

# INDEX

## Numbers and Symbols

., 17. *See also* directory, current  
/. *See* directory, root  
.., 17. *See also* directory, parent  
#, 13  
#!. *See* shebang  
\$, 12–13. *See also* shell, prompt  
##, 297  
\$\$, 33, 298  
\$0, 297  
\$1, 296  
\$?, 298. *See also* exit code  
\$@, 297  
&&, 300–301  
\*, 18–19. *See also* glob  
|, 28–29. *See also* pipe  
||, 300–301  
<. *See* file, redirect command input  
    from  
<<. *See* here document  
>. *See* file, redirect command output to  
>>. *See* file, redirect command output to  
?, 18–19. *See also* glob  
[, 299. *See also* test  
~, 17

## A

abstraction, 1–2  
administrator. *See* root  
AFS (Andrew File System), 333–334  
alias, 339  
ALSA (Advanced Linux Sound  
    Architecture), 55–56  
Apple partition. *See* filesystem, HFS+  
application layer. *See* network,  
    application layer  
archive, 39–41  
    table of contents, 40  
    testing, 40, 387–388

ARP (Address Resolution Protocol),  
    264–265  
at, 187–188  
ATA, 64–66  
autoconf, 388–393  
Autotools. *See* GNU Autotools  
Avahi, 281  
awk, 309

## B

basename, 308–309  
bash, 12. *See also* Bourne Shell  
    startup file (*see* startup file, bash)  
    *.bash\_profile*, 340–342  
    *.bashrc*, 340–342  
bg, 34  
/bin, 42  
/bin/bash. *See* bash  
/bin/sh. *See* Bourne Shell  
BIOS, 121–122  
    boot partition, 133  
bison, 379  
blkid, 85  
block bitmap, 114  
block device. *See* device, block  
blockdev, 76  
/boot, 43, 127–131  
boot, 117–118. *See also* init  
    init (*see* init)  
    loader (*see* boot loader)  
    messages, 118–119, 171–172  
    network configuration, 239–240  
boot loader, 117, 121–123  
    chainloading, 132  
    filesystem access, 121–122 (*see also*  
        GRUB, filesystem access)  
    GRUB (*see* GRUB)  
    internals, 132–135  
    multi-stage, 133  
    system other than Linux, 132

- Bourne Shell, 12–13
  - basic use, 12–13
  - Bourne-again (*see* `bash`)
  - script (*see* shell script)
- `bpfilter`, 259
- Btrfs. *See* filesystem, Btrfs
- building software, 386–399
- `bunzip2`, 41
- bus error, 31–32
- BusyBox, 258
- `bzip2`, 41

## C

- C, 364–365
  - compiler, 376–377, 392
  - preprocessor, 372–373, 377, 391, 398
- case, 304
- `cat`, 13–14
- `cd`, 17
- `cgroup`, 144, 147, 216–220
  - container, 406
  - controller, 219–221
  - creating, 220–221
  - listing, 218–219
  - version 1, 218–219
- chainloading. *See* boot loader, chainloading
- character device. *See* device, character
- child process. *See* process, child
- `chmod`, 36–37. *See also* permissions
- Chrome OS, 362
- `chroot`, 406
- `chsh`, 12, 22, 193–195
- `chvt`, 55, 355
- CIDR (Classless Inter-Domain Routing), 229–232
- CIFS. *See* filesystem, CIFS
- `clang`, 364
- CLASSPATH, 382
- `clobber`, 28
- clock. *See* real-time clock; system clock
- cloud services, 403–404
- cloud storage, 333
- CMake, 388, 399
- command-line editing, 25
- command substitution, 306
- compiler, 383

- compiling, 364–366
- compositor. *See* Wayland, compositor
- compress. *See* file, compress
- concatenate (files), 13–14
- configuration file, 42
- `configure`, 388–393
- container
  - building, 407–409
  - definition, 406
  - filesystem, 410–411
  - image, 407–409, 413
  - limitations, 415–417
  - networking, 411
  - operation, 412–414
  - privilege requirements, 406–407
  - purpose, 405
  - rootless, 407
  - running, 409–410
  - storing data, 416
- context switch, 5–6
- control group. *See* `cgroup`
- controlling terminal, 54
- coreboot, 123
- `coreutils`, 389, 395
- `cp`, 15
- `cpio`, 164
- `cpp`, 373. *See also* C, preprocessor
- CPU, 2–6
  - load (*see* load average)
  - multiple, 6, 205
  - performance, 208–210, 212–214
  - time, 32, 200, 207–208, 221
  - virtual machine, 403–404
- `cron`, 183–185, 187
- `csh`, 342
- CTRL-C, 14
- CTRL-D, 14
- CUPS, 360–362
- `curl`, 271–272
- current working directory. *See* directory, current
- cylinder (disk), 78–79

## D

- D-Bus, 148, 241, 359–360
  - instance, 360
  - monitoring, 360
  - systemd unit, 142

- date, 182
- dd, 50–51, 93
- debugfs, 93
- default gateway, 230–231, 238
- default route, 230
- default.target*, 143
- default user settings, 343–344
- demand paging, 210
- desktop, 347–348
- desktop background, 359
- Desktop Bus. *See* D–Bus
- desktop environment, 350
- /dev*, 42, 48–66
- /dev/dm-\**, 53, 100
- /dev/hd\**, 53
- /dev/lp\**, 55
- /dev/mapper*, 53, 100, 105
- /dev/null*, 48–49
- /dev/nvme\**, 53
- /dev/parport\**, 55
- /dev/pts*, 54
- /dev/sd\**, 52–53
- /dev/sg\**, 53, 66–67
- /dev/snd*, 55
- /dev/sr\**, 53, 67
- /dev/tty\**, 54–55
- /dev/ud\**, 53
- /dev/xvd\**, 53, 403
- /dev/zero*, 50–51
- device, 47
  - audio, 55–56
  - block, 48–50, 56, 64, 66–67, 69–78, 96–97
  - character, 49–50, 56
  - creating file, 56
  - disk, 48–50
  - driver, 4, 6–7, 117
  - file, 42, 48–49, 56–61
  - finding, 51
  - information, 49–50, 58, 60–61
  - initialization, 57–62
  - major and minor numbers, 49, 58, 100
  - monitor, 61
  - name, 51–55
  - network, 49
  - node (*see* device, file)
  - optical, 53, 67, 81
  - parallel, 55
  - pipe (*see* pipe, named)
  - SCSI (*see* SCSI)
  - serial, 55
  - socket, 49, 289–290
  - terminal, 53–55
  - types, 48–49
- device mapper, 53, 108–110
- devtmpfs, 57–58
- df, 89–91
- DHCP (Dynamic Host Configuration Protocol), 252–253
- diff, 21, 395
- directory, 16–18, 36
  - change, 17
  - create, 17
  - current, 17, 20, 201
  - errors, 31
  - hierarchy, 16–17, 42–44
  - home (*see* home directory)
  - internal structure, 112–113
  - listing contents, 15
  - parent, 17, 112–114
  - permissions (*see* permissions, directory)
  - remove, 17–18
  - root, 16–17, 42–43, 117, 120, 124–125, 144 (*see also* inode, root)
- disk
  - buffer and cache, 86
  - capacity, 72–74 (*see also* filesystem, capacity)
  - device, 52–53, 69–78
  - device file (*see* device, disk)
  - format (*see* filesystem, creating; partition, creating table)
  - geometry, 77–80
  - monitoring usage, 212–216
  - partition (*see* partition)
  - PATA, 53
  - quota, 222
  - raw access, 71
  - SATA, 52, 58–60, 62, 64–66
  - scheduling priority, 215
  - schematic, 70–71
  - SCSI, 52–53, 62–63
  - solid state, 80

- disk (*continued*)
  - swap (*see* swap)
  - usage (*see* filesystem, usage)
  - virtual, 53
- display manager, 355
- display modes, 54–55
- dmesg, 118. *See also* kernel, log
- dmsetup, 109. *See also* device mapper
- DNS (Domain Name Service), 235, 243–246
- dnsmasq, 245
- Docker, 406–414
- documentation, 26–28
- Domain Name Service. *See* DNS
- dot file, 22, 336
- DPMS (Display Power Management Signaling), 359
- du, 90–91
- dual-stack network, 233
- Dynamic Host Configuration Protocol (DHCP), 252–253

## E

- echo, 13, 16
- EDITOR, 344
- effective user ID, 189–190
- EFL. *See* UEFI
- efilinux, 123
- egrep, 19
- elapsed time, 207
- Emacs, 26
- emulator, 402
- encryption, 197–198, 273–274
- env, 292, 380
- environment variable, 22–23, 311
- EOF (end-of-file) message, 14
- error message, 29–30, 204
- ESP (EFI System Partition). *See* UEFI, ESP
  - /etc*, 42, 141, 167, 176–177
  - /etc/fstab*, 52, 85, 88–89
  - /etc/group*, 180
  - /etc/hosts*, 244
  - /etc/init.d*, 159
  - /etc/inittab*, 157–158
  - /etc/ld.so.cache*, 369
  - /etc/ld.so.conf*, 369
  - /etc/localtime*, 182

- /etc/login.defs*, 197
- /etc/mtab*, 86–87
- /etc/nologin*, 162
- /etc/nsswitch.conf*, 246
- /etc/passwd*, 27, 36, 177–179, 192–193
- /etc/profile*, 340
- /etc/rc.d*, 157–161
- /etc/resolv.conf*, 245
- /etc/services*, 249–250
- /etc/shadow*, 177, 179, 197
- /etc/shells*, 179, 193–195
- /etc/sudoers*, 45
- eth0*, 236
- Ethernet, 235–236, 264–265
  - bridge, 236
  - wireless, 266–268
- euid. *See* effective user ID
- exec, 311
- exec(), 7, 203, 311
- executable, 36–37, 42–43, 87, 292, 365–367, 380
- exit, 298
- exit code, 298
- export, 23
- expr, 311
- ext4. *See* filesystem, ext2/ext3/ext4

## F

- fail2ban, 276–277
- fdisk, 72–73, 75–78
- fg, 34–35
- FHS (Filesystem Hierarchy Standard), 42
- file
  - compare with another file, 21
  - compress, 39–41, 321–322
  - copy, 15 (*see also* file transfer)
  - create empty, 16
  - delete, 16, 113–114
  - descriptor (*see* file descriptor)
  - details, 15
  - device (*see* device, file)
  - dot (*see* dot file)
  - errors, 30–31
  - find, 21
  - find text in, 19–20
  - format, 21
  - group, 15, 35–37

- link, 38, 111–114, 303
  - link count, 113–114
  - listing, 15
  - mode, 35–37 (*see also* permissions)
  - move, 16
  - open, 200–202
  - owner, 15, 35–37
  - permissions (*see* permissions)
  - redirect command input from, 29
  - redirect command output to, 28–29
  - regular, 35
  - rename, 15
  - sharing across a network, 323–334
  - sharing with other users, 9
  - socket (*see* device, socket)
  - swap, 97
  - temporary, 43, 307
  - test, 301–303
  - type, 35, 38, 48, 201
  - update timestamp, 16
  - file (command), 21
  - file descriptor, 201, 203–204
  - file transfer, 315–316
    - choosing method, 316
    - rsync (*see* rsync)
    - SSH (secure shell), 278
    - with Python, 316
  - filesystem, 70–71, 80
    - boot loader access (*see* boot loader, filesystem access)
    - Btrfs, 81–82
    - capacity, 89–91
    - cgroup, 219 (*see also* cgroup)
    - checking, 91–93
    - CIFS, 331
    - creating, 82–83, 105
    - currently attached, 84
    - ext2/ext3/ext4, 81–85, 91–93
    - FAT, 81
    - HFS+, 81
    - hierarchy, 42–44
    - internal structure, 82, 111–115
    - ISO 9660, 81
    - journal, 81, 91–93
    - mount, 83–89, 140
    - mounting, 105
    - mount options, 86–87
    - NFS (Network File System), 332–333
    - overlay, 94, 410–411
    - proc (*see* /proc)
    - read-only, 86, 121
    - remount, 87–88
    - repairing, 91–93
    - resizing, 97, 107
    - squashfs, 94
    - tmpfs, 93–94
    - types, 81–82
    - usage, 89–91
    - user space, 81, 115, 333–334
    - UUID (universally unique identifier), 85, 88, 96, 120–121, 124–126
    - XFS, 81
  - Filesystem Hierarchy Standard (FHS), 42
  - find, 21, 310
  - finding appropriate command, 26–27
  - firewall, 259–264
    - rule, 261–262
    - strategy, 262–264
  - flex, 379
  - folder. *See* directory
  - for, 305
  - fork(), 7, 147–148, 203, 205, 272
  - frame (Ethernet), 236
  - free, 96
  - fsadm, 107
  - fsck, 88, 91–93
  - fsuid, 190
  - FTP, 278, 287
  - FUSE (File System in User Space). *See* filesystem, user space
- ## G
- gateway, 227, 230–231
  - gcc, 364
  - GECOS, 178
  - geteuid(), 191–192
  - getty, 54, 143, 158, 181
  - Ghostsript, 361–362
  - glob, 18–19, 22, 293–294. *See also* regular expression
  - global unicast address, 232–233
  - GNOME, 350
  - gnome-shell, 351–352
  - GNU Autotools, 386, 399. *See also* autoconf

- gparted, 72
- GPT (Globally Unique Identifier Partition Table), 72–73, 126
- grep, 19–20, 300
- group, 10, 178, 180
  - listing, 36
  - permissions (*see* permissions, group)
- groups, 36
- GRUB, 123–135
  - boot command, 127
  - command line, 126–127
  - configuration, 124–125, 127–129
  - devices, 124–126
  - filesystem access, 126–127
  - insmod, 124–125
  - installing, 130–131
  - internals, 134–135
  - menu, 123–125, 128–129
  - on removable media, 131
  - root, 124–128
- grub-mkconfig, 127–129
- GTK+, 350
- guest (operating system), 403
- gunzip, 39–41
- gzip, 39–41

**H**

- halt, 162–163
- hard link. *See* file, link
- hardware operation, 4
- head, 21
- header file, 44, 371–372, 391, 393–394
  - locating, 398
- help, 26–28
- here document, 308
- /home, 42
- home directory, 17, 42, 178
- host, 224, 235
- host key, 274–276
- HTTP, 270–272
- hypervisor, 402–403

**I**

- I/O monitoring, 214–216
- ICMP, 234–235, 254
- if/then/else, 299–300
- ifconfig, 228. *See also* ip
- image, 4. *See also* container, image
- include file. *See* header file
- inetd, 279
- info (GNU), 28
- init, 118–120, 138–139. *See also* systemd
  - container, 413–414
  - identifying, 139
  - process tracking, 158 (*see also* systemd, process tracking)
  - runlevel (*see* runlevel)
  - System V, 139, 156–161
  - System V sequence, 158–159
  - Upstart, 139
- initramfs, 124–125, 135, 163–164
- initrd, 164. *See also* initramfs
- inode, 91–92, 111–115, 303
  - root, 112–113
- installing software, 385–386, 394–395
- interactive shell, 340–342
- interface ID (IPv6), 232
- internet layer. *See* network, internet layer
- iostat, 214–215
- iotop, 216–217
- ip (command), 228–230, 232–233, 237–238, 264–265
- IP (internet protocol), 226
  - address, 227–228, 237–238
  - chain, 259–260
  - filter, 259–262
  - forwarding, 255
  - masquerading, 256
  - subnet (*see* subnet)
  - table, 259–260
- IPP (Internet Print Protocol), 361
- iptables, 261–264
- IPv4, 226, 231. *See also* IP
- IPv6, 226–227, 231–233, 235, 238, 247, 253–254, 266
- iw, 267

**J**

- jar, 382
- Java, 382, 404
- job control, 34–35
- jobs, 34
- journalctl, 46, 51, 118–119, 145, 169–172, 175, 186–187
- journald, 154, 156, 168–169, 173, 175, 186–187

## K

KDE, 350  
Kerberos, 333–334  
kernel, 2–5

- as a resource, 199
- boot, 117, 119–123
- boot messages, 118–119
- compiling, 399
- disk buffer and cache (*see* disk, buffer and cache)
- disk I/O system, 71, 111
- image location, 44, 125
- load, 117, 121–122
- log, 51, 61, 172
- mode, 3
- modules, 44
- network interface (*see* network, interface)
- parameters, 120–122, 124–125
- reading partition table (*see* partition, reading table)
- ring buffer, 118–119
- routing table, 230
- SCSI subsystem, 62–67
- space, 3
- thread, 4

keyboard, 357–359  
kill, 33–34  
Kubernetes, 415

## L

LAN (local area network), 224  
*lastlog*, 169  
layer, 2

- network (*see* network, layer)

LBA (Logical Block Addressing), 79, 122  
LDAP (Lightweight Directory Access Protocol), 178  
ldconfig, 369  
LD\_LIBRARY\_PATH, 344, 369–371  
ld.so, 369–370  
ldd, 368–369  
less, 20, 341–344  
level, 2

- in user space, 8–9

Lex, 379  
*/lib*, 42

libata, 64–66  
libinput, 352–353  
library, 42

- C, 366
  - linking against, 366–367, 370, 377, 390–391, 393–394
  - shared (*see* shared library)
  - static, 367–368

Lightweight Directory Access Protocol (LDAP), 178  
LILO, 123  
link

- count (*see* file, link count)
- farm, 159
- hard (*see* file, link)
- symbolic (*see* symbolic link)

link-local address, 232–233, 254  
listening (on network port), 248–249, 279–280, 288–289  
literal, 293–295  
LLMNR (Link-Local Multicast Name Resolution), 245  
LLVM project, 364, 383  
ln, 38–39, 111, 113, 115. *See also* link, hard; link, symbolic  
*lo*, 247  
loadable kernel modules. *See* kernel, modules  
load average, 208–210  
LOADLIN, 123  
local area network (LAN), 224  
localhost, 242, 247  
locate, 21  
log, 9, 167–168. *See also* kernel, log;  
journal; journalctl

- autoconf, 392–393
- facility/severity/priority, 174–175
- message, 168
- monitoring, 172
- Samba, 328
- structured data, 175
- sudo, 46
- systemd unit (*see* systemd, unit log)

logger, 186  
logical volume. *See* LVM  
Logical Volume Manager (LVM). *See* LVM  
login, 181

- loginctl, 188
- login shell, 340–342
- logrotate, 172–173
- loop. *See* shell script, loop
- lost+found, 92, 114
- ls, 15
- lsuf, 200–202
  - network, 280–281
  - Unix domain socket, 290
- lsscsi, 52, 63, 66
- lsusb, 65
- ltrace, 204
- LV (logical volume). *See* LVM, logical volume
- LVM (Logical Volume Manager), 52–53, 96–110
  - advantages, 96–97
  - constructing system, 102–105
  - creating filesystem, 105
  - device names, 100
  - devices, 73–74
  - implementation, 107–110
  - listing, 97–100
  - logical volume, 96–100
  - logical volume, arrangement, 109–110
  - logical volume, creating, 104–105
  - logical volume, removing, 106–107
  - physical extent, 99
  - physical volume, 96–99, 101–103
  - physical volume, creating, 103
  - physical volume, metadata, 101, 108
  - resizing, 106–107, 110
  - scanning volumes, 108
  - schematic, 96–97
  - volume group, 96–99, 101–103
  - volume group, creating, 103
- LXC, 414–415

**M**

- MAC address, 235–237, 243, 264–265
- main memory. *See* memory
- make, 373–379
- Makefile
  - dependency, 373–375, 377, 379
  - organization, 378–379
  - rule, 374, 377
  - separator, 375
  - standard target, 378, 392
  - staying up-to-date, 375–376
  - target, 374
- man, 26–28
- manual page, 26–28, 44, 338. *See also* man
- MBR (Master Boot Record), 72–73, 126
  - boot, 130–131, 133
- mDNS, 245
- /media, 43
- memory, 3–4
  - capacity, 94–96, 209–210
  - insufficient, 94–96, 209–210
  - management, 6, 119, 210–214
  - monitoring usage, 212–214
  - page (*see* page)
  - problems, 31–32
  - protection, 3
  - swap (*see* swap)
  - test, 129
  - virtual (*see* virtual memory)
- mkdir, 17
- mkfs, 82–83
- mknod, 56
- mkswap, 96–97
- MMU (memory management unit), 6, 210–211
- modules. *See* kernel, modules
- mount, 83–89. *See also* filesystem, mount
- mouse, 358
- multitasking, 5–6
- mv, 16

**N**

- namespace. *See* network, namespace; process, namespace
- nano, 26, 344
- NAT (Network Address Translation), 255–258
- NDP (Neighbor Discovery Protocol), 266
- netcat, 282–283
- Netplan, 239
- netstat, 248–249, 279
- network, 223–224
  - application layer, 225, 269–272
  - client, 248–249



- configuration, 237–243, 252–254  
(*see also* network configuration manager)
- connection, 248–249, 270–271, 281
- container (*see* container, networking)
- firewall (*see* firewall)
- host (*see* host)
- interface, 49, 236–238, 411–412
- internet layer, 225–235 (*see also* IP layer, 223, 225–227)
- localhost (*see* localhost)
- namespace, 411–412
- packet (*see* packet)
- physical layer, 226, 235–236
- port, 248–250, 270
- prefix, 228
- private (*see* private network)
- promiscuous mode, 281
- route, 230–231
- router (*see* router)
- security, 285–287
- server, 248–249, 272
- simple, 224, 227, 252
- stack, 225
- transport layer, 225–226, 247
- troubleshooting, 234–235, 279–284
- wireless (*see* wireless network)
- Network Address Translation (NAT), 255–258
- network configuration manager, 240–243
- Network Information Service (NIS), 178
- network layer, 225–226. *See also* network, internet layer
- NetworkManager, 240–243, 267–268
- network mask. *See* subnet, mask
- Network Time Protocol (NTP), 182–183, 251
- NFS (Network File System). *See* filesystem, NFS
- nftables, 259
- nice value, 208
- NIS (Network Information Service), 178
- nmap, 284

- nobody (user), 178
- nslookup, 245
- NTP (Network Time Protocol), 182–183, 251
- NVMe (Non-Volatile Memory Express), 53, 63

## O

- object file, 365–366
- OOM killer, 96
- open(), 203–204
- open source, 385–386
- OpenWRT, 258
- operating system–level virtualization, 406
- /opt, 43
- OSS (Open Sound System), 55–56

## P

- package, 390, 394–395, 399–400
- packet, 224–225
- page, 210–213
- page fault, 211–212
- PAGER, 344
- pager, 20, 344
- page table, 6, 210
- PAM (Pluggable Authentication Modules), 192–198
- parallel port, 55
- paravirtualization, 403
- parted, 72–73, 75–76
- partition, 52, 57, 70, 82
  - alignment, 79–80
  - altering table, 75–76
  - Apple (*see* filesystem, HFS+)
  - capacity, 72–74 (*see also* filesystem, capacity)
  - creating table, 76–78
  - extended, 72–73
  - logical, 72–73
  - primary, 72–73
  - reading table, 74–76
  - swap, 72–73, 96 (*see also* swap)
  - system ID, 72–74
  - table, 70–79
  - viewing, 72–75
  - Windows (*see* filesystem, FAT)
- passwd, 22, 35–36, 179

password  
     change, 22  
     file (*see* `/etc/passwd`)  
 password change, 197–198  
 password file. *See* `/etc/passwd`  
 patch, 395–396  
 patchelf, 370  
 PATH. *See* path, command  
 path  
     absolute, 17  
     command, 23–24, 337–338  
     relative, 17  
 pathname. *See* path  
 pattern matching, 18–20  
 PE. *See* LVM, physical extent  
 performance, 199–200, 210  
     memory, 95–96  
 Perl, 20, 381  
 permissions, 31, 35–37  
     bits, 35–37  
     changing, 36–37  
     default, 37, 339–340  
     directory, 37  
     execute, 35–37  
     group, 35–37  
     other, 35–37  
     preserving, 40  
     read, 35–37  
     testing, 302–303  
     user, 35–37  
     world (*see* permissions, other)  
     write, 35–37  
 physical layer. *See* network, physical layer  
 physical volume (PV). *See* LVM,  
     physical volume  
 Pico, 26  
 PID. *See* process, ID  
 pidstat, 216  
 ping, 234–235  
 pipe, 20, 28–29, 41  
     named, 49, 56  
 pkg-config, 393–394  
 Pluggable Authentication Modules  
     (PAM), 192–198  
 plymouth, 54  
 Podman, 406–407, 411  
 port. *See* network, port  
 port scan, 284  
 PostScript, 360–362  
 predictable network interface device  
     name, 236  
 printing, 55, 360–362  
 private network, 255–257  
     `/proc`, 42, 88, 93  
     `/proc/devices`, 51  
 process, 3–4, 32–35, 93  
     accounting, 222  
     background, 34–35  
     blocked, 213  
     child, 204, 413–414  
     continue, 33–35  
     grouping (*see* `cgroup`)  
     ID, 32–34, 201, 205–206, 220, 298  
     interface, 42  
     listing, 32–33  
     log messages, 169  
     management, 5–6  
     memory, 6, 96, 200, 210–212  
     monitoring, 216  
     namespace, 410  
     open files, 200–202  
     owner, 9, 189–190  
     parent, 413–414  
     priority, 207–208  
     ready to run, 208–210  
     starting new, 7  
     status, 32  
     stop, 33–35  
     terminate, 33–34  
     tracking, 200  
     unexpected termination, 96  
     *.profile*, 340  
     prompt. *See* shell, prompt  
 ps, 32–33, 190, 212  
 pseudodevice, 8  
 pseudoterminal, 54  
 pseudo-user, 178–179  
 public key encryption, 274  
 pulseaudio, 56  
 PV (physical volume). *See* LVM, physical  
     volume  
 pwd, 20  
 Python, 292, 380–381, 417–418

## Q

Qt, 350

## R

read, 312  
real-time clock, 181  
real user ID, 189–190  
reboot, 162–163  
redraw display, 35  
regular expression, 19–20  
regular file. *See* file, regular  
remote login, 273–278  
renice, 208  
rescue image or CD, 164–165  
resolvectl, 246  
resolved. *See* system-resolved  
resource

- limiting, 216–222, 406
- utilization, 207, 216, 221

resource monitoring, 206  
reverse isearch, 35  
RIP (Raster Image Processor), 361–362  
rm, 16  
rmdir, 17–18  
root, 9, 178–179. *See also* directory, root

- running programs as, 44–46

root directory. *See* directory, root  
route, 230. *See also* network, route  
router, 224, 227, 233, 254–259  
RPC (remote procedure call), 284–285  
rsync, 317

- bandwidth, 322
- compression, 321–322
- copying from remote host, 322
- copying to remote host, 317–322
- exact copy, 318–319
- excluding files, 320
- verifying transfer, 321

rsyslogd, 169, 175  
ruid. *See* real user ID  
/run, 43  
runlevel, 156–157  
run-parts, 160–161  
runtime-based virtualization, 417–418  
runtime information, 43  
runtime library search path, 369, 394

## S

Samba, 324–330

- client, 329–330

sar, 222

saved user ID, 190  
/sbin, 43  
scheduling class, 215  
scheduling tasks, 183–188  
SCons, 399  
scp, 278  
screen, 34  
scripting language, 380–382  
SCSI (Small Computer System Interface), 52–53, 62–67

- disk (*see* disk, SCSI)
- generic, 53, 66–67
- ID, 62–63
- listing device information, 52, 63, 66

sector, 79  
secure shell. *See* SSH  
security, 191–198

- application, 405
- in command path, 338
- file sharing, 323–324, 331–334
- network (*see* network, security)

sed, 309–310  
segmentation fault, 31–32  
serial port, 55  
server role, 8–9  
setuid, 36, 87, 189–191  
sftp, 278  
shadow password. *See* /etc/shadow  
shared library, 42, 367–371, 390–391

- system calls, 203
- trace, 204

shebang, 292, 380  
shell, 12–14. *See also* Bourne Shell

- change, 12, 22
- default, 343–344
- editing commands, 25
- process ID, 33, 298
- prompt, 12–13, 22, 338–339
- quoting, 293–295
- special variable, 295–298
- user, 178–179
- variable, 22–23, 33, 295
- window, 13, 35, 54

shell script, 12, 291–292

- arguments, 296–297
- arithmetic, 303–304, 311, 313
- conditional, 299–304

- shell script (*continued*)
  - include, 312
  - limitations, 292–293, 312–313
  - loop, 305–306
  - name, 297
  - permission, 292
  - reading user input, 312
  - string test, 303
- shift, 296
- shortcut. *See* symbolic link
- shutdown, 159, 162–163
- signal, 33–34
  - in shell script, 307
- single-user mode, 121, 156, 164–165
- Small Computer System Interface. *See* SCSI
- socket, 288–290
  - device (*see* device, socket)
  - Unix domain (*see* Unix domain socket)
- socket unit. *See* systemd, socket unit
- sort, 22
- sound, 55–56
- source code, 364
- sourcing, 312
- special characters, 24–25
- splash screen, 54, 118, 120
- SSD (solid-state disk). *See* disk, solid state
- SSH (secure shell), 272–278
  - systemd unit, 142–143
- SSHFS, 331–332
- SSID, 266
- standard error, 29, 35
- standard I/O, 14
  - redirection, 28–29
- standard input, 14, 20, 29, 35, 39, 51
- standard output, 14, 20, 28–29, 35, 39, 51
- startup. *See* boot
- startup file, 335–336
  - bash, 340–342
  - command path, 337–338
  - example, 341–343
  - order, 340–342
  - problems, 344
  - tcsh, 342–343
- stat command, 113–114
- stat() system call, 115
- state, 4
- stateless (network) configuration, 253–254
- static library. *See* library, static
- stderr. *See* standard error
- stdin. *See* standard input
- stdio. *See* standard I/O
- stdout. *See* standard output
- strace, 202–205
- stream, 14, 20, 28–29, 49
  - edit (*see* sed)
  - ID (in shell), 29
  - search (*see* grep)
- subnet, 227–229, 236
  - choosing, 255–256
  - mask, 228–230, 238
  - routing between, 254–256
- subshell, 311–312
- sudo, 13, 45–46, 190
- superblock, 82, 92, 114
- superserver, 279
- superuser. *See* root
- swap, 88, 94–96, 212–214
  - partition (*see* partition, swap)
- swapoff, 95
- swapon, 94–95
- symbolic link, 38–39, 302
- sync, 86
- /sys, 43, 49–50. *See also* sysfs
- syscall. *See* system call
- sysctl, 255
- sysfs, 49–50, 58, 93
- SYSLINUX, 123
- syslog, 168–169, 174–176
- system call, 4, 7
  - trace, 202–205
- system clock, 181–183
- systemctl, 142, 144–147, 149
- systemd, 118, 139–140
  - activating unit, 146
  - conditional dependencies, 150
  - configuration, 141–143
  - Conflicts dependency, 149
  - creating (adding) unit, 146–147
  - deactivating unit, 147
  - dependency, 140–141, 147–155
  - enabling unit, 147, 150–151

- instance, 154
- job, 145–146
- mount unit, 89, 140, 144
- on-demand resource, 151–154
- operation, 144–147
- parallel unit activation, 154–156
- process tracking, 143, 147–148
- reload unit configuration, 145
- Requires dependency, 148–151
- Requisite dependency, 149
- service unit, 140, 142–143, 186
- socket unit, 140, 142, 152–154, 279
- specifier, 143, 153–154
- System V compatibility, 161
- target unit, 140, 146–147, 150–151
- timer unit, 185–188
- unit, 140–148
- unit cgroup, 144
- unit file, 142–143, 146–147, 150–151, 185–186
- unit listing, 144–145
- unit log, 144–145
- unit startup order, 140–141, 148–149
- unit status, 144, 146
- variable, 143
- Wants dependency, 146, 148–151
- systemd- (prefix), 156
- systemd-analyze, 140–141, 149
- systemd-boot, 123
- systemd-resolved, 156, 245
- systemd-run, 188
- system time, 207
- System V init. *See* init, System V
- system virtual machine, 402

## T

- tail, 21
- TAP interface, 412
- tar, 39–41, 312
- TCP (Transmission Control Protocol), 247–251, 279–281
  - filtering, 262–264
  - interacting with service, 270–272
  - wrapper, 279
- tcpdump, 281–283
- tcsh, 342–343
- telinit, 161

- telnet, 270, 273, 287
- tempfs. *See* filesystem, tmpfs
- temporary file. *See* file, temporary
- terminal, 53–54. *See also* shell, window
  - controlling (*see* controlling terminal)
  - device (*see* device, terminal)
  - virtual (*see* virtual console)
- test, 299–304
- text editor, 25–26, 344
- text search, 19–20
- thrash, 209–211. *See also* memory, insufficient
- thread, 204–206
- time, 207, 211–212. *See also* CPU, time; system time; elapsed time
- time (of day), 181–183
- timer unit. *See* systemd, timer unit
- time slice, 5
- timesyncd, 182–183
- time zone, 182
- TLS (Transport Layer Security), 226, 287
- /tmp, 43
- toolkit, 350
- top, 200, 205–208
- touch, 16
- Transmission Control Protocol. *See* TCP
- transport layer. *See* network, application layer
- Transport Layer Security. *See* TLS
- troubleshooting, 168
- tune2fs, 85

## U

- udev, 48, 51–52, 56–62, 109
  - configuration and rules, 58–60
  - event (*see* uevent)
- udevadm, 50–51, 60–61, 76
- udevd, 56–62, 85, 156, 163
- udisksd, 62
- UDP (User Datagram Protocol), 250–251, 279–281
- UEFI (Unified Extensible Firmware Interface), 121–122, 130–132
  - ESP (EFI System Partition), 133–135
  - secure boot, 131–132

- uevent, 58, 61
- umask, 37, 339–340
- umount, 84
- Unified Extensible Firmware Interface.
  - See UEFI
- Universal Coordinated Time (UTC), 181–183
- Universally Unique Identifier (UUID), 52
- Unix, 11–12
- Unix domain socket, 289–290
- unlink, 114. *See also* file, delete
- unxz, 41
- unzip, 41
- uplink, 224. *See also* default gateway
- Upstart, 139
- uptime, 209
- USB
  - listing device information, 65
  - relationship to SCSI, 52, 64–65
  - serial port, 55
- user, 9
  - change, 44–46
  - id (*see* user ID)
  - management, 177–180
  - name (*see* username)
  - regular, 12
  - root (*see* root)
- user authentication, 192–198. *See also* PAM; */etc/passwd*
- user authorization, 193. *See also* PAM
- User Datagram Protocol (UDP), 250–251, 279–281
- user environment, 335–336
- user ID, 9, 177–179, 189–190
- user identification, 191–192
- userland. *See* user space
- user mode, 3
- username, 9, 177–179
- user process. *See* process
- user space, 3
  - and filesystems, 111
  - and LVM, 107
  - and user IDs, 179, 191–192
  - creating filesystems in, 82
  - filesystem (*see* filesystem, user space)
  - organization, 8–9
  - start, 117–118, 120, 137–139
    - (*see also* init)
  - /usr*, 43–44
  - /usr/lib*, 367
  - /usr/local*, 44, 390, 395
  - /usr/share*, 44
- UTC (Universal Coordinated Time), 181–183
- UUID (Universally Unique Identifier), 52
  - filesystem (*see also* filesystem, UUID)

**V**

- /var*, 43
- /var/log*, 169
- VFS (Virtual File System), 81, 115
- vi, 26
- vipw, 179
- virtual, 401
- VirtualBox, 402–403
- virtual console, 54–55, 158, 355
- virtual disk. *See* disk, virtual
- virtual interface (network), 411–412
- virtual machine, 53, 382, 402–405
- virtual memory, 6, 96, 401. *See also* memory, management
- vmstat, 212–214
- volume group. *See* LVM, volume group

**W**

- wait(), 413
- wallpaper. *See* desktop background
- warning messages, 30
- Wayland, 349–350
  - compositor, 349–352
  - input, 352–353
  - window manager, 349
  - X compatibility, 353–354
- web server, 316
- WEP (Wired Equivalent Privacy), 268
- Weston, 351–352, 354
- while, 305–306
- who, 156
- widget, 350
- WiFi Protected Access (WPA), 268

wildcard. *See* glob  
windowing system (determining), 351  
window manager, 349–350  
Windows  
    boot, 132  
    file sharing, 324–330  
    partition (*see* filesystem, FAT)  
    password, 326–327  
    printer sharing, 329  
Wired Equivalent Privacy (WEP), 268  
wireless network, 240–241. *See also*  
    Ethernet, wireless  
*wlan0*, 236, 267  
worker process, 272  
WPA (WiFi Protected Access), 268  
*wtmp*, 169

**X**

xargs, 310  
XDG Desktop Entry, 142  
Xen, 403  
xev, 356–357  
X event. *See* X Window System, event  
xinetd, 279  
xinput, 357–358  
XKB (X keyboard extension), 358–359

xlsclients, 356  
xset, 359  
X Window System  
    application, 350  
    client, 348–349, 355–356  
    diagnostics, 356–357  
    display, 354  
    event, 356–357  
    input, 357–359  
    network transparency, 355  
    preferences, 357–359  
    server, 54, 348–349, 354–355  
    tunneling, 273, 355  
    Wayland compatibility, 354  
    window manager (*see* window manager)  
xwininfo, 356  
xz, 41

**Y**

Yacc, 379

**Z**

zcat, 41  
zip, 41