

Index

Note to the Reader: Page numbers in **bold** indicate the principle discussion of a topic or the definition of a term. Page numbers in *italic* indicate illustrations.

Symbols

? (question mark) help key, 150, **159–161**

Numbers

80/20 rule in virtual LANs, 358
 10Base2 Ethernet, 30, 30
 10Base5 Ethernet, 30, 30
 10BaseT Ethernet, 30, 30
 100BaseFX Ethernet, 31
 100BaseT Ethernet, 30–31, 550
 100BaseTX Ethernet, 31, 550
 100VG-AnyLAN cable, 31
 1000BaseCX Ethernet, 31
 1000BaseLX Ethernet, 31
 1000BaseSX Ethernet, 31
 1000BaseT Ethernet, 31
 0.0.0.0 255.255.255.255 wildcard mask, 450, 456

A

ABRs (Area Border Routers), 281, 281
 access layer, 39, 41
 access links in VLANs, 357, 357–358
 access lists, **444–475**
 applying
 example, 451, 451
 to inbound packets, 445–446
 to outbound packets, 446
 to routing protocols, 444
 rules/guidelines for, 446–447
 commands for configuring
 0.0.0.0 255.255.255.255, 450, 456
 access-class, 452
 access-list, 448, 515
 any, 450, 452, 456
 defined, 463
 ip access-group, 451, 457, 459
 ip access-list, 458

 commands for verifying
 defined, 463
 show access-list, 459–460
 show ip access-list, 460
 show ip interface, 460–461
 show running-config, 459, 460
 creating, 445
 defined, 444–445
 dial-on-demand routing with, 515
 exam essentials, 462
 extended IP access lists
 configuring, 453–456
 defined, 445, 453
 example, 457
 hands-on lab, 464, 465–467
 as named access lists, 445, 457–458
 number ranges for, 453
 wildcard masking, 448–450
 key terms, 462
 overview of, 461–462
 packet rules for, 445
 review question answers, 473–474
 review questions, 468–472
 in security, 444
 standard IP access lists
 configuring, 448
 defined, 445, 447
 example, 450–451, 451, 452–453
 hands-on lab, 464–465
 as named access lists, 445, 457–459
 number ranges for, 447
 securing VTY line access, 451–452
 wildcard masking, 448–450
 types of, 447
 uses, 444
 written lab answers, 475
 written lab questions, 463–464
 access rate, **492**, 551
 acknowledgements, 16, 17, 551
 Acknowledgment Number field in TCP segments, 63, 63
 active state of routes, 279, 552
 active state of virtual circuits, 496
 Address Resolution Protocol (ARP), 76–77, 77

610 addressing – buffers

addressing, *See also* IP addressing; MAC
 adjacency, 282, 552
 ADs (administrative distances), 218, 224–225
 ANSI signaling format, 495, 496
 any command, 450, 452, 456
 Application layer, 8–9, 10–11, 553, *See also* OSI
 Area Border Routers (ABRs), 281, 281
 areas, OSPF, 280–281, 281, 282
 ASBRs (Autonomous System Boundary Routers), 281, 281
 ASes (autonomous systems)
 AS numbers, 237
 defined, 223
 multiple, in EIGRP, 269–270
 ASICs (application-specific integrated circuits), 20, 554
 ASP (AppleTalk Session Protocol), 12
 ATM (Asynchronous Transfer Mode), 481, 555
 AUIs (Attachment Interface Units), 30
 authentication in PPP protocol, 485, 486–488
 auto-detect mechanisms, 24
 auxiliary ports, *See also* ports
 connecting to routers via, 147, 148
 setting passwords on, 166–167

B

B channels, 508
 backing up
 configurations to TFTP servers, 405–407, 432
 and restoring configurations, 407–408
 router IOS
 and restoring to flash memory, 402–405, 431–432
 to TFTP servers, 400, 401–402, 431
 verifying flash memory, 400–401
 warning, 402
 backspace key, 162
 bandwidth
 and cabling WANs, 482
 configuring, 176, 198
 default bandwidth, 184
 defined, 557
 in Frame Relay, 492–493
 OSPF cost metric and, 284
 banners, router, 170–172, 197
 baseband, 30
 Basic Management setup mode, 150

Basic Rate Interface (BRI) ISDN, 504, 508, 525–528
 BDRs (backup designated routers), 282, 283
 BECN (Backward Explicit Congestion Notification), 496–497
 BGP (Border Gateway Protocol), 223
 binary subnetting method, 107–108
 bits (binary digits), *See also* Physical layer
 in configuration registers, 394–395
 converting to decimals, 79–80
 converting to hexadecimals, 80–81
 defined, 37, 38, 78–79, 82
 IP addresses in, 82
 block sizes
 defined, 448
 overview of, 104, 126
 wildcards and, 449–450
 blocked ports, 322, 323
 boot fields in configuration registers, 395
 Boot Protocol (Boot P), 61
 boot sequence, router, 148–150, 393–394, 398
 bootloader, 393
 bootstrap, 392, 393
 BPDUs (Bridge Protocol Data Units), 321–322
 BRI (Basic Rate Interface) ISDN, 504, 508, 525–528
 bridges, *See also* switches
 bridge IDs, 322
 at Data Link layer, 20–21
 defined, 3–5, 5, 559
 network design with, 316
 nonroot bridges, 322
 root bridges, 321–323
 versus switches, 4, 20–21, 314, 315, 317
 transparent bridging, 20–21, 605–606
 broadband PCS networks, 35, 36
 broadcast addresses, *See also* IP
 addressing
 defined, 17–18, 18, 82, 559
 in IP subnetting, 107–108
 layer 2 broadcasts, 89
 layer 3 broadcasts, 89
 multicasts, 89, 90
 unicasts, 89, 90
 broadcast control in VLANs, 352
 broadcast domains, 3, 4–5, 5, 350
 broadcast (multi-access) networks, 282, 283
 broadcast storms, 3, 21, 320, 320
 Buffer Full messages, 74
 buffers, 14, 14–15

bulletin boards, 10
 bursts of data, 492–493, 496
 bytes, 78–81, 82

C

cabling WANs, 482–483, *See also* Ethernet
 call setup. *See* connection-oriented
 callback, PPP, 486
 Catalyst switches. *See* layer 2 switching;
 VLANs
 CCNP: Building Cisco Multilayer Switched
 Networks Study Guide (Sybex), 323, 326
 CCNP: Building Scalable Cisco Internetworks
 Study Guide (Timm and Edwards), 223, 268
 CCNP/CCIP: BSCI Study Guide (Sybex),
 235, 237
 CDP (Cisco Discovery Protocol), *See also*
 Cisco routers, managing
 cdp enable command, 412, 413
 configuring holdtime, 409
 configuring timers, 409
 defined, 408–409
 example of use, 414
 hands-on lab, 432–433
 neighbor information, 410–412
 port interface information, 412–413
 Telnet and, 414
 traffic information, 412
 turning on/off, 409, 412, 413
 central offices (COs), 479, 492
 CHAP (Challenge Handshake Authentication
 Protocol), 487, 488
 Checksum field in TCP segments, 63, 64
 Checksum field in UDP segments, 66, 66
 CIDR (Classless Inter-Domain Routing),
 104–106, 562
 CIR (committed information rate), 492–
 493, 496
 circuit switching WANs, 479, 480
 Cisco hierarchical model, *See also*
 internetworking
 access layer, 39, 41
 core layer, 39–40, 39
 defined, 38–39, 39
 distribution layer, 39, 40–41
 Cisco IOS, switches and, 146–147
 Cisco LMI signaling format, 495, 496

Cisco router IOS (Internetwork Operating
 System), 146–204
 accessing, 147
 backing up
 and restoring to flash memory, 402–
 405, 431–432
 to TFTP servers, 400, 401–402, 431
 verifying flash memory, 400–401
 warning, 402
 booting up routers, 148–150
 bringing up router interfaces, 173–174
 command keys for configuring
 ?, 150, 159–161
 backspace, 162
 Ctrl+A, 161, 164
 Ctrl+B, 161
 Ctrl+C, 150
 Ctrl+D, 162
 Ctrl+E, 161
 Ctrl+F, 161
 Ctrl+N (or down arrow), 162
 Ctrl+P (or up arrow), 162
 Ctrl+R, 162
 Ctrl+U, 162
 Ctrl+W, 162
 Ctrl+Z, 162
 Esc+B, 161
 Esc+F, 161
 Q (or any), 160
 Tab, 162
 commands for configuring
 bandwidth, 176
 banner, 170–172
 clear counters, 184–185
 clock rate, 175–176
 config-subif, 158
 configure memory, 156–157
 configure network, 156, 157
 configure terminal, 156–157
 copy run start, 178–179
 defined, 189–191
 description, 177–178
 disable, 156
 enable, 155–156
 enable password, 151, 165–166
 enable secret, 151, 165–166
 erase startup-config, 180
 error messages when entering, 161
 exec-timeout, 168
 exit, 156, 167

612 Cisco router IOS (Internetwork Operating System) – Cisco router IOS

- global commands, 156, 159
- hostname, 176–177, 487
- interface, 157–158, 172–176
- ip address, 174–175
- line, 158–159, 166–169
- logging synchronous, 168
- login, 166, 167
- logout, 156
- media-type, 173
- for negating commands, 164
- no login, 166, 169
- no shutdown, 173–174
- in privileged exec mode, 159–160
- reload, 180
- router rip, 159
- service password-encryption, 170
- shutdown, 173
- subcommands, 159
- terminal history size, 163–164
- viewing lists of, 159–161
- commands for verifying
 - ping, 180–181
 - show controllers, 176, 186
 - show history, 162–163
 - show interface, 173, 174, 177, 181–185
 - show ip interface, 185–186
 - show ip interface brief, 186
 - show running-config, 169, 174, 177, 179
 - show startup-config, 179–180
 - show terminal, 162, 163
 - show version, 164–165
 - telnet, 169, 180, 181
 - traceroute, 181
- configuring in command-line interface
 - accessing CLI, 154
 - bandwidth, 176
 - banners, 170–172
 - clock rates, 175–176
 - command prompts for, 157–159
 - configs stored on TFTP hosts, 156–157
 - as DCE devices, 175–176
 - descriptions, 177–178
 - using editing/help features, 159–164
 - EXEC sessions and, 147, 572
 - in global configuration mode, 156–157
 - history size, 163–164
 - hostnames, 176–177
 - in interface configuration mode, 158
 - IP addresses on, 174–175
 - logging into router modes, 155–156, 192–193
 - overview of, 147, 154–155
 - passwords, 158–159, 165–169
 - in privileged exec mode, 155–156
 - router interfaces, 157–158, 172–176
 - router subinterfaces, 158
 - routing protocols, 159
 - running-configs, 156, 157
 - saving configurations, 178–179
 - versus setup mode, 151, 180
 - startup-configs, 156, 157
 - user exec mode and, 155, 156
 - verifying configurations, 179–186
- configuring passwords
 - on auxiliary ports, 166–167
 - on console ports, 167–168
 - enable passwords, 151, 165–166
 - enable secret passwords, 151, 165, 166
 - and encrypting, 169, 170
 - for privileged exec mode, 151, 165–166
 - for user exec mode, 158–159, 166–169
 - and viewing, 169
 - for vty sessions, 151, 166, 168–169
- configuring in setup mode
 - Basic Management setup, 150
 - versus in CLI, 151, 180
 - defined, 150
 - entering setup mode, 150
 - and exiting, 150, 180
 - Extended Setup, 150–154
 - interface parameters, 152–153
 - modems, 152
 - passwords, 151
- connecting to routers
 - 2500 versus 2600 routers, 148, 148
 - via auxiliary ports, 147–148
 - via console ports, 147
 - via Telnet, 148
- console ports
 - connecting to routers via, 147, 148
 - setting exec session timeouts on, 168
 - setting passwords for, 167–168
 - stopping pop-up messages on, 168
- defined, 146–147
- exam essentials, 187–188
- gathering routing information, 164–165
- hand-on labs
 - using editing/help features, 193–194
 - logging into routers, 192–193
 - saving configurations, 194–195
 - setting clock rates/bandwidth, 198
 - setting descriptions/IP addresses, 198

- setting hostnames/banners, 197
 - setting passwords, 195–196
 - kernel, 146
 - key terms, 188–189
 - mini-IOS (RXBOOT), 393
 - overview of, 146–147, 186–187
 - privileged exec mode
 - commands available in, 159–160
 - defined, 593
 - enabling/disabling, 155–156
 - setting console port timeouts, 168
 - setting passwords for, 151, 165–166
 - review question answers, 203
 - review questions, 199–202
 - running-configs
 - changing in CLI, 156, 157
 - copying to NVRAM, 178–179
 - creating in Extended Setup, 153–154
 - verifying, 169, 174, 177, 179–186
 - shutting down interfaces, 173
 - startup-configs
 - changing in CLI, 156, 157
 - erasing, 180
 - verifying, 179–180
 - user exec mode
 - activating exec banners in, 172
 - defined, 606
 - logging in/out of, 155, 156
 - setting passwords for, 158–159, 166–168
 - written lab answers, 204
 - written lab questions, 192
- Cisco routers
- advantages, 3
 - broadcast domains and, 3
 - defined, 3, 4–5, 5, 18–19
 - fixed/modular interfaces, 483
 - media translation and, 21
 - network locations and, 19, 20
 - "routers on a stick", 363, 363
 - securing VTY lines on, 451–452
 - subinterfaces
 - command prompt for, 158
 - configuring in Frame Relay, 497–499, 524–525
 - VLANs and, 369
 - subinterfaces, VLANs and, 369
 - versus switches, 315–316, 316
- Cisco routers, managing on internetworks, 392–442
- using Cisco Discovery Protocol
 - configuring holdtime, 409
 - configuring timers, 409
 - defined, 408–409
 - example of use, 414
 - hands-on lab, 432–433
 - neighbor information, 410–412
 - port interface information, 412–413
 - Telnet and, 414
 - traffic information, 412
 - turning on/off, 409, 412, 413
- Cisco router IOS
- backing up to TFTP servers, 400, 401–402, 431
 - mini-IOS (RXBOOT), 393
 - restoring to flash memory, 402–405, 431–432
 - verifying flash memory, 400–401
 - warning, 402
- commands for managing
- cdp enable, 412, 413
 - cdp holdtime, 409
 - cdp timer, 409
 - clear line, 419
 - config mem, 407
 - config-register, 398, 400
 - confreg, 398
 - copy flash tftp, 401, 402
 - copy run start, 405, 406–407
 - copy run tftp, 405, 407
 - copy start run, 399–400, 407
 - copy start tftp, 405
 - copy tftp flash, 402–405
 - copy tftp run, 407–408
 - copy tftp start, 407
 - Ctrl+Break keys, 398
 - Ctrl+Shift+6, then X keys, 416–417, 421
 - defined, 428–430
 - disconnect, 418–419
 - erase startup-config, 408
 - exit, 416, 418
 - ip domain-lookup, 422, 423
 - ip domain-name, 423, 424
 - ip host, 420
 - ip name-server, 422, 423
 - no cdp enable, 412, 413
 - no cdp run, 409, 412
 - no ip domain-lookup, 422
 - no ip host, 422
 - no shutdown, 408

614 Cisco routers – Cisco routers

- o/r, 398–399
- tftp-server flash, 405
- commands for verifying
 - defined, 429–430
 - ping, 401, 423, 424–425
 - show cdp, 409
 - show cdp entry, 411–412
 - show cdp interface, 412–413
 - show cdp neighbor, 410
 - show cdp neighbor detail, 411, 414
 - show cdp traffic, 412
 - show flash, 400–401
 - show hosts, 420–421, 423
 - show running-config, 406
 - show sessions, 417–418, 422
 - show startup-config, 406, 407
 - show users, 418, 419
 - show version, 396, 397
 - telnet, 414, 415
- configuration registers
 - bits, 394–395
 - boot fields, 395
 - changing bit values, 396–397
 - checking current values, 396
 - defined, 393
 - overview of, 394
 - recovering passwords, 397–400
- exam essentials, 427–428
- hands-on labs
 - backing up configurations, 432
 - backing up router IOS, 431
 - using CDP protocol, 432–433
 - overview of, 431
 - resolving hostnames, 434–435
 - restoring router IOS, 431–432
 - using Telnet, 433–434
- key terms, 428
- overview of, 426
- password recovery
 - changing passwords, 400
 - changing register bit value, 398–399
 - copying running-config to startup-config, 400
 - copying startup-config to running-config, 399–400
 - entering privileged mode, 399
 - interrupting boot sequence, 398
 - overview of, 397
 - reloading routers, 399
 - resetting register defaults, 400
 - warning, 398
- resolving hostnames
 - using DNS, 422–424
 - hands-on lab, 434–435
 - using host tables, 420–422, 424
 - overview of, 419–420
- review question answers, 440–441
- review questions, 436–439
- router boot sequence, 148–150, 393–394
- router components and
 - bootstrap, 392, 393
 - configuration register, 393
 - flash memory, 393, 394
 - mini-IOS (RXBOOT/bootloader), 393
 - NVRAM memory, 393–394
 - power-on self-test, 392, 393
 - RAM memory, 393, 400
 - ROM memory, 393
 - ROM memory monitor, 392, 395
- running-configs
 - changing in CLI, 156, 157
 - copying to NVRAM, 178–179, 406–407
 - copying to TFTP servers, 405, 407, 432
 - restoring from NVRAM, 407
 - restoring from TFTP servers, 407–408
 - verifying, 179–186, 406
- startup-configs
 - changing, 156, 157
 - copying to TFTP servers, 405, 407
 - erasing, 180, 408
 - restoring from TFTP servers, 407–408
 - verifying, 179–180, 406
- Telnet connections
 - CDP and, 414
 - checking, 417, 422
 - checking users, 418
 - defined, 414
 - ending, 416, 418–419
 - using IP addresses, 415–416
 - to multiple devices at once, 416–417
 - previous, returning to, 418
 - privileged mode and, 416
 - setting VTY passwords for, 415
 - using telnet command, 414, 415
- verifying
 - CDP global parameters, 409
 - CDP interfaces, 412–413
 - CDP neighbors, 410–412
 - CDP traffic, 412
 - configuration registers, 396
 - DNS name resolution, 423
 - flash memory, 400–401

- host tables, 420–421
 - network connectivity, 424–426
 - running-configs, 179–186, 406
 - startup-configs, 179–180, 406
 - Telnet sessions, 417, 422
 - Telnet users, 418, 419
 - TFTP connections, 401
 - valid host IDs, 427–428
 - written lab answers, 442
 - written lab questions, 430
- Cisco switch IOS, 146–147, *See also*
 - layer 2 switching; switches
- CiscoFusion, 147, 562
- classes, network address. *See* IP
- classful routing, 123–124, 123, 230, 563, *See also* IGRP; RIPv1
- Classless Inter-Domain Routing (CIDR), 104–106, 562
- classless routing, 123, 230, 563, *See also* EIGRP; OSPF; RIPv2
- clear counters command, 184–185, *See also* delete; erase
- clear line command, 419
- client mode in VTP, 360, 361
- CLNS (Connectionless Network Service), 267
- clock rate command, 175–176, 198, 524–525
- Code bits field in TCP segments, 63, 64
- collision domains
 - defined, 4–5, 5, 563
 - overview of, 21
 - VLANs and, 350, 351, 351
- command-line interface (CLI). *See* Cisco router IOS; layer 2 switching
- commands
 - access list configuration
 - 0.0.0.0 255.255.255.255, 450, 456
 - access-class, 452
 - access-list, 448
 - any, 450, 452, 456
 - defined, 463
 - ip access-group, 451, 457, 459
 - ip access-list, 458
 - access list verification
 - defined, 463
 - show access-list, 459–460
 - show ip access-list, 460
 - show ip interface, 460–461
 - show running-config, 459, 460
 - EIGRP configuration
 - defined, 297
 - network, 272, 273, 274–276
 - no auto-summary, 276–277
 - passive-interface, 273
 - router eigrp, 272, 274–276
 - EIGRP verification
 - defined, 297–298
 - overview of, 277
 - show ip eigrp neighbor, 278–279
 - show ip eigrp topology, 279
 - show ip route, 277–278
 - Frame Relay configuration
 - clock rate 64000, 524–525
 - defined, 519–520
 - encapsulation frame-relay, 493
 - frame intf-type dce, 524
 - frame-relay interface-dlci, 495
 - frame-relay lmi-type, 495–496
 - frame-relay map, 520
 - frame-relay route, 524–525
 - frame-relay switching, 524
 - int s0.16 multipoint, 498
 - int s0.16 point-to-point, 498
 - no inverse-arp, 520
 - Frame Relay verification
 - debug frame-relay lmi, 502–503
 - defined, 519–520, 525
 - show frame, 500
 - show frame relay lmi, 500
 - show frame relay map, 502
 - show frame relay pvc, 501
 - show interface, 501–502
 - IP routing configuration
 - defined, 247–248
 - ip classless, 223
 - ip route, 218
 - network, 231–232
 - no ip route, 222, 231
 - router igrp, 237–238
 - router rip, 231
 - IP routing verification
 - debug ip igrp events, 244–245
 - debug ip igrp transactions, 244, 245
 - debug ip rip, 243–244
 - defined, 247, 248
 - overview of, 240–241
 - ping, 221–222
 - show ip protocols, 241–243
 - show ip route, 214, 221, 233–235, 239–240
 - show protocols, 241
 - ISDN configuration
 - access-list, 515

616 commands – commands

- defined, 519–520
- dialer idle-timeout, 514–515
- dialer load-threshold, 514–515
- dialer map, 511, 512–513
- dialer-group, 511–512, 515
- dialer-list, 511–512, 515
- ip address, 509
- isdn dialer map, 509
- isdn spid1, 509
- isdn spid2, 509
- isdn switch-type, 507, 509
- ISDN verification
 - debug dialer, 516
 - debug isdn q921, 516
 - debug isdn q931, 516
 - defined, 519–520
 - int bri0, 516
 - isdn disconnect, 516
 - ping, 516
 - show dialer, 516
 - show ip route, 516
 - show isdn active, 516
 - show isdn status, 516
 - telnet, 516
- layer 2 switch configuration
 - copy run start, 335
 - defined, 337–338
 - delete nvram, 335
 - description, 334–335
 - enable, 330, 331
 - enable password level 1, 331
 - enable password level 15, 331
 - enable secret, 332
 - erase startup-config, 336
 - hostname, 332–333
 - int vlan, 334
 - ip address, 333–334
 - ip default gateway, 333, 334
- layer 2 switch verification
 - show interface, 335
 - show ip, 333, 338
 - show running-config, 335
- OSPF configuration
 - defined, 297
 - ip ospf cost, 284
 - network, 285–287
 - router ospf, 284
- OSPF verification
 - defined, 297–298
 - show ip ospf, 288–289, 294
 - show ip ospf database, 289–290, 294
 - show ip ospf interface, 290–291, 294
 - show ip ospf neighbor, 291
 - show ip protocols, 291–292
 - show ip route, 287–288
 - show running-config, 293
- PPP configuration
 - defined, 519–520
 - encapsulation hdlc, 523
 - encapsulation ppp, 487, 522
 - hostname, 487, 522
 - ppp authentication chap, 488
 - ppp authentication pap, 488
 - service password-encryption, 487
 - username password, 487, 523
- PPP verification
 - debug ppp, 488
 - defined, 519–520
 - show interface, 488
- router configuration
 - ? key, 150, 159–161
 - backspace key, 162
 - bandwidth, 176
 - banner, 170–172
 - clear counters, 184–185
 - clock rate, 175–176
 - config memory, 156–157
 - config network, 156, 157
 - config terminal, 156–157
 - config-subif, 158
 - copy run start, 178–179
 - Ctrl+A keys, 161, 164
 - Ctrl+B keys, 161
 - Ctrl+C keys, 150
 - Ctrl+D keys, 162
 - Ctrl+E keys, 161
 - Ctrl+F keys, 161
 - Ctrl+N (or down arrow) keys, 162
 - Ctrl+P (or up arrow) keys, 162
 - Ctrl+R keys, 162
 - Ctrl+U keys, 162
 - Ctrl+W keys, 162
 - Ctrl+Z keys, 162
 - defined, 189–191
 - description, 177–178
 - disable, 156
 - enable, 155–156
 - enable password, 151, 165–166
 - enable secret, 151, 165–166
 - erase startup-config, 180

- Esc+B keys, 161
- Esc+F keys, 161
- exec-timeout, 168
- exit, 156, 167
- hostname, 176–177
- interface, 157–158, 172–176
- ip address, 174–175
- line, 158–159, 166–169
- logging synchronous, 168
- login, 166, 167
- logout, 156
- media-type, 173
- no login, 166, 169
- no shutdown, 173–174
- Q (or any) key, 160
- reload, 180
- router rip, 159
- service password-encryption, 170
- shutdown, 173
- Tab key, 162
- terminal history size, 163–164
- router configuration verification
 - ping, 180–181
 - show controllers, 176, 186
 - show history, 162–163
 - show interface, 173, 174, 177, 181–185
 - show ip interface, 185–186
 - show ip interface brief, 186
 - show running-config, 169, 174, 177, 179
 - show startup-config, 179–180
 - show terminal, 162, 163
 - show version, 164–165
 - telnet, 169, 180, 181
 - traceroute, 181
- router management
 - cdp enable, 412, 413
 - cdp holdtime, 409
 - cdp timer, 409
 - clear line, 419
 - config mem, 407
 - config-register, 398, 400
 - copy flash tftp, 401, 402confreg, 398
 - copy run start, 405, 406–407
 - copy run tftp, 405, 407
 - copy start run, 399–400, 407
 - copy start tftp, 405
 - copy tftp flash, 402–405
 - copy tftp run, 407–408
 - copy tftp start, 407
 - Ctrl+Break keys, 398
 - Ctrl+Shift+6, then X keys, 416–417, 421
 - defined, 428–430
 - disconnect, 418–419
 - erase startup-config, 408
 - exit, 416, 418
 - ip domain-lookup, 422, 423
 - ip domain-name, 423, 424
 - ip host, 420
 - ip name-server, 422, 423
 - no cdp enable, 412, 413
 - no cdp run, 409, 412
 - no ip domain-lookup, 422
 - no ip host, 422
 - no shutdown, 408
 - o/r, 398–399
 - tftp-server flash, 405
- router management verification
 - defined, 429–430
 - ping, 401, 423, 424–425
 - show cdp, 409
 - show cdp entry, 411–412
 - show cdp interface, 412–413
 - show cdp neighbor, 410
 - show cdp neighbor detail, 411, 414
 - show cdp traffic, 412
 - show flash, 400–401
 - show hosts, 420–421, 423
 - show running-config, 406
 - show sessions, 417–418, 422
 - show startup-config, 406, 407
 - show users, 418, 419
 - show version, 396, 397
 - telnet, 414, 415
- VLAN configuration
 - defined, 380–381
 - encapsulation dot1q, 370
 - encapsulation isl, 369
 - switchport access vlan, 367
 - switchport mode trunk, 368, 374–375
 - trunk, 368
 - vlan 2 name, 364–365
 - vlan database, 364–365
 - vlan-membership static, 366
 - vtp domain, 370, 371
 - vtp mode, 371

618 committed information rate (CIR) – data encapsulation

- vtp password, 370
 - vtp server, 370, 371
 - VLAN verification
 - defined, 380–381
 - show running-config, 368–369, 378–379
 - show vlan, 364, 366–367
 - show vlan brief, 365–366, 367, 376, 377
 - show vtp, 370–372
 - committed information rate (CIR), 492–493, 496
 - composite metric, 236, 239, 564
 - compression, 486, 564
 - configuration commands, *See also* commands
 - config memory, 156–157, 407
 - config network, 156, 157
 - config terminal, 156–157
 - config-register, 398, 400
 - config-subif, 158
 - confreg, 398
 - configuration registers, *See also* Cisco routers, managing
 - bits, 394–395
 - boot fields, 395
 - changing bit values, 396–397
 - checking current values, 396
 - defined, 393
 - overview of, 394
 - recovering passwords
 - changing passwords, 400
 - changing register bit value, 398–399
 - copying run-config to start, 400
 - copying start-config to run, 399–400
 - entering privileged mode, 399
 - interrupting boot sequence, 398
 - overview of, 397
 - reloading routers, 399
 - resetting register defaults, 400
 - warning, 398
 - configuring routers. *See* Cisco router IOS
 - connection-oriented, 13–14, 13–15, 62, 67, 564
 - Connectionless Network Service (CLNS), 267
 - connectionless protocols, 65
 - console ports, *See also* Cisco router IOS; ports
 - configuring exec session timeouts, 168
 - configuring passwords, 167–168
 - connecting to routers via, 147, 148
 - stopping pop-up messages, 168
 - contention media access, 20, *See also* Ethernet
 - convergence, routing table, 226, 227, 565
 - convergence, switch port, 324
 - copy commands, *See also* Cisco routers, managing
 - copy flash tftp, 401, 402
 - copy run start, 178–179, 335, 405, 406–407
 - copy run tftp, 405, 407
 - copy start run, 399–400, 407
 - copy start tftp, 405
 - copy tftp flash, 402–405
 - copy tftp run, 407–408
 - copy tftp start, 407
 - core layer, 39, 39–40
 - COs (central offices), 479, 492
 - cost metric, 283–284, 565
 - counting to infinity, 228, 565, *See also* loops, routing
 - CPE (customer premises equipment), 478
 - crossover cable, 32, 32
 - CSMA/CD (Carrier Sense Multiple Access with Collision Detection), 22–23, 565
 - CSU/DSU (channel service unit/data service unit) devices, 482–483, 492, 565
 - Ctrl key combos, *See also* commands, router
 - Ctrl+A, 161, 164
 - Ctrl+B, 161
 - Ctrl+Break, 398
 - Ctrl+C, 150
 - Ctrl+D, 162
 - Ctrl+E, 161
 - Ctrl+F, 161
 - Ctrl+N (or down arrow), 162
 - Ctrl+P (or up arrow), 162
 - Ctrl+R, 162
 - Ctrl+Shift+6, then X, 416–417, 421
 - Ctrl+U, 162
 - Ctrl+W, 162
 - Ctrl+Z, 162
 - cumulative interface delay, 239
 - customer premises equipment (CPE), 478
 - cut-through switches, 327, 327–328
-
- ## D
- D channels, 508, 567
 - DAs (destination addresses) in frames, 26, 26
 - data bits. *See* bits; Physical layer
 - data communication equipment. *See* DCE
 - data encapsulation. *See* encapsulation

- Data fields
 - in Ethernet frames, 26, 26
 - in TCP segments, 63, 64
 - in UDP segments, 66, 66
- data frames. *See* Data Link layer; frame
- Data Link Connection Identifiers (DLCIs), 494–495
- Data Link layer, *See also* Frame Relay; layer 2; OSI; PPP
 - bridges, 20–21
 - defined, 19, 19
 - Ethernet at
 - 802.1Q frames, 358–359
 - 802.2 frames, 24, 27–28, 28
 - 802.2 sublayer, 19, 20
 - 802.3 frames, 24, 25–27, 26
 - 802.3 sublayer, 19, 20
 - defined, 24
 - Ethernet II frames, 24, 25–27, 26
 - MAC addressing, 24–25, 24, 583
 - SNAP frames, 24, 27–29, 28
 - filter tables, 20–21
 - frames, 19–20, 37–38, 37, 76
 - Logical Link Control sublayer, 19, 20
 - mapping to DoD model, 57, 57
 - Media Access Control sublayer
 - defined, 19, 20
 - forward/filter decisions, 317, 319
 - forward/filter tables, 20–21, 317–319, 318
 - MAC address learning, 317–319, 318
 - MAC addressing, 24–25, 24, 583
 - switches, 20–21
- data segments, *See also* Transport layer
 - defined, 37, 37–38
 - TCP segment format, 63–64, 63
- datagrams, 566, *See also* packets
- DCE (data communication equipment)
 - in cabling WANs, 482–483
 - configuring routers as, 175–176
 - defined, 567
 - overview of, 21–22
- DDR (dial-on-demand routing)
 - commands
 - dialer idle-timeout command, 514–515
 - dialer load-threshold command, 514–515
 - dialer map command, 511, 512–513
 - dialer-group command, 511–512, 515
 - dialer-list command, 511–512, 515
 - DDR (dial-on-demand routing), *See also* ISDN; WANs
 - with access lists, 515
 - configuring dialer information, 512–514
 - configuring static routes, 511
 - defined, 510
 - defining interesting packets, 511–512
 - optional commands, 514–515
 - verifying, 515–516
 - DE (Discard Eligibility) bit, 496, 567
 - de-encapsulation, 38
 - debug commands, *See also* commands
 - debug dialer, 516
 - debug frame-relay lmi, 502–503
 - debug ip igrp events, 244–245
 - debug ip igrp transactions, 244, 245
 - debug ip rip, 243–244
 - debug isdn q921, 516
 - debug isdn q931, 516
 - debug ppp, 488
 - decimals
 - converting binary to, 79–80
 - converting to hexadecimals, 80–81
 - IP addresses in, 82
 - dedicated leased-line WANs, 479, 480, 489–490
 - default routing, 222–223
 - delay metric, 272, 567
 - delete nvram command, 335, *See also* clear; erase
 - deleted state of virtual circuits, 496
 - deleting static routing, 222, 231
 - demarcation points, 479, 483, 491, 492
 - descriptions, router, 177–178, 198
 - descriptions, switch, 334–335
 - designated ports, 322, 323
 - designated routers (DRs), 282, 283, 568
 - desktop (access) layer, 39, 41
 - Destination IP Address field in IP headers, 72, 72
 - Destination Port field in TCP segments, 63, 63
 - Destination Port field in UDP segments, 66, 66
 - destination port numbers, 68–70, 68
 - Destination Unreachable messages, 74, 210
 - DHCP (Dynamic Host Configuration Protocol), 61–62, 568
 - dial-on-demand routing. *See* DDR
 - Diffusing Update Algorithm (DUAL), 269
 - disable command, 156
 - disabled ports, 324

620 Discard Eligibility (DE) bit – encapsulation

Discard Eligibility (DE) bit, **496**
 disconnect command, **418–419**
 discontinuous network support in EIGRP,
 270, 270–271
 distance-vector routing protocols, **225,**
 226–227, 226–227, 568, See
also IGRP; RIP
 distribute lists, **444**
 distribution layer, **39, 40–41**
 DLCIs (Data Link Connection Identifiers),
 494–495
 DNA SCP (Digital Network Architecture
 Session Control Protocol), **12**
 DNS (Domain Name Service), **61, 422–424**
 DoD (Department of Defense) model, *See*
also TCP/IP
 mapping OSI model to, **56–57, 57**
 mapping TCP/IP protocols to, **57, 58**
 overview of, **56**
 DRAM (dynamic RAM), **156, See also**
 running-configs
 DRs (designated routers), **282, 283, 568**
 DTE (data terminal equipment), **569**
 in cabling WANs, **482–483**
 communication process, **491–492, 491**
 overview of, **21–22, 175**
 DUAL (Diffusing Update Algorithm), **269**
 Dynamic Host Configuration Protocol
 (DHCP), **61–62, 568**
 dynamic NAT (Network Address Translation), **91**
 dynamic routing, **207, 223–224, See also**
 routing protocols
 dynamic VLANs (Virtual LANs), **355–356,**
 570

E

e-mail gateways, **10**
 EDI (electronic data interchange), **10**
 Edwards, Wade, **223, 268**
 EEPROM memory, **148, 570**
 EGPs (exterior gateway protocols), **223,**
 See also routing protocols
 EIA/TIA (Electronic Industries Association/
 Telecommunication Industry Alliance), **30**
 80/20 rule in virtual LANs, **358**
 EIGRP (Enhanced Interior Gateway Routing
 Protocol), *See also* IP routing; routing
 protocols
 active route state, **279**
 commands for configuring
 defined, **297**
 network, **272, 273, 274–276**
 no auto-summary, **276–277**
 passive-interface, **273**
 router eigrp, **272, 274–276**
 commands for verifying
 defined, **297–298**
 overview of, **277**
 show ip eigrp neighbor, **278–279**
 show ip eigrp topology, **279**
 show ip route, **277–278**
 configuring for IP, **272–277, 273**
 defined, **266**
 Diffusing Update Algorithm, **269**
 exam essentials, **295**
 external EIGRP routes, **270**
 hands-on lab, **298–300**
 versus IGRP, **240, 266**
 internal EIGRP routes, **270**
 key terms, **296**
 using in large networks
 discontinuous network support,
 270–271, 270
 multiple AS support, **269–270**
 overview of, **269**
 route discovery/storage, **271–272**
 summarization support, **271, 271,**
 276–277
 VLSM support, **270**
 metrics, **268, 272**
 neighbor discovery, **267–268**
 neighbor tables, **272**
 Network layer protocol support, **267**
 overview of, **223, 294–295**
 passive route state, **279**
 protocol-dependent modules, **267**
 Reliable Transport Protocol, **268**
 review question answers, **307–308**
 review questions, **303–306**
 versus RIP, **240**
 route tables, **272**
 topology tables, **272**
 written lab answers, **309**
 written lab questions, **298**
 electronic data interchange (EDI), **10**
 enable command, **155–156, 330, 331**
 enable passwords. *See* passwords
 encapsulation

- commands for configuring
 - encapsulation dot1q, 370
 - encapsulation frame-relay, 493
 - encapsulation hdlc, 523
 - encapsulation isl, 369
 - encapsulation ppp, 487, 522
- defined, 36–38, 37, 566, 571
- options in PPP, 485–486
- types in Frame Relay, 493
- encrypting passwords, 169–170, 487
- Enhanced IGRP. *See* EIGRP
- erase startup-config command, 180, 336, 408, *See also* clear; delete
- error detection option in PPP, 486
- error messages in IP routing, 210
- error messages when entering commands, 161
- Esc+B keys, 161
- Esc+F keys, 161
- Ethernet, *See also* Data Link layer; internetworking
 - cabling
 - crossover cable, 32, 32
 - overview of, 31
 - rolled cable, 33–34, 33–34
 - straight-through cable, 32, 32
 - CSMA/CD protocol, 22–23, 565
 - at Data Link layer
 - 802.1Q frames, 358–359
 - 802.2 frames, 24, 27–28, 28
 - 802.2 sublayer, 19, 20
 - 802.3 frames, 24, 25–27, 26
 - 802.3 sublayer, 19, 20
 - defined, 24
 - Ethernet II frames, 24, 25–27, 26
 - MAC addressing, 24–25, 24
 - SNAP frames, 24, 27–29, 28
 - defined, 22, 571
 - full-duplex Ethernet, 23–24
 - half-duplex Ethernet, 23, 24
 - IEEE 802.3 standards
 - 802.3ab, 29
 - 802.3ae, 29
 - 802.3u, 29, 30–31
 - at Physical layer, 29–31, 30
- EXEC sessions, 147, 572, *See also* Cisco router IOS
 - privileged exec mode
 - commands available in, 159–160
 - defined, 593
 - enabling/disabling, 155–156

- setting console port timeouts, 168
- setting router passwords for, 151, 165–166
- setting switch passwords for, 330–332
- user exec mode
 - activating exec banners in, 172
 - defined, 606
 - logging in/out of, 155, 156
 - setting router passwords for, 158–159, 166–168
 - setting switch passwords for, 330–332
- exit command, 156, 167, 416, 418
- extended IP access lists, *See also* access lists
 - configuring, 453–456
 - defined, 445, 453
 - example, 457
 - hands-on lab, 464, 465–467
 - as named access lists, 445, 457–458
 - number ranges for, 453
 - wildcard masking, 448–450
- Extended Setup mode, 150–154, *See also* Cisco router IOS
- external EIGRP routes, 270, 572

F

- FastForward switches, 327, 327–328
- FCS (Frame Check Sequence) fields, 26, 26
- feasible distance metric, 268
- feasible successors, 268
- FECN (Forward Explicit Congestion Notification), 496
- File Transfer Protocol. *See* FTP
- filter tables, 20–21, 317–319, 318
- financial transaction services, 10
- finding valid IP hosts, 86–87, 107–108
- Flags field in IP headers, 71, 72
- flapping routes/links problem, 229, 292
- flash memory, *See also* Cisco routers, managing; memory
 - defined, 393, 394, 573
 - overview of, 148
 - restoring router IOS to, 402–405, 431–432
 - verifying, 400–401
- flow control. *See* traffic
- flush timers, 230, 236
- forward delay, 324
- forward/filter tables, 20–21, 317–319, 318
- forwarding ports, 322, 324

622 FQDNs (fully qualified domain names) – hostnames

FQDNs (fully qualified domain names), 61
 Fragment Offset field in IP headers, 72, 72
 FragmentFree switches, 327, 327, 328, 574
 Frame Check Sequence (FCS) fields, 26, 26
 frame filtering in layer 2, 319, 574, *See also*
 also layer 2
 frame format in HDLC protocol, 484, 484
 Frame Relay protocol, 489–503, *See also*
 Data Link layer; WANs
 access rate, 492
 bandwidth specifications, 492–493
 bursts of data, 492–493, 496
 commands for configuring
 clock rate 64000, 524–525
 defined, 519–520
 encapsulation frame-relay, 493
 frame intf-type dce, 524
 frame-relay interface-dlci, 495
 frame-relay lmi-type, 495–496
 frame-relay map, 520
 frame-relay route, 524–525
 frame-relay switching, 524
 int s0.16 multipoint, 498
 int s0.16 point-to-point, 498
 no inverse-arp, 520
 commands for verifying
 debug frame-relay lmi, 502–503
 defined, 519–520, 525
 show frame, 500
 show frame relay lmi, 500
 show frame relay map, 502
 show frame relay pvc, 501
 show interface, 501–502
 committed information rate, 492–493, 496
 configuring single interfaces, 497
 configuring subinterfaces, 497–499, 524–525
 congestion control, 496–497
 Data Link Connection Identifiers, 494–495
 defined, 480
 DTE communication process, 491–492, 491
 encapsulation types, 493
 versus leased lines, 489–490, 492
 Local Management Interface, 495–496
 monitoring, 500–503
 overview of, 489
 virtual circuits, 493–494, 495, 496
 X.25 and, 489
 frame tagging VLANs, 358–359, 574
 FTP (File Transfer Protocol), 59, 60
 full-duplex Ethernet, 23–24
 fully qualified domain names (FQDNs), 61

G

G/L bits in MAC addresses, 24, 25
 Gang-of-Four LMI, 496
 global addressing, DLCIs and, 495
 global commands, 156, 159
 global configuration mode, 156–157
 GMII (Gigabit Media Independent Interface), 31

H

half-duplex Ethernet, 23, 24
 hardware addresses. *See* MAC
 HDLC (High-Level Data-Link Control) protocol,
 481, 483–484, 484–485, 485, 523
 Header Checksum field in IP headers, 72, 72
 hexadecimal
 converting binary/decimals to, 80–81
 defined, 26
 IP addresses in, 82–83
 history of LANs, 312–315, 313–315
 history size, terminal, 163–164
 HLEN (Header Length) field in IP headers,
 71, 72
 holddown timers, 230, 236
 holddowns, 229–230, 576
 holdtime, CDP, 409
 hops, *See also* metrics; routing protocols
 defined, 225, 577
 defining maximum hop counts, 228
 hop counts, 18, 224, 577
 hop limits, 74
 next-hop addresses, 218
 host (node) addresses, 83
 Host-to-Host layer, *See also* TCP/IP;
 Transport layer
 defined, 57, 57
 port numbers, 67–70, 68
 protocols, overview, 58, 62
 Transmission Control Protocol, 62–65, 63
 User Datagram Protocol, 65–67, 66
 hostnames
 configuring on routers, 176–177, 197, 487
 configuring on switches, 332–333
 resolving
 using DNS, 422–424
 hands-on lab, 434–435
 using host tables, 420–422, 424
 overview of, 419–420

hosts, valid IP, finding, 86–87, 107–108

hubs

defined, 22

overview of, 4, 5, 41, 42

versus switches, 6, 21, 315

hybrid routing protocols, 225, 266, *See also* EIGRP

I

I/G bits in MAC addresses, 24, 25

ICMP (Internet Control Message Protocol), 74–76

Identifier field in IP headers, 71, 72

IEEE standards. *See* Ethernet

IETF frame-relay encapsulation, 493

IGPs (interior gateway protocols), 223, *See also* routing protocols

IGRP (Interior Gateway Routing Protocol), *See also* IP routing; routing protocols

configuring, 232, 237–238

defined, 236

distance-vector protocols, 225, 226–227, 226–227

versus EIGRP, 240, 266

hands-on lab, 252–253

metrics, 236, 239

versus RIP, 236, 237, 240

timers, 236

verifying configurations, 239–245

"in-band", 148, *See also* Telnet

inactive state of virtual circuits, 496

incoming banners, 172

infinite. *See* unreachable

infrared wireless LANs, 35, 36

inside networks, 90

int bri0 command, 516

int s0.16 multipoint command, 498

int s0.16 point-to-point command, 498

int vlan command, 334

Inter-Switch Link (ISL) routing, 358, 359

interface configuration mode, 158, *See also* Cisco router IOS

internal EIGRP routes, 270

Internet layer, *See also* IP; Network layer

Address Resolution Protocol, 76–77, 77

defined, 57, 57

Internet Control Message Protocol, 74–76

Internet Protocol, 71–74, 72–73

protocols, overview, 58, 70–71

Reverse Address Resolution Protocol, 77–78, 78

Internet navigation utilities, 10

Internet Protocol. *See* IP; TCP/IP

internetworking, 2–53

bridges in, 3–5, 5

Cisco hierarchical model for

access layer, 39, 41

core layer, 39–40, 39

defined, 38–39, 39

distribution layer, 39, 40–41

data encapsulation, 36–38, 37

defined, 2

Ethernet at Data Link layer

802.1Q frames, 358–359

802.2 frames, 24, 27–28, 28

802.3 frames, 24, 25–27, 26

defined, 24

Ethernet II frames, 24, 25–27, 26

MAC addressing, 24–25, 24

SNAP frames, 24, 27–29, 28

Ethernet cabling

crossover cable, 32, 32

overview of, 31

rolled cable, 33–34, 33–34

straight-through cable, 32, 32

Ethernet networking

CSMA/CD protocol, 22–23, 565

defined, 22

full-duplex Ethernet, 23–24

half-duplex Ethernet, 23, 24

IEEE 802.3 standards, 30–31, 30

at Physical layer, 29–31, 30

exam essentials, 42

hubs in, 4, 5, 6, 22

key terms, 43–44

OSI model for, *See also* OSI

advantages, 7

Application layer, 8–9, 10–11

Data Link layer, 9, 19–21, 19

defined, 6–9, 8–9

Network layer, 9, 16–19, 17–18

overview of, 2

Physical layer, 9, 21–22

Presentation layer, 8–9, 11

Session layer, 8–9, 11–12

Transport layer, 9, 12–16, 13–16

overview of, 41

review question answers, 51–52

624 invalid timers – IP routing

- review questions, 47–50
- routers in, 3, 4–5, 5
- switches in, 3–5, 5, 42
- uses, 10–11
- wireless networks, 34–36, 35
- written lab answers, 53–54
- written lab questions, 44–46
- invalid timers, 230, 236
- IOS. *See* Cisco router IOS
- IP access lists. *See* access lists
- IP addressing, *See also* TCP/IP
 - in binary, 82
 - binary/decimal/hex conversions, 78–81
 - bits, 37, 38, 78–81, 82, 103
 - broadcast addresses and
 - defined, 17–18, 18, 82
 - in IP subnetting, 107–108
 - layer 2 broadcasts, 89
 - layer 3 broadcasts, 89
 - multicasts, 89, 90
 - unicasts, 89, 90
 - bytes, 78–81, 82
 - commands for configuring
 - ip address, 509
 - ip default gateway, 333, 334
 - ip domain-lookup, 422, 423
 - ip domain-name, 423, 424
 - ip host, 420
 - ip name-server, 422, 423
 - ip ospf cost, 284
 - configuring on routers, 174–175, 198
 - configuring on switches, 333–334
 - in decimal, 82
 - defined, 82
 - in hexadecimal, 82–83
 - hierarchical scheme, 83
 - IP header fields, 71–74, 72–73
 - Network Address Translation, 88, 90–91
 - network addresses, *See also* IP
 - subnetting
 - Class A addresses, 83–84, 84, 86, 88–89
 - Class B addresses, 83, 84, 84, 86–87, 88–89
 - Class C addresses, 83, 84, 85, 87, 88–89
 - Classes D/E addresses, 84, 85
 - defined, 17–18, 18, 82, 83, 84
 - finding valid hosts, 86–87, 107–108
 - node (host) addresses, 83
 - private IP addresses, 87–89
 - reserved IP addresses, 85
 - octets, 82
 - terminology, 82
 - troubleshooting, 132–134, 133–134
- IP (Internet Protocol), defined, 71
- IP routing, 206–263
 - commands for configuring
 - defined, 247–248
 - ip classless, 223
 - ip route, 218
 - network, 231–232
 - no ip route, 222, 231
 - passive-interface, 235, 273
 - router igrp, 237–238
 - router rip, 231
 - commands for verifying
 - debug ip igrp events, 244–245
 - debug ip igrp transactions, 244, 245
 - debug ip rip, 243–244
 - defined, 247, 248
 - overview of, 240–241
 - ping, 221–222
 - show ip protocols, 241–243
 - show ip route, 214, 221, 233–235, 239–240
 - show protocols, 241
 - configuring routers for, 211–217, 212
 - default routing, 222–223
 - defined, 206–207
 - dynamic routing, *See also* EIGRP; OSPF
 - administrative distances, 224–225
 - defined, 207, 223
 - defining maximum hop counts, 228
 - distance-vector protocols, 225, 226–227, 226–227
 - exterior gateway protocols, 223
 - holddowns, 229–230
 - hybrid protocols, 225
 - interior gateway protocols, 223
 - link-state protocols, 225
 - overview of, 224
 - route poisoning, 229
 - routing loops, 227–228, 228
 - split horizons, 229
 - timers, 230, 236
 - triggered updates, 229–230
 - dynamic routing with IGRP
 - configuring, 232, 237–238
 - defined, 236
 - versus EIGRP, 240, 266
 - hands-on lab, 249, 249, 252–253

- metrics, 236, 239
- versus RIP, 236, 237, 240
- timers, 236
- verifying, 239–245
- dynamic routing with RIPv1
 - configuring, 231–233, 231
 - convergence time, 226
 - defined, 230
 - versus EIGRP, 240
 - hands-on lab, 249, 249, 251–252
 - holding down propagations, 235
 - versus IGRP, 236, 237, 240
 - metrics, 226, 226
 - versus OSPF, 280
 - passive interfaces, 235, 273
 - pinhole congestion, 226, 226
 - route redistribution and, 235
 - timers, 230
 - verifying, 233–235, 240–245
- error messages, 210
- exam essentials, 246
- key terms, 247
- overview of, 246
- review question answers, 261–262
- review questions, 254–260
- static routing
 - command syntax, 218
 - benefits, 218
 - configuring, 218–221
 - defined, 207
 - deleting, 222, 231
 - hands-on lab, 249–251, 249
 - overview of, 217
 - verifying, 221–222
- steps in process, 207–211, 207
- written lab answers, 263
- written lab questions, 248
- IP subnetting, 102–144
 - 1 subnet bit rule, 106–107, 113, 117–118
 - benefits, 102–103
 - bits in, 103, 104, 107
 - broadcast addresses in, 107–108
 - Class A addresses
 - 255.255.0.0, 121
 - 255.255.240.0, 121–122
 - 255.255.255.192, 122
 - overview of, 120–121
 - Class B addresses
 - 255.255.192.0, 115–116
 - 255.255.240.0, 116
 - 255.255.254.0, 116
 - 255.255.255.0, 117
 - 255.255.255.128, 117–118
 - 255.255.255.192, 118, 120
 - 255.255.255.224, 119, 120
 - 255.255.255.252, 120
 - overview of, 114–115
 - in your head, 120
 - Class C addresses
 - 255.255.255.128, 113
 - 255.255.255.192, 107–110
 - 255.255.255.224, 110, 114
 - 255.255.255.240, 110–111, 114
 - 255.255.255.248, 111–112
 - 255.255.255.252, 112–113, 114
 - using binary method, 107–108
 - overview of, 106–107
 - using powers of 2, 108–113
 - WANs and, 112
 - in your head, 114
 - Classless Inter-Domain Routing, 104–106
 - defined, 102
 - exam essentials, 135
 - key terms, 136
 - overview of, 103, 135
 - powers of 2 and, 103
 - review question answers, 142–143
 - review questions, 137–141
 - subnet masks, 104–106
 - subnet-zero, 107, 130
 - valid hosts, 107–108
 - Variable Length Subnet Masks
 - block sizes, 126
 - classful routing and, 123–124, 123–124
 - classless routing and, 123
 - defined, 123
 - designing, 124–126, 124–125
 - implementing, 126–131, 127–131
 - summarizing routes, 126
 - written lab answers, 144
 - written lab questions, 136
- IS-IS (Intermediate System-to-Intermediate System) protocol, 267
- ISDN (Integrated Services Digital Network), 503–516
 - Basic Rate Interface, 504, 508
 - benefits, 503–504
 - with Cisco routers, 508–509
 - commands for configuring
 - access-list, 515
 - defined, 519–520

626 ISL (Inter-Switch Link) routing – layer 2 switching

dialer idle-timeout, 514–515
dialer load-threshold, 514–515
dialer map, 511, 512–513
dialer-group, 511–512, 515
dialer-list, 511–512, 515
ip address, 509
isdn dialer map, 509
isdn spid1, 509
isdn spid2, 509
isdn switch-type, 507, 509
commands for verifying
 debug dialer, 516
 debug isdn q921, 516
 debug isdn q931, 516
 defined, 519–520
 int bri0, 516
 isdn disconnect, 516
 ping, 516
 show dialer, 516
 show ip route, 516
 show isdn active, 516
 show isdn status, 516
 telnet, 516
configuring ISDN BRI, 525–528
defined, 480, 503
dial-on-demand routing
 with access lists, 515
 configuring dialer information, 512–514
 configuring static routes, 511
 defined, 510
 defining interesting packets, 511–512
 optional commands, 514–515
 verifying, 515–516
network termination devices, 504–506, 505
PPP and, 503
Primary Rate Interface, 504, 508
protocols, 507
S reference points, 504, 505, 506
service profile identifiers, 508, 509
switch types, 507
T reference points, 504, 505, 507
terminal adapters, 505, 506, 508
terminal equipment, 505, 506, 508
U reference points, 504, 505, 507
when to use, 510
ISL (Inter-Switch Link) routing, 358, 359

J

JPEG (Joint Photographic Experts Group), 11

K

keepalives, 183, 184, 495
keys, shortcut. *See* commands, router

L

LANs (local area networks), *See also* layer 2 switching; VLANs
 causes of congestion, 3
 defined, 580
 history of, 312–315, 313–315
 versus WANs, 478
LAPB (Link Access Procedure, Balanced)
 protocol, 481
latency, 20, 581
layer 1. *See* Physical layer
layer 2 broadcasts, 89, *See also* Data Link layer
layer 2 switching, 312–348, *See also* VLANs
 benefits, 315–316, 316, 351, 351
 versus bridges, 314, 315, 317
 broadcast domains and, 350
 broadcast storms, 320, 320
 collision domains and, 350, 351, 351
 commands for configuring
 copy run start, 335
 defined, 337–338
 delete nvram, 335
 description, 334–335
 enable, 330, 331
 enable password, 331
 enable secret, 332
 erase startup-config, 336
 hostname, 332–333
 int vlan, 334
 ip address, 333–334
 ip default gateway, 333, 334
 commands for verifying
 ping, 342
 show interface, 335
 show ip, 333, 338
 show running-config, 335
 configuring 1900/2950 switches in CLI
 accessing CLI, 329–330
 defined, 328
 descriptions, 334–335
 erasing configurations, 335–336
 hostnames, 332–333
 IP addresses, 333–334

- overview of, 328–329
 - user mode/enable passwords, 330–332
 - defined, 20–21, 312
 - exam essentials, 336–337
 - flat network structure, 350–351, 351
 - frame filtering, 319
 - functions
 - address learning, 317–319, 318
 - forward/filter decisions, 317, 319
 - loop avoidance, 317, 319–320, 320–321
 - overview of, 317
 - hands-on labs
 - configuring switches, 339–341
 - overview of, 339
 - verifying configurations, 342
 - history of, 312–315, 313–315
 - versus hubs, 315
 - key terms, 337
 - LAN switch types
 - cut-through, 327–328, 327
 - modified cut-through, 327, 327, 328
 - store-and-forward, 327, 327, 328
 - limitations, 316–317
 - MAC forward/filter tables, 317–319, 318
 - overview of, 312, 336
 - review question answers, 347
 - review questions, 343–346
 - versus routing, 315–316, 316
 - security problem, 351
 - Spanning Tree Protocol
 - blocked port state, 322, 323
 - BPDUs messages, 321–322
 - bridge IDs, 322
 - defined, 321
 - designated ports, 322, 323
 - disabled ports, 324
 - example, 324–326, 325–326
 - forward delay, 324
 - forwarding ports, 322, 324
 - learning port state, 324
 - listening port state, 324
 - nondesignated ports, 322
 - nonroot bridges, 322
 - number of switches and, 326
 - port convergence, 324
 - port cost, 322
 - port states, 323–324
 - root bridges, 321, 322–323
 - root ports, 322
 - written lab answers, 348
 - written lab questions, 338
 - layer 3 broadcasts, 89, *See also* Network layer
 - layer 4. *See* Transport layer
 - layer 5. *See* Session layer
 - layer 6. *See* Presentation layer
 - layer 7. *See* Application layer
 - layered architecture, 6–7, 581, *See also* OSI
 - LCP (Link Control Protocol), 484, 485, 485–486
 - learning ports, 324
 - leased-line WANs, 479, 480, 489–490
 - Length field in UDP segments, 66, 66
 - Length fields in frames, 26, 26
 - line commands, *See also* passwords
 - line aux, 166–167
 - line console, 159, 167–168
 - line vty, 166, 168–169
 - overview of, 158–159, 166
 - Line Printer Daemon (LPD) protocol, 60
 - Link Access Procedure, Balanced (LAPB) protocol, 481
 - Link State Advertisements (LSAs), 282
 - link-state protocols, 225, 582, *See also* OSPF
 - links, 281, 582
 - listening ports, 324
 - LLC (Logical Link Control) sublayer, 19, 20, *See also* Data Link
 - LMI (Local Management Interface), 495–496
 - load metric, 272, 582–583
 - logging into router modes, 155–156, 192–193
 - logging synchronous command, 168
 - logical topologies, 20, 22
 - login banners, 172
 - login command, 166, 167
 - logout command, 156
 - loopback interfaces in OSPF, 292–293
 - loops
 - local loops, 479, 492
 - network loops, 317, 319–320, 320–321
 - routing loops, 227–228, 228
 - LPD (Line Printer Daemon) protocol, 60
 - LSAs (Link State Advertisements), 282
-
- ## M
- MAC (Media Access Control) sublayer, *See also* Data Link layer; layer 2
 - address learning, 317–319, 318
 - addressing, 24–25, 24
 - defined, 19, 20

628 maximum hop counts – network segmentation

forward/filter decisions, 317, 319
 forward/filter tables, 20–21, 317–319, 318
 maximum hop counts, 228
 maximum transmission units (MTUs), 184, 272, 585
 media access methods, 25, *See also*
 Ethernet
 media translation, 21
 media-type command, 173
 memberships, VLAN, 355–356
 memory components, *See also* Cisco
 routers, managing
 config memory command, 156–157, 407
 EEPROM memory, 148, 570
 flash memory
 defined, 393, 394, 573
 overview of, 148
 restoring router IOS to, 402–405, 431–432
 verifying, 400–401
 NVRAM memory, 393–394
 RAM memory, 393, 400, 594
 ROM memory, 393, 596
 ROM monitor, 392, 395
 metrics, *See also* hops; routing protocols
 composite metric, 236, 239, 564
 cost metric in OSPF, 283–284
 defined, 18, 18, 224, 597
 delay metric, 272, 567
 in EIGRP, 268, 272
 feasible distance metric, 268
 in IGRP, 236, 239
 load metric, 272, 582–583
 reliability metric, 272, 595
 reported distance metric, 268
 in RIP, 226, 226
 Microsoft Callback Control Protocol (MSCP), 486
 MIDI (Musical Instrument Digital Interface), 11
 MII (Media Independent Interface), 30–31
 mobile broadband PCS networks, 35, 36
 modems, configuring, 152
 modified cut-through switches, 327, 327, 328
 monitoring (verification) commands. *See* commands
 MOTD (message of the day) banners, 171
 MPEG (Moving Picture Experts Group), 11
 MSCP (Microsoft Callback Control Protocol), 486
 MTUs (maximum transmission units), 184, 272, 585

multicast, 89, 90, 495, 586
 multilink encapsulation in PPP, 486
 multiplexing, 498, 586
 multipoint virtual circuit subinterfaces, 498

N

named access lists, 445, 457–459
 names, host. *See* hostnames
 names, user, 487, 523
 narrowband PCS networks, 35, 35–36
 narrowband wireless LANs, 35, 35
 NAT (Network Address Translation), *See*
 also IP addressing
 defined, 90
 dynamic NAT, 91
 overloading, 91
 overview of, 88
 static NAT, 91
 native VLANs, 365, 367
 navigation utilities, Internet, 10
 NBMA (nonbroadcast multi-access)
 networks, 283, 588
 NCP (Network Control Protocol), 485, 486
 neighbors
 defined, 282, 586
 discovering in CDP, 410–412
 discovering in EIGRP, 267–268
 neighborship tables, 272, 282, 587
 Network Access layer, 57–58, 57, *See also*
 TCP/IP
 network addresses. *See* IP addressing
 network command
 in configuring
 EIGRP, 272, 273, 274–276
 IP routing, 231–232
 OSPF, 285–287
 routers, 156, 157
 Network layer, *See also* Internet layer; IP;
 OSI
 data packets, 17, 37–38, 37
 defined, 16–17
 exit interfaces, 18, 18
 metrics, 18, 18
 network addresses, 17–18, 18
 protocols, EIGRP support for, 267
 route update packets, 17
 routing tables, 17–19, 18, 20
 network segmentation, 3

network termination (NT) devices,
504–506, 505

network traffic control. *See* access lists;
traffic

networks, local area. *See* LANs

networks, virtual. *See* VLANs

networks, wide area. *See* WANs

NFS (Network File System) protocol, 11, 60

nibbles, 31, 78–81

no cdp enable command, 412, 413

no cdp run command, 409, 412

no inverse-arp command, 520

no ip domain-lookup command, 422

no ip host command, 422

no ip route command, 222, 231

no login command, 166, 169

no shutdown command, 173–174, 408

node (host) addresses, 83

nonbroadcast multi-access (NBMA)
networks, 283, 588

nondesigned ports, 322

nonroot bridges, 322

NT (network termination) devices, 504–
506, 505

NVRAM (non-volatile RAM), 393–394, *See*
also startup-configs

O

o/r command, 398–399

octets, 82, *See also* bytes

Offset field in TCP segments, 63, 63

100BaseFX Ethernet, 31

100BaseT Ethernet, 30–31, 550

100BaseTX Ethernet, 31, 550

100VG-AnyLAN cable, 31

1000BaseCX Ethernet, 31

1000BaseLX Ethernet, 31

1000BaseSX Ethernet, 31

1000BaseT Ethernet, 31

Options field in IP headers, 72, 72

Options field in TCP segments, 63, 64

OSI (Open Systems Interconnection)
model, 6–22, *See also* internetworking
advantages, 7

Application layer, 8–9, 10–11

Data Link layer, *See also* Data Link;
layer 2
defined, 19, 19

Ethernet at, 24–29, 26, 28

filter tables, 20–21

frames, 19–20, 37–38, 37, 76

Logical Link Control sublayer, 19, 20

Media Access Control sublayer, 19, 20

switches and bridges, 20–21

defined, 6–9, 8–9

mapping DoD model to, 56–57, 57

mapping PPP protocol to, 484–485,
485

Network layer
defined, 16–17

exit interfaces, 18, 18

metrics, 18, 18

network addresses, 17–18, 18

packets, 17, 37–38, 37

protocols, EIGRP support for, 267

route update packets, 17

routing tables, 17–19, 18, 20

overview of, 2

Physical layer
data bits, 37, 38

defined, 21–22

Ethernet at, 29–31, 30

hubs at, 22

Presentation layer, 8–9, 11

Session layer, 8–9, 11–12

Transport layer
acknowledgements, 16, 17

connection-oriented sessions, 13–15,
13–14

data segments, 37–38, 37

defined, 9, 12

flow control, 12–13, 14–15, 14

windowing, 15, 16

OSPF (Open Shortest Path First) protocol,
See also IP routing; routing protocols

bandwidth and, 284

commands for configuring
defined, 297

ip ospf cost, 284

network, 285–287

router ospf, 284

commands for verifying
defined, 297–298

show ip ospf, 288–289, 294

show ip ospf database, 289–290, 294

show ip ospf interface, 290–291, 294

show ip ospf neighbor, 291

show ip protocols, 291–292

630 OUI (organizationally unique identifiers) – PDMs (protocol-dependent modules)

show ip route, 287–288
 show running-config, 293
 configuring single area OSPF
 enabling, 284
 loopback interfaces, 292–293
 overview of, 284, 285–287
 wildcard masks in, 285
 cost metric, 283–284
 defined, 279–280
 exam essentials, 295–296
 hands-on labs
 configuring OSPF, 301–302
 enabling OSPF, 301
 overview of, 298–299
 verifying OSPF, 302
 hierarchical design, 280–281, 281
 key terms, 296
 overview of, 223, 295
 review question answers, 307–308
 review questions, 303–306
 versus RIPv1, 280
 SPF tree calculation, 283–284
 terminology
 adjacency, 282
 backup designated routers, 282, 283
 broadcast multi-access networks,
 282, 283
 designated routers, 282, 283
 Link State Advertisements, 282
 links, 281
 neighbors, 282
 neighborship database, 282
 nonbroadcast multi-access net-
 works, 283
 OSPF areas, 280–281, 281, 282
 overview of, 281
 point-to-multipoint connections, 283
 point-to-point connections, 283
 Process IDs, 284, 285
 Router IDs, 281–282
 topology database, 282
 when to use, 240
 written lab answers, 309
 written lab questions, 298
 OUI (organizationally unique identifiers),
 24, 25
 "out-of-band", 148, *See also* auxiliary ports
 outside networks, 90
 overloading NAT, 91

P

packet switching WANs, 479, 480, 490,
 See also Frame Relay
 packets, 17, 37, 37–38, 590, *See also* IP;
 Network layer
 PAP (Password Authentication Protocol),
 486–487, 488
 passive interfaces, 235, 273
 passive route state in EIGRP, 279
 passwords
 configuring on routers, *See also* Cisco
 router IOS
 auxiliary port passwords, 166–167
 console port passwords, 167–168
 enable passwords, 151, 165–166
 enable secret passwords, 151, 165, 166
 and encrypting, 169–170, 487
 hands-on lab for, 195–196
 for PPP authentication, 487, 523
 for privileged mode, 151, 165–166
 for user mode, 158–159, 166–168
 VTY passwords, 151, 166, 168–169
 configuring on switches
 on 1900 switches, 330–331, 332
 on 2950 switches, 330, 331–332
 enable passwords, 330–331
 enable secret passwords, 332
 overview of, 330
 for privileged mode, 330–331, 332
 for user mode, 330–332
 recovering, *See also* Cisco routers,
 managing
 changing passwords, 400
 changing register bit value, 398–399
 copying run-configs to startup, 400
 copying start-configs to run, 399–400
 entering privileged mode, 399
 interrupting boot sequence, 398
 overview of, 397
 reloading routers, 399
 resetting register defaults, 400
 warning, 398
 PAT (port address translation), 91
 path cost metric, 283–284, 565
 PCS (Personal Communication Services)
 networks, 35, 35
 PDMs (protocol-dependent modules) in
 EIGRP, 267

- PDUs (Protocol Data Units), 37, 37–38
- Permanent Virtual Circuits (PVCs), 494
- Physical layer, *See also* bits; OSI
 - data bits, 37, 38
 - defined, 21–22
 - Ethernet at, 29–31, 30
 - hubs at, 22
 - mapping to DoD model, 57, 57
- physical star topologies, 22
- PICT format, 11
- Ping (Packet Internet Groper) program
 - defined, 74–75, 180, 591
 - error messages, 74, 210
 - modes to be used in, 425
 - protocols usable with, 424–425
 - verifying
 - DNS name resolution, 423, 425
 - IP addressing, 132
 - ISDN connections, 516
 - layer 2 switching, 342
 - network connectivity, 425
 - router configurations, 180–181
 - static routing, 221–222
 - TFTP connections, 401
- point-to-multipoint router connections, 283
- point-to-point (leased line) WAN connections, 479, 480, 489–490
- Point-to-Point Protocol. *See* PPP
- point-to-point router connections, 283
- point-to-point virtual circuit subinterfaces, 498–499
- poison reverse, 229
- polling media access method, 25
- pop-up messages in console ports, stopping, 168
- POPs (points of presence), 479, 492
- port address translation (PAT), 91
- ports, *See also* layer 2 switching
 - auxiliary ports
 - connecting to routers via, 147, 148
 - setting passwords on, 166–167
 - console ports
 - connecting to routers via, 147, 148
 - setting exec session timeouts on, 168
 - setting passwords for, 167–168
 - stopping pop-up messages on, 168
 - destination ports in TCP, 63, 63
 - destination ports in UDP, 66, 66
 - port numbers in TCP/IP, 67–70, 68
 - source ports in TCP, 63, 63
 - source ports in UDP, 66, 66
- switch ports
 - assigning to VLANs, 366–367
 - convergence of, 324
 - discovering in CDP, 412–413
 - trunking in VLANs, 367–369, 374–375
- positive acknowledgement with retransmission, 16, 17
- POSTs (power-on self-tests), 148–149, 392, 393
- powers of 2, 103, 108–113
- PPP (Point-to-Point Protocol), *See also*
 - Data Link layer; WANs
 - authentication
 - using CHAP protocol, 487
 - configuring, 487–488
 - overview of, 485, 486
 - using PAP protocol, 486–487
 - commands for configuring
 - defined, 519–520
 - encapsulation hdlc, 523
 - encapsulation ppp, 487, 522
 - hostname, 487, 522
 - password, 487, 523
 - ppp authentication chap, 488
 - ppp authentication pap, 488
 - service password-encryption, 487
 - username, 487, 523
 - commands for verifying
 - debug ppp, 488
 - defined, 519–520
 - show interface, 488
 - configuring on routers, 487, 522–523
 - defined, 481, 481, 484
 - encapsulation
 - authentication option, 485
 - compression option, 486
 - error detection option, 486
 - multilink option, 486
 - PPP callback option, 486
 - verifying, 488
 - protocols in
 - High-Level Data-Link Control, 481, 483–484, 484–485, 485, 523
 - Link Control Protocol, 484, 485–486, 485
 - mapping to OSI layers, 484–485, 485
 - Network Control Protocol, 485, 485, 486
 - serial connector standards, 485
 - session establishment
 - authentication phase, 486
 - link-establishment phase, 486
 - Network layer protocol phase, 486
- preamble field in frames, 25, 26

632 Precedence bits field in IP headers – route discovery in EIGRP

Precedence bits field in IP headers, 71, 72
 prefix routing, 230
 Presentation layer, 8–9, 11, *See also* OSI
 PRI (Primary Rate Interface) ISDN, 504, 508
 privileged exec mode, *See also* Cisco router IOS; EXEC
 commands available in, 159–160
 defined, 593
 enabling/disabling, 155–156
 setting console port timeouts, 168
 setting router passwords for, 151, 165–166
 setting switch passwords for, 330–332
 Process IDs, 284, 285
 Process/Application layer, *See also* TCP/IP Boot Protocol, 61
 defined, 57, 57
 Domain Name Service, 61
 Dynamic Host Configuration Protocol, 61–62
 File Transfer Protocol, 59, 60
 Line Printer Daemon protocol, 60
 mapping to OSI layers, 57, 57
 Network File System protocol, 60, 65
 protocols, overview, 58, 58
 Simple Mail Transfer Protocol, 60
 Simple Network Management Protocol, 61, 65
 Telnet protocol, 59
 Trivial File Transfer Protocol, 59
 X Window protocol, 60
 Protocol Data Units (PDUs), 37, 37–38
 Protocol field in IP headers, 72–73, 72, 73–74
 protocol-dependent modules (PDMs), 267
 pruning VTP, 362
 PVCs (Permanent Virtual Circuits), 494

Q

Q (or any) key, 160
 Q.921 protocol, 507, 508, 516
 Q.931 protocol, 507, 508, 516
 Q.933A signaling format, 495, 496
 question mark (?) help key, 150, 159–161

R

RAM (random-access memory), 393, 400, 594, *See also* running-configs
 RARP (Reverse Address Resolution Protocol), 77–78, 78
 reference models, 6–7, *See also* DoD; OSI
 reliability metric, 272, 595
 reliable multicast, 268
 Reliable Transport Protocol (RTP), 268
 reload command, 180
 repeaters, 22
 reported distance metric, 268
 "request timed out" messages, 210
 Reserved field in TCP segments, 63, 63
 resolving hostnames
 using DNS, 422–424
 hands-on lab, 434–435
 using host tables, 420–422, 424
 overview of, 419–420
 resolving names, *See also* hostnames
 restoring. *See* backing up
 RFCs (Requests for Comments), 65
 RIDs (Router IDs), 281–282, 596
 RIPv1 (Routing Information Protocol), *See also* IP routing; routing protocols
 configuring, 231–233, 231
 convergence time, 226
 defined, 230
 versus EIGRP, 240
 hands-on lab, 251–252
 holding down propagations, 235
 versus IGRP, 236, 237, 240
 metrics, 226, 226
 versus OSPF, 280
 passive interfaces, 235, 273
 pinhole congestion, 226, 226
 route redistribution and, 235
 timers, 230
 verifying, 233–235, 240–245
 RIPv2, 230
 RJ (registered jack) connectors, 30, 147, 148, 596
 rolled cable, defined, 33–34, 33–34
 ROM monitor, 392, 395
 ROM (read-only memory), 393, 596
 root bridges, 321, 322–323
 root ports, 322
 route discovery in EIGRP, 271–272

- route flush timers, 230, 236
 - route invalid timers, 230, 236
 - route poisoning, 229
 - route redistribution, 235, 279
 - route states, 279
 - route summarization, 126, 271, 271, 276–277
 - route tables in EIGRP, 272
 - route update packets, 17
 - route update timers, 230, 236
 - routing protocols, 17, 206, *See also* IP
 - router eigrp command, 272, 274–276
 - Router IDs (RIDs), 281–282, 596
 - router igrp command, 237–238
 - router IOS. *See* Cisco router IOS
 - router ospf command, 284
 - router rip command, 159, 231
 - router traffic control. *See* access lists; traffic
 - routers, 596, *See also* Cisco routers
 - routing, *See also* IP routing
 - defined, 206–207, 596
 - routing by rumor, 226
 - between VLANs, 350, 355, 355, 362–363, 362–363, 369–370
 - routing protocols, *See also* EIGRP; IGRP; OSPF; RIP
 - routing metrics. *See* metrics
 - administrative distances, 224–225
 - applying access lists to, 444
 - command prompts, 159
 - defined, 17, 206, 223–224
 - distance-vector protocols, 225, 226–227, 226–227
 - exterior gateway protocols, 223
 - holddowns, 229–230
 - hops
 - defined, 225
 - defining maximum hop counts, 228
 - hop counts, overview, 18, 224
 - hop limits, 74
 - next-hop addresses, 218
 - hybrid protocols, 225, 266
 - interior gateway protocols, 223
 - link-state protocols, 225, 582
 - metrics, *See also* hops
 - composite metric, 236, 239, 564
 - cost metric in OSPF, 283–284
 - defined, 18, 18, 224
 - delay metric, 272, 567
 - in EIGRP, 268, 272
 - feasible distance metric, 268
 - in IGRP, 236, 239
 - load metric, 272, 582–583
 - reliability metric, 272, 595
 - reported distance metric, 268
 - in RIP, 226, 226
 - route poisoning, 229
 - routing loops, 227–228, 228
 - split horizons, 229
 - triggered updates, 229–230
 - routing tables, 17–19, 18, 20, 597
 - RPC (Remote Procedure Call) protocol, 12
 - RTF (Rich Text Format), 11
 - RTP (Reliable Transport Protocol), 268
 - running-configs, *See also* Cisco routers, managing; startup-configs
 - for 1900 switches, changing, 335
 - for 2950 switches, copying to NVRAM, 335
 - for routers
 - changing in CLI, 156, 157
 - copying startup-configs to, 399–400
 - copying to NVRAM, 178–179, 400, 406–407
 - copying to TFTP servers, 407
 - creating in Extended Setup, 153–154
 - verifying, 169, 174, 177, 179–186
 - RXBOOT, 393
-
- ## S
- S reference points, 504, 505, 506
 - SA (source address) fields in frames, 26, 26
 - satellite-based networks, 35, 36
 - saving router configurations, 178–179, 194–195
 - SDLC (Synchronous Data Link Control) protocol, 481
 - search engines, 10
 - security, *See also* access lists
 - access lists and, 444
 - problem, in layer 2 switching, 351
 - securing VTY line access, 451–452
 - in VLANs, 352–353
 - segments, *See also* Transport layer
 - defined, 37, 37–38
 - TCP segment format, 63–64, 63
 - Sequence Number field in TCP segments, 63, 63
 - serial connections, 482, 485, 485

634 serial interfaces – STP (Spanning Tree Protocol)

- serial interfaces, 175–176, *See also* Cisco router IOS
- serial transmission, 482
- server mode in VLAN Trunk Protocol, 360, 361
- service password-encryption command, 170, 487
- service profile identifiers (SPIDs), 508, 509
- Session layer, 8–9, 11–12, *See also* OSI
- setup mode. *See* Cisco router IOS
- shortcut keys. *See* commands, router
- shortest path first (SPF), 283–284, 598, 600, *See also* OSPF
- show commands. *See* commands
- shutdown command, 173
- SMTP (Simple Mail Transfer Protocol), 60
- SNAP (Subnetwork Access Protocol) frames, 24, 27–29, 28
- SNMP (Simple Network Management Protocol), 61, 65, 599
- software addresses, 599, *See also* IP addressing
- Source IP Address field in IP headers, 72, 72
- Source Port field in TCP segments, 63, 63
- Source Port field in UDP segments, 66, 66
- source port numbers, 67–70, 68
- Spanning Tree Protocol. *See* STP
- SPF (shortest path first), 283–284, 598, 600, *See also* OSPF
- SPIDs (service profile identifiers), 508, 509
- split horizons, 229
- spread spectrum wireless LANs, 35, 36
- SQL (Structured Query Language) protocol, 12
- standard IP access lists, *See also* access lists
 - configuring, 448
 - defined, 445, 447
 - example, 450–451, 451, 452–453
 - hands-on lab, 464–465
 - as named access lists, 445, 457–459
 - number ranges for, 447
 - securing VTY line access, 451–452
 - wildcard masking, 448–450
- Start Frame Delimiter (SFD)/Synch in frames, 25
- startup-configs, *See also* Cisco routers, managing; running-configs
 - for 1900 switches, deleting, 335
 - for 2950 switches, copying from run-configs, 335
 - for 2950 switches, erasing, 336
 - for routers
 - changing, 156, 157
 - copying run-configs to NVRAM, 178–179, 400, 406–407
 - copying to run-configs, 399–400
 - erasing, 180, 408
 - verifying, 179–180
 - storing in NVRAM, 393–394
- state transitions, 21
- static NAT (Network Address Translation), 91
- static routing, *See also* IP routing
 - benefits, 218
 - command syntax, 218
 - configuring, 218–221
 - defined, 207
 - deleting, 222, 231
 - hands-on lab, 250–251
 - overview of, 217
 - verifying, 221–222
- static VLAN memberships, 366
- static VLANs, 355, 356
- store-and-forward switches, 327, 327, 328
- STP (Spanning Tree Protocol), *See also* layer 2 switching
 - BPDU messages, 321–322
 - bridge IDs, 322
 - defined, 321, 600
 - example, 324–326, 325–326
 - nonroot bridges, 322
 - number of switches and, 326
 - operations
 - overview of, 322
 - port convergence, 324
 - port states, 323–324
 - selecting designated ports, 323
 - selecting root bridges, 322–323
 - ports
 - in blocking state, 322, 323
 - designated ports, 322
 - disabled ports, 324
 - forward delay and, 324
 - forwarding ports, 322, 324

straight-through cable – TCP/IP (Transmission Control Protocol/Internet Protocol) **635**

- in learning state, 324
- in listening state, 324
- nondesignated ports, 322
- port cost, 322
- root ports, 322
- root bridges, 321, 322
- straight-through cable, 32, 32
- subcommands, 159
- subinterfaces. *See* Cisco routers
- subnetting. *See* IP subnetting; VLSMs
- summarization, route, 126, 271, 271, 276–277
- Switched Virtual Circuits (SVCs), 494
- switches, *See also* bridges; layer 2 switching; VLANs
 - versus bridges, 4, 20–21, 314, 315, 317
 - Cisco switch IOS, 146–147
 - collision domains and, 4
 - at Data Link layer, 20–21
 - defined, 3–5, 5, 42, 603
 - versus hubs, 6, 21, 315
 - main purpose, 3
 - versus routers, 315–316, 316
 - switch fabric, 358, 603
 - switch ports
 - assigning to VLANs, 366–367
 - convergence of, 324
 - discovering in CDP, 412–413
 - trunking in VLANs, 367–369, 374–375
- switchport access vlan command, 367
- switchport mode trunk command, 368, 374–375
- Synchronous Data Link Control (SDLC) protocol, 481

T

- T reference points, 504, 505, 507
- Tab key, 162
- TAs (terminal adapters), 505, 506, 508, 605
- TCP (Transmission Control Protocol)
 - data segment format, 63–64, 63
 - defined, 62
 - port numbers, 67–70, 68
 - versus User Datagram Protocol, 64–65, 67

- TCP/IP (Transmission Control Protocol/Internet Protocol) suite, 56–99, *See also* IP
 - DoD model of
 - mapping OSI model to, 56–57, 57
 - mapping TCP/IP protocols to, 57, 58
 - overview of, 56
 - exam essentials, 91–92
 - Host-to-Host layer
 - defined, 57, 57
 - port numbers, 67–70, 68
 - protocols, overview, 58, 62
 - Transmission Control Protocol, 62–65, 63, 67
 - User Datagram Protocol, 65–67, 66
 - Internet layer, *See also* IP
 - Address Resolution Protocol, 76–77, 77
 - defined, 57, 57
 - Internet Control Message Protocol, 74–76
 - Internet Protocol, 71–74, 72–73
 - protocols, overview, 58, 70–71
 - Reverse Address Resolution Protocol, 77–78, 78
 - IP addressing, *See also* IP addressing binary, decimal, hex conversion and, 78–81
 - broadcast addresses and, 89–90
 - defined, 82
 - versus hardware addressing, 82
 - as hierarchical scheme, 83
 - Network Address Translation, 88, 90–91
 - network addresses, 83–89
 - terminology, 82
 - key terms, 92–93
 - Network Access layer, 57, 57, 58
 - overview of, 56, 91
 - Process/Application layer
 - Boot Protocol, 61
 - defined, 57, 57
 - Domain Name Service, 61
 - Dynamic Host Configuration Protocol, 61–62
 - File Transfer Protocol, 59, 60
 - Line Printer Daemon protocol, 60
 - Network File System protocol, 60
 - protocols, overview, 58, 58
 - Simple Mail Transfer Protocol, 60

636 telcos (telecommunication companies) – Type of Service (ToS) field in IP headers

- Simple Network Management Protocol, 61, 65
- Telnet protocol, 59
- Trivial File Transfer Protocol, 59
- X Window protocol, 60
- review question answers, 98–99
- review questions, 93–97
- written lab answers, 100
- written lab questions, 93
- telcos (telecommunication companies), 479, 489–490
- Telnet protocol
 - CDP protocol and, 414
 - connecting to routers via, 148, 151
 - defined, 59, 148
 - hands-on lab, 433–434
 - passwords workaround, 168–169
 - problem connecting to, 169
 - setting VTY passwords, 151, 166, 168–169
 - verifying ISDN connections, 516
 - verifying router configurations, 169, 180, 181
- 10Base2 Ethernet, 30, 30
- 10Base5 Ethernet, 30, 30
- 10BaseT Ethernet, 30, 30
- terminal adapters (TAs), 505, 506, 508, 605
- terminal equipment (TE), 505, 506, 508, 604
- terminal history size command, 163–164
- TFTP (Trivial File Transfer Protocol)
 - servers, *See also* Cisco routers, managing
 - backing up router configurations to, 405–407, 432
 - backing up router IOS to, 400, 401–402, 431
 - changing configurations stored on, 156–157
 - restoring router configurations from, 407–408
 - TFTP, defined, 59
 - tftp-server flash command, 405
 - verifying connections to, 401
- thicknet. *See* 10Base5 Ethernet
- thinnet. *See* 10Base2 Ethernet
- three-way handshakes, 605, *See also* connection-oriented
- TIFF (Tagged Image File Format), 11
- timers, CDP, 409
- timers in dynamic routing, 230, 236
- Timm, Carl, 223, 268
- token passing method, 25
- toll networks, 479
- topology databases, 272, 282, 605
- ToS (Type of Service) field in IP headers, 71, 72
- Total Length field in IP headers, 71, 72
- traceroute command
 - defined, 74, 181, 425
 - protocols usable with, 425–426
 - verifying network connectivity, 426
 - verifying router configurations, 181
- traffic, *See also* access lists
 - controlling congestion with Frame Relay, 496–497
 - flow control in Transport layer, 12–13, 14–15, 14, 574
 - information on via CDP protocol, 412
- transparent bridging, 20–21, 605–606
- transparent mode in VTP protocol, 360, 361, 361
- Transport layer, *See also* Host-to-Host layer; OSI
 - acknowledgements, 16, 17
 - connection-oriented sessions, 13–15, 13–14
 - data segments, 37–38, 37
 - defined, 9, 12
 - flow control, 12–13, 14–15, 14
 - windowing, 15, 16
- triggered updates, 229–230
- Trivial File Transfer Protocol. *See* TFTP
- troubleshooting IP addressing, 132–134, 133–134
- troubleshooting (verification) commands. *See* commands
- trunk command, 368
- trunk links in VLANs, 357, 357
- trunk ports in VLANs, 366–369
- TTL (Time to Live) field in IP headers, 72, 72
- tunneling, 25
- Type fields in frames, 26, 26
- Type of Service (ToS) field in IP headers, 71, 72

U

U/L bits in MAC addresses, 24, 25
 UDP (User Datagram Protocol), *See also* TCP/IP
 data segment format, 65–66, 66
 port numbers, 67–68, 68
 versus Transmission Control Protocol, 64–65, 67
 unicasts, 89, 90
 Unreachable messages, Destination, 74, 210
 update timers, 230, 236
 Urgent Pointer field in TCP segments, 63, 64
 user exec mode, *See also* Cisco router IOS; EXEC
 activating exec banners in, 172
 defined, 606
 logging in/out of, 155, 156
 setting router passwords for, 158–159, 166–168
 setting switch passwords for, 330–332
 username command, 487, 523
 UTP (unshielded twisted-pair) cabling, 30, 607

V

valid IP hosts, finding, 86–87, 107–108
 verification commands. *See* commands
 Version field in IP headers, 71, 72
 viewing, *See also* commands (verification)
 command history, 162–163
 lists of commands, 159–161, 189–191
 passwords, 169
 virtual circuits, 62, 493–494, 495, 496
 Virtual TeleType (VTY). *See* Telnet
 VLANs (Virtual LANs), 350–389, *See also* LANs; layer 2 switching
 80/20 rule, 358
 benefits, 351–352, 355, 358
 broadcast control, 352
 broadcast domains and, 350
 collision domains and, 350, 351, 351
 commands for configuring
 defined, 380–381
 encapsulation dot1q, 370
 encapsulation isl, 369
 switchport access vlan, 367
 switchport mode trunk, 368, 374–375
 trunk, 368
 vlan 2 name, 364–365
 vlan database, 364–365
 vlan-membership static, 366
 vtp domain, 370, 371
 vtp mode, 371
 vtp password, 370
 vtp server, 370, 371
 commands for verifying
 defined, 380–381
 show interface trunk, 375
 show running-config, 368–369, 378–379
 show vlan, 364, 366–367
 show vlan brief, 365–366, 367, 376, 377
 show vtp, 370–372
 configuring
 on 1900 switches, 363–364, 366–368, 369
 on 2950 switches, 334, 364–366, 367, 368–369, 370
 assigning switch ports to VLANs, 366–367
 inter-VLAN routing, 369–370
 overview of, 363
 in sample internetwork, 372–379, 372
 static memberships, 366
 switches, example, 372–379, 372
 trunking on switch ports, 367–369
 defined, 350
 dynamic VLANs, 355–356, 570
 exam essentials, 379–380
 flexibility/scalability, 353–355, 354–355
 identifying
 access links, 357–358, 357
 with frame tagging, 358–359
 using IEEE 802.1Q, 358–359
 using ISL routing, 358, 359
 overview of, 356–357
 switch fabrics and, 358
 trunk links, 357, 357
 VLAN IDs, 358
 key terms, 380
 layer 2 flat networks and, 350–351, 351
 memberships, 355–356
 native VLANs, 365, 367
 overview of, 4, 315, 315, 379
 review question answers, 387–388
 review questions, 383–386

638 VLSMs (Variable Length Subnet Masks) – WANs (wide area networks)

router subinterfaces and, 369
 routing between, 350, 355, 355, 362–363, 362–363, 369–370
 security, 352–353
 static VLANs, 355, 356
 traditional LANs and, 353–354, 354
 VLAN 1, 354, 364
 VLAN Trunk Protocol
 benefits, 360
 client mode, 360, 361
 configuring, 360, 361, 370–372
 defined, 359
 pruning, 362
 server mode, 360, 361
 transparent mode, 360, 361, 361
 written lab answers, 389
 written lab questions, 381–382
 VLSMs (Variable Length Subnet Masks),
 See also IP subnetting
 block sizes, 126
 classful routing and, 123–124, 123–124
 classless routing and, 123
 defined, 123
 designing, 124–126, 124–125
 implementing, 126–131, 127–131
 route summarization, 126
 support for in EIGRP, 270
 VTP (VLAN Trunk Protocol)
 benefits, 360
 client mode, 360, 361
 configuring, 360, 361, 370–372
 defined, 359
 pruning, 362
 server mode, 360, 361
 transparent mode, 360, 361, 361
 VTY (Virtual TeleType). *See* Telnet

W

WANs (wide area networks), 478–536
 cabling
 bandwidth and, 482
 CSU/DSU devices and, 482–483, 492
 DTE/DCE connections, 482–483
 fixed/modular interfaces, 483
 overview of, 482
 serial connections, 482, 485, 485
 commands for Frame Relay
 configuration

 clock rate 64000, 524–525
 defined, 519–520
 encapsulation frame-relay, 493
 frame intf-type dce, 524
 frame-relay interface-dlci, 495
 frame-relay lmi-type, 495–496
 frame-relay map, 520
 frame-relay route, 524–525
 frame-relay switching, 524
 int s0.16 multipoint, 498
 int s0.16 point-to-point, 498
 no inverse-arp, 520
 commands for Frame Relay verification
 debug frame-relay lmi, 502–503
 defined, 519–520, 525
 show frame, 500
 show frame relay lmi, 500
 show frame relay map, 502
 show frame relay pvc, 501
 show interface, 501–502
 commands for ISDN configuration
 access-list, 515
 defined, 519–520
 dialer idle-timeout, 514–515
 dialer load-threshold, 514–515
 dialer map, 511, 512–513
 dialer-group, 511–512, 515
 dialer-list, 511–512, 515
 ip address, 509
 isdn dialer map, 509
 isdn spid1, 509
 isdn spid2, 509
 isdn switch-type, 507, 509
 commands for ISDN verification
 debug dialer, 516
 debug isdn q921, 516
 debug isdn q931, 516
 defined, 519–520
 int bri0, 516
 isdn disconnect, 516
 ping, 516
 show dialer, 516
 show ip route, 516
 show isdn active, 516
 show isdn status, 516
 telnet, 516
 commands for PPP configuration
 defined, 519–520
 encapsulation hdlc, 523
 encapsulation ppp, 487, 522

- hostname, 487, 522
- password, 487, 523
- ppp authentication chap, 488
- ppp authentication pap, 488
- service password-encryption, 487
- username, 487, 523
- commands for PPP verification
 - debug ppp, 488
 - defined, 519–520
 - show interface, 488
- connection types
 - circuit switching, 479, 480
 - dedicated leased lines, 479, 480, 489–490
 - overview of, 479, 481
 - packet switching, 479, 480, 490
 - wireless, 481
- dial-on-demand routing in ISDN
 - with access lists, 515
 - configuring dialer information, 512–514
 - configuring static routes, 511
 - defined, 510
 - defining interesting packets, 511–512
 - optional commands, 514–515
 - verifying, 515–516
- exam essentials, 517
- Frame Relay protocol
 - access rate, 492
 - bandwidth specifications, 492–493
 - bursts of data, 492–493, 496
 - committed information rate, 492–493, 496
 - configuring single interfaces, 497
 - configuring subinterfaces, 497–499, 524–525
 - congestion control, 496–497
 - Data Link Connection Identifiers, 494–495
 - defined, 480
 - DTE communication process, 491–492, 491
 - encapsulation types, 493
 - versus leased lines, 489–490, 492
 - Local Management Interface, 495–496
 - monitoring, 500–503
 - overview of, 489
 - virtual circuits, 493–494, 495, 496
 - X.25 and, 489
- hands-on labs
 - configuring Frame Relay, 524–525
 - configuring ISDN BRI, 525–528
 - configuring PPP, 522–523
 - configuring/monitoring HDLC, 523
 - overview of, 521–522
- Integrated Services Digital Network
 - Basic Rate Interface, 504, 508
 - benefits, 503–504
 - with Cisco routers, 508–509
 - configuring ISDN BRI interfaces, 525–528
 - defined, 480, 503
 - dial-on-demand routing, 510–516
 - network termination devices, 504–506, 505
 - PPP and, 503
 - Primary Rate Interface, 504, 508
 - protocols, 507
 - S reference points, 504, 505, 506
 - service profile identifiers, 508, 509
 - switch types, 507
 - T reference points, 504, 505, 507
 - terminal adapters, 505, 506, 508
 - terminal equipment, 505, 506, 508
 - U reference points, 504, 505, 507
 - when to use, 510
- IP subnetting in, 112
- key terms, 518
- versus LANs, 478
- overview of, 478, 515–516
- Point-to-Point Protocol, *See also* PPP
 - authentication methods, 485, 486–488
 - configuring on routers, 487, 522–523
 - defined, 481, 484
 - encapsulation options, 485–486
 - High-Level Data-Link Control, 481, 483–484, 484–485, 485, 523
 - Link Control Protocol, 484, 485–486, 485
 - mapping to OSI layers, 484–485, 485
 - Network Control Protocol, 485, 485, 486
 - serial connector standards, 485, 485
 - session establishment, 486
 - verifying encapsulation, 488
- protocols
 - Asynchronous Transfer Mode, 481
 - Frame Relay, 480, 489–503, 491
 - HDLC High-Level Data-Link Control, 481, 483–484, 484–485, 485, 523



640 wildcards – X.25 protocol

- Integrated Services Digital Network, 480, 503–516, 505
- Link Access Procedure, Balanced, 481
- overview of, 480
- Point-to-Point Protocol, 481, 484–488, 484–485
- review question answers, 533–534
- review questions, 529–532
- serial transmission, 482
- terminology
 - central offices, 479, 492
 - customer premises equipment, 478
 - demarcation points, 479, 483, 491, 492
 - local loops, 479, 492
 - points of presence, 479, 492
 - telecommunication companies, 479, 489–490
 - toll networks, 479

- written lab answers, 535–536
- written lab questions, 521
- wildcards
 - 0.0.0.0 255.255.255.255 mask, 450, 456
 - in configuring access lists, 448–450
 - in configuring OSPF areas, 285
 - defined, 608
- Window field in TCP segments, 63, 64
- windowing in Transport layer, 15, 16
- wireless networks, 34–36, 35, 481
- WISPs (wireless ISPs), 481
- workgroup (distribution) layer, 39, 40–41
- WWW (World Wide Web), 10

X

- X Window protocol, 12, 60, 608
- X.25 protocol, 489, 608

