block 32 is a good first choice. You can locate an alternative copy of the superblock by running the `newfs -N` command on the slice. Be sure to specify the `-N` option; otherwise, `newfs` overwrites the existing file system.

```
UNDEFINED OPTIMIZATION IN SUPERBLOCK (SET TO DEFAULT)
```

Reason Error Occurred

The superblock optimization parameter is neither `OPT_TIME` nor `OPT_SPACE`.

How to Solve the Problem

To minimize the time to perform operations on the file system, type `y` at the `SET TO DEFAULT` prompt. To ignore this error condition, type `n`.

Phase 1: Check Blocks and Sizes Messages

This phase checks the inode list. It reports error conditions encountered while:

- Checking inode types
- Setting up the zero-link-count table
- Examining inode block numbers for bad or duplicate blocks
- Checking inode size
- Checking inode format

All errors in this phase except `INCORRECT BLOCK COUNT`, `PARTIALLY TRUNCATED INODE`, `PARTIALLY ALLOCATED INODE`, and `UNKNOWN FILE TYPE` terminate `fsck` when it is preening a file system.

The other possible error messages displayed in this phase are referenced below.

- *BAD STATE state-number TO BLKERR*
- *block-number DUP I=inode-number*
- *EXCESSIVE BAD BLOCKS I=inode-number (CONTINUE)*
- *EXCESSIVE DUP BLKS I=inode-number (CONTINUE)*
- *INCORRECT BLOCK COUNT I=inode-number*
(number-of-BAD-DUP-or-missing-blocks should be number-of-blocks-in-filesystem)
(CORRECT)
- *LINK COUNT TABLE OVERFLOW (CONTINUE)*
- *PARTIALLY ALLOCATED INODE I=inode-number (CLEAR)*
- *PARTIALLY TRUNCATED INODE I=inode-number (SALVAGE)*
- *UNKNOWN FILE TYPE I=inode-number (CLEAR)*

These messages (in alphabetical order) may occur in phase 1:

<i>block-number BAD I=inode-number</i>
--

Reason Error Occurred**How to Solve the Problem**

Inode *inode-number* contains a block number *block-number* with a number lower than the number of the first data block in the file system or greater than the number of the last block in the file system. This error condition may generate the EXCESSIVE BAD BLKS error message in phase 1 if inode *inode-number* has too many block numbers outside the file system range. This error condition generates the BAD/DUP error message in phases 2 and 4.

N/A

```
BAD MODE: MAKE IT A FILE?
```

Reason Error Occurred**How to Solve the Problem**

The status of a given inode is set to all 1s, indicating file system damage. This message does not indicate physical disk damage, unless it is displayed repeatedly after `fsck -y` has been run.

Type `y` to reinitialize the inode to a reasonable value.

```
BAD STATE state-number TO BLKERR
```

Reason Error Occurred**How to Solve the Problem**

An internal error has scrambled the `fsck` state map so that it shows the impossible value *state-number*. `fsck` exits immediately.

Contact your local service provider or another qualified person.

```
block-number DUP I=inode-number
```

Reason Error Occurred**How to Solve the Problem**

Inode *inode-number* contains a block number *block-number*, which is already claimed by the same or another inode. This error condition may generate the EXCESSIVE DUP BLKS error message in phase 1 if inode *inode-number* has too many block numbers claimed by the same or another inode. This error condition invokes phase 1B and generates the BAD/DUP error messages in phases 2 and 4.

N/A

DUP TABLE OVERFLOW (CONTINUE)

Reason Error Occurred**How to Solve the Problem**

There is no more room in an internal table in `fsck` containing duplicate block numbers. If the `-o p` option is specified, the program terminates.

To continue the program, type `y` at the CONTINUE prompt. When this error occurs, a complete check of the file system is not possible. If another duplicate block is found, this error condition repeats. Increase the amount of virtual memory available (by killing some processes, increasing swap space) and run `fsck` again to recheck the file system. To terminate the program, type `n`.

EXCESSIVE BAD BLOCKS I=*inode-number* (CONTINUE)

Reason Error Occurred**How to Solve the Problem**

Too many (usually more than 10) blocks have a number lower than the number of the first data block in the file system or greater than the number of the last block in the file system associated with inode *inode-number*. If the `-o p` (preen) option is specified, the program terminates.

To continue the program, type `y` at the CONTINUE prompt. When this error occurs, a complete check of the file system is not possible. You should run `fsck` again to recheck the file system. To terminate the program, type `n`.

EXCESSIVE DUP BLKS I=*inode-number* (CONTINUE)

Reason Error Occurred

Too many (usually more than 10) blocks are claimed by the same or another inode or by a free-list. If the `-o p` option is specified, the program terminates.

How to Solve the Problem

To continue the program, type `y` at the `CONTINUE` prompt. When this error occurs, a complete check of the file system is not possible. You should run `fsck` again to recheck the file system. To terminate the program, type `n`.

```
INCORRECT BLOCK COUNT I=inode-  
number (number-of-BAD-DUP-or-missing-blocks should be  
number-of-blocks-in-filesystem) (CORRECT)
```

Reason Error Occurred

The block count for inode *inode-number* is *number-of-BAD-DUP-or-missing-blocks*, but should be *number-of-blocks-in-filesystem*. When preening, `fsck` corrects the count.

How to Fix the Problem

To replace the block count of inode *inode-number* by *number-of-blocks-in-filesystem*, type `y` at the `CORRECT` prompt. To terminate the program, type `n`.

```
LINK COUNT TABLE OVERFLOW (CONTINUE)
```

Reason Error Occurred

There is no more room in an internal table for `fsck` containing allocated inodes with a link count of zero. If the `-o p` (`preen`) option is specified, the program exits and `fsck` has to be completed manually.

How to Fix the Problem

To continue the program, type `y` at the `CONTINUE` prompt. If another allocated inode with a zero-link count is found, this error condition repeats. When this error occurs, a complete check of the file system is not possible. You should run `fsck` again to recheck the file system. Increase the virtual memory available by killing some processes or increasing swap space, then run `fsck` again. To terminate the program, type `n`.

```
PARTIALLY ALLOCATED INODE I=inode-number (CLEAR)
```

Reason Error Occurred

Inode *inode-number* is neither allocated nor unallocated. If the `-o p` (preen) option is specified, the inode is cleared.

How to Solve the Problem

To deallocate the inode *inode-number* by zeroing out its contents, type `y`. This may generate the `UNALLOCATED` error condition in phase 2 for each directory entry pointing to this inode. To ignore the error condition, type `n`. A no response is appropriate only if you intend to take other measures to fix the problem.

```
PARTIALLY TRUNCATED INODE I=inode-number (SALVAGE)
```

Reason Error Occurred

`fsck` has found inode *inode-number* whose size is shorter than the number of blocks allocated to it. This condition occurs only if the system crashes while truncating a file. When preening the file system, `fsck` completes the truncation to the specified size.

How to Solve the Problem

To complete the truncation to the size specified in the inode, type `y` at the `SALVAGE` prompt. To ignore this error condition, type `n`.

```
UNKNOWN FILE TYPE I=inode-number (CLEAR)
```

Reason Error Occurred

The mode word of the inode *inode-number* shows that the inode is not a pipe, special character inode, special block inode, regular inode, symbolic link, FIFO file, or directory inode. If the `-o p` option is specified, the inode is cleared.

How to Solve the Problem

To deallocate the inode *inode-number* by zeroing its contents, which results in the `UNALLOCATED` error condition in phase 2 for each directory entry pointing to this inode, type `y` at the `CLEAR` prompt. To ignore this error condition, type `n`.

Phase 1B: Rescan for More DUPS Messages

When a duplicate block is found in the file system, this message is displayed:

```
block-number DUP I=inode-number
```

Reason Error Occurred

Inode *inode-number* contains a block number *block-number* that is already claimed by the same or another inode. This error condition generates the `BAD/DUP` error message in phase 2. Inodes that have overlapping blocks may be determined by examining this error condition and the `DUP` error condition in phase 1.

How to Solve the Problem

When a duplicate block is found, the file system is rescanned to find the inode that previously claimed that block.

Phase 2: Check Path Names Messages

This phase removes directory entries pointing to bad inodes found in phases 1 and 1B. It reports error conditions resulting from:

- Incorrect root inode mode and status
- Directory inode pointers out of range
- Directory entries pointing to bad inodes
- Directory integrity checks

When the file system is being preened (`-o p` option), all errors in this phase terminate `fsck`, except those related to directories not being a multiple of the block size, duplicate and bad blocks, inodes out of range, and extraneous hard links.

Other possible error messages displayed in this phase are referenced below.

- *BAD INODE state-number TO DESCEND*
- *BAD INODE NUMBER FOR '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)*
- *BAD INODE NUMBER FOR '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)*
- *BAD RETURN STATE state-number FROM DESCEND*
- *BAD STATE state-number FOR ROOT INODE*
- *BAD STATE state-number FOR INODE=inode-number*
- *DIRECTORY TOO SHORT I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)*
- *DIRECTORY filename: LENGTH file-size NOT MULTIPLE OF block-number (ADJUST)*
- *DIRECTORY CORRUPTED I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (SALVAGE)*
- *DUP/BAD I=inode-number OWNER=O MODE=M SIZE=file-size MTIME=modification-time TYPE=filename (REMOVE)*
- *DUPS/BAD IN ROOT INODE (REALLOCATE)*

- EXTRA '.' ENTRY I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)
- EXTRA '..' ENTRY I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)
- hard-link-number IS AN EXTRANEIOUS HARD LINK TO A DIRECTORY filename (REMOVE)
- inode-number OUT OF RANGE I=inode-number NAME=filename (REMOVE)
- MISSING '.' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)
- MISSING '.' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename CANNOT FIX, FIRST ENTRY IN DIRECTORY CONTAINS filename
- MISSING '.' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename CANNOT FIX, INSUFFICIENT SPACE TO ADD '.'
- MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (FIX)
- MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename CANNOT FIX, SECOND ENTRY IN DIRECTORY CONTAINS filename
- MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename CANNOT FIX, INSUFFICIENT SPACE TO ADD '..'
- NAME TOO LONG filename
- ROOT INODE UNALLOCATED (ALLOCATE)
- ROOT INODE NOT DIRECTORY (REALLOCATE)
- UNALLOCATED I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time type=filename (REMOVE)
- ZERO LENGTH DIRECTORY I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time DIR=filename (REMOVE)

BAD INODE <i>state-number</i> TO DESCEND
--

Reason Error Occurred

An `fsck` internal error has passed an invalid state *state-number* to the routine that descends the file system directory structure. `fsck` exits.

How to Solve the Problem

If this error message is displayed, contact your local service provider or another qualified person.

```
BAD INODE NUMBER FOR '.' I=inode-number OWNER=UID MODE=file-mode
SIZE=file-size MTIME=modification-time DIR=filename (FIX)
```

Reason Error Occurred

A directory *inode-number* has been found whose inode number for "." does not equal *inode-number*.

How to Solve the Problem

To change the inode number for "." to be equal to *inode-number*, type *y* at the FIX prompt To leave the inode numbers for "." unchanged, type *n*.

```
BAD INODE NUMBER FOR '..' I=inode-number OWNER=UID MODE=file-mode
SIZE=file-size MTIME=modification-time DIR=filename (FIX)
```

Reason Error Occurred

A directory *inode-number* has been found whose inode number for ".." does not equal the parent of *inode-number*.

How to Solve the Problem

To change the inode number for ".." to be equal to the parent of *inode-number*, type *y* at the FIX prompt. (Note that ".." in the root inode points to itself.)To leave the inode number for ".." unchanged, type *n*.

```
BAD RETURN STATE state-number FROM DESCEND
```

Reason Error Occurred

An *fsck* internal error has returned an impossible state *state-number* from the routine that descends the file system directory structure. *fsck* exits.

How to Solve the Problem

If this message is displayed, contact your local service provider or another qualified person.

```
BAD STATE state-number FOR ROOT INODE
```

Reason Error Occurred

An internal error has assigned an impossible state *state-number* to the root inode. *fsck* exits.

How to Solve the Problem

If this error message is displayed, contact your local service provider or another qualified person.

```
BAD STATE state-number FOR INODE=inode-number
```

Reason Error Occurred

An internal error has assigned an impossible state *state-number* to inode *inode-number*.
fsck exits.

How to Solve the Problem

If this error message is displayed, contact your local service provider or another qualified person.

```
DIRECTORY TOO SHORT I=inode-number OWNER=UID MODE=file-mode  
SIZE=file-size MTIME=modification-time DIR=filename (FIX)
```

Reason Error Occurred

A directory *filename* has been found whose size *file-size* is less than the minimum directory size. The owner *UID*, mode *file-mode*, size *file-size*, modify time *modification-time*, and directory name *filename* are displayed.

How to Solve the Problem

To increase the size of the directory to the minimum directory size, type *y* at the `FIX` prompt. To ignore this directory, type *n*.

```
DIRECTORY filename: LENGTH file-size NOT MULTIPLE OF block-number (ADJUST)
```

Reason Error Occurred

A directory *filename* has been found with size *file-size* that is not a multiple of the directory block size *block-number*.

How to Solve the Problem

To round up the length to the appropriate block size, type *y*. When preening the file system (`-o p` option), `fsck` only displays a warning and adjusts the directory. To ignore this condition, type *n*.

```
DIRECTORY CORRUPTED I=inode-number OWNER=UID MODE=file-mode  
SIZE=file-size MTIME=modification-time DIR=filename (SALVAGE)
```

Reason Error Occurred

A directory with an inconsistent internal state has been found.

How to Solve the Problem

To throw away all entries up to the next directory boundary (usually a 512-byte boundary), type *y* at the `SALVAGE` prompt. This drastic action can throw away up to 42 entries. Take this action only after other recovery efforts have failed. To skip to the next directory boundary and resume reading, but not modify the directory, type *n*.

```
DUP/BAD I=inode-number OWNER=O MODE=M SIZE=file-size
MTIME=modification-time TYPE=filename (REMOVE)
```

Reason Error Occurred

Phase 1 or phase 1B found duplicate blocks or bad blocks associated with directory or file entry *filename*, inode *inode-number*. The owner *UID*, mode *file-mode*, size *file-size*, modification time *modification-time*, and directory or file name *filename* are displayed. If the `-p` (preen) option is specified, the duplicate/bad blocks are removed.

How to Solve the Problem

To remove the directory or file entry *filename*, type *y* at the `REMOVE` prompt. To ignore this error condition, type *n*.

```
DUPS/BAD IN ROOT INODE (REALLOCATE)
```

Reason Error Occurred

Phase 1 or phase 1B has found duplicate blocks or bad blocks in the root inode (usually inode number 2) of the file system.

How to Solve the Problem

To clear the existing contents of the root inode and reallocate it, type *y* at the `REALLOCATE` prompt. The files and directories usually found in the root will be recovered in phase 3 and put into the `lost+found` directory. If the attempt to allocate the root fails, `fsck` will exit with: `CANNOT ALLOCATE ROOT INODE`. Type *n* to get the `CONTINUE` prompt. Type: *y* to respond to the `CONTINUE` prompt, and ignore the `DUPS/BAD` error condition in the root inode and continue running the file system check. If the root inode is not correct, this may generate many other error messages. Type *n* to terminate the program.

```
EXTRA '..' ENTRY I=inode-number OWNER=UID MODE=file-mode
SIZE=file-size MTIME=modification-time DIR=filename (FIX)
```

Reason Error Occurred

A directory *inode-number* has been found that has more than one entry for “.”.

How to Solve the Problem

To remove the extra entry for “.” type *y* at the `FIX` prompt. To leave the directory unchanged, type *n*.

```
EXTRA '..' ENTRY I=inode-number OWNER=UID MODE=file-mode
SIZE=file-size MTIME=modification-time DIR=filename(FIX)
```

Reason Error Occurred

A directory *inode-number* has been found that has more than one entry for “..” (the parent directory).

How to Solve the Problem

To remove the extra entry for “..” (the parent directory), type *y* at the `FIX` prompt. To leave the directory unchanged, type *n*.

```
hard-link-number IS AN EXTRANEIOUS HARD LINK TO A DIRECTORY filename (REMOVE)
```

Reason Error Occurred

`fsck` has found an extraneous hard link *hard-link-number* to a directory *filename*. When preening (`-o p` option), `fsck` ignores the extraneous hard links.

How to Solve the Problem

To delete the extraneous entry *hard-link-number* type *y* at the `REMOVE` prompt. To ignore the error condition, type *n*.

```
inode-number OUT OF RANGE I=inode-number NAME=filename (REMOVE)
```

Reason Error Occurred

A directory entry *filename* has an inode number *inode-number* that is greater than the end of the inode list. If the `-p` (preen) option is specified, the inode will be removed automatically.

How to Solve the Problem

To delete the directory entry *filename* type *y* at the `REMOVE` prompt. To ignore the error condition, type *n*.

```
MISSING '.' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size  
MTIME=modification-time DIR=filename (FIX)
```

Reason Error Occurred

A directory *inode-number* has been found whose first entry (the entry for `."`) is unallocated.

How to Solve the Problem

To build an entry for `."` with inode number equal to *inode-number*, type *y* at the `FIX` prompt. To leave the directory unchanged, type *n*.

```
MISSING '.' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size  
MTIME=modification-time DIR=filename CANNOT FIX, FIRST ENTRY IN  
DIRECTORY CONTAINS filename
```

Reason Error Occurred

A directory *inode-number* has been found whose first entry is *filename*. `fsck` cannot resolve this problem.

How to Solve the Problem

Mount the file system and move entry *filename* elsewhere. Unmount the file system and run `fsck` again.

```
MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size
MTIME=modification-time DIR=filename CANNOT FIX, INSUFFICIENT
SPACE TO ADD '..'
```

Reason Error Occurred

A directory *inode-number* has been found whose first entry is not ".". `fsck` cannot resolve the problem.

How to Solve the Problem

If this error message is displayed, contact your local service provider or another qualified person.

```
MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size
MTIME=modification-time DIR=filename (FIX)
```

Reason Error Occurred

A directory *inode-number* has been found whose second entry is unallocated.

How to Solve the Problem

To build an entry for "." with inode number equal to the parent of *inode-number*, type `y` at the `FIX` prompt. (Note that "." in the root inode points to itself.) To leave the directory unchanged, type `n`.

```
MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size
MTIME=modification-time DIR=filename CANNOT FIX, SECOND ENTRY IN
DIRECTORY CONTAINS filename
```

Reason Error Occurred

A directory *inode-number* has been found whose second entry is *filename*. `fsck` cannot resolve this problem.

How to Solve the Problem

Mount the file system and move entry *filename* elsewhere. Then unmount the file system and run `fsck` again.

```
MISSING '..' I=inode-number OWNER=UID MODE=file-mode SIZE=file-size
MTIME=modification-time DIR=filename CANNOT FIX, INSUFFICIENT SPACE
TO ADD '..'
```

Reason Error Occurred

A directory *inode-number* has been found whose second entry is not “.” (the parent directory). `fsck` cannot resolve this problem.

How to Solve the Problem

Mount the file system and move the second entry in the directory elsewhere. Then unmount the file system and run `fsck` again.

```
NAME TOO LONG filename
```

Reason Error Occurred

An excessively long path name has been found, which usually indicates loops in the file system name space. This error can occur if a privileged user has made circular links to directories.

How to Solve the Problem

Remove the circular links.

```
ROOT INODE UNALLOCATED (ALLOCATE)
```

Reason Error Occurred

The root inode (usually inode number 2) has no allocate-mode bits.

How to Solve the Problem

To allocate inode 2 as the root inode, type `y` at the `ALLOCATE` prompt. The files and directories usually found in the root will be recovered in phase 3 and put into the `lost+found` directory. If the attempt to allocate the root fails, `fsck` displays this message and exits: `CANNOT ALLOCATE ROOT INODE`. To terminate the program, type `n`.

```
ROOT INODE NOT DIRECTORY (REALLOCATE)
```

Reason Error Occurred

The root inode (usually inode number 2) of the file system is not a directory inode.

How to Solve the Problem

To clear the existing contents of the root inode and reallocate it, type *y* at the REALLOCATE prompt. The files and directories usually found in the root will be recovered in phase 3 and put into the `lost+found` directory. If the attempt to allocate the root fails, `fsck` displays this message and exits `:CANNOT ALLOCATE ROOT INODE`. To have `fsck` prompt with `FIX`, type *n*.

```
UNALLOCATED I=inode-number OWNER=UID MODE=file-mode SIZE=file-size  
MTIME=modification-time type=filename(REMOVE)
```

Reason Error Occurred

A directory or file entry *filename* points to an unallocated inode *inode-number*. The owner *UID*, mode *file-mode*, size *file-size*, modify time *modification-time*, and file name *filename* are displayed.

How to Solve the Problem

To delete the directory entry *filename*, type *y* at the REMOVE prompt. To ignore the error condition, type *n*.

```
ZERO LENGTH DIRECTORY I=inode-number OWNER=UID MODE=file-mode  
SIZE=file-size MTIME=modification-time DIR=filename (REMOVE)
```

Reason Error Occurred

A directory entry *filename* has a size *file-size* that is zero. The owner *UID*, mode *file-mode*, size *file-size*, modify time *modification-time*, and directory name *filename* are displayed.

How to Solve the Problem

To remove the directory entry *filename*, type *y* at the REMOVE prompt. This results in the `BAD/DUP` error message in phase 4. To ignore the error condition, type *n*.

Phase 3: Check Connectivity Messages

This phase checks the directories examined in phase 2 and reports error conditions resulting from:

- Unreferenced directories

- Missing or full `lost+found` directories

Other possible error messages displayed in this phase are referenced below.

- *BAD INODE state-number TO DESCEND*
- *DIR I=inode-number1 CONNECTED. PARENT WAS I=inode-number2*
- *DIRECTORY filename LENGTH file-size NOT MULTIPLE OF block-number (ADJUST)*
- *lost+found IS NOT A DIRECTORY (REALLOCATE)*
- *NO lost+found DIRECTORY (CREATE)*
- *NO SPACE LEFT IN /lost+found (EXPAND)*
- *UNREF DIR I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time (RECONNECT)*

```
BAD INODE state-number TO DESCEND
```

Reason Error Occurred	How to Solve the Problem
An internal error has caused an impossible state <i>state-number</i> to be passed to the routine that descends the file system directory structure. <code>fsck</code> exits.	If this occurs, contact your local service provider or another qualified person.

```
DIR I=inode-number1 CONNECTED. PARENT WAS I=inode-number2
```

Reason Error Occurred	How to Solve the Problem
This is an advisory message indicating a directory inode <i>inode-number1</i> was successfully connected to the <code>lost+found</code> directory. The parent inode <i>inode-number2</i> of the directory inode <i>inode-number1</i> is replaced by the inode number of the <code>lost+found</code> directory.	N/A

```
DIRECTORY filename LENGTH file-size NOT MULTIPLE OF block-number (ADJUST)
```

Reason Error Occurred

A directory *filename* has been found with size *file-size* that is not a multiple of the directory block size B. (This condition can recur in phase 3 if it is not adjusted in phase 2.)

How to Solve the Problem

To round up the length to the appropriate block size, type *y* at the ADJUST prompt. When preening, *fsck* displays a warning and adjusts the directory. To ignore this error condition, type *n*.

```
lost+found IS NOT A DIRECTORY (REALLOCATE)
```

Reason Error Occurred

The entry for *lost+found* is not a directory.

How to Solve the Problem

To allocate a directory inode and change the *lost+found* directory to reference it, type *y* at the REALLOCATE prompt. The previous inode reference by the *lost+found* directory is not cleared and it will either be reclaimed as an unreferenced inode or have its link count adjusted later in this phase. Inability to create a *lost+found* directory displays the message: SORRY. CANNOT CREATE *lost+found* DIRECTORY and aborts the attempt to link up the lost inode, which generates the UNREF error message in phase 4. To abort the attempt to link up the lost inode, which generates the UNREF error message in phase 4, type *n*.

```
NO lost+found DIRECTORY (CREATE)
```

Reason Error Occurred

There is no *lost+found* directory in the root directory of the file system. When preening, *fsck* tries to create a *lost+found* directory.

How to Solve the Problem

To create a *lost+found* directory in the root of the file system, type *y* at the CREATE prompt. This may lead to the message NO SPACE LEFT IN / (EXPAND). If the *lost+found* directory cannot be created, *fsck* displays the message: SORRY. CANNOT CREATE *lost+found* DIRECTORY and aborts the attempt to link up the lost inode. This in turn generates the UNREF error message later in phase 4. To abort the attempt to link up the lost inode, type *n*.

```
NO SPACE LEFT IN /lost+found (EXPAND)
```

Reason Error Occurred

Another entry cannot be added to the `lost+found` directory in the root directory of the file system because no space is available. When preening, `fsck` expands the `lost+found` directory.

How to Solve the Problem

To expand the `lost+found` directory to make room for the new entry, type `y` at the `EXPAND` prompt. If the attempted expansion fails, `fsck` displays: `SORRY. NO SPACE IN lost+found DIRECTORY` and aborts the request to link a file to the `lost+found` directory. This error generates the `UNREF` error message later in phase 4. Delete any unnecessary entries in the `lost+found` directory. This error terminates `fsck` when preening is in effect. To abort the attempt to link up the lost inode, type `n`.

```
UNREF DIR I=inode-number OWNER=UID MODE=file-mode SIZE=file-size
MTIME=modification-time (RECONNECT)
```

Reason Error Occurred

The directory inode *inode-number* was not connected to a directory entry when the file system was traversed. The owner *UID*, mode *file-mode*, size *file-size*, and modification time *modification-time* of directory inode *inode-number* are displayed. When preening, `fsck` reconnects the non-empty directory inode if the directory size is non-zero. Otherwise, `fsck` clears the directory inode.

How to Solve the Problem

To reconnect the directory inode *inode-number* into the `lost+found` directory, type `y` at the `RECONNECT` prompt. If the directory is successfully reconnected, a `CONNECTED` message is displayed. Otherwise, one of the `lost+found` error messages is displayed. To ignore this error condition, type `n`. This error causes the `UNREF` error condition in phase 4.

Phase 4: Check Reference Counts Messages

This phase checks the link count information obtained in phases 2 and 3. It reports error conditions resulting from:

- Unreferenced files
- A missing or full `lost+found` directory
- Incorrect link counts for files, directories, symbolic links, or special files
- Unreferenced files, symbolic links, and directories
- Bad or duplicate blocks in files and directories
- Incorrect total free-inode counts

All errors in this phase (except running out of space in the `lost+found` directory) are correctable when the file system is being preened.

Other possible error messages displayed in this phase are referenced below.

- *BAD/DUP type I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time (CLEAR)*
- *(CLEAR)*
- *LINK COUNT type I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time COUNT link-count SHOULD BE corrected-link-count (ADJUST)*
- *lost+found IS NOT A DIRECTORY (REALLOCATE)*
- *NO lost+found DIRECTORY (CREATE)*
- *NO SPACE LEFT IN /lost+found (EXPAND)*
- *UNREF FILE I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time (RECONNECT)*
- *UNREF type I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time (CLEAR)*
- *ZERO LENGTH DIRECTORY I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time (CLEAR)*

BAD/DUP type I=inode-number OWNER=UID MODE=file-mode SIZE=file-size MTIME=modification-time (CLEAR)

Reason Error Occurred

Phase 1 or phase 1B found duplicate blocks or bad blocks associated with file or directory inode *inode-number*. The owner *UID*, mode *file-mode*, size *file-size*, and modification time *modification-time* of inode *inode-number* are displayed.

How to Solve the Problem

To deallocate inode *inode-number* by zeroing its contents, type *y* at the *CLEAR* prompt. To ignore this error condition, type *n*.

(CLEAR)

Reason Error Occurred

The inode mentioned in the *UNREF* error message immediately preceding cannot be reconnected. This message does not display if the file system is being preened because lack of space to reconnect files terminates *fsck*.

How to Solve the Problem

To deallocate the inode by zeroing out its contents, type *y* at the *CLEAR* prompt. To ignore the preceding error condition, type *n*.

```
LINK COUNT type I=inode-number OWNER=UID MODE=file-mode  
SIZE=file-size  
MTIME=modification-time COUNT link-count SHOULD BE  
corrected-link-count (ADJUST)
```

Reason Error Occurred

The link count for directory or file inode *inode-number* is *link-count* but should be *corrected-link-count*. The owner *UID*, mode *file-mode*, size *file-size*, and modification time *modification-time* of inode *inode-number* are displayed. If the `-o p` option is specified, the link count is adjusted unless the number of references is increasing. This condition does not occur unless there is a hardware failure. When the number of references is increasing during preening, `fsck` displays this message and exits: LINK COUNT INCREASING

How to Solve the Problem

To replace the link count of directory or file inode *inode-number* with *corrected-link-count*, type `y` at the ADJUST prompt. To ignore this error condition, type `n`.

```
lost+found IS NOT A DIRECTORY (REALLOCATE)
```

Reason Error Occurred

The entry for `lost+found` is not a directory.

How to Solve the Problem

To allocate a directory inode and change the `lost+found` directory to reference it, type `y` at the REALLOCATE prompt. The previous inode reference by the `lost+found` directory is not cleared. It will either be reclaimed as an unreferenced inode or have its link count adjusted later in this phase. Inability to create a `lost+found` directory displays this message: SORRY. CANNOT CREATE `lost+found` DIRECTORY and aborts the attempt to link up the lost inode. This error generates the UNREF error message later in phase 4. To abort the attempt to link up the lost inode, type `n`.

```
NO lost+found DIRECTORY (CREATE)
```

Reason Error Occurred

There is no `lost+found` directory in the root directory of the file system. When preening, `fsck` tries to create a `lost+found` directory.

How to Solve the Problem

To create a `lost+found` directory in the root of the file system, type `y` at the `CREATE` prompt. If the `lost+found` directory cannot be created, `fsck` displays the message: `SORRY. CANNOT CREATE lost+found DIRECTORY` and aborts the attempt to link up the lost inode. This error in turn generates the `UNREF` error message later in phase 4. To abort the attempt to link up the lost inode, type `n`.

```
NO SPACE LEFT IN / lost+found (EXPAND)
```

Reason Error Occurred

There is no space to add another entry to the `lost+found` directory in the root directory of the file system. When preening, `fsck` expands the `lost+found` directory.

How to Solve the Problem

To expand the `lost+found` directory to make room for the new entry, type `y` at the `EXPAND` prompt. If the attempted expansion fails, `fsck` displays the message: `SORRY. NO SPACE IN lost+found DIRECTORY` and aborts the request to link a file to the `lost+found` directory. This error generates the `UNREF` error message later in phase 4. Delete any unnecessary entries in the `lost+found` directory. This error terminates `fsck` when preening (`-o p` option) is in effect. To abort the attempt to link up the lost inode, type `n`.

```
UNREF FILE I=inode-number OWNER=UID MODE=file-mode SIZE=file-size  
MTIME=modification-time (RECONNECT)
```

Reason Error Occurred

File inode *inode-number* was not connected to a directory entry when the file system was traversed. The owner *UID*, mode *file-mode*, size *file-size*, and modification time *modification-time* of inode *inode-number* are displayed. When `fsck` is preening, the file is cleared if either its size or its link count is zero; otherwise, it is reconnected.

How to Solve the Problem

To reconnect inode *inode-number* to the file system in the `lost+found` directory, type *y*. This error may generate the `lost+found` error message in phase 4 if there are problems connecting inode *inode-number* to the `lost+found` directory. To ignore this error condition, type *n*. This error always invokes the `CLEAR` error condition in phase 4.

```
UNREF type I=inode-number OWNER=UID MODE=file-mode SIZE=file-size
MTIME=modification-time (CLEAR)
```

Reason Error Occurred

Inode *inode-number* (whose *type* is directory or file) was not connected to a directory entry when the file system was traversed. The owner *UID*, mode *file-mode*, size *file-size*, and modification time *modification-time* of inode *inode-number* are displayed. When `fsck` is preening, the file is cleared if either its size or its link count is zero; otherwise, it is reconnected.

How to Solve the Problem

To deallocate inode *inode-number* by zeroing its contents, type *y* at the `CLEAR` prompt. To ignore this error condition, type *n*.

```
ZERO LENGTH DIRECTORY I=inode-number OWNER=UID MODE=file-mode
SIZE=file-size MTIME=modification-time(CLEAR)
```

Reason Error Occurred

A directory entry *filename* has a size *file-size* that is zero. The owner *UID*, mode *file-mode*, size *file-size*, modification time *modification-time*, and directory name *filename* are displayed.

How to Solve the Problem

To deallocate the directory inode *inode-number* by zeroing out its contents, type *y*. To ignore the error condition, type *n*.

Phase 5: Check Cylinder Groups Messages

This phase checks the free-block and used-inode maps. It reports error conditions resulting from:

- Allocated inodes missing from used-inode maps
- Free blocks missing from free-block maps
- Free inodes in the used-inode maps
- Incorrect total free-block count
- Incorrect total used inode count

The possible error messages displayed in this phase are referenced below.

- *BLK(S) MISSING IN BIT MAPS (SALVAGE)*
- *CG character-for-command-option: BAD MAGIC NUMBER*
- *SUMMARY INFORMATION BAD (SALVAGE)*
- *number-of files, number-of-files used, number-of-files free (number-of frags, number-of blocks, percent fragmentation)*
- ****** FILE SYSTEM WAS MODIFIED ******
- *filename FILE SYSTEM STATE SET TO OKAY*
- *filename FILE SYSTEM STATE NOT SET TO OKAY*

BLK(S) MISSING IN BIT MAPS (SALVAGE)

Reason Error Occurred

A cylinder group block map is missing some free blocks. During preening, `fsck` reconstructs the maps.

How to Solve the Problem

To reconstruct the free-block map, type `y` at the `SALVAGE` prompt. To ignore this error condition, type `n`.

CG character-for-command-option: BAD MAGIC NUMBER

Reason Error Occurred

The magic number of cylinder group *character-for-command-option* is wrong. This error usually indicates that the cylinder group maps have been destroyed. When running interactively, the cylinder group is marked as needing reconstruction. `fsck` terminates if the file system is being preened.

How to Solve the Problem

If this occurs, contact your local service provider or another qualified person.

FREE BLK COUNT(S) WRONG IN SUPERBLK (SALVAGE)

Reason Error Occurred

The actual count of free blocks does not match the count of free blocks in the superblock of the file system. If the `-o p` option was specified, the free-block count in the superblock is fixed automatically.

How to Solve the Problem

To reconstruct the superblock free-block information, type `y` at the `SALVAGE` prompt. To ignore this error condition, type `n`.

```
SUMMARY INFORMATION BAD (SALVAGE)
```

Reason Error Occurred

The summary information is incorrect. When preening, `fsck` recomputes the summary information.

How to Solve the Problem

To reconstruct the summary information, type `y` at the `SALVAGE` prompt. To ignore this error condition, type `n`.

Cleanup Phase Messages

Once a file system has been checked, a few cleanup functions are performed. The cleanup phase displays the following status messages.

```
number-of files, number-of-files  
used, number-of-files free (number-of frags, number-of blocks,  
percentfragmentation)
```

This message indicates that the file system checked contains *number-of* files using *number-of* fragment-sized blocks, and that there are *number-of* fragment-sized blocks free in the file system. The numbers in parentheses break the free count down into *number-of* free fragments, *number-of* free full-sized blocks, and the *percent* fragmentation.

```
***** FILE SYSTEM WAS MODIFIED *****
```

This message indicates that the file system was modified by `fsck`. If this file system is mounted or is the current root (`/`) file system, reboot. If the file system is mounted, you may need to unmount it and run `fsck` again; otherwise, the work done by `fsck` may be undone by the in-core copies of tables.

```
filename FILE SYSTEM STATE SET TO OKAY
```

This message indicates that file system *filename* was marked as stable. Use the `fsck -m` command to determine if the file system needs checking.

```
filename FILE SYSTEM STATE NOT SET TO OKAY
```

This message indicates that file system *filename* was *not* marked as stable. Use the `fsck -m` command to determine if the file system needs checking.

Troubleshooting Software Administration Problems

This chapter describes problems you may encounter when installing or removing software packages. There are two sections: Specific Software Administration Errors, which describes package installation and administration errors you might encounter, and General Software Administration Problems, which describes behavioral problems that might not result in a particular error message.

This is a list of information in this chapter.

- “Specific Software Administration Errors ” on page 661
- “General Software Administration Problems” on page 662

See “Software Administration (Overview)” in *System Administration Guide, Volume I* for information about managing software packages.

Specific Software Administration Errors

```
WARNING: filename <not present on Read Only file system>
```

Reason Error Occurred**How to Fix the Problem**

This error message indicates that not all of a package's files could be installed. This usually occurs when you are using `pkgadd` to install a package on a client. In this case, `pkgadd` attempts to install a package on a file system that is mounted from a server, but `pkgadd` doesn't have permission to do so.

If you see this warning message during a package installation, you must also install the package on the server. See "How to Add Packages to a Server" on page 308 for details.

General Software Administration Problems

Reason Error Occurred**How to Fix the Problem**

There is a known problem with adding or removing some packages developed prior to the Solaris 2.5 release. Sometimes, when adding or removing these packages, the installation fails during user interaction or you are prompted for user interaction and your responses are ignored.

Set the following environment variable and try to add the package again.

```
NONABI_SCRIPTS=TRUE
```

Index

Special Characters

- * (asterisk)
 - in crontab file, 416
 - wildcard character, 348
- + (plus sign)
 - /etc/hosts.equiv file syntax, 174
- (dot)
 - path variable entry, 250
 - rcp command syntax, 194, 197
- ? (question mark) in ASET tune files, 348
- ~ (tilde)
 - abbreviated pathnames, 191, 192
 - rcp command syntax, 194, 197

Numbers

- 4.1 systems (running with 5.7 systems), 18

A

- absolute mode
 - changing file permissions, 271, 274
 - described, 271
 - setting special permissions, 272, 282
- accept command, 82
- accepting print requests, 81, 82, 109
- access, 245
 - root access
 - displaying attempts on console, 301, 302
 - monitoring su command use, 256, 301
 - restricting, 260, 300

- security, 248, 251
 - ACLs, 252, 280
 - file access restriction, 249
 - firewall setup, 250
 - login access restrictions, 253
 - login control, 248
 - monitoring system usage, 249
 - network control, 249
 - path variable setting, 249, 250
 - physical site security, 248
 - reporting problems, 251
 - root access restrictions, 300
 - root login tracking, 256
 - setuid programs, 250
- sharing files, 260
- system logins, 253, 254
- to forms
 - limiting for printers, 114
 - limiting for users, 113
- to printers
 - deleting, 60
- access control lists, , *see* ACLs (access control lists)\x0d,
- security, 245
- accounting, 433, 440, 443, 461
 - automatic, 434
 - billing users, 437, 446, 450
 - connect, 443 to 445, 449, 450, 456, 459
 - daily, 445, 461
 - reports, 447, 454
 - step-by-step summary of, 445, 447
 - disk, 444 to 446, 450
 - files for, 458, 461

- fixing corrupted files
 - tacct file, 439
 - wtmp file, 438, 456
- installation-dependent local programs, 456
- maintaining, 438, 440
- process, 444, 446, 449, 450
- raw data, 445
- reports, 447, 454
 - daily command summary, 451, 452, 456, 459 to 461
 - daily report (tty line utilization), 448, 449
 - daily usage report, 449, 450
 - last login report, 453
 - overview, 447
 - total command summary (monthly), 447, 452, 460, 461
- setting up, 437
- types of, 437, 443
- user fee calculation, 437, 446, 450
- acct file, 434
- acct.h format files, 454
- acctcms command, 456, 461
- acctcom command, 452, 454
- acctcon command, 438, 456, 459
- acctdusg command, 444, 450, 458
- acctprc command, 456
- acctwtmp command, 444, 445, 448
- ACLs (access control lists), 280
 - adding entries, 286
 - changing entries, 286
 - checking entries, 285
 - commands, 252
 - default entries for directories, 282
 - deleting entries, 252, 287
 - described, 252, 280
 - directory entries, 282
 - displaying entries, 252, 288
 - format of entries, 280
 - setting entries, 283, 285
 - valid file entries, 281
- active file, 439, 456, 459
- active.MMDD file, 439, 459
- adapter board (serial port), 203
- Add Access To Printer window, 42
- Add Local Printer window, 37
- adding
 - access to remote printers, 42
 - forms, 107
 - local printers, 38
 - printer description, 66
 - swap space, 475
 - terminfo entry, 124
- address space map, 470, 484
- address translation page faults, 518
- adjusting printer port characteristics, 121
- adm file, 415, 435
- adm login account, 253
- administering
 - character sets, 10, 92, 99
 - fonts, 10, 115, 119
 - forms, 10, 105, 115
 - print filters, 10, 100, 104
 - printers, 59, 90
- Admintool
 - ability to define printer with, 22
 - Add Access To Printer window, 42
 - Add Local Printer window, 37
 - Browse menu, 35
 - main window, 35, 36
 - prerequisites for using, 35
 - Printers window, 36, 37, 42
 - starting, 35
 - terminals and modems, 204
- alert message priority, 573
- alerts
 - for mounting character sets, 96
 - for mounting font cartridges, 94
 - for mounting forms, 106, 110
 - for mounting print wheels, 94
 - for printer faults, 72
- alias for selectable character set, 93, 98, 99
- aliases file (ASET)
 - described, 339
 - example, 349
 - format, 349
 - specification, 342
- alignment pattern
 - defining, 146
 - printing, 109
 - protection of, 107
- allow list
 - for printer access to forms, 114
 - for user access to forms, 114
 - for user access to printers, 76

- alphanumeric terminal, , *see* terminal,
- anonymous ftp accounts, 183, 185
- application threads, 468, 469
- ASCII file
 - file content type of, 26
- ASET CKLISTPATH_level variable, 348
- aset command, 245
 - d option, 350
 - n option, 335
 - p option, 351
 - initiating ASET sessions, 332
 - running ASET interactively, 350
 - running ASET periodically, 351
 - stop running periodically, 352
- ASET environment file asetenv not found
 - message, 354
- ASET error messages, 354
- ASET task list TASKLIST undefined
 - message, 354
- ASET working directory \$ASETDIR missing
 - message, 354
- ASET, , *see* Automated Security Enhancement Tool (ASET)\x0d,
- aset.restore utility, 343
- aset: invalid/undefined security level
 - message, 354
- ASETDIR variable, 344, 345
- asetenv file
 - described, 340
 - error messages, 354
 - modifying, 340
 - running ASET periodically, 351
- ASETSECLEVEL variable
 - described, 344
 - setting security levels, 345
- asterisk (*)
 - in crontab file, 416
 - wildcard character, 348
- at command, 363, 425, 426, 430
 - l option (list), 427, 428
 - m option (mail), 426
 - automatic scheduling of, 415
 - controlling access to, 413, 425, 429, 430
 - error messages, 430
 - overview, 363, 364, 413, 425, 476
 - quitting, 363
- at job files, 425, 429
 - creating, 426, 427
 - deleting, 428, 429
 - described, 363, 364
 - displaying, 427, 428
 - displaying queue of, 427
 - location of, 364
 - submitting, 425
 - verifying, 427
- at.deny file, 413, 425, 429, 430
- /atjobs directory, 364, 413, 415
- atq command, 427
- atrun command, 364
- audio devices, 248
- auth facility, 573
- authentication
 - defined, 258
 - DH, 305, 315
 - KERB, 309, 315
 - network security, 258, 260
 - remote logins using ftp, 183, 185
 - remote logins using rlogin, 172, 175, 182
 - /etc/hosts.equiv file, 174
 - .rhosts files, 175
 - direct vs. indirect logins, 177
 - network vs. remote system
 - authentication, 172, 174, 177
 - types, 258
- authorization
 - defined, 258
 - network security, 258, 260
 - types, 258
- AUTH_DH authentication, 314
- AUTH_DH client-server session, 305, 308
 - additional transaction, 308
 - client authenticates server, 308
 - contacting the server, 306
 - decrypting the conversation key, 307
 - generating public and secret keys, 305
 - generating the conversation key, 306
 - running keylogin, 305
 - storing information on the server, 307
 - verifier returned to client, 307
- AUTH_KERB authentication, 315
- Automated Security Enhancement Tool (ASET), 331, 349, 354
- automatic accounting, 434
- automatic quota turn on, 362, 397

- automatic system activity data collection, 528, 531
- automatic system activity reporting, 528, 529
- automatic system event execution
 - repetitive events, 362, 413, 422, 424
 - single events, 363, 413, 425, 426, 430

B

- background processing, 253
- backup files, 363, 426, 427
- banner option, 69
- banner pages
 - making optional, 69
 - nothing else prints, 619
 - reasons to turn off, 68
 - setting
 - with Admintool, 22, 68
 - with lpadmin command, 68, 69
 - with nobanner variable, 70
 - troubleshooting incorrect output, 600
 - turning off, 70
- baud settings, 600
- bidirectional modem service, 202, 228
- billing users, 437, 446, 450
- /bin directory, 470, 484
- bin login account, 253
- block devices
 - checking activity, 530
- booting
 - displaying messages generated during, 571
 - running sadc command when, 528
- Bourne shell
 - ASET working directory specification, 345
- Browse menu (Admintool), 36
- buffer cache
 - checking activity, 508, 509, 530
 - overview, 476
 - setting maximum memory usage for, 545
- bufhwm parameter, 545
- bye command, 184, 186

C

- C shell
 - ASET working directory specification, 345
- cable pin configuration, 604

- caches
 - buffer cache, 476, 508, 509, 530, 545
 - directory name lookup cache, 476, 477, 508, 545
- cancel command, 85
- canceling
 - print requests, 85
 - by disabling printer, 84
 - for specific user, 86
 - remote logins, 172
- cartridges, , *see* font cartridges,
- catman database, 363
- centralized
 - print administration, 7
 - print configuration, 17
- CERT/CC, , *see* Computer Emergency Response Team/Coordination Center (CERT/CC)\x0d,
- changing
 - /etc/system file, 371, 375, 378
 - crontab files, 417, 418
 - date, 371, 373, 374
 - forms paper, 109
 - kernel parameter values, 544
 - message of the day, 374, 375
 - number of lock requests, 371
 - number of processes per user, 371, 375, 376
 - number of pseudo-ttys, 371, 376
 - number of shared memory segments, 371, 377
 - priority, 490 to 492, 495
 - real-time processes, 554, 556
 - timesharing processes, 492, 494, 495
 - priority of print requests, 79, 89
 - quotas for individual users, 408, 409
 - scheduling classes, 493, 494, 552
 - soft limit time, 407, 408
 - time, 371, 373
- character sets
 - hardware, 92, 93
 - managing, 92, 99
 - number, 92
 - selectable, 92, 93
 - software, 92
- characters transferred
 - read/write system calls, 452, 454, 510
 - terminal I/O, 526

- chargefee command, 437, 446, 450
- chgrp(1) command
 - described, 251
 - syntax, 270
- chkey command, 305, 313
- chmod command
 - changing special permissions, 275, 276
 - described, 251
 - syntax, 275
- chown command
 - described, 251
 - syntax, 269
- cklist.rpt file
 - described, 334, 337
 - format, 338
- ckpacct command, 433, 435, 446
- class (printer), 70
 - checking status for, 80
 - defining with lpadmin command, 71
 - not valid for enabling/disabling printer, 84
- clients
 - AUTH_DH client-server session, 305, 308
 - displaying information about, 533, 540, 542
 - tracing calls to servers, 533, 536
- close command, 184
- closewtmp command, 456
- closing remote system connections, 186
- cmsn file, 461
- cmsprev file, 460
- collision rate (network), 537
- Command not found error message, 591
- commands
 - monitoring usage of, 459, 461
- comment lines in crontab file, 416
- common key, 305
 - calculation, 307
- Computer Emergency Response Team/Coordination Center (CERT/CC), 251
- configuration scheduler, 554, 563
- configuring
 - ASET, 340, 342
 - printer ports, 24
 - for x86 systems, 24
 - with Admintool, 37
- connect accounting, 443 to 445, 449, 450, 456, 459
- consistency checking, 402
- console
 - displaying su command use on, 301, 302
 - root access restriction to, 300
- context switches
 - displaying information on, 498
- controlling
 - access to at command, 413, 425, 429, 430
 - access to crontab command, 413, 421, 422, 424
 - printer access to forms, 114
 - processes, 487
 - user access to forms, 113
- conversation key
 - decrypting, 307
 - generating, 306
 - “copy-on-writes”, 518
- copying (remote)
 - using ftp, 184
 - using rcp, 191, 197
- core files
 - automatically deleting, 425
 - finding and deleting, 389, 393
- core program name, 452
- CPU (central processing unit)
 - defined, 468
 - displaying information on
 - context switch rate, 498
 - daily command summary, 452
 - dead processes, 454
 - queue activity and, 521
 - time usage, 450, 482, 496, 498, 503, 522, 523, 530
 - high-usage processes, 496
 - when to add capacity, 521
- cpu fields
 - iostat report, 503
- /crash directory, 393
- crash utility, 570, 581, 582
- crashes, 572, 587
 - customer service and, 568, 578
 - deleting crash dump files, 393
 - displaying system information generated by, 570, 582
 - examining crash dumps, 581, 582

- procedure following, 568, 587
- rebooting fails after, 585
- saving crash dump information, 577
- saving other system information, 571
- creating
 - at jobs, 426, 427
 - crontab files, 417, 418
 - directories on remote system, 184
 - form definitions, 147
 - forms, 144
 - print filters, 133, 142
- cred database, 305, 311
- cred table
 - information stored by server, 307
- credentials, 484
 - described, 306
- cron daemon, 364, 415
- cron.allow file, 421 to 424
- cron.deny file, 421, 423
- crontab command, 363, 422
 - accounting commands run by, 433, 436
 - controlling access to, 421, 422, 424
 - denying access, 421, 423
 - limiting access to specific users, 422 to 424
 - overview, 413, 421, 422
- cron daemon and, 415
- e option (edit), 417, 418
- l option (list), 419, 420
- r option (remove), 420, 421
- /var/adm maintenance and, 571
- daily tasks, 363
- error messages, 424
- files used by, 415
- overview, 363, 413
- quitting without saving changes, 418
- scheduling of, 415
- /crontab directory, 413, 415, 417
- crontab files
 - creating, 417, 418
 - deleting, 420, 421
 - described, 415, 416
 - displaying, 419, 420
 - editing, 417, 418
 - location of, 415
 - running ASET periodically, 332
 - stop running ASET periodically, 352
 - syntax, 416

- verifying existence of, 419
- crypt command, 252
- csch program, 297, 298
 - .cshrc file, 250
- ctacct.MMDD file, 456, 459
- ctmp file, 459
- current user, 192
- customer service, 568, 578
- customizing
 - exit codes, printer, 130
 - LP print service, 10, 121, 149
 - printer interface program, 128, 131
 - stty modes, 129
 - system logging, 572

D

- daemon facility, 573
- daemon login account, 253
- daemons
 - keyser, 310
 - lpd, 612
 - lpsched, 160, 163, 168
 - print, 152
- daily accounting, 445, 461
 - reports, 447, 454
 - daily command summary, 451, 452, 456, 459 to 461
 - daily report (tty line utilization), 448, 449
 - daily usage report, 449, 450
 - last login report, 453
 - overview, 447
 - step-by-step summary of, 445, 447
- daily tasks (scheduling with crontab), 363
- Data Encryption Standard, , *see* DES,
- date
 - changing, 371, 373
 - displaying, 367, 370
 - synchronizing with another system, 371, 373
- date command
 - accounting data and, 444, 445
 - described, 367, 370, 371
- dayacct file, 450, 456, 459, 461
- deadfiles file, 391
- deadlock avoidance, 549

- decrypting
 - conversation key, 307
 - secret key, 305
- default printer
 - ability to set with Admintool, 22
 - setting with Admintool, 67
 - setting with lpadmin command, 67, 68
- defaults, 545, 557
 - ACL entries for directories, 282
 - at.deny file, 429
 - cron.deny file, 422
 - crontab files, 415
 - /etc/syslog.conf file, 330
 - maxusers parameter, 476
 - message of the day, 375
 - nice number, 495
 - priority levels, 472, 473
 - real-time parameter table, 561
 - scheduling classes, 491, 553
 - soft limit time, 407, 408
 - time slices, 558
 - timesharing parameter table, 559
- defining
 - font cartridges, 94
 - print wheels, 94
 - printer characteristics, 66
- delete command, 184
- deleting
 - access to printers, 60
 - ACL entries, 252, 287
 - at jobs, 428, 429
 - backup files, 363, 426, 427
 - core files, 393
 - crash dump files, 393
 - crontab files, 420, 421
 - .rhosts files, 175
 - directories on remote system, 184
 - files from remote directories, 184
 - forms, 108
 - log files, 418
 - old/inactive files, 363, 389, 394, 418
 - print filters, 103
 - temporary files, 392
- deny list
 - for printer access to forms, 114
 - for user access to forms, 114
 - for user access to printers, 76
- DES encryption, 304
- destination printer, 67
- /dev/term/a, 23
- /dev/term/b, 23
- device drivers, 515
- device interrupts, 498, 502, 526, 527
- devices
 - system device access control, 248, 300
- df command, 381, 506, 507
 - F option (unmounted file systems), 381, 383
 - g option (statvfs structure), 381
 - k option (kilobytes), 381, 383, 506, 507
 - t option (total blocks), 381, 383
 - examples, 382, 506, 507
 - overview, 381, 506
- dfstab file, 260
- DH authentication, 305
 - AUTH_DH client-server session, 305, 308
 - mounting files, 314
 - sharing files, 314
- DH security
 - for an NIS client, 312
 - for an NIS+ client, 311
- dial-in modem service, 202
- dial-out modem service, 202
- dial-up passwords, 295, 298
 - basic sequence, 296
 - /etc/dialups file, 296
 - /etc/d_passwd file, 296 to 298
 - disabling dial-up logins temporarily, 300
- dialups file
 - creating, 298
 - described, 296
- diff utility (ASET), 339
- direct printing, 26, 27
- direct remote logins
 - indirect logins vs.
 - rlogin, 176, 177
 - using rlogin, 181, 182
- directio command, 473
- directories
 - abbreviated pathnames, 191, 192
 - ACL entries, 282

- ASET files, 332
 - checklist task (CKLISTPATH)
 - setting, 341, 347
 - master files, 339
 - reports, 337
 - working directory, 345, 350
- current working directory for
 - processes, 470, 484
- displaying files and related
 - information, 251, 267, 268
- displaying information about, 384, 385, 387, 389
- ftp commands, 184
- permissions
 - defaults, 267
 - described, 264
- public directories, 266
- remote copying, 193
- setgid permissions, 266
- size of, 387, 389
- sticky bit permissions, 266
- temporary, clearing out, 389, 392
- working directory, 192

directory name lookup cache, 476, 477, 508, 545

disable command, 81, 84

disabling, 245

- dial-up logins temporarily, 300
- printers, 61, 84
- quotas for individual users, 409, 410
- user logins, 293

disk accounting, 444 to 446, 450

disk drives

- described, 473

displaying information about, 503, 511, 512

- basic activity statistics, 498, 503, 511, 512
- df command, 381, 506
- directory sizes, 387, 389
- extended activity statistics, 505
- file sizes, 384, 385, 387, 389
- free disk space, 381, 506
- iostat command, 473, 503
- mount point, 383, 506
- overview, 473
- sar command, 511, 512
- UFS file system user allocation, 388, 389
- vmstat command, 498

file system usage, 381, 473, 506

finding and deleting old/inactive

- files, 389, 394, 418, 426, 427

finding files exceeding a size limit, 386

finding large files, 385, 386

fragmentation of, 473

optimizing, 381, 394

overview, 473

slowdowns

- avoiding, 473
- checking for, 523
- defined, 473

space

- amount of free, 381, 506
- optimizing usage, 381, 394

disk space for print queue, 20

DiskSuite, 473

disktacct file, 445, 446, 456, 459

disktacct.MMDD file, 456

diskusg command, 444, 445

dispadmin command

- overview, 490
- real-time parameter table display, 561, 562
- rebooting and, 555
- timesharing parameter table display, 559

dispatch activity, 518, 519, 530

displaying, 498

- acct.h format files, 454
- ACL entries, 252, 288
- ASET task status, 333, 336
- at jobs, 427, 428

- at queue, 427
- booting messages, 571
- cache flushing information, 502
- context switch information, 498
- crash information, 570, 582
- crontab files, 419, 420
- date, 367, 370
- directory information, 384, 385, 387, 389
- file information, 384, 385, 387, 389, 390
- file system information, 381, 473, 506
- files and related information, 251, 267, 268
- host ID, 367, 369
- interrupt information, 498, 502, 526, 527
- kernel parameters, 543
- linked libraries, 470, 484
- LWP information, 470, 501
- network information, 533, 534, 536, 542
- operating system information, 368, 369
- pacctn file, 454
- priority information, 482, 491, 556
- queue information, 505, 512, 520, 521, 530
- quota information, 397, 403, 404
- remote directory contents, 184
- remote directory name, 184
- root access attempts on console, 301, 302
- scheduling class information, 482, 490, 491
- status of forms, 113
- su command use on console, 301, 302
- swap area information, 498, 521, 522
- swapping information, 501, 520, 522, 525, 526, 530
- switching information, 525, 526, 530
- system activity information, 507, 529, 531
- system call information, 498, 510, 530
- system event information, 500
- system information
 - commands for, 367, 370
- terminal I/O information, 503, 526, 528, 530
- time, 367, 370
- tty line I/O information, 503, 526, 528, 530
- unmounted file system list, 381
- user's login status, 291, 292
- dmesg command, 571
- dodisk command, 444, 445, 456
 - caution, 445
 - crontab entry that runs, 436
 - files created by, 445, 446, 456, 459

- overview, 444 to 446
- domains (remote logins), 172
- dot (.)
 - path variable entry, 250
 - rcp command syntax, 194, 197
- download filter, 116, 117
- downloaded PostScript fonts, 118
- downloading
 - fonts, 116, 620
 - host-resident fonts, 117
- dropped packets, 536
- dtmp file, 458
- du command, 387, 389
- dump command, 589
- d_passwd file
 - creating, 298
 - described, 296 to 298
 - disabling dial-up logins temporarily, 300
 - /etc/passwd file and, 297

E

- editing
 - crontab files, 417, 418
- edquota command
 - changing quotas for individual users, 408
 - disabling quotas for individual users, 409, 410
 - p option (prototype), 401
 - t option (time limit), 408
 - overview, 397, 398, 406
 - setting up user quotas, 400, 401
- eeeprom.rpt file, 335, 337, 338
- enable command, 81
- enabling
 - printers, 84
- encrypting
 - capturing encrypted passwords, 299
 - files, 252
- encryption, 304
- env.rpt file, 335, 337, 338
- environment file (ASET)
 - described, 340
 - error messages, 354
 - modifying, 340
 - running ASET periodically, 351
- environment variables

- ASET, 344, 348
 - ASETDIR, 345
 - ASETSECLEVEL, 345
 - CKLISTPATH_level, 341, 347
 - PERIODIC_SCHEDULE, 342, 346, 347, 351, 354
 - summary table, 344
 - TASKS, 341, 347
 - UID_ALIASES, 339, 342, 347
 - YPCHECK, 342, 347
- LPDEST, 68
- PRINTER, 68
- equals sign (=)
 - file permissions symbol, 272
- error messages
 - at command, 430
 - crash messages, 570, 571
 - crontab command, 424
 - customizing logging of, 572
 - log file for, 568, 571
 - priorities for, 573
 - runacct command, 439
 - sources of, 572
 - specifying storage location for, 571 to 573
- error protection, 456
 - /etc/acct/holidays file, 435, 436, 450
 - /etc/cron.d/at.deny file, 425, 429, 430
 - /etc/cron.d/cron.allow file, 421 to 424
 - /etc/cron.d/cron.deny file, 421, 423
 - /etc/default/login file
 - restricting root access to console, 300
 - /etc/default/su file
 - displaying su command use on console, 301, 302
 - /etc/dfs/dfstab file, 260
 - /etc/dialups file
 - described, 296, 298
 - /etc/d_passwd file
 - described, 296 to 298, 300
 - /etc/passwd file and, 297
 - /etc/hosts.equiv file, 174
 - /etc/hosts.lpd file, 613
 - /etc/init.d/acct file, 434
 - /etc/init.d/perf file, 528, 531
 - /etc/inittab file, 226
 - /etc/logindevperm file, 248
 - /etc/lp directory, 8
 - /etc/lp directory, 151
 - /etc/lp/classes/printer-class file, 71
 - /etc/lp/default file, 68
 - /etc/lp/fd directory, 101, 162
 - /etc/lp/filter.table file, 101
 - /etc/lp/filter.table file
 - filter added in, 102, 103
 - /etc/lp/forms directory, 107
 - /etc/lp/forms/form-name file, 108
 - /etc/lp/forms/form-name/alert.sh file, 111
 - /etc/lp/forms/form-name/allow file, 114
 - /etc/lp/forms/form-name/deny file, 114
 - /etc/lp/forms/form-name/describe file, 107
 - /etc/lp/interfaces directory, 70
 - /etc/lp/printers directory, 152
 - /etc/lp/printers directory
 - of print client, 61
 - of print server, 62
 - /etc/lp/printers/printer-name/alert.sh file, 73
 - /etc/lp/printers/printer-name/comment file, 67
 - /etc/lp/printers/printer-name/configuration file, 69, 75
 - /etc/lp/printers/printer-name/configuration file, 95, 109
 - banner page setting entered in, 70, 94, 96, 109
 - /etc/lp/printers/printer-name/form.allow file, 115
 - /etc/lp/printers/printer-name/form.deny file, 115
 - /etc/lp/printers/printer-name/users.allow file, 77
 - /etc/lp/printers/printer-name/users.deny file, 78
 - /etc/lp/pwheels/charset-name/alert.sh file, 97
 - /etc/lp/Systems file, 61
 - /etc/motd file, 371, 374, 375
 - /etc/nologin file, 294
 - /etc/nsswitch.conf file, 173, 253
 - /etc/passwd file
 - ASET checks, 334
 - /etc/d_passwd file and, 297
 - /etc/password file, 183
 - /etc/printcap file, 151, 616
 - /etc/saf/_sactab file, 226
 - /etc/syslog.conf file, 572

- /etc/system file
 - changing, 371, 375, 378
 - kernel module variables, 545
 - kernel parameter values, 544, 548, 550
 - maxusers parameter, 476
 - max_nprocs parameter, 544
 - number of lock requests, 371
 - number of processes per user, 375, 376
 - number of pseudo-ttys, 371, 376
 - number of shared memory segments, 371, 377
 - scheduler configuration tuning and, 556, 558
 - number of processes per user, 371
- /etc/utmp file, 228
- /etc/vfstab file, 399, 402
- /etc/publickey file, 305
- execute permissions
 - symbolic mode, 272
- execution log (ASET), 335, 336
- exit codes (printer interface), 130
 - standard, 129
 - table of, 130
- exit command, 182, 183
- export command, 345

F

- failed login attempts, 294, 295
- fast print filters, 117
- fault notification (printer)
 - ability to set with Admintool, 22
 - setting with Admintool, 37, 71
 - setting with lpadmin command, 71, 73
 - values for alerts, 72
- fault recovery (printer), 22, 74
- faults
 - page, 498, 518, 519
- fcntl information, 470, 484, 486
- fd2log file, 439, 456, 459
- fee file, 437, 446, 456, 458
- fees (user), 437, 446, 450
- file content type, 26
 - ability to set with Admintool, 22
 - converted by print filters, 100, 134
 - for common printers, 27
 - menu in Admintool, 27
 - non-PostScript printers, 27

- PostScript, 26
 - simple, 26
 - troubleshooting incorrect output, 600
- file systems
 - disk space usage, 381, 506
 - displaying information about, 381, 473, 506
 - for swapping, 475
 - mount point, 383, 506
 - network statistics for, 540, 542
 - restoring, 437, 450
 - statvfs structure for mounted, 381
 - unmounted, 381, 383
- file table, 523, 524
- File Transfer Protocol, , *see* ftp command,
- file transfers, 253
- filename doesn't exist or is not readable
 - message, 354
- files, 529, 530
 - accounting, 458, 461
 - backup, 363
 - checking access operations, 507, 508, 530
 - deleting old/inactive, 363, 389, 394, 418
 - displaying information about
 - listing, 384, 385
 - listing newest, 390
 - size, 384, 385, 387, 389
 - finding and deleting old/inactive, 389, 394, 418, 426, 427
 - finding files exceeding a size limit, 386
 - fixing corrupted
 - tacct file, 439
 - wtmp file, 438, 456
 - for setting search path, 592
 - fstat and fcntl information display, 470, 484, 486
 - lock requests, 371
 - sa filename prefix, 531
 - size of, 384, 385, 387, 389
 - usage monitoring, 444, 445, 450
 - used by LP print service, 152
- files and file systems
 - abbreviated pathnames, 191, 192

- ACL entries
 - adding or modifying, 286
 - checking, 285
 - deleting, 252, 287
 - displaying, 252, 288
 - setting, 283, 285
 - valid entries, 281
- administration commands, 251
- ASET checks, 333, 334
- ownership
 - changing, 251
 - setgid permission and, 266
 - setuid permission and, 265
- permissions
 - absolute mode, 271, 274
 - changing, 251, 271, 277
 - defaults, 267
 - described, 264
 - setgid, 266
 - setuid, 265
 - sticky bit, 266
 - symbolic mode, 271, 272, 276, 277
 - umask setting, 267
- security, 251, 263, 280
 - access restriction, 249
 - ACLs (access control lists), 252, 280
 - changing ownership, 269, 271
 - changing permissions, 271, 277
 - directory permissions, 264
 - displaying file information, 251, 267, 269
 - encryption, 252
 - file permissions, 264
 - file types, 268
 - overview, 247
 - special file permissions, 266, 272, 278
 - umask default, 267
 - user classes, 264
- sharing files, 260
- system logins, 253
- files entry in nsswitch.conf file, 253
- filtering, 26
 - printing without, 26
- filters, 100
 - download, 116, 117
- find command, 386, 389, 391, 393
 - finding files with setuid permissions, 277, 278
 - searching .rhosts files, 179
- finding
 - files exceeding a size limit, 386
 - large files, 385
 - old/inactive files, 389, 394, 418, 427
- finding and deleting, old/inactive files, 427
- firewall systems
 - ASET setup, 258, 335
 - described, 250, 257
 - packet smashing, 258
 - trusted hosts, 258
- firewall.rpt file, 335, 337, 338
- /fiscal directory, 459, 461
- fiscrptn file, 461
- font cartridges, 93
 - alerts for mounting, 94, 96
 - defining, 94
 - mounting, 95
 - naming, 93
 - unmounting, 95
- fonts
 - downloaded PostScript, 118
 - downloading, 116, 117, 620
 - host-resident, 116, 117
 - installing, 118
 - managing, 115
 - permanently downloaded, 116
 - PostScript, 115
 - printer-resident, 116
 - styles, 92
- forcing programs to quit, 587
- forms
 - adding, 105, 107
 - alerts for mounting, 106
 - allowing user access, 113
 - changing, 105
 - controlling access to, 107
 - creating, 144
 - default values for, 145, 146
 - definition, creating, 147
 - deleting, 105, 108
 - denying user access, 113
 - displaying attributes of, 106
 - limiting printer access to, 114
 - limiting user access to, 113
 - managing, 105
 - mounting, 106, 108

- paper (loading and removing), 109
- printer access required for, 108
- setting alerts for mounting, 110
- tracking forms mounted, 106
- unmounting, 108
- viewing status of, 113

fragmentation, 473

frame buffers, 248

free list, 498

freeing memory, 476, 513, 514, 530

freemem parameter, 549

fsck command, 363

fsflush command, 549

fstat information, 470, 484, 486

ftp command

- authenticating remote logins, 183
- authentication, 258
- described, 184
- interrupting logins, 172
- opening remote system connections, 185
- remote logins compared to rlogin and rcp, 183

ftp command interpreter, 184

ftp sessions, 169

- anonymous ftp accounts, 183, 185
- authenticating remote logins, 183
- closing remote system connections, 186
- commands, 184
- copying files
 - from remote system, 186
 - to remote system, 188
- opening remote system connections, 185
- remote logins compared to rlogin and rcp, 183

G

get command

- copying from remote systems, 186
- described, 184
- example, 187

getfacl command

- described, 252
- displaying ACL entries, 288
- examples, 288
- verifying ACLs set on files, 284

getty, 203

global priorities

- construction of, 556
- defined, 490
- displaying, 491, 556
- initial, 556
- maximum, 557
- real-time processes, 555, 562
- scheduler and, 552, 555, 556
- system processes, 555
- timesharing processes, 556, 560

group 14, 35

group ACL entries

- default entries for directories, 282
- described, 281
- setting, 283, 285

group identifier numbers (GIDs), 253

groups

- ASET check, 334
- changing file ownership, 270

H

hard disk

- recommended for print server, 21

held signals, 470, 484

help command, 184

hex+symbolic stack trace, 470

high ASET security level, 332

history log (print requests), 154

hog factor

- reporting on, 452, 454

holidays file, 435, 436, 450

host-resident fonts

- downloading, 117
- PostScript, 118

hostid command, 367, 369

hosts

- checking response of, 534
- in /etc/hosts.equiv file, 174
- sending packets to, 534, 535
- trusted hosts, 258

hosts.equiv file, 174

I

I/O (input/output) devices

- described, 468

I/O, direct, 473

- I/O-intensive processes, 476
- ICMP protocol, 537
- idle mode (CPU), 500, 503, 522
- igets command
 - with page flushes, 514
 - number of requests for inodes not in directory name lookup table, 508
- IGMP protocol, 537
- indirect remote logins, 176, 177
- init process, 444, 445, 552, 556
- init program, 226
- initializing quotas, 398, 402
- inode table
 - size of, 476, 545
 - status of, 523, 524
- inodes, 508, 513, 514
- installing
 - local printers, 38
 - PostScript fonts, 118
- interactive
 - commands for restore, 589
- interactive processes, 473
- interactively running ASET, 350
- interface program (printer)
 - customizing, 128, 131
 - standard, 132
- Internet firewall setup, 250
- interprocess communication
 - checking, 517, 530
 - increasing shared memory, 377
 - parameters, 546
 - tuning parameters, 548
- interrupting programs, 587
- interrupting remote logins, 172
- interrupts, 498, 502, 526, 527
- iostat command, 503
 - basic information display, 503, 504
 - xtc option (extended), 504, 505
 - overview, 473, 503
- IP routing table, 538

K

- KDC, , *see* key distribution center,
- kdestroy command, 308, 309, 318
- kerbd, 309
- Kerberos, 308

- acquiring a ticket for root, 315
- destroying tickets, 318
- logging into, 316
- Kerberos authentication, 308
 - implementing, 309
 - sharing file systems with, 315
- kern facility, 573
- kernel
 - buffer cache and, 476
 - memory allocation for, 515, 516, 530
 - module variable setting, 544, 545
 - paging and, 475
 - parameters
 - buffer cache, 545
 - changing value of, 544
 - IPC, 546
 - kernel-mode parameter table, 563
 - memory management, 548, 550
 - miscellaneous, 550
 - overview, 476, 477
 - scheduler configuration, 556, 558
 - STREAMS, 546
 - tuning, 548, 550, 556, 558
 - UFS, 476, 477, 545
 - system process priority and, 473
- Kernel Memory Allocator, 515, 516, 530
- kernel thread
 - displaying information on, 520, 521, 525
 - scheduling and, 482, 551
 - structures, 469, 482
- kernel-mode parameter table, 563
- /kernel/sched directory, 553, 554, 558
- key distribution center, 309
- key, how to create for an NIS user, 313
- keyboards, 248
- keylogin command, 311, 312
 - running, 305
- keyserver daemon, verifying, 310
- keyserver, starting, 310
- kill command, 472, 489
- killing processes, 470, 472, 489
- kilobytes
 - file system disk usage in, 506
 - read/write statistics in, 505
- kinit command, 308, 309, 316
- klwp structure, 469
- Korn shell

- ASET working directory specification, 345
 - ksh program, 297, 298
 - ksrvrtgt command, 316
 - kthread structure, 469
- L**
- large files, 385, 386
 - last login report, 453
 - lastdate file, 456, 459
 - lastlogin command, 456
 - lcd command, 184
 - leaks, memory, 515
 - libraries (linked), 470, 484
 - limiting
 - printer access to forms, 114
 - user access to forms, 113
 - line discipline, 227
 - line usage monitoring, 443, 444, 448, 449, 456, 459, 461
 - lineuse file, 456, 459, 461
 - linked libraries, 470, 484
 - linking remote logins, 175
 - listing
 - files and directories, 384, 385, 390
 - kernel parameters, 543
 - processes being executed, 483
 - listing, , *see* displaying\x0d,
 - loading form paper, 109
 - local printer
 - adding by using Admintool, 38
 - defined, 18
 - task map for setting up, 33
 - local printing, 164
 - lock file, 439, 456, 459
 - lock1 file, 456
 - locks
 - as critical resources, 563
 - increasing number of requests for, 371
 - software, 518
 - log file, 459
 - log files, 163
 - ASET execution log, 335, 336
 - cleaning out, 163
 - codes in request log, 155
 - deleting automatically, 418
 - for LP print service, 153, 599
 - monitoring su command, 256, 301
 - print queue, 153
 - print request history log, 154
 - requests, 163
 - log.MMDD file, 459
 - logging in
 - displaying user's login status, 291, 292
 - remote logins, 172, 186
 - authentication (ftp), 183
 - authentication (rlogin), 172, 175
 - direct vs. indirect (rlogin), 176, 177
 - finding who is logged in, 181
 - ftp commands, 184
 - interrupting, 172
 - linking logins, 175
 - opening ftp connection, 185
 - using rlogin, 181, 182
 - root login
 - access restrictions, 300
 - account, 253, 300
 - restricting to console, 300
 - tracking, 256
 - security
 - access restrictions, 253
 - saving failed attempts, 294, 295
 - system access control, 248
 - system device access control, 248
 - tracking root login, 256
 - system logins, 253, 254
 - logging out (remote systems), 182, 183
 - login command, 444, 445
 - .login file, 250
 - restricting root access to console, 300
 - restricting root access to devices, 300
 - login monitoring
 - last login, 453, 456, 461
 - number of logins, 450
 - time usage, 443, 444, 446, 450, 456
 - logindevperm file, 248
 - loginlog file, 456, 460, 461
 - overview, 294
 - saving failed login attempts, 294, 295
 - logins command
 - displaying user's login status, 291, 292
 - displaying users with no passwords, 293
 - syntax, 292, 293
 - lotsfree parameter, 549
 - low ASET security level, 332

- LP commands, 624
- lp login account, 253
- LP print service
 - checking basic functions of, 610, 606
 - configuration files in, 150
 - customizing, 10, 121, 147
 - daemons, 152
 - defined, 149
 - defining printer characteristics to, 18
 - directories in, 150
 - files used by, 152
 - hung LP commands, 624
 - interface program, 163
 - log files, 153, 599
 - overview of, 10, 149
 - structure of, 150
 - tracking forms, 106
 - tracking print wheels, 94
 - troubleshooting, 599, 601
- LP print service, *see* print scheduler scheduler,
- LP print spooler, 53
- lpadmin command
 - adding printer description with, 66
 - adjusting printer port characteristics with, 123
 - defining font cartridges with, 94
 - defining print wheels with, 94
 - defining printer class with, 71
 - limiting access to printers with, 77
 - limiting printer access to forms with, 114
 - making banner pages optional with, 69
 - mounting font cartridge with, 96
 - mounting forms with, 109
 - mounting print wheel with, 96
 - setting alerts to mount forms with, 110
 - setting alerts to mount print wheels with, 97
 - setting default printer with, 68
 - setting printer fault alerts with, 72
 - setting printer fault recovery with, 75
 - unmounting forms with, 109
- lpd daemon, 612
- LPDEST environment variable, 68
- lpfilter command, 101
- lpsched daemon, 160, 163, 168
- lpsched log file, 163

- lpset command, 6
- ls command, 384, 385, 390
 - l option (size in bytes), 384, 385
 - s option (size in blocks), 384, 385
 - t option (newest files), 390
- LWPs (lightweight processes)
 - defined, 468
 - displaying information on, 470, 501, 520, 525
 - kernel stack size for, 550
 - processes and, 468, 469
 - structures for, 469
 - swapping, 475, 520, 525

M

- madvise command, 476
- mail facility, 573
- mask ACL entries
 - default entries for directories, 282
 - described, 281
 - setting, 283, 285
- master files (ASET), 333, 339
- maxclsypri parameter, 557
- maximums
 - acctdusg users processed, 445
 - buffer cache memory, 545
 - finding files exceeding maximum size, 386
 - frlocks, 549
 - global priority, 557
 - inode table size, 476
 - nice number, 495
 - pacct file size, 444
 - priority, 491, 557, 558
 - process size, 476, 477
 - real-time process priority, 558
 - user processes per user-id, 476, 477
 - users, 476
- maxuprc parameter, 375, 376, 476, 477
- maxusers parameter, 476
- max_nprocs parameter, 476, 477, 544
- mdelete command, 184
- medium ASET security level, 332
- memory
 - deadlock avoidance, 549
 - described, 468
 - disk slowdowns and, 473

- displaying information on
 - amount installed, 367, 370
 - daily command summary, 452
 - daily usage report, 450
 - dead processes, 454
 - free space, 498
 - freeing activities, 513, 514, 530
 - kernel allocation, 515, 516
 - swap activity, 525, 526
 - swap space, 498, 521, 522
 - swapping activities, 501, 520, 522, 530
 - unused memory, 521, 522
 - virtual memory statistics, 367, 370, 498
- free list, 498
- freeing, 476, 513, 514, 530
- leaks in, 515
- parameters, 548, 550
- preventing monopolization of, 476
- process structures and, 469
- shared
 - increasing number of segments, 371, 377
 - interprocess communication
 - parameters, 548
 - process virtual memory, 469
 - record table, 523, 524
- unused, 521, 522, 530
- virtual
 - displaying information on, 367, 370, 498
 - process, 469
 - when to add more, 513, 514
- MERGE command, 456
- MERGETACCT command, 456
- message of the day (MOTD) facility, 371, 374, 375
- messages file, 568, 572
- messages.n file, 571
- metadata, 508
- mget command
 - copying from remote systems, 186
 - described, 184
 - example, 188
- minimums
 - memory to avoid deadlocks, 549
 - nice number, 495
 - priority, 491
- minus sign (-)
 - file permissions symbol, 272
 - /etc/hosts.equiv file syntax, 174
- mmap command, 476
- modem
 - defined, 202
- modem interrupts, 526, 527
- modems
 - bidirectional service, 202, 228
 - dial-in service, 202
 - dial-out service, 202
 - different ways to use, 202
 - menu items in Serial Port Manager, 211
 - overview of Serial Port Manager, 207
 - setting up, 215
 - setting up for use with UUCP, 217
 - tools for managing, 204
- monacct command
 - crontab entry that runs, 435
 - files used/produced by, 461
 - monthly command summary and, 451, 452
 - runacct command and, 447, 456
 - scheduling running of, 433
- monitoring
 - su command use, 256, 301
 - system usage, 249
- monthly command summary, 447, 452
- monthly tasks, 363
- MOTD (message of the day) facility, 371, 374, 375
- motd file, 371, 374, 375
- mount point, 383, 506
- mounting
 - font cartridges, 95
 - forms, 106, 108
 - print wheels, 95
- mouse (system device access control), 248
- moving print requests, 87, 88
- mput command
 - copying to remote systems, 188
 - described, 184
 - example, 190
- msginfo_xxxxx parameters, 545, 548
- multiple files (ftp), 186
- multiuser state, 448

N

- name service
 - advantages of, 7
- names, 364
 - directory name lookup cache, 476
 - .a file extension, 425
 - sa filename prefix, 529 to 531
- ncsize parameter, 476, 545
- ndquot parameter, 476, 477
- netpr file, 6
- netstat command, 536, 538
 - i option (interfaces), 536, 537
 - r option (IP routing table), 538
 - s option (per protocol), 537
 - overview, 533, 536
- network authentication for remote logins, 172, 174, 177
- network printer
 - adding, 48
 - defined, 48
 - task map for setting up, 33
- network security, 256, 260
 - authentication, 258, 260
 - authorization, 258, 260
 - firewall systems, 257, 258
 - described, 250, 257
 - need for, 250
 - packet smashing, 258
 - trusted hosts, 258
 - issues, 249
 - overview, 247, 256
- networks
 - commands for monitoring
 - performance, 533
 - displaying performance information, 533, 534, 536, 542
 - client statistics, 540, 542
 - collision rate, 537
 - host response, 534
 - interface statistics, 536, 538
 - IP routing table, 538
 - server statistics, 540, 542
 - packets
 - capturing from network, 533, 536
 - dropped, 536
 - error rates, 537
 - number transmitted, 536
 - reliability testing, 533 to 535
 - sending to hosts, 534, 535
 - recognizing access problems, 595
 - tracing client calls to servers, 533, 536
 - troubleshooting
 - hardware components, 542
 - high retransmission rate, 539
- newkey command, 305, 313
- NFS system, 304
- NFS systems (ASET), 343, 344
- nfsstat command, 540, 542
 - c option (clients), 539, 540
 - m option (per file system), 540, 542
 - s option (servers), 540
 - overview, 533, 540
- nice command, 494 to 496
- nice number, 482, 494, 495
- NIS, 7
- nis entry in nsswitch.conf file, 253
- NIS+
 - advantages of, 7
 - ASET checks, 342
 - authentication, 258
 - authorization, 258
 - cred database, 304, 311
 - publickey database, 305
- nisaddcred command, 305, 311
- nisplus entry in nsswitch.conf file, 253
- nlsadmin command, 230
- nobanner option, 69, 70
- nobody user, 260
- non-PostScript printers, 27, 92, 93
- npty parameter, 550
- nsswitch.conf file, 173, 253
- nstrpush parameter, 546
- nuucp login account, 253

O

- open command, 184
- opening remote system connections, 184, 185
- OpenWindows software, 35

- operating system, 368, 369
- optimizing disks, 381, 394
- other ACL entries
 - default entries for directories, 282
 - described, 281
 - setting, 283, 285
- ownership
 - why it changes, 594
- ownership of files
 - ACLs and, 252, 280
 - changing, 251, 269
 - changing group ownership, 270
- owtmp file, 460

P

- pacctn file
 - displaying, 454
 - monitoring size of, 446, 456
 - overview, 446, 456, 458
- packet transfers
 - firewall security, 250
 - packet smashing, 258
- page daemons
 - cycles used by, 513
 - scheduling policies and, 553
- paging
 - defined, 475
 - displaying information on
 - general paging activity, 498
 - page faults, 498, 518, 519
 - page-ins, 498, 518, 519, 530
 - page-outs, 498, 513, 514, 530
 - unused pages, 521, 522
 - priority of, 472
- panic: messages, 570
- parallel printer, 23
- parity bit, 601
- passwd file
 - ASET checks, 334
 - /etc/d_passwd file and, 297
- passwords, 169
 - authentication for remote logins
 - ftp, 183, 185
 - rlogin, 172, 177, 182
 - capturing encrypted passwords, 299

- dial-up passwords, 295, 298
 - basic sequence, 296
 - disabling dial-up logins
 - temporarily, 300
 - /etc/dialups file, 296
 - /etc/d_passwd file, 296 to 298
- displaying users with no passwords, 293
- eeprom security, 254
- login security, 248, 253, 254
- secret-key decryption, 305
- system logins, 253, 254
- PATH environment variable, 335
- path variable, 249, 250
- pathnames
 - rcp command
 - absolute vs. abbreviated, 191, 192
 - syntax options, 192
 - tilde (~) in, 191, 192
- pcrcd command, 484
- pending signals, 470, 484
- perf file, 528, 531
- performance, 467, 498, 531
 - activities that are tracked, 477
 - automatic collection of activity data, 528, 529, 531
 - books on, 468
 - buffer activity, 508, 509, 530
 - cache flushing, 502
 - disk management, 498, 503, 511, 512
 - file access, 507, 508, 530
 - interprocess communications, 517, 530
 - interrupts, 498, 502, 526, 527
 - kernel parameters, 476, 477
 - manual collection of activity data, 507, 528, 529, 531
 - memory management, 475, 476, 498, 513, 516, 521, 522, 525, 526, 548, 550
 - paging, 498, 513, 514, 530
 - process management, 468, 472, 481, 495
 - queue, 505, 512, 520, 521, 530
 - reports on, 507, 531
 - swap areas, 498, 521, 522
 - swapping, 501, 520, 522, 525, 526, 530
 - system activity monitoring, 477, 507, 528, 531
 - system calls, 498, 510, 530

- system event monitoring, 500
- system tables, 523, 524, 530
- terminal I/O, 503, 526, 528, 530
- tools for monitoring, 478, 531
- traps, 498
- PERIODIC_SCHEDULE variable
 - described, 344
 - scheduling ASET, 342, 346, 347, 351
- permissions, 245
 - ACLs and, 252, 280
 - ASET handling of, 332, 333
 - changing file permissions, 251
 - absolute mode, 271, 274
 - symbolic mode, 271, 272, 276, 277
 - copying requirements, 193
 - defaults, 267
 - directory permissions, 264
 - file permissions
 - absolute mode, 271, 274
 - changing, 271, 277
 - described, 264
 - special permissions, 266, 272, 278
 - symbolic mode, 271, 272, 276, 277
 - setgid permissions
 - absolute mode, 272, 276
 - described, 266
 - symbolic mode, 272
 - setuid permissions
 - absolute mode, 272, 276
 - described, 265
 - finding files with permissions set, 277, 278
 - security risks, 266
 - symbolic mode, 272
 - special file permissions, 266, 272, 278
 - sticky bit, 266
 - tune files (ASET), 339, 342
 - umask settings, 267
 - user classes and, 264
- pfiles command, 470, 484, 486
- pflags command, 470, 484
- physical security, 248
- pin configuration in cables, 604, 605
- ping command, 180, 533, 534
- pldd command, 470, 484
- plus sign (+)
 - file permissions symbol, 272
 - /etc/hosts.equiv file syntax, 174
- pmadm command
 - adding a ttymon service with, 235
 - disabling a ttymon service with, 239
 - enabling a ttymon service with, 238
 - explained, 226
 - listing a ttymon service with, 236
- pmap command, 470, 484
- port, 24
 - defined, 202
 - disabling, 219
 - initialization process of, 227
 - initializing, 218
 - removing service, 220
 - states of (table), 243
- port monitor
 - defined, 203
 - states of (table), 242
 - ttymon and listen (defined), 203, 228
- ports in /etc/dialups file, 296
- PostScript fonts, 115, 118
 - installing, 118
- PostScript printers, 92
 - character sets for, 93
 - default print filters, 101, 102
 - file content type for, 26
 - printer type for, 25
- PostScript Reverse printer, , *see* Reverse PostScript printer
- power cycling, 587
- power failure recoveries, 448
- prdaily command
 - files used by, 459, 460
 - line usage reporting and, 461
 - overview, 456
 - runacct command and, 456, 461
- print administration, centralized, 7
- print client
 - checking configuration of, 608
 - defined, 18
 - deleting access to printers, 60
 - freeing jobs in, 627
 - setting up, 42
- print client software, 7
- print configuration
 - centralized, 17
 - using SunOS 5.7 and 4.1 systems, 18
- print daemons, 152

- print filters
 - adding, 101
 - bypassing, 619, 620
 - changing, 100, 101
 - characteristics of, 140
 - converting file content type, 100
 - creating, 100, 133, 142
 - defined, 100, 162
 - definitions, 136
 - deleting, 103
 - displaying definition of, 103
 - download, 117
 - fast, 117
 - handling special modes, 134
 - managing, 100, 101
 - not provided in SunOS 5.7, 102
 - options keywords, 140, 145
 - PostScript, 101
 - removing, 100, 101
 - required for printer fault recovery, 74
 - requirements for, 135
 - restoring, 100, 101
 - slow, 117
 - templates to define options, 139
 - to convert from troff to PostScript, 143
 - TranScript, 101
 - types of, 133
 - used to convert files, 133
 - used to put request on hold, 135
 - viewing information about, 103
- print forms, , *see* forms,
- print jobs, , *see* print requests,
- print management, 3, 10
- print protocol adaptor, 5
- print queue
 - log of, 153
- print requests
 - IDs
 - canceling print requests by, 85, 86
 - changing priority of print requests using, 90
 - accepting, 81, 109
 - canceling, 85
 - by disabling printer, 84
 - for specific user, 86
 - changing priority of, 79, 89
 - checking status of, 79
 - cleaning out from log file, 163
 - IDs, 80
 - canceling print requests by, 85
 - components of, 85
 - in banner page, 68
 - in status of print request, 80
 - moving print requests by, 88
 - log, 155
 - managing, 78, 79
 - moving to another printer, 87, 88
 - moving to head of queue, 89
 - putting on hold, 89
 - rejecting, 61, 81
 - scheduling, 162
 - setting printer to accept or reject, 82
- print scheduler
 - if not running, 606
 - managing, 60
 - restarting, 65
 - starting, 66, 161
 - stopping, 65, 161
 - updating LP system files, 160
- print server
 - checking access to, 611
 - checking configuration of, 608
 - checking connections of, 607
 - defined, 18, 36
 - deleting printer from, 62
 - hard disk requirements for, 21
 - setting up, 36, 37
 - spooling space required for, 20
 - system resource requirements for, 20
- print service, , *see* LP print service,
- print spooler (SVR4), 53
- print wheels, 93
 - alerts for mounting, 94, 96
 - defining, 94
 - mounting, 95
 - naming, 93
 - tracking, 94
 - unmounting, 95
- printcap entry, 616
- printer class, 70
 - checking status for, 80
 - defining with lpadmin command, 71
 - not valid for enabling/disabling printer, 84
 - setting, 22

- printer description
 - ability to set with Admintool, 22
 - setting with lpadmin command, 66
- printer destination
 - ability to set with Admintool, 22
 - setting with Admintool, 67
 - setting with lpadmin command, 67
- PRINTER environment variable, 68
- printer interface program, 163
- printer name, 22
- printer port
 - ability to set with Admintool, 22
 - adjusting characteristics of, 123
 - characteristics, adjusting, 121
 - configuring, 24
 - enabling multiple ports, 24
 - parallel, 23
 - serial, 23
- printer status, 63
- printer type
 - ability to set with Admintool, 22
 - defined in terminfo database, 152
 - not in terminfo database, 26
 - troubleshooting setting of, 618
- printer(s)
 - accepting print requests, 82
 - access to
 - deleting, 60
 - access to forms, 108
 - administering, 59, 90
 - allow list, 76
 - allowing user access, 77
 - baud settings, 600
 - controlling availability of, 82
 - default, 68
 - deleting, 60, 63
 - deleting client access to, 60
 - deleting from print server, 60, 62
 - deny list, 76
 - denying user access, 77
 - description, adding, 66
 - disabling, 61, 81, 84
 - enabling, 81, 84
 - fault alerts, 72
 - fault notification, 71
- faults
 - detecting, 134
 - messages, 131
 - restarting printing, 626
- file content types
 - effect on filtering, 619
 - incorrect output, 619
- font cartridges, 92
- interface program
 - customizing, 128, 131
 - exit codes, 130
 - standard, 129, 132
- local, 18, 33, 164
 - adding by using Admintool, 38
- network, 33, 48
- non-PostScript, 92, 133
- parity bit, 601
- PostScript
 - character sets for, 93
 - treatment of text, 92
- print wheels, 92
- rejecting print requests, 82
- remote, 165
- setting definitions for, 66
- setting up, 29
 - with Admintool, 35, 42
- settings
 - baud, 600
 - parity, 601
 - return, 601
 - stty, 122, 125, 621 to 623, 626
 - tab, 601
- status
 - checking, 63, 79
 - conflicting messages, 603
- stty settings, 129, 621 to 623, 626
- troubleshooting
 - backup in printer queue, 602
 - conflicting status messages, 627, 603
 - hung LP commands, 624
 - hung printers, 625, 602
 - incorrect output, 618, 600
 - incorrect printer type, 618
 - not accepting requests, 607
 - only banner page prints, 619
 - print service commands, 601
 - unsupported, 124

- printer(s), *see* alerts
 - alerts,,
- printer(s), *see* fonts
 - fonts,,
- printer(s), *see* printer class
 - class,,
- printer(s), *see* printer type
 - type,,
- printer-resident fonts, 116
- Printers window, 37
- printers.conf file, 6
- printing
 - banner pages, 68
 - local (diagram), 164
 - processing or stopping, 81
 - remote, 165
 - special modes, 134
 - spooling directory, 157
 - status messages, 627
 - user fee calculation for, 437
- printing (remote), 437
- prionctl command
 - overview, 490, 555
 - c option (scheduling class designation), 491, 493
 - e option (execute), 491
 - i option (ID type), 492, 493
 - l option (scheduling class display), 490, 491
 - m option (max/min priority), 491, 492
 - p option (priority designation), 491, 492, 556
 - s option (priority upper limit/change priority), 492, 493
- priority (process)
 - changing, 490 to 492, 495
 - real-time processes, 554, 556
 - timesharing processes, 492, 494, 495
 - defaults, 472, 473
 - designating, 491, 492
 - displaying information on, 482, 491, 556
 - global
 - construction of, 556
 - defined, 490
 - displaying, 491, 556
 - initial, 556
 - maximum, 557
 - real-time processes, 555, 562
 - scheduler and, 552, 555, 556
 - system processes, 555
 - timesharing processes, 555, 560
 - maximums, 491, 557, 558
 - overview, 472, 490, 495
 - scheduling classes and, 472, 473, 491, 492, 551
 - user-mode priority, 490
- priority of print requests, 79, 89
- private interfaces, 151
- private key, 305
- /proc directory, 470
- /proc file system, 383
- proc structure, 469, 482
- /proc/bin directory, 484
- /proc/bin directory, 470
- process accounting, 444, 446, 449, 450
- process file system (PROCFS), 470
- process table, 523, 524
- processes, 471
 - accounting utilities for, 444, 446, 449, 450
 - address space map, 470, 484
 - application threads and, 468, 469
 - controlling, 487
 - credentials, 484
 - current working directory for, 470, 484, 486
 - defined, 468
 - displaying information on, 482, 487
 - acctcom command, 454
 - daily usage report, 449, 450
 - dead processes, 454
 - listing processes being executed, 483
 - LWPs, 470, 501, 520, 525
 - priocntl command, 490
 - ps command, 482, 483, 491
 - sar -q command, 520, 521
 - tool commands, 470, 484, 487
 - vmstat command, 498, 501

- fstat and fcntl information for open files, 470, 484, 486
- init, 444, 552, 556
- interactive, 473
- killing, 472, 489
- libraries linked into, 470, 484
- maximum size of, 476, 477
- maximum user processes per user-id, 476, 477
- nice number of, 482, 494 to 496
- number per user, 371, 375, 376, 476, 477
- priority, 472, 495
 - changing, 490 to 492, 495
 - changing real-time process priority, 554, 556
 - changing timesharing process priority, 492, 494, 495
 - defaults, 472, 473
 - designating, 491, 492
 - displaying information on, 482, 491
 - global priorities, 490, 491, 552, 555 to 557, 560, 562
 - maximums, 491, 557, 558
 - overview, 472, 490, 495
 - scheduling classes and, 472, 473, 490 to 492, 551
 - user-mode priority, 490
- restarting, 470, 487
- runaway, 496
- scheduling classes, 472, 473, 490, 495
 - changing, 493, 494, 552
 - changing priority of, 490 to 492, 495
 - defaults, 491
 - described, 472, 473
 - designating, 491, 492
 - displaying information on, 482, 490, 491
 - priority levels and, 472, 473, 490 to 492, 551
 - scheduling policies and, 472, 473, 552, 553
 - types of, 472, 473
- signal actions, 470, 484
- sleeping, 553, 560, 563
- stack trace, 470, 484
- stopping temporarily, 470, 487
- structures for, 469, 482
- system
 - described, 472
 - priority of, 472, 473, 552, 553, 555, 557
 - real-time processes and, 552
 - scheduling policies for, 553, 555
 - timesharing processes and, 552
- terminology, 468, 469
- timing, 484
- tool commands, 470, 484
- tracing flags, 470, 484
- trees, 470, 484, 486
- troubleshooting, 496
- UNIX, priority of, 472
- waiting for, 487, 560
- processing printing, 81
- processors, allocating groups for applications, 470
- PROCFS (process file system), 470
- .profile file, 250
- programs
 - disk-dependency of, 508
 - forcing to quit running, 587
 - interrupting, 587
- protection page faults, 518
- prtconf command, 367, 370
- prun command, 487
- ps command, 482, 484
 - fields in reports from, 482, 495, 496
 - overview, 482
 - c option (scheduling class), 482, 496
 - ecl option (global priority), 491
 - ef option (full information), 471, 483
 - elf option (page daemon cycles), 513
- PS printer type, 25
- pseudo-ttys
 - changing number of, 371, 376
 - number configured, 550
- psig command, 470, 484
- PSR printer type, 25
- psrset command, 470
- pstack command, 470, 484
- pstop command, 487
- ptactn.MMDD file, 458
- ptime command, 484
- ptree command, 470, 484, 486
- pt_cnt parameter, 376, 550
- public directories, 266

- public key, 305
- public-key cryptography
 - AUTH_DH client-server session, 305, 308
 - changing public and secret keys, 305
 - common key
 - calculation, 307
 - database of public keys, 305
 - generating keys
 - conversation key, 306
 - public and secret keys, 305
 - secret key
 - changing, 305
 - database, 305
 - decrypting, 305
 - generating, 305
- publickey map, 305
- put command
 - copying to remote systems, 188
 - described, 184
 - example, 189
- pwait command, 484, 487
- pwdx command, 470, 484, 486

Q

- question mark (?) wildcard character, 348
- queue
 - displaying at queue, 427
 - displaying information about, 505, 512, 520, 521, 530
- quitting
 - at command, 363
 - crontab command without saving changes, 418
 - forcing programs to quit, 587
- quot command, 388, 389
- quota command, 397, 403, 404, 408
- quota structures, number of, 476
- quotacheck command, 397, 398, 402
- quotaon command, 397, 402, 403
- quotas, 395, 405
 - administering, 405
 - automatic turning on of, 362, 397
 - changing, 406
 - changing for individual users, 408, 409
 - checking, 403
 - checking for exceeded user quotas, 404
 - checking on file systems, 405

- configuring file systems for, 399
- consistency checking, 402
- disabling for individual users, 409, 410
- displaying information on, 397, 403, 404
- initializing, 398, 402
- overview, 397
- prototype for multiple users, 401
- removing, 406
- requirements, 398
- setting up, 397, 403
- soft limit time
 - changing, 407, 408
 - exceeding, 407
- turning off, 398, 410
- turning on, 398, 402, 403
- user
 - changing for individual users, 408, 409
 - checking for exceeded, 404
 - disabling for individual users, 409, 410
 - setting up, 400, 401
 - soft limit time, 407, 408
 - verifying, 397, 403, 408
- quotas file, 362, 397, 399

R

- rcp command, 191, 197
 - authentication, 258
 - compared to ftp, 183
 - copying between local and remote systems, 193, 197
 - copying directories, 193
 - described, 191
 - examples, 194, 197
 - pathnames
 - absolute vs. abbreviated, 191, 192
 - syntax options, 192
 - security issues, 191
 - specifying source and target, 191, 192
- rdate command, 371, 373
- read permissions
 - symbolic mode, 272
- read system call
 - statistics on, 452, 454, 510
- reads, 505, 508, 512

- real-time parameter table, 561, 562
 - default, 561
 - fields, 562
 - overview, 554, 558
 - sample, 561
 - scheduler configuration changes and, 555
- real-time processes
 - changing class of, 493, 494
 - described, 472
 - overview, 472, 473
 - priority of
 - changing, 554, 556
 - global, 555, 562
 - initial, 556
 - maximum, 558
 - overview, 472, 473, 552, 554
 - parameters controlling, 562
 - specifying relative, 491
 - scheduling policies for, 554, 555
 - system processes and, 552
 - timesharing processes and, 552, 554
- rebooting
 - fails after crash, 585
 - monitoring, 443 to 445, 448, 456
- reboots file, 456, 459
- receiver hardware interrupts, 526, 527
- recognizing network access problems, 595
- reject command, 82
- rejecting, 81
- rejecting print requests, 61, 82
- remote copying, 169
 - using ftp, 184
 - using rcp, 191, 197
- remote ftp server, 184
- remote login and security, 307
- remote logins
 - authentication, 258
 - authentication (ftp), 183
 - authentication (rlogin), 172, 175
 - network authentication vs. remote system authentication, 172, 174
 - /etc/hosts.equiv file, 174
 - .rhosts files, 175
 - authorization, 258
 - closing ftp connection, 186
 - direct vs. indirect (rlogin), 176, 177
 - domains, 172
 - finding who is logged in, 181
 - ftp commands, 184
 - interrupting, 172
 - linking logins, 175
 - nuucp login account, 253
 - opening ftp connection, 185
 - removing .rhosts files, 179
 - using rlogin, 181, 182
 - verifying remote system operation, 180
- remote printing
 - diagram of process, 165
 - user fee calculation for, 437
- remote systems, 172
 - communication methods, 183
 - defined, 172
 - logging in, 172, 186
 - authentication, 258
 - authorization, 258
 - nuucp login account, 253
 - logging out (exit), 183
 - remote copying
 - using ftp, 184
 - using rcp, 191, 197
 - verifying operation, 180
- removing form paper, 109
- repetitive system events, 363, 413, 422, 424
- replayed transactions, 307
- reporting
 - automatic, 528, 529
- reports
 - ASET, 337 to 339
- reports (ASET), 337, 338, 344
- reports directory, 337
- repquota command, 403, 405
- requests log, 163
- reset command, 184
- residentfonts file, 118
- restarting
 - lpd daemon, 613
 - print scheduler, 65
 - processes, 470, 487
 - runacct command, 440, 456, 458
- restore
 - interactive commands, 589
 - using matching commands, 589
- restoring (ASET), 343
- restoring file systems, 437, 450

- restricted shell (rsh), 255
- return settings, 601
- Reverse PostScript printer
 - file content type for, 27
 - method of printing, 26
 - printer type for, 25 to 27
- .rhosts files
 - remote system authentication process, 173 to 176, 179
- rlogin command
 - authentication, 172, 175, 258
 - network vs. remote system authentication, 172, 173
 - /etc/hosts.equiv file, 174
 - .rhosts files, 175
 - compared to ftp, 183
 - described, 172
 - direct vs. indirect logins, 176, 177
 - interrupting logins, 172
 - process after logging in, 178, 179
 - using, 181, 182
- rm command, 175, 391, 392
- root access
 - displaying attempts on console, 301, 302
 - monitoring su command use, 256, 301
 - restricting, 260, 300
- root file, 414, 415, 435, 444
- root login
 - account
 - access restrictions, 300
 - described, 253
 - restricting to console, 300
 - tracking, 256
- RPC, 539, 540
- rprt.MMDD file, 447, 460, 461
- rpt.MMDD file, 456
- RS-232-C, , *see* serial port,
- rsh program, 255
- RT_DPTBL loadable module, 554, 555, 558, 561
- rt_dptbl parameter table, 554, 555, 558, 561, 562
- rt_maxpri parameter, 558
- runacct command, 456, 461
 - caution, 458
 - crontab entry that runs, 456
 - diagnostics file, 456
 - error messages, 439
 - error protection, 456

- failure of, 439
- files used/produced by, 458, 459, 461
- fixing corrupted files, 438, 456
- last time executed, 459
- monacct command and, 456
- overview, 446, 456
- prdaily command and, 456, 461
- progress file, 456
- restarting, 440, 456, 458
- running after midnight, 456
- scheduling running of, 433
- serial use of, 459
- states of, 456
- user fee calculation and, 437, 450

- runacct.local command, 456
- runaway processes, 496
- running, , *see* starting\x0d,
- rusers command, 181

S

- sa filename prefix, 529 to 531
- sa1 command, 528, 529
- sa2 command, 528, 529
- SAC, , *see* Service Access Controller,
- sacadm command
 - adding a ttymon port monitor with, 231
 - disabling a ttymon port monitor with, 233
 - enabling a ttymon port monitor with, 234 (explained), 225
 - killing a ttymon port monitor with, 233
 - listing a ttymon port monitor with, 231
 - removing a ttymon port monitor with, 234
 - starting a ttymon port monitor with, 233
- sadc command, 528, 529, 531
- sadcnt parameter, 546
- sadd file, 529 to 531
- SAF, , *see* Service Access Facility,
- sar command, 507, 528, 529, 531
 - options listed, 530, 531
 - overview, 473, 507, 529
 - a option (file access), 507, 508
 - A option (overall performance), 528, 530
 - a option (file access), 530
 - b option (buffers), 508, 509, 530
 - c option (system calls), 510, 530
 - d option (block devices), 511, 512, 530

- e option (ending time), 530
- f option (file to extract data from), 530
- g option (page-out/memory freeing), 513, 514, 530
- i option (interval), 530
- k option (kernel memory), 515, 516, 530
- m option (interprocess communication), 517, 530
- p option (page-in/page faults), 518, 519, 530
- q option (queue), 520, 521, 530
- r option (unused memory), 521, 522, 530
- s option (starting time), 530
- u option (CPU usage), 522, 523, 530
- v option (system tables), 523, 524, 530
- w option (swapping/switching volume), 525, 526, 530
- y option (terminal activity), 530
- saving
 - crash dump information, 577
 - failed login attempts, 294, 295
- Schedule undefined for periodic invocation
 - message, 354
- scheduler, 551, 563
 - activation, 552
 - configuration of, 554, 563
 - global priorities and, 552, 555, 556
 - overview, 551, 552
 - scheduling classes and, 551 to 553
 - time slices used by, 553, 558, 560
 - tunable parameters, 556, 558
- scheduler, , see print scheduler
- scheduling ASET execution
 - (PERIODIC_SCHEDULE), 332, 342, 346, 347, 351
- scheduling class tables, 558, 563
 - maxclsypri parameter and, 557
 - overview, 558
 - rt_dptbl parameter table, 554, 555, 558, 561, 562
 - rt_maxpri parameter and, 558
 - ts_dptbl parameter table, 553, 555, 558, 560
 - ts_kmdpris table, 558, 563
- scheduling classes, 472, 473, 490, 495
 - changing, 493, 494, 552
 - changing priority of, 490 to 492, 495
 - defaults, 491, 553
 - described, 472, 473
 - designating, 491, 492
 - displaying information on, 482, 490, 491
 - priority levels and, 472, 473, 490 to 492, 551, 552
 - scheduling policies and, 472, 473, 552, 553
 - types of, 472, 473
- scheduling one-time system events, 363, 413, 425, 426, 430
- scheduling repetitive system events, 363, 413, 422, 424
- SCSI disk drives, 513
- search path
 - files for setting, 592
- searching
 - files with setuid permissions, 277, 278
 - .rhosts files, 179
 - users logged in to remote system, 181
- secret key
 - changing, 305
 - database, 305
 - decrypting, 305
 - generating, 305
- secure access, 314
- secure NIS+, adding a user, 312
- Secure RPC, 304
 - implementation of, 305
- Secure RPC authentication, 258
- security, 169
 - at command, 425
 - copy operation issues, 191
 - crontab command, 422
 - DH authentication
 - AUTH_DH client-server session, 305, 308
 - /etc/hosts.equiv file issues, 174
 - .rhosts file issues, 175, 179
- selectable character sets, 92, 93, 98, 99
- seminfo_XXXXXX parameters, 377, 548
- serial port
 - adapter board, 203
 - defined, 202
- Serial Port Manager, 204
 - Modify window field descriptions, 208
 - prerequisites for running, 213
 - starting, 213
 - when to use, 204
- serial printer, adding to system, 23

- servers
 - AUTH_DH client-server session, 305, 308
 - displaying information about, 533, 540, 542
 - scheduling policies and, 553
 - tracing client calls to, 533, 536
- Service Access Controller, 225
- Service Access Facility
 - description, 204
 - files associated with (table), 239
 - overview of, 206, 223
 - programs associated with (table), 224
 - services controlled by
 - states of (table), 242
 - uses for, 206, 223
 - when to use, 204
- service times, 505, 512
- set-group identification permissions, , *see* setgid permissions\x0d,
- set-user identification permissions, , *see* setuid permissions\x0d,
- setenv command
 - ASET security level specification, 345
 - ASET working directory specification, 345
- setfacl command
 - adding ACL entries, 286
 - deleting ACL entries, 287
 - described, 252
 - examples, 284, 287
 - modifying ACL entries, 286
 - setting ACL entries, 283, 285
 - syntax, 283
- setgid permissions
 - absolute mode, 272, 276
 - described, 266
 - symbolic mode, 272
- setting
 - alerts to mount font cartridges, 96
 - alerts to mount print wheels, 96
 - alias for selectable character set, 98, 99
- setuid permissions
 - absolute mode, 272, 276
 - described, 265
 - finding files with permissions set, 278
 - security risks, 266
 - symbolic mode, 272
- setuid programs, 250
- sh program, 297, 298
- share command, 260
- shared memory
 - increasing number of segments, 371, 377
 - interprocess communication
 - parameters, 548
 - process virtual memory, 469
 - shared memory record table, 523, 524
- sharing files (network security), 260
- shell, 452
- shell programs, 245
 - ASET security level specification, 345
 - ASET working directory specification, 345
 - /etc/d_passwd file entries, 297, 298
- shminfo_XXXXXX parameters, 377, 548
- showing, , *see* displaying\x0d,
- shutacct command, 446, 447
- shutdown command, 447
- shutdowns, 446 to 448
- signal actions, 470, 484
- simple file content type, 26
- size
 - directory, 387, 389
 - file, 384, 385, 387, 389
 - system table, 523, 524
- sleeping processes, 553, 560, 563
- slow print filters, 117
- snoop command, 533, 536
- soft limit time
 - changing, 407, 408
 - exceeding, 407
- software administration
 - adding packages
 - troubleshooting, 661
 - removing packages
 - troubleshooting, 661
 - troubleshooting, 661
- software locks, 518
- Solaris environment, 18
- Solstice AdminSuite software, 258
- Solstice DiskSuite, 473
- Solstice Printer Manager, 7
- Spacctn.MMDD file, 456, 458
- space (disk)
 - amount of free, 381, 506
 - optimizing usage, 381, 394
- spooling directory
 - creating for a printer, 616

- print service, 157
- spooling space required for print server, 20
- spray command, 533 to 535
- stack trace, 470, 484
- standard printer interface program, 132
- starting
 - Admintool, 35
 - ASET
 - initiating sessions from shell, 332
 - running interactively, 350
 - lpd daemon, 612
 - print scheduler, 66
- startup command, 445
- statefile file, 440, 456, 459
- states, (runacct command), 456
- status
 - of print requests, 79
 - of printer, 63, 79
- statvfs structure, 381
- sticky bit permissions
 - absolute mode, 272, 276
 - described, 266
 - symbolic mode, 272
- stopping
 - dial-up logins temporarily, 300
 - ftp command interpreter, 184
 - print scheduler, 65
 - printer, 81
 - processes temporarily, 470, 487
- strctlsz parameter, 546
- STREAMS
 - KMA resources and, 515
 - parameters, 546
- strmsgsz parameter, 546
- strthresh parameter, 546
- structures
 - process, 469, 482
 - quota, 476, 477
 - statvfs, 381
- stty option, 123
- stty settings
 - customizing, 129
 - defaults, 122, 125, 621, 622
 - suggestions for, 623, 626
 - troubleshooting, 600
- su command
 - displaying use on console, 301, 302
 - monitoring use, 256, 301

- su file
 - displaying su command use on
 - console, 301, 302
 - monitoring su command, 301
- sulog file, 256, 301
- SunOS 5.7, 18
- SunOS operating systems, 18
- SVR4 LP print spooler, 53
- swap areas
 - adding, 475
 - defined, 475
 - displaying information on, 498, 521, 522
 - unused disk blocks, 521, 522
- swapping
 - defined, 475
 - displaying information on, 501, 520, 522, 525, 526, 530
 - LWPs, 475, 520, 525
 - minimum memory to avoid deadlock, 549
 - priority of, 472
 - reducing, 473
- switching
 - displaying information on, 525, 526, 530
- symbolic links
 - file permissions, 264
 - latest directory (ASET), 337
- symbolic mode
 - changing file permissions, 272, 276, 277
 - described, 271
- synchronizing command-reply sequencing
 - with remote ftp server, 184
- synchronizing date and time with another
 - system, 373
- syntax (crontab files), 416
- sys file, 415, 529, 531
- sys login account, 253
- sysadmin group, 35
- sysconf.rpt file, 334, 337, 338
- sysdef command, 543
- syslog.conf file, 572
- syslogd daemon, 571
- system activities
 - automatic collection of data on, 528, 531
 - list of activities tracked, 477
 - manual collection of data on, 507, 528, 529, 531

- system authentication for remote logins, 172, 173, 177
- system calls
 - displaying information on, 498, 510, 530
- system events
 - displaying information on, 500
- scheduling
 - one-time events, 363, 413, 425, 426, 430
 - repetitive events, 363, 413, 422, 424
- system exit status, 454
- system logging (customizing), 572
- system messages
 - specifying storage location for, 571
- system mode (CPU), 500, 503, 522
- system processes
 - described, 472
 - priority of, 472, 473, 552, 553, 555, 557
 - real-time processes and, 552
 - scheduling policies for, 553, 555
 - timesharing processes and, 552
- system resources
 - allocating for print server, 20
 - critical, 563
 - monitoring, 362, 426
 - accounting, 433, 440, 443
 - accounting system for, 461
 - automatic, 363, 426
 - crashes, 572, 587
 - quotas, 395, 405
 - overview, 467, 476
- system security, 252, 291, 301
 - dial-up passwords, 295, 298
 - basic sequence, 296
 - disabling dial-up logins
 - temporarily, 300
 - /etc/dialups file, 296
 - /etc/d_passwd file, 296 to 298
 - displaying
 - user's login status, 291, 292
 - users with no passwords, 293
 - login access restrictions, 253
 - overview, 247, 252
 - passwords, 254
 - restricted shell, 255
 - restricting root login to console, 300
 - root access restrictions, 260, 300
 - saving failed login attempts, 294, 295

- special logins, 253, 254
- su command monitoring, 256, 301
- system tables
 - checking status, 524, 530
 - space allocation for, 476
- sys_name parameter, 557

T

- tab settings, 601
- tacct file, 439, 456, 460, 461
- tacct.MMDD file, 439, 456, 460
- tacct.prv file, 439
- tacctn file, 461
- tacctprev file, 460
- TASKS variable
 - configuring ASET, 341, 347
 - described, 344
 - error messages, 354
- taskstat utility (ASET), 333, 336
- TCP protocol, 537
- TCP/IP traffic, 533, 536, 537
- technical support, 568, 578
- templates (print filters), 139
- temporary directories, 389, 392
- terminal
 - alphanumeric, 202
 - defined, 202
 - distinctions between types of, 202
- terminal characteristics, 129
- terminals
 - displaying I/O information for, 503, 526, 528, 530
 - line usage monitoring, 443, 444, 448, 449, 456, 459, 461
 - menu items in Serial Port Manager, 210
 - overview of Serial Port Manager, 207
 - process controlling, 482
 - setting up, 214
 - tools for managing, 204
 - troubleshooting bad lines, 449, 461
- terminfo database
 - character set names, 92
- terminfo entry
 - adding, 124
 - for unsupported printer, 127
 - list of required items, 124, 125

- selectable character sets in, 92
- testing packet reliability, 533
- tilde (~)
 - abbreviated pathnames, 191, 192
 - rcp command syntax, 194, 197
- time
 - changing, 371, 373
 - CPU usage, 450, 482, 496, 498, 503, 522, 523, 530
 - disk slowdowns, 473, 523
 - displaying, 367, 370
 - process timing, 484
 - processes accumulating large amounts of
 - CPU time, 496
 - service, 505, 512
 - soft limit, 407, 408
 - synchronizing with another system, 371, 373
- time slices, 553, 558, 560
- timesharing parameter table, 558, 560
 - default, 559
 - fields, 560
 - overview, 553, 558, 559
 - sample, 559
 - scheduler configuration changes and, 555
- timesharing processes
 - changing scheduling parameters, 492
 - described, 472
 - overview, 473
 - priority of
 - changing, 492, 494, 495
 - global, 555, 560
 - overview, 472, 473, 490, 552
 - parameters controlling, 560
 - range of, 490, 557
 - real-time processes and, 552, 554
 - scheduling policies for, 472, 473, 552, 553, 555
 - sleeping, 560, 563
 - system processes and, 552
- /tmp directory, clearing out, 389, 392
- /tmp file system, 383
- /tmp/diskacct.MMDD file, 456
- tmpfs file system, 266
- tmpwtmp file, 456, 459, 461
- tools
 - process, 470, 484
 - system performance monitoring, 478, 531
- total command summary, 447, 453, 460, 461
- TOTAL REAL-MIN column (daily command summary), 452
- tracing flags, 470, 484
- TranScript filters, 101
- translation page faults, 518
- transmitter hardware interrupts, 526, 527
- traps, 498
- trees, 470, 484, 486
- troff filter to convert to PostScript, 143
- Trojan horse, 249, 250
- troubleshooting, 601
 - networks, 539, 542
 - printing problems, 597, 628
 - processes, 450, 496, 497
 - software package
 - installation/removal, 661
 - tty lines, 449, 461
- trusted hosts, 258
- trusting network environment
 - remote login
 - authentication process, 173
 - process after logging in, 178, 179
- TS_DPTBL loadable module, 553, 555, 557, 558, 563
- ts_dptbl parameter table, 553, 555, 558, 560
- ts_kmdpris parameter table, 558, 563
- ts_maxupri parameter, 557
- tty lines
 - displaying I/O information for, 503, 526, 528, 530
 - troubleshooting bad lines, 449, 461
 - usage monitoring, 443, 444, 448, 449, 456, 459, 461
- ttyadm command, 230
- ttymon command, 228, 444
- ttymon port monitor
 - adding, 231
 - bidirectional modem service and, 228
 - disabling, 233
 - enabling, 234
 - (figure), 227
 - killing, 233
 - listing, 231
 - overview of function of, 226
 - removing, 234
 - starting, 233

- ttymon service
 - adding, 235
 - disabling, 239
 - enabling, 238
 - listing, 236
- ttys (pseudo)
 - changing number of, 371, 376
 - number configured, 550
- tune files (ASET)
 - described, 339, 342
 - example files, 348
 - format, 348
 - modifying, 342
 - rules, 348
- tune.rpt file, 333, 337, 338
- tune_t_fckrec parameter, 549
- tune_t_fsflushr parameter, 549
- tune_t_gpgslo parameter, 549
- tune_t_minarmem parameter, 549
- tune_t_minasmem parameter, 549
- tuning
 - daily command summary and, 451
 - kernel parameters, 548, 550, 556, 558
- turnacct switch command, 446, 456
- turning off
 - quotas, 398, 410
- turning on
 - quotas, 398, 402, 403

U

- UDP protocol, 537
- UFS file systems
 - displaying information about
 - space usage, 383
 - user allocation, 388, 389
- UFS parameters, 476, 477, 545
- ufs_ninode parameter, 476, 477, 545
- uid_aliases file
 - described, 339
 - specifying, 342
- UID_ALIASES variable
 - aliases file specification, 342, 347
 - described, 339, 344
- umask, 267
- UMASK environment variable, 335
- uname command, 368, 369
- UNIX processes (priority), 472

- UNIX systems (crash information), 577
- unmounting
 - font cartridges, 95
 - forms, 108
 - print wheels, 95
- unsupported printers, 28, 124
- Usage: aset message, 354
- user
 - access to printer
 - ability to limit with Admintool, 22
 - limiting with Admintool, 75
 - limiting with lpadmin command, 75
 - canceling print requests for, 87
- user accounts
 - ASET check, 334
 - displaying login status, 291, 292
- user ACL entries
 - default entries for directories, 282
 - described, 281
 - setting, 283, 285
- user allocation, 388, 389
- user classes of files, 264
- user facility, 573
- user fees, 437, 446, 450
- user logins
 - last login monitoring, 453, 456, 461
 - number of logins, 450
 - time monitoring, 443, 444, 450, 456
- user mode (CPU), 499, 503, 522
- user names
 - current user, 192
 - direct vs. indirect logins (rlogin), 176, 177
 - finding users logged in to remote
 - system, 181
- user processes
 - changing priority, 494, 495
 - CPU usage by, 450
 - in kernel mode, 553
 - maximum per user-id, 476, 477
 - number per user, 371, 375, 376
 - priority of, 472, 473, 490
- user quotas
 - changing for individual users, 408, 409
 - checking for exceeded, 404
 - disabling for individual users, 409, 410
 - setting up, 400, 401
 - soft limit time, 407

user structure, 469
 user-mode daemon for kerberos, 309
 user-mode priority, 490
 users (maximum number), 476
 usr cache name, 502
 /usr/adm directory, 568, 571
 /usr/adm/messages file, 568, 572
 /usr/adm/messages.n file, 571
 /usr/adm/sa directory, 528
 /usr/aset directory, 332
 /usr/aset/asetenv file
 described, 340, 351, 354
 /usr/aset/masters/tune files
 described, 339, 342, 348
 /usr/aset/masters/uid_aliases file, 339
 /usr/aset/reports directory
 structure, 336, 337
 /usr/aset/reports/latest directory, 337
 /usr/lib/acct/runacct.local command, 456
 /usr/lib/acct/startup command, 445
 /usr/lib/lp directory, 101
 /usr/lib/lp/model directory, 163
 /usr/lib/lp/model/netstandard file, 6
 /usr/lib/lp/postscript directory, 100, 162
 /usr/lib/sa/sa1 command, 528, 529
 /usr/lib/sa/sa2 command, 528, 529
 /usr/lib/sa/sadc command, 528, 529, 531, 533
 /usr/proc/bin directory, 470, 484
 /usr/sbin/crash utility, 570, 581, 582
 /usr/spool/cron/atjobs directory, 364
 usrgrp.rpt file
 described, 334, 337
 example, 338
 format, 338
 /usr/sbin/kerbd daemon, 309
 utmp2wtmp command, 456
 uucico program, 297, 298
 uucp login account, 253
 UUCP program, 253

V

validity faults, 518
 /var partition, 20
 /var/adm directory
 controlling size of, 391, 458
 controlling size of, 568, 571
 raw accounting data in, 445
 /var/adm/acct directory, 459
 /var/adm/acct/fiscal directory, 461
 /var/adm/acct/fiscal directory, 459
 /var/adm/acct/nite directory, 459
 /var/adm/acct/nite/active file, 439, 456, 459
 /var/adm/acct/nite/active.MMDD file, 456, 459
 /var/adm/acct/nite/cms file, 456, 459
 /var/adm/acct/nite/ctacct.MMDD file, 456, 459
 /var/adm/acct/nite/cttmp file, 459
 /var/adm/acct/nite/daycms file, 456, 459, 461
 /var/adm/acct/nite/dayacct file, 450, 456, 459, 461
 /var/adm/acct/nite/disktacct file, 445, 446, 456, 459
 /var/adm/acct/nite/disktacct.MMDD file, 456
 /var/adm/acct/nite/fd2log file, 439, 456, 459
 /var/adm/acct/nite/lastdate file, 456, 459
 /var/adm/acct/nite/lineuse file, 456, 459, 461
 /var/adm/acct/nite/lock file, 439, 456, 459
 /var/adm/acct/nite/lock1 file, 456
 /var/adm/acct/nite/log file, 459
 /var/adm/acct/nite/log.MMDD file, 459
 /var/adm/acct/nite/owtmp file, 460
 /var/adm/acct/nite/reboots file, 456, 459
 /var/adm/acct/nite/statefile file, 440, 456, 459
 /var/adm/acct/nite/tmpwtmp file, 456, 459, 461
 /var/adm/acct/nite/wtmp.MMDD file, 438, 456, 460
 /var/adm/acct/nite/wtmperror file, 459
 /var/adm/acct/nite/wtmperror.MMDD file, 459
 /var/adm/acct/nite/xwtmp file, 438
 /var/adm/acct/sum directory, 446, 459, 460
 /var/adm/acct/sum/cms file, 456, 460, 461
 /var/adm/acct/sum/cmsprev file, 460
 /var/adm/acct/sum/daycms file, 456, 460, 461
 /var/adm/acct/sum/loginlog file, 456, 460, 461
 /var/adm/acct/sum/rprt.MMDD file, 446, 461

- /var/adm/acct/sum/rpt.MMDD file, 456
- /var/adm/acct/sum/tacct file, 439, 456, 460, 461
- /var/adm/acct/sum/tacct.MMDD file, 439, 456, 460
- /var/adm/acct/sum/tacct.prv file, 439
- /var/adm/acct/sum/tacctprev file, 460
- /var/adm/acct/sum/xtacct file, 439
- /var/adm/dtmp file, 458
- /var/adm/fee file, 437, 446, 456, 458
- /var/adm/loginlog file
 - overview, 294, 295
- /var/adm/messages file, 568, 572
- /var/adm/messages.n file, 571
- /var/adm/sa/sadd file, 530, 531
- /var/adm/sa/sadd file, 529
- /var/adm/Spacctn.MMDD file, 456, 458
- /var/adm/sulog file, 256, 301
- /var/crash directory, 393
- /var/lp/logs directory, 163
- /var/lp/logs/lpsched file, 163, 599
- /var/spool directory, 389, 392
- /var/spool/cron/atjobs directory, 364, 413, 415
- /var/spool/cron/crontab directory, 415
- /var/spool/cron/crontabs/adm file, 415
- /var/spool/cron/crontabs/lp file, 163
- /var/spool/cron/crontabs/root file, 414, 415, 444
- /var/spool/cron/crontabs/lp file, 415, 529, 531
- /var/spool/lp directory, 20, 157
- /var/spool/lp/requests directory, 153
- /var/spool/lp/tmp directory, 153
- /var/tmp directory, 389, 392
- /var/tmp/deadfiles file, 391
- variables
 - ASET environment variables, 344, 348
 - ASETDIR, 345
 - ASETSECLEVEL, 345
 - CKLISTPATH_level, 339, 341, 347
 - PERIODIC_SCHEDULE, 342, 346, 347, 351
 - summary table, 344
 - TASKS, 341, 347
 - UID_ALIASES, 339, 342, 347
 - YPCHECK, 342, 347

verifiers

- described, 306
- returned to client, 307
- window, 306
- verifying
 - at jobs, 427
 - crontab file existence, 418
 - quotas, 397, 403, 408
 - remote system operation, 180
- vfstab file, quotas and, 399, 402
- viewing, , see displaying\x0d,
- virtual caches, 502
- virtual memory
 - displaying information on, 367, 370, 498
 - process, 469
- viruses, 245
 - Trojan horse, 249, 250
- vmstat command, 498
 - fields in reports from, 498, 500, 501
 - overview, 498
 - c option (cache flushing), 502
 - i option (interrupts), 502
 - s option (system events), 500
 - S option (swapping), 501

W

- wait mode (CPU), 503, 522
- waiting
 - for disk transfer requests, 512
 - for processes, 487, 560
- Warning! Duplicate ASET execution scheduled message, 354
- “WARNING: ” message, 662
- Watchdog reset ! message, 570
- weekly tasks, scheduling with crontab, 363
- wildcard characters, 348
- window verifier, 306
- working directory
 - defined, 192
 - ftp commands, 184
- write permissions
 - symbolic mode, 272
- write system call
 - statistics on, 452, 454, 510
- writes, 505, 508, 512
- wtmp file
 - daily report and, 448

- fixing corrupted, 438, 456
- overview, 438, 444, 445, 456
- shutdowns and, 447
- wtmp.MMDD file, 438, 456, 460
- wtmperror file, 459
- wtmperror.MMDD file, 459
- wtmpfix command, 438, 456, 459

X

- xtacct file, 439

- xwtmp file, 438

Y

- YPCHECK variable
 - described, 344
 - specifying system configuration file tables, 342, 347