

# Index

## ***Symbols & Numerics***

---

- (delimiting character), 337, 539
- ? command. *See* help (?)
  - command
- { } notation, 569
- | (pipe) sign, 569
- 2.4-GHz band
  - overview, 653–654
  - WLAN standards, 657–661
- 2-based numbering system.
  - See* binary system
- 2n (binary powers of two)
  - numbering system, 239–240
- 3DES (Triple DES), 788
- 5-GHz band
  - defined, 653
  - overview, 655
  - WLAN standards, 660–661
- 6to4 tunneling, 282
- 8 Position 8 Contact
  - connector. *See* RJ-45 connector
- 8P8C connector. *See* RJ-45 connector
- 10 Gigabit Ethernet (10GigE)
  - 10GBASE-T, 191
  - implementing on LANs, 78
  - over fiber-optic cabling, 73–75
  - over twisted-pair cabling, 73
  - overview, 75
  - STP path cost, 393
- 10/100 PC connection.
  - See* PC (10/100 PC) connection, Cisco IP phone
- 10/100 SW (uplink)
  - connection, Cisco IP phone, 447–449
- 10BASE2 (Thinnet), 67, 75
- 10BASE5 (Thicknet), 66–67, 75
- 10-based numbering system. *See* decimal system
- 10BASE-T, 67, 75, 191
- 10GBASE-ER (IEEE 802.3 C49 64B/66B), 74–75
- 10GBASE-LR (IEEE 802.3 C49 64B/66B), 74
- 10GBASE-SR (IEEE 802.3 C49 64B/66B), 73–74
- 10GBASE-T, 75, 191
- 10GigE. *See* 10 Gigabit Ethernet
- 10-Mbps Ethernet
  - 10BASE2, 67, 75
  - 10BASE5, 66–67, 75
  - 10BASE-T, 67, 191
  - overview, 75
  - STP path cost, 393
- 16-based numbering system. *See* hexadecimal system
- 60-pin serial connection, 810
- 64-bit encryption, WEP, 95
- 64-bit Extended Unique Identifier. *See* EUI-64
- 100BASE-FX (IEEE 802.3u), 69, 75
- 100BASE-SX (IEEE 802.3u), 70
- 100BASE-T
  - full-duplex transmission, 66
  - half-duplex transmission, 65
  - overview, 191
- 100BASE-T2 (IEEE 802.3y), 68
- 100BASE-T4 (IEEE 802.3u), 68, 75
- 100BASE-TX (IEEE 802.3u), 69, 75
- 100-Mbps Fast Ethernet.
  - See* Fast Ethernet
- 128-bit encryption, WEP, 95
- 1000BASE-LH (IEEE 802.3z), 72
- 1000BASE-LX (IEEE 802.3z), 71–72, 75
- 1000BASE-SX (IEEE 802.3z), 72, 75
- 1000BASE-T (IEEE 802.3ab), 70–71, 75, 191
- 1000BASE-TX (IEEE 802.3ab), 71
- 1000BASE-ZX (IEEE 802.3z), 72–73
- 1000-Mbps Gigabit Ethernet (GigE). *See* Gigabit Ethernet
- 10000-Mbps Gigabit Ethernet. *See* 10 Gigabit Ethernet

---

## ***A***

- AAA. *See* authentication, authorization, and accounting
- ABM (asynchronous balanced mode), HDLC, 825

- absorption, defined, 685
- access (desktop) layer
  - (Cisco hierarchical model)
  - overview, 103, 105, 392
  - routers best suited for, 518
  - scalability, 106
  - specialization, 105
  - switches best suited for, 313
- access attack, 723–724
- access control entry (ACE), 739, 746, 752–753
- access control list (ACL)
  - commands, 749, 750
  - creating, 742–755
  - distribution layer, 104
  - keywords, 748
  - managing, 740–742, 756–758
  - overview, 726–727
  - purpose of, 735–738
  - rules for, 758
  - troubleshooting, 755–758
  - types of, 738–740
- access layer switch
  - core layer, 102–103
  - Ethernet LANs, 78
- access mode, DTP, 430
- Access Mode VLAN field, 477
- access point (AP). *See also* LWAPP
  - automatic tuning, 688
  - autonomous mode
    - wireless networking, 681
  - Cisco Aironet, 695
  - Cisco GUI, 709–710
  - functions of, 696
  - infrastructure mode
    - wireless networking, 679–680
  - layout of, 685–688
  - lightweight mode wireless networking, 681–683
  - management access, 672
  - SSIDs, 671–672
  - VPNs, 669
  - WEP, 668
  - WLANs, configuring, 705–707
- access port
  - DTP, 426, 430
  - overview, 427–428
  - VoIP, 446, 451–452
- access rate, reserving
  - bandwidth using, 858–859
- access-class command, 750
- ACE (access control entry), 739, 746, 752–753
- acknowledgment (ACK)
  - connection-oriented transport, 29
  - EIGRP, 612
  - flow control, 30–31
  - IP spoofing, 725
  - positive acknowledgment and retransmission process, 31
  - TCP, 203
  - three-way handshake process, 30
  - WLANs, 659
- ACL. *See* access control list
- ACL number, defined, 750
- active destination network, defined, 619
- AD. *See* administrative distance
- ad hoc mode
  - defined, 675
  - WLANs, 675–679
- Adaptive Security Appliance (ASA)
  - firewall
    - ASDM, 709
    - GUI, 711
- Adaptive Security Device Manager (ASDM), 709
- Adaptive Wireless Path Protocol (AWPP), 697
- Address field
  - Frame Relay frames, 860–861
  - HDLC frames, 824
  - PPP frames, 833
- address learning, defined, 305
- Address Resolution Protocol. *See* ARP; RARP
- Address-Family Identifier (AFI) field
  - RIPv1, 595
  - RIPv2, 596
- administrative distance (AD)
  - EIGRP, 609
  - overview, 573–574
  - weighting protocols by, 589
- administrative VLAN. *See* VLAN 1
- ADSL (asymmetric digital subscriber line)
  - circuit-switched connections, 87
  - overview, 818
- ADSL tranceiver unit (ATU), defined, 818

- Advanced Encryption Standard. *See* AES
- Advanced Firewall
  - Configuration Wizard screen, SDM, 757
- Advanced Research Projects Agency (ARPA), 168–169
- AES (Advanced Encryption Standard)
  - encryption, 668
  - IPsec, 788
  - WLAN security, 705
- AFI field. *See* Address-Family Identifier field
- AfriNIC (African Network Information Centre), 266
- agent (zombie), 724
- AH. *See* Authentication Header
- all-nodes multicast group, IPv6, 271
- all-routers multicast group, IPv6, 271
- alternate port, 406
- %Ambiguous command error message, 123
- American Registry for Internet Numbers (ARIN), 266
- American Standard Code for Information Interchange (ASCII) table, 56
- amplitude
  - defined, 651–652
  - modulating, 653
- analog telephone lines, 87
- ANDing binary numbers, 256
- ANSI LMIs, 860
- antispyware, 723
- any keyword
  - ACLs, 748
  - function of, 750
- anycasting, 269, 271
- AP. *See* access point; LWAPP (Lightweight Access Point Protocol)
- APIPA (Automatic Private IP Addressing), 677
- AP-Manager Interface, WLCs, 693
- APNIC (Asian Pacific Network Information Centre), 266
- AppleTalk, 609
- application layer (DoD model), 179–180
- application layer (OSI reference model)
  - encapsulation process, 180–182
  - information exchange between layers, 175–177, 188
  - overview, 16–17, 177–178, 205–207
  - PDUs, 43–44
  - placement in stack, 174–176
  - SSL, 791
  - TCP/IP applications at, 27
  - TCP/IP protocols at, 26
- application layer (TCP/IP), 208
- archive keyword, 347, 549
- ARIN (American Registry for Internet Numbers), 266
- ARM (asynchronous response mode), HDLC, 825
- ARP (Address Resolution Protocol). *See also* RARP
  - command-line screen shot, 196
  - compared to Inverse ARP, 863
  - data link layer, 37, 196
  - determining MAC addresses, 308
  - function of, 196
  - overview, 173, 225
  - proxy, 226
  - purpose of, 226
  - sending frames to remote network, 370, 372–374
  - sending frames within LAN, 369–371
- ARP -a command, 196
- ARP -s command, 196
- ARPA (Advanced Research Projects Agency), 168–169
- ARPANET
  - origin of, 168–169
  - RIP, 587
- AS. *See* autonomous system
- as\_id (routing domain ID), 615
- ASA firewall. *See* Adaptive Security Appliance firewall
- ASCII (American Standard Code for Information Interchange) table, 56
- ASDM (Adaptive Security Device Manager), 709
- Asian Pacific Network Information Centre (APNIC), 266

- ASN (Autonomous System Number). *See* BGP
  - asymmetric cryptography, defined, 788
  - asymmetric digital subscriber line. *See* ADSL
  - asynchronous balanced mode (ABM), HDLC, 825
  - asynchronous response mode (ARM), HDLC, 825
  - ATM (Asynchronous Transfer Mode)
    - cell-switched connections, 90
    - overview, 813–814
  - ATU (ADSL transceiver unit), defined, 818
  - Authenticate-ACK message, PAP, 839
  - Authenticate-NAK message, PAP, 839
  - authentication. *See also* IPsec; password
    - ACLs, 737
    - asymmetric cryptography, 788
    - CHAP, 840–841, 844–845
    - data origin, 786
    - LCP, 838
    - PAP, 839–840, 844–845
    - PPP, 833, 843
    - router, 554–562
    - switch, 352–365
    - VPNs, 728
    - Web authentication process, 708–709
    - WEP, 667–668
    - WLANs, 667–670
  - authentication,
    - authorization, and accounting (AAA) enabling on routers, 799
    - MAC address filtering, 670
  - Authentication Header (AH)
    - overview, 794
    - transport mode, 795
    - tunnel mode, 796
  - Authentication-Request message, PAP, 839
  - autoconfiguration, address, 263, 272–273
  - auto-cost reference-bandwidth command, 628
  - Autoinstall feature, IOS, 328–329
  - automatic boot process
    - defined, 339, 541
    - interrupting, 341–345, 361
  - Automatic Private IP Addressing (APIPA), 677
  - autonegotiating duplex mode, 379
  - autonomous mode, WLANs, 681
  - autonomous system (AS; single routing domain)
    - defined, 275
    - IGPs, 625
    - RIP, 588–589
    - routing domain ID, 615
  - Autonomous System Number (ASN). *See* BGP
  - autonomous system number command, 278
  - aux keyword, line <first\_arg> ? command, 130
  - auxiliary password
    - defined, 333, 352, 535, 555
    - routers, 557–558
    - switches, 354–355
  - auxiliary port. *See also* auxiliary password
    - routers, 521–522
    - switches, 317–318
  - avoiding loops. *See also* STP
    - defined, 305
    - overview, 304–307
    - with STP, 379–380, 388
  - AWPP (Adaptive Wireless Path Protocol), 697
- 
- ## B
- backbone. *See* core layer (backbone) (Cisco hierarchical model)
  - BackboneFast option, 405
  - back-end firewall, 721
  - backing up
    - router running
      - configuration, 550–552
    - switch running
      - configuration, 348–349
  - backplane, defined, 101
  - backup controllers,
    - configuring, 707–708
  - backup designated router (BDR), OSPF
    - configuring, 637–638
    - OSPF priority, 638
    - overview, 629–630, 634
    - summarization, 631–632
  - backup port, 406
  - backward explicit congestion notification (BECN), 861–862

- bandwidth
  - broadcast loops, 303, 386
  - cell-switched
    - connections, 90
  - circuit-switching
    - technology, 169
  - core layer, 101, 106
  - CSMA/CD, 293
  - defined, 9
  - distribution layer, 106
  - EtherChannel, 408, 424
  - Fast Ethernet, 324
  - IGRP, 200
  - LANs, 67–75, 78
  - overview, 575
  - PPPoE, 818
  - reserving using access
    - rate and CIR guarantee, 858–859
  - static routing, 276
  - STP path cost, 393
  - summarization, 253
  - WANs, 85, 86, 88
- banner command, 336
- banner motd - command, 337, 539
- banners
  - configuring for routers, 538–539
  - configuring for switches, 336–337
- base 2 numbering system. *See* binary system
- base 10 numbering system. *See* decimal system
- base 16 numbering system. *See* hexadecimal system
- base numbers, 50
- Basic configuration form, SDM Express, 154–155
- basic input-output system (BIOS), WPA-1, 96
  - autonomous systems, 588, 625
  - network layer, 199–200
- bidirectional TCP
  - connections, 30–32
- binary powers of two ( $2^n$ )
  - numbering system, 239–240
- binary system
  - compared to hexadecimal system, 55
  - configuration register, 545
  - converting hexadecimal to, 58, 250
  - converting to hexadecimal, 57–58
  - notation, 56
  - overview, 51–53
- BIOS (basic input-output system), WPA-1, 96
- bit mask, defined, 635
- bits
  - configuration register, 545–547
  - defined, 56–57
  - SDUs, 189
- blade, defined, 101
- blocking frames. *See* blocking port
- blocking port
  - assigning, 389
  - defined, 393, 395
  - overview, 399–400
  - setting, 398
- boot command
  - functions of, 339–341
  - routers, 541–544
- boot enable-break
  - command
    - function of, 362
  - interrupting automatic boot process, 344–345
- Basic NAT Wizard welcome screen, SDM, 779
- Basic Rate Interface (BRI), 846
- basic service set (BSS), 684
- basic service set identifier (BSSID), 684
- Bc (Committed Burst) rate, 859
- BDR. *See* backup designated router, OSPF
- Be (Bursts), 859
- BECN (backward explicit congestion notification), 861–862
- Bellman-Ford algorithm. *See* RIP best practices
  - for access control lists, 740–742
  - for debug command, 497–498
  - to decrease STP convergence duration, 401
  - for duplex modes, 378
  - for router configuration backup and recovery, 550–551
  - for router passwords, 536
  - for routers, 517–519
  - for switch configuration backup and recovery, 348
  - for switch passwords, 334
  - for switches, 313–314
  - for VTP operating modes, 436
- BGP (Border Gateway Protocol)
  - administrative distance, 589

- boot host option, 542
- boot loader software. *See* bootstrap program
- bootstrap program
- boot manual command (manual boot option), 342–343, 361
- boot network option, 543
- boot process
  - obtaining IOS version from output, 456
  - router, 541, 544–548
  - switch, 338–339, 341–345, 361–362
- (boot)> (Rx-boot) prompt
  - accessing Rx-boot image, 113
  - booting from, 544
  - function of, 321, 525
- bootlpr option, 340
- BOOTP, 33
- bootstrap option, 542
- bootstrap program (boot loader software)
  - defined, 113
  - routers, 525–526, 541
  - switches, 321, 339
- Border Gateway Protocol. *See* BGP
- border router. *See* perimeter router
- BPDU (bridge protocol data unit)
  - overview, 398–399
  - STP recalculation process, 405
  - structure of, 399
  - TCN, 399
- BPDUFilter option, 403
- BPDUGuard option, 402
- BRI (Basic Rate Interface), 846

- bridge ID
  - electing root bridge, 389
  - setting designated ports according to, 395–398
- bridge protocol data unit. *See* BPDU
- bridges
  - compared to hubs, 294
  - compared to switches, 295
  - defined, 9
  - purpose of, 294–295
  - segmenting with, 197
- broadcast command, 873
- broadcast domain
  - broadcast query noise, 8
  - defined, 417
  - limiting size of, 10, 418
  - VLANs, 417–418
- broadcast IP address
  - data link layer, 223
  - network layer, 223–225
  - overview, 223–225
  - subnetting, 236
- broadcast storm
  - cause of, 380
  - defined, 8, 306, 388
  - example of, 303–305, 386–387
- broadcast transmission, 308–311
- brute-force attack, 723
- BSS (basic service set), 684
- BSSID (basic service set identifier), 684
- Buffer logging field, 471
- buffersize option, 340
- Bursts (Be), 859
- bus topology
  - defined, 10
  - figure of, 11
  - first-generation LANs, 292–293

- business partner VPN, 787
- bytes, defined, 56–57

---

## C

---

- C (Check Sequence; Frame Check Sequence [FCS])
  - field, data link frames, 78
- cabling, verifying
  - connectivity of, 473–474. *See also names of specific types of cabling*
- Cain and Able software, 679
- call setup. *See* three-way handshake
- call setup state, SVCs, 857
- call termination state, SVCs, 857
- callback service
  - ISDN DDR, 845–846
  - LCP, 838
  - PPP, 833
- carrier protocol, 792
- carrier sense, defined, 658
- carrier sense multiple
  - access collision detect protocol. *See* CSMA/CD protocol
- carrier signal, defined, 651
- Cat1 (Category 1) cabling, 192
- Cat2 (Category 2) cabling, 192
- Cat3 (Category 3) cabling
  - 10-Mbps Ethernet, 67, 75
  - Fast Ethernet, 68–69, 75
  - full-duplex transmission, 65
  - half-duplex transmission, 65

- number of hosts, 78
- overview, 192
- T568B and T568A UTP termination standards, 79
- Cat4 (Category 4) cabling, 192
- Cat5 (Category 5) cabling
  - 10-Mbps Ethernet, 67, 75
  - Fast Ethernet, 68–69, 75
  - Gigabit Ethernet, 70–71, 75
  - number of hosts, 78
  - overview, 192
  - T568B and T568A UTP termination standards, 79
- Cat5e (Category 5e) cabling
  - 10-Mbps Ethernet, 67
  - Fast Ethernet, 69
  - Gigabit Ethernet, 70–71, 75
  - number of hosts, 78
  - overview, 192
  - T568B and T568A UTP termination standards, 79
  - verifying connectivity of, 474
- Cat6 (Category 6) cabling
  - 10 Gigabit Ethernet, 73
  - Gigabit Ethernet, 70–71, 75
  - number of hosts, 78
  - overview, 192
  - T568B and T568A UTP termination standards, 79
- Cat6a (Category 6a) cabling
  - 10 Gigabit Ethernet, 73
  - Gigabit Ethernet, 75
  - overview, 193
- Cat7 (Category 7) cabling
  - Gigabit Ethernet, 70–71
  - overview, 193
  - T568B and T568A UTP termination standards, 79
- Cat7a (Category 7a) cabling, 193
- Catalyst switch. *See* Cisco Catalyst switch; switch
- CBAC (Context-Based Access Control), 729
- CCK. *See* Complementary Code Keying
- CCKM (Cisco Centralized Key Management), 705
- CCMP (Counter Mode with Cipher Block Chaining Message Authentication Code Protocol) encryption algorithm, 96
- cd command, 351, 465–466, 553
- CDP (Cisco Discovery Protocol)
  - Cisco IP phone PC port, 450–451
  - CoS, 450
  - gathering network information, 491–494
  - VLANs, 450
- cdp enable command, 492
- cdp run command, 492
- Cell Loss Priority (CLP) field, 814
- cell-switched connection
  - advantages of, 89–90
  - defined, 811
  - disadvantages of, 90
  - protocols, 90
- central processing unit (CPU) register, 321
- certificate (key), IPsec, 788, 790
- Challenge Handshake Authentication Protocol. *See* CHAP
- challenge text message, CHAP, 840
- channel (inherent)
  - attenuation, defined, 79
- channel service unit/data service unit. *See* CSU/DSU
- channel-group <#> mode command, 426
- channel-group <channel #> mode active command, 410, 432
- channel-group <channel #> mode auto command, 409, 432
- channel-group <channel #> mode desirable command, 410, 432
- channel-group <channel #> mode off command, 409, 432
- channel-group <channel #> mode on command, 409, 432
- channel-group <channel #> mode passive command, 410, 432
- channel-group 1 mode on command, 409, 432
- channel-group mode command, 409, 432
- CHAP (Challenge Handshake Authentication Protocol)
  - overview, 840–841, 844–845
  - PPP, 835

- chassis, defined, 101
  - cHDLC (Cisco HDLC). *See also* HDLC
    - data framing, 824
    - overview, 823
    - SLARP, 825
  - Check Sequence (C; Frame Check Sequence [FCS])
    - field, data link frames, 78
  - Choose a Wireless Network dialog box, Windows XP
    - ad hoc mode wireless networking, 678
    - infrastructure mode wireless networking, 680–681
  - CIDR (classless interdomain routing)
    - addressing table, 238
    - overview, 237–238
    - RIPv2, 595
    - subnet zero, 240
    - subnetting, 236–238
  - CIR (committed information rate) guarantee, 858–859
  - circuit-switched connection
    - advantages of, 87
    - defined, 811
    - disadvantages of, 87–88
    - packet switching networks versus, 169
    - protocols, 88
  - Cisco Aironet access
    - points, 695
  - Cisco Catalyst switch. *See also* switch
    - accessory items, 325
    - auxiliary modem
      - connection, 317–318
    - boot loader output, 456
  - Cisco ISL frame-tagging
    - method, 422
  - console connection, 316
  - Device Manager
    - dashboard view, 131–132
  - displaying free space
    - available in flash memory, 461
  - electing root bridge, 390–391
  - Express Setup utility, 326–331
  - front and rear panels of, 314
  - inspecting logs and system messages, 468
  - inter-VLAN routing, 440
  - running configuration, 462–463
  - starting up, 322
  - startup configuration, 463–464
  - STP priority, 392–393
  - VMPS, 421
- Cisco Centralized Key Management (CCKM), 705
  - Cisco Device Manager (DM)
    - GUI, 131–138
    - obtaining IOS version through, 458–459
    - overview, 112
    - verifying port status, 479
  - Cisco Discovery Protocol. *See* CDP
  - Cisco HDLC (cHDLC). *See* cHDLC; HDLC
  - Cisco hierarchical design
    - model
      - access layer, 105
      - benefits of, 105–107
      - core layer, 99–103
      - distribution layer, 103–104
      - overview, 99
      - STP priority, 391–393
  - Cisco Internetwork Operating System (IOS)
    - command-line interface, 116–130
    - GUI, 130–160
    - loading, 321–322, 339, 525, 541
    - overview, 112
    - router setup, 533–539
    - switch setup, 331–337
    - verifying port status, 474–479
    - version of, obtaining, 456–460
  - Cisco IOS File System (IFS)
    - inspecting memory contents, 464–466
    - managing router configurations, 552–554
    - managing switch configurations, 349–352
    - NVRAM buffer size, 340
  - Cisco IOS Firewall, 728–730. *See also* firewall
  - Cisco IOS software image (tar file)
    - downloading, 357–358, 459, 560–561
    - lightweight mode wireless networking, 681
    - obtaining IOS version from name, 457
    - testing, 339, 541
    - verifying presence of, 461–462
  - Cisco IP phone
    - CDP, 450–451
    - overview, 447–450
    - picture of, 448

- Cisco ISL frame tagging
  - overview, 421–422
  - trunk ports, 429
- Cisco LMIs, 860
- Cisco Network Assistant (CNA)
  - gathering network information, 490–491
  - GUI, 139–144
  - inspecting switch logs and system messages with, 472–473
  - obtaining IOS version through, 459–460
  - overview, 112–113, 540
  - verifying port status, 480–482
- Cisco router. *See also* router
  - accessory items, 518–519, 529
  - console connection, 520
  - front and rear panels of, 518–519
- Cisco SDM client
  - installation package, 145
  - launching, 149
  - purpose of, 145
- Cisco SDM Express Web-based client, 151–152
- Cisco SDM Installation Wizard, 145–148
- Cisco SDM item, SDM Express, 159–160
- Cisco SDM server, 145, 151
- Cisco Security Device Manager (SDM)
  - access control lists, 757–758
  - creating administrators, 527–528
  - firewalls, configuring, 757–758
  - Frame Relay, 873
  - installing client, 145–149
  - IPsec VPNs, 799–801
  - launching, 709
  - launching client, 149–151
  - NAT, 776, 779–780
  - overview, 113, 144–145, 540
  - PPP, 846
- Cisco Security Device Manager (SDM) Express
  - GUI, 151–160
  - overview, 540
- Cisco serial interfaces, 809–810
- Cisco Unified Wireless Networks Architecture (CUWN)
  - Cisco WCS, 695
  - Cisco WLAN AP devices, 695
  - Cisco WLC, 692–694
  - overview, 691–692
- Cisco Wireless Control System (WCS), 695
- Cisco Wireless LAN Controller. *See* WLC
- Cisco WLAN Access Point (AP) devices, 695
- Class A IP address
  - address range and number of possible hosts, 219
  - binary ranges of, 217
  - disadvantages of, 237, 261
  - overview, 215–216
- Class A network
  - determining host addresses, 247–248
  - determining subnet addresses, 245–247
  - private IP addressing, 222
  - subnet mask for, 221, 234
  - subnet table, 249
- Class B IP address
  - address range and number of possible hosts, 219
  - binary ranges of, 217
  - overview, 215–217
- Class B network
  - determining host addresses, 244–245
  - determining subnet addresses, 243–244
  - private IP addressing, 222
  - subnet mask for, 221, 234
  - subnet table, 246
- Class B subnet, 243–245
- Class C IP address
  - address range and number of possible hosts, 219
  - binary ranges of, 217
  - overview, 215–217
- Class C network
  - determining host addresses, 241–242
  - determining subnet addresses, 240–241
  - private IP addressing, 222
  - subnet mask for, 221, 234
  - subnet table, 243
  - VLSM, 251, 253
- Class C subnet, 240
- Class D IP address
  - address range and number of possible hosts, 219
  - binary ranges of, 218
  - overview, 215, 218

- Class E IP address
  - address range and number of possible hosts, 219
  - binary ranges of, 218
  - overview, 215, 218
- class of service (CoS), VoIP, 447, 449–452
- classful addressing, 236–237
- classful routing protocols. *See also* EIGRP
  - EIGRP, 614–615
  - features of, 614
  - RIPv1, 593–595
- classless interdomain routing. *See* CIDR
  - classless routing, 614–615. *See also* EIGRP
- clear access-list counter [list#] command, 749
- clear ip nat statistics command, 777–778
- clear ip nat translation command, 777, 780
- CLI. *See* command-line interface
- client mode, VTP switches, 435
- client roaming support, WLCs, 694
- clock rate, 855–856
- clock rate command, 826
- CLP (Cell Loss Priority) field, 814
- CNA. *See* Cisco Network Assistant
- coaxial cabling
  - 10-Mbps Ethernet, 66–67
  - effect of number of hosts, 78
  - as example of bus topology, 10
  - half-duplex transmission, 65
- codec (coder/decoder), 90
- Code-Reject frame, LCP, 836
- collision detection. *See* CSMA/CD protocol
- collision domain
  - bridged networks, 294, 296
  - defined, 9–10, 417
  - effect of number of hosts, 78
  - Ethernet, 65
  - hub networks, 294, 296
  - LANs, 63, 293
  - switched networks, 295, 296
- colon hexadecimal notation. *See also* hexadecimal system
  - configuring IPv6, 271
  - defined, 264
- Command field
  - RIPng, 597
  - RIPv1, 594
  - RIPv2, 596
- command-line interface (CLI)
  - command shortcuts, 122–123
  - context-sensitive help, 124–130
  - default answers, 123–124
  - enabling and disabling components and services, 124
  - error messages, 123
  - NAT, 776–779
  - operation modes, 116–121
  - PPP, 841–842
  - selecting component range to work with, 122
  - selecting components to work with, 121
- Command/Response (C/R) bit, Frame Relay frames, 860–861
- commands. *See also names of specific commands*
  - listing, 125–129
  - listing arguments, 129–130
  - shortcuts, 122–123
- Committed Burst (Bc) rate, 859
- committed information rate (CIR) guarantee, 858–859
- Committed Rate Measurement Interval (Tc), 859
- CompactFlash cards, accessing, 114
- Complementary Code Keying (CCK)
  - IEEE 802.11b, 659–660
  - IEEE 802.11g, 660
- compression
  - HDLC, 826
  - LCP, 838
  - PPP, 833, 843
- compression stac command, 826
- computer cluster, defined, 7
- computer host device. *See* host device
  - (config) prompt, 333, 535
- config t command. *See* configure terminal
  - (config t) command
- config-file option, 340
- (config-if) prompt, 333, 535

- (config-if-range) prompt, 333, 535
- config-register command, 548
- config.text file. *See* startup configuration file
- config.text.renamed file, 461–462
- Configuration Archive option, CNA, 144
- configuration register changing value, 113 managing router boot process with, 544–548 purpose of, 115
- Configure button, SDM, 150–151
- Configure menu, CNA, 141–142
- configure terminal (config t) command function of, 119–120, 307, 332, 410, 534 short forms of, 123
- Configure-ACK frame, LCP, 836–837
- configured VLAN, defined, 427
- Configure-NAK frame, LCP, 836–837
- Configure-Reject frame, LCP, 836–837
- Configure-Request frame, LCP, 836–837
- Congestion Control fields, Frame Relay frames, 860–861
- Connect Web form, CNA, 140
- connectionless transport protocols transport layer, 29, 203 UDP as example of, 169–170
- connection-oriented transport protocols TCP as example of, 169–170 transport layer, 29, 203
- connectors, verifying connectivity of, 473–474. *See also* names of specific connectors
- console Cisco Catalyst switch, 316 Cisco router, 520 logging system events and alerts to, 469, 471 UTP cabling, 816 console facility, 315, 519–520, 522 console keyword, line <first\_arg> ? command, 130 Console logging field, 471 console password configuring, 334 defined, 333, 352, 535, 555 routers, 536–537, 555–556 switches, 334, 353 console port. *See also* console password routers, 519–521 switches, 315–317 Console Terminal Server connecting remotely to routers, 523–524 connecting remotely to switches, 318, 320 contact lid, verifying connectivity of, 473 content encryption, defined, 728. *See also* encryption Context-Based Access Control (CBAC), 729
- context-sensitive help listing command arguments, 129–130 listing commands, 125–129 overview, 124–125
- Control field HDLC frames, 824 PPP frames, 833
- controller link aggregation (LAG), WLCs, 694
- controller port mirroring, WLCs, 694
- converged network, defined, 398
- convergence distance vector routing, 577 EIGRP, 612–613 hybrid routing, 582 link-state routing, 581 OSPF, 627 RIP, 587–588, 592–593 STP, 389, 398–401, 403, 405
- copy command, 349, 351–352
- copy running-config startup-config (copy run start) command function of, 115–116, 345–346, 548–549, 846 short forms of, 123
- copy running-config tftp command, 348, 551
- copy tftp running-config command, 551–552, 554
- core layer (backbone) (Cisco hierarchical model) defined, 391 high availability, 100–103 overview, 99–100, 103 routers best suited for, 517–518

- core layer (backbone)
    - (Cisco hierarchical model) (*continued*)
    - scalability, 106
    - specialization, 106
    - speed, 101–103
    - switches best suited for, 313
  - CoS (class of service), VoIP, 447, 449–452
  - cost metric
    - OSPF, 628, 639
    - overview, 576
  - Count and timestamp logging field, 471
  - Counter Mode with Cipher Block Chaining Message Authentication Code Protocol (CCMP) encryption algorithm, 96
  - “counting to infinity”, 590
  - coverage hole detection and correction, WLCs, 694
  - CPE (customer premises equipment), defined, 809
  - CPU (central processing unit) register, 321
  - C/R (Command/Response) bit, Frame Relay frames, 860–861
  - CRC. *See* cyclic redundancy check
  - CRC (Cyclic redundancy check) field, HDLC frames, 825
  - crossover cable
    - connecting routers, 817
    - full-duplex transmission, 66
    - overview, 80, 815
    - trunk ports, 428
    - VTP, 437
  - crosstalk
    - defined, 79
    - effect on full-duplex transmission, 66
  - crypto key generate rsa command
    - %Invalid input error, 357, 560
    - SSH encryption keys, 359
  - crypto map command, 799
  - crypto map, VPNs, 797–798
  - CSMA/CD (carrier sense multiple access collision detect) protocol
    - data link layer (TCP/IP), 37
    - Ethernet, 293
    - half-duplex transmission, 378
    - IEEE 802.11 standards, 658–659
    - IEEE 802.3 standards, 191
    - overview, 64–65, 194–195
  - CSU/DSU (channel service unit/data service unit)
    - connecting routers, 817
    - as example of DCE, 809, 826
  - Ctrl+Break key combination
    - disabling, 547
    - interrupting switch boot process with, 343–345, 361–362
    - overview, 113, 115
  - custom queuing, defined, 736
  - customer premises equipment (CPE), defined, 809
  - cut-through switching
    - mode, 376–377
  - CUWN. *See* Cisco Unified Wireless Networks Architecture
  - cyclic redundancy check (CRC)
    - Cisco ISL frame-tagging method, 421
    - data link layer, 196
    - overview, 78
    - WLANs, 659
  - Cyclic redundancy check (CRC) field, HDLC frames, 825
- 
- ## D
- dashboard view, Device Manager, 131–132, 458
  - data communications
    - equipment (DCE; data circuit terminating equipment)
      - connectors, 809–810
      - Frame Relay, 855–856, 865
      - keepalive frames, 825
      - LMIs, 860
      - overview, 808–809
      - serial interfaces, 810
      - X.25, 815
  - data encapsulation. *See* encapsulation
  - Data Encryption Standard (DES), 788, 789
  - Data field
    - data link frames, 76–78, 195
    - Frame Relay frames, 861
    - HDLC frames, 824
    - PPP frames, 833

- data frame. *See* frame (data frame)
- data integrity, VPNs, 786
- Data Link Connection
  - Identifier (DLCI) value, Frame Relay frames, 860–861
- data link layer (OSI reference model)
  - address resolution, 37
  - ARP and RARP, 196
  - broadcast IP addresses, 223
  - compared to network layer, 505
  - cyclic redundancy check, 196
  - encapsulation, 16, 180–182
  - Ethernet in, 75–78
  - frames, 195
  - function of, 506
  - information exchange
    - between layers, 175–177, 188
  - overview, 18–19, 36–37, 178–179, 193–194, 291–292
  - PDUs, 43–45
  - placement in stack, 174–176
  - segmenting with bridges, 197
  - TCP/IP protocols at, 37
- data segment. *See* segment
- data terminal equipment (DTE)
  - connectors, 809
  - Frame Relay, 855–856, 862, 865–866
  - keepalive frames, 825
  - LMIs, 860
  - overview, 808–809
  - X.25, 814
- data transfer state
  - PVCs, 857
  - SVCs, 857
- datagram. *See* access control list; packet (datagram); UDP
- data-link connection identifier (DLCI), 857–858
- DB9 serial-to-USB converter, 521
- DB-25 cabling and adapters, 816–817
- DCE. *See* data communications equipment
- DDoS (distributed denial of service) attack, 724
- DDR (Dial on Demand Routing)
  - callback, 845–846
  - show dialer command, 851
  - traffic control, 737
- DE (discard eligible), 861–862
- debug commands
  - disadvantage of, 828
  - function of, 497
  - PPP, 848–851
  - troubleshooting switch running configuration, 497–498
- debug dialer command, 851
- debug eigrp command, 620
- debug frame-relay events command, 876–877
- debug frame-relay lmi command, 877
- debug frame-relay packet command, 877
- debug ip nat command, 776, 779, 780
- debug ip nat detailed command, 779
- debug ip ospf command, 641
- debug ip rip command, 603
- debug ip rip database command, 603
- debug ip rip events command, 603
- debug ip rip trigger command, 603
- debug mode
  - EIGRP, 620
  - OSPF, 641
  - overview, 497
- debug ppp authentication command, 848–849, 851
- debug ppp chap command, 849
- debug ppp command, 851
- debug ppp compression command, 851
- debug ppp error command, 849–850, 851
- debug ppp multilink events command, 851
- debug ppp negotiation command, 850, 851
- debug ppp packet command, 850, 851
- debug ppp pap command, 851
- debug serial interface command, 828, 851

- decentralized network, defined, 168
- decimal system
  - compared to hexadecimal system, 55
  - notation, 56
  - overview, 50–51
- dedicated leased line
  - connection
  - advantages of, 86
  - compared to VPNs, 786
  - defined, 86, 811
  - disadvantages of, 86
  - protocols, 87
- deencapsulation, 189
- default route
  - defined, 219
  - overview, 570
- delay, 575
- deleting startup configuration
  - routers, 540, 550
  - switches, 325, 338, 347–348
- delimiting character (-), 337, 539
- Deliver Configuration to Router screen, SDM, 779
- demarc (demarcation point), defined, 809
- demilitarized zone (DMZ), 719–721
- demodulating, defined, 652
- denial of service (DoS) attack
  - Cisco IOS Firewall, 729
  - overview, 724
- deny any statement, 750
- deny ip any any command, 741
- deny statement, 750
- Department of Defense (DoD) model
  - compared to OSI and TCP/IP models, 207–208
  - layers of, 180
  - TCP/IP in, 179
- DES (Data Encryption Standard), 788, 789
- Description column
  - Port Settings Web form, Device Manager, 133
  - Port Status Web form, Device Manager, 136
- Description: field, CNA, 472–473
- designated port, 393, 395
- designated router (DR), OSPF
  - configuring, 636–638
  - loopback interfaces, creating, 633–634
  - OSPF priority, 638
  - overview, 629–630, 632–633
  - router ID, 633
  - selecting, 633
  - summarization, 631–632
- desktop layer. *See* access layer (Cisco hierarchical model)
- dest\_ip syntax, ip route command, 569
- destination IP address, defined, 750
- destination MAC address (D-MAC; D-M) field
  - broadcast transmission, 308
  - MAC address of Layer 2 switches, 374
  - MAC address table
  - thrashing, 306, 387
  - overview, 76–77
- destination mask, defined, 750
- destination service access point (DSAP)
  - LLC layer, 194
  - overview, 77
- Device column, CNA, 472–473
- Device Manager. *See* Cisco Device Manager
- Device Properties screen, CNA, 459–460
- DHCP (Dynamic Host Configuration Protocol)
  - access point discovery, 706
  - address
    - autoconfiguration, 272–273
    - application layer, 207
    - compared to DHCPv6, 274
    - function of, 26
    - NAT, 764
    - overview, 171–172
    - TCP/IP port, 33
    - Web authentication process, 708
    - WLCs, 694, 702
  - DHCP client, defined, 155
  - DHCP configuration form, SDM Express, 157
  - DHCP item, SDM Express, 155
  - dhcp pool command, 274
  - DHCPv6 (Dynamic Host Configuration Protocol version 6)
    - compared to DHCP, 274
    - stateful addressing assignment, 273–274
  - DHCP Proxy, WLCs, 694
  - Dial on Demand Routing. *See* DDR

- dialer callback-secure command, 846
- dialer callback-server command, 846
- dialer enable-timeout command, 846
- dialer group command, 846
- dialer map command, 846
- dialup modem, 87
- dictionary attack, 723
- Diffie-Hellman key exchange, 788
- Diffusing Update Algorithm. *See* DUAL
- DIFS (distributed interframe space), 659
- digital subscriber line access multiplexer (DSLAM), 818
- Digital Subscriber Line (DSL) connections, 817–819
- digital telephone lines, 87
- Dijkstra shortest path first (SPF) routing algorithm, 628–629
- dir all-filesystems command
  - displaying available IFS directories through, 465
  - function of, 350, 553
- dir command, 350–351, 465–466, 552–553
- direct broadcast, 223–225
- direct-sequence spread spectrum. *See* DSSS
- disable command, 118
- disabled port, defined, 400
- discard eligible (DE), 861–862
- Discard-Request frame, LCP, 836
- discontiguous network, defined, 615
- distance command, 589
- distance vector routing (rumor routing). *See also* BGP (Border Gateway Protocol); EIGRP (Enhanced Interior Gateway Routing Protocol); IGRP (Interior Gateway Routing Protocol); RIP (Routing Information Protocol)
  - convergence, 577
  - overview, 576
  - protocols, 199–200, 577
  - route updates, 577
  - routing loops, 577–580
- distribute list, defined, 736
- distributed denial of service (DDoS) attack, 724
- distributed interframe space (DIFS), 659
- distribute-list prefixlist command, 277
- distribution (workgroup) layer (Cisco hierarchical model)
  - overview, 103–104, 391
  - routers best suited for, 517–518
  - scalability, 106
  - specialization, 106
  - switches best suited for, 313
- Distribution System Port, WLCs, 693
- DLCI (Data Link Connection Identifier) value, Frame Relay frames, 860–861
- DLCI (data-link connection identifier), 857–858
- DM. *See* Cisco Device Manager (DM)
- D-M field. *See* destination MAC address (D-MAC; D-M) field
- D-MAC field. *See* destination MAC address (D-MAC; D-M) field
- DMZ (demilitarized zone), 719–721
- DNS (Domain Name System)
  - access point discovery, 706
  - application layer, 207
  - function of, 26
  - lookup queries, 723
  - overview, 171–172
  - purpose of, 7–8
  - TCP/IP port, 33
- dns-server command, 274
- do prefix, 119, 359
- DoD model. *See* Department of Defense (DoD) model
- domain name, defined, 207
- Domain Name System. *See* DNS (Domain Name System)
- domain-name command, 274
- DoS attack. *See* denial of service (DoS) attack
- dot1q encapsulation method (IEEE 802.1q frame-tagging standard), 422, 429, 447
- dotted-decimal notation, defined, 214–215

- DR. *See* designated router (DR), OSPF
- DRS (dynamic rate shifting), 659
- DSAP. *See* destination service access point (DSAP)
- DSL (Digital Subscriber Line) connections, 817–819
- DSLAM (digital subscriber line access multiplexer), 818
- DSSS (direct-sequence spread spectrum)
  - IEEE 802.11, 658
  - IEEE 802.11b, 660
  - overview, 656
- DTE. *See* data terminal equipment (DTE)
- DTP (Dynamic Trunking Protocol)
  - overview, 429–430
  - port operation modes, 430–431
  - setting switch port operation mode, 426, 429
- DUAL (Diffusing Update Algorithm)
  - EIGRP, 609, 610, 613–614
  - EIGRPv6, 277
- dual firewall, 720
- dual-stack protocols
  - migrating to IPv6, 280–281
  - NAT-PT, 284
- Duplex column
  - Port Settings Web form, Device Manager, 133
  - Port Status Web form, Device Manager, 136
- duplex command, 379
- duplex modes. *See also* full-duplex transmission; half-duplex transmission
  - best practice, 378
  - configuring, 378–379
  - full-duplex, 65–66, 378
  - half-duplex, 65, 378
  - port speed, 379
  - selecting port, 379
- dynamic auto port mode, DTP, 431
- dynamic channel
  - assignment, WLCs, 694
- dynamic desirable port mode, DTP, 431
- Dynamic Host Configuration Protocol. *See* DHCP (Dynamic Host Configuration Protocol)
- Dynamic Host Configuration Protocol version 6. *See* DHCPv6 (Dynamic Host Configuration Protocol version 6)
- Dynamic Interface, WLCs, 693
- dynamic map set reverse-route command, 798–799
- dynamic NAT
  - configuring, 772–775
  - operational flow, 768–769
  - overview, 765–766
- dynamic rate shifting (DRS), 659
- dynamic routes
  - advantages of, 571
  - configuring, 571
  - defined, 157
  - disadvantages of, 571
- IPv6, 275
  - overview, 198
- dynamic transmit power control, WLCs, 694
- Dynamic Trunking Protocol. *See* DTP (Dynamic Trunking Protocol)
- dynamic VLAN membership
  - overview, 420–421
  - VLAN trunking, 423

---

## E

- EA (Extended Address) marker, Frame Relay frames, 860–861
- Easy VPN Server Wizard, SDM, 799
- Echo-Reply frame, LCP, 836
- Echo-Request frame, LCP, 836
- ECL (emitter-coupled logic), defined, 810
- edge port, defined, 405
- EGP (Exterior Gateway Protocol). *See also* BGP (Border Gateway Protocol)
  - administrative distance, 589
  - IPv6, 275
- EIA-310-D data center rack
  - configuring routers, 529
  - configuring switches, 325
- EIA/TIA (Electronic Industries Alliance and the Telecommunications Industry Association), 79, 192–193
- EIA/TIA-232 connector, 810

- EIA/TIA-449 connector, 810
- EIA/TIA-530 connector, 810
- EIA/TIA-568-B cabling
  - standard, 79
- EIGRP (Enhanced Interior Gateway Routing Protocol)
  - administrative distance, 573, 589
  - benefits of, 608–609
  - characteristics of, 609
  - classful and classless routing, 614–615
  - components of, 610
  - configuring, 615–617
  - convergence, 612–613
  - DUAL, 613–614
  - IGRP, 608
  - maximum hop count, 578
  - metrics, 575–576
  - monitoring, 617–619
  - network layer, 199–200
  - next-hop routers, 612
  - overview, 607
  - packet types, 612
  - route updates, 613
  - routing tables, 610–611
  - split horizon, 592
  - troubleshooting, 620
- EIGRPv6 (Enhanced Interior Gateway Routing Protocol version 6), 277–278
- Electronic Industries Alliance and the Telecommunications Industry Association (EIA/TIA), 79, 192–193
- e-mail (electronic mail). *See also* SMTP (Simple Mail Transfer Protocol)
  - application layer, 27
  - defined, 6
  - IMAP, 174
  - Multipurpose Internet Mail Extensions (MIME) protocol, 27
  - POP3, 33, 173, 207
  - presentation layer, 27–28
- emitter-coupled logic (ECL), defined, 810
- enable (en) command, 118, 332, 350, 534, 552
- Enable column, Port Settings Web form, Device Manager, 133
- enable password my\_priv\_password command, 355–356, 558–559
- enable secret my\_priv\_encrypt\_password command, 355–357, 558–559
- enable-break option, 340
- Encapsulating Security Payload. *See* ESP (Encapsulating Security Payload)
- encapsulation
  - defined, 16
  - HDLC, 826
  - overview, 16, 41–45, 180–182, 189
  - PPP, 832, 843, 847
  - tunneling, 281
  - VPNs, 786–787
  - WANs, 811–815
- encapsulation frame-relay command, 870
- encapsulation frame-relay ietf command, 870
- encapsulation hdlc command, 826
- encrypted privileged mode password
  - configuring, 356, 559
  - routers, 531–532
  - switches, 329–330
- encryption. *See also* IPsec (Internet Protocol Security)
  - Cisco IOS image, 561
  - content, 728
  - password, 330, 532
  - router passwords, 559
  - SSH, 357, 559, 669
  - switch password, 356–357
  - VPNs, 786–787
  - WEP, 95, 667–668
  - WLANs, 667–670
- Enhanced Interior Gateway Routing Protocol. *See* EIGRP (Enhanced Interior Gateway Routing Protocol)
- Enhanced Interior Gateway Routing Protocol version 6 (EIGRPv6), 277–278
- enterprise-class router, 100
- erase startup-config command, 347–348, 461, 540, 550
- error detection
  - HDLC, 823
  - PPP, 827
  - transport layer, 18, 28
- error messages
  - CLI, 123
  - ICMPv6, 275
- ESP (Encapsulating Security Payload)
  - overview, 794
  - transport mode, 795
  - tunnel mode, 796
- ESS (extended service set), 684
- EtherChannel
  - bandwidth, increasing, 424
  - displaying data regarding, 467

EtherChannel (*continued*)  
 enabling, 409–410, 431–432  
 fault tolerance, 424  
 LACP, 408, 424  
 load balancing, 424  
 overview, 407–408, 423–424  
 PAgP, 408, 424  
 trunking, 425–427  
 versions of, 408, 424  
 Ethernet. *See also* 10  
     Gigabit Ethernet (10GigE); 10-Mbps Ethernet; Fast Ethernet; Gigabit Ethernet (GigE)  
 cabling standards, 191  
 CSMA/CD protocol, 64–65  
 duplex communication, 65–66  
 in OSI reference model, 75–80  
 overview, 63–64  
 wiring standards, 192–193  
 Ethernet\_II data-link frame standard, 76–78  
 ETSI (European Telecommunications Standards Institute), 650  
 EUI-64 (64-bit Extended Unique Identifier)  
     defined, 266  
     IPv6, configuring, 271  
     MAC-to-EUI64 conversion, 273  
 European Telecommunications Standards Institute (ETSI), 650  
 Event Description column, CNA, 472–473  
 Exception logging field, 471  
 EXEC process creation  
     banner, 337, 539

exit command, 334, 353, 355, 537, 556, 558  
 expansion module slot, 107  
 Explanation: field, CNA, 472–473  
 Express Setup menu, Device Manager, 133–134  
 Express Setup utility, Cisco switch, 326–331  
 Express Setup Web form  
     Device Manager, 133–134  
     IOS, 326–327  
 extended ACL  
     configuring, 755  
     creating, 747–749  
     naming, 748  
     overview, 726–727, 738–739  
     placing, 740, 748  
 Extended Address (EA)  
     marker, Frame Relay frames, 860–861  
 extended service set (ESS), 684  
 Exterior Gateway Protocol. *See also* BGP (Border Gateway Protocol)  
 external attack, 722

---

**F**

---

false synchronization  
     packet, 739  
 Fast Ethernet  
     100BASE-T, 191  
     implementing on LANs, 78  
     over fiber-optic cabling, 69–70  
     over twisted-pair cabling, 68–69  
     overview, 75  
     STP path cost, 393  
 fastethernet command, 123

fault tolerance,  
     EtherChannel, 408, 424  
 FCC (Federal Communications Commission), 649–650  
 FCS. *See* frame check sequence (FCS)  
 FCS field. *See* Frame check sequence (FCS) field  
 feasible successor route  
     EIGRP, 612, 614  
     topology table, 611, 618  
 FECN (forward explicit congestion notification), 861–862  
 Federal Communications Commission (FCC), 649–650  
 FHSS (frequency-hopping spread spectrum), 655–656, 658  
 fiber-optic cabling  
     10 Gigabit Ethernet, 73–75  
     Fast Ethernet, 69–70  
     Gigabit Ethernet, 71–73  
 File logging field, 471  
 File Management option, CNA, 143–144  
 file sharing, defined, 6  
 file transfer, defined, 6  
 File Transfer Protocol. *See* FTP (File Transfer Protocol)  
 filtering frames  
     action triggered by filter, 308  
     based on MAC address, 307  
     based on number of devices connected, 308  
     based on sticky MAC address, 308  
     defined, 305  
     overview, 301–304

- firewall
  - ASA, 709, 711
  - Cisco IOS Firewall, 728–730
  - configuring with Cisco SDM, 757–758
  - demilitarized zone, 719–721
  - distribution layer, 104
  - ICMP, 486–487
  - infrastructure mode
    - wireless networking, 680
  - IPsec, 790
  - SSL, 791
  - static routes, 568
  - VPNs, 669
- Firewall Configuration
  - Summary box, SDM, 758
- Firewall item, SDM Express, 155
- firewall router
  - ACLs, 736
  - overview, 719
- Flag field
  - Frame Relay frames, 860–861
  - HDLC frames, 825
  - PPP frames, 832
- flash: directory, 351, 465, 553
- flash keyword, 346, 549
- flash memory
  - booting from, 544
  - displaying contents of, 552–553
  - displaying free space available in, 461
  - inspecting contents with Cisco IFS, 464–466
  - logging system events and alerts to, 469, 471
  - purpose of, 114
  - router startup process, 525–526
  - switch startup process, 321–323
- flooded (limited)
  - broadcast, 223–225
- flooding frames
  - defined, 305
  - fragment-free switching mode, 377
  - overview, 300–301
  - store-and-forward switching mode, 376
- flow control
  - TCP/IP, 29–32
  - UDP, 32
- flush timer
  - default setting, 600
  - error mitigation, 591
- forward delay timer
  - convergence duration, 401
  - defined, 400
- forward explicit congestion notification (FECN), 861–862
- forwarding frames. *See also* forwarding port
  - defined, 305
  - fragment-free switching mode, 377
  - overview, 301
  - store-and-forward switching mode, 375
- forwarding port
  - assigning, 389, 400
  - transitioning edge ports to, 406–407
- forwarding table, 197
- fragment-free switching mode, 376–377
- frame (data frame)
  - data link layer, 19, 36, 76–78, 193, 195, 291–292, 506
  - encapsulation process, 44–45, 181–182
  - filtering, 301–305, 307–308
  - flooding, 300–301, 305, 376–377
  - forwarding, 301, 305, 375, 377
  - Frame Relay, 860–861
  - HDLC, 824–825
  - LANs, 369–370, 659
  - physical layer, 19, 506
  - remote networks, sending to, 370–375
  - SDUs, 189
  - STP, 386
  - tagging with VLAN ID, 421–422
  - WLANs, 659
- frame (message) collision.  
*See also* collision domain; CSMA/CD (carrier sense multiple access collision detect) protocol
  - defined, 8–9
  - Ethernet, 64–66
  - full-duplex transmission, 378
  - half-duplex transmission, 378
  - hub networks, 293
  - overview, 194–195
- frame check sequence (FCS)
  - cut-through switching mode, 376
  - fragment-free switching mode, 377

- frame check sequence
  - (FCS) (*continued*)
  - network access layer, 208
  - store-and-forward switching mode, 375
- Frame check sequence (FCS) field
  - data link frames, 78, 195
  - Frame Relay frames, 861
  - HDLC frames, 825
  - PPP frames, 833
- Frame Relay
  - flow and congestion control, 861–862
  - frame structure, 860–861
  - Inverse ARP, 862–863
  - link status control, 859–860
  - managing, 863–873
  - monitoring, 873–877
  - overview, 89, 812–813
  - purpose of, 855–856
  - reserving bandwidth, 858–859
  - troubleshooting, 873–877
  - virtual circuits, 856–858
- frame-relay interface dlci command, 870
- frame-relay lmi-type cisco command, 870
- frame-relay map command, 863, 873
- frequency
  - defined, 652
  - modulating, 653
- frequency-hopping spread spectrum (FHSS), 655–656, 658
- front-end firewall, 721
- FTP (File Transfer Protocol)
  - application layer, 206
  - function of, 26
  - overview, 171

- port for, 206
- TCP/IP port, 33

- ftp keyword, 347, 549
- full-duplex transmission
  - 10 Gigabit Ethernet, 73–74
  - defined, 191
  - Ethernet, 64
  - Fast Ethernet, 68–69
  - Gigabit Ethernet, 70–73
  - overview, 65–66, 378
  - setting switch transmission mode, 378
- full-mesh topology, 12, 864–865
- fully qualified domain name, defined, 207

---

## G

---

- G. *See* giga (G)
- gateway
  - defined, 16, 507–508
  - encapsulation process, 44
  - routing, 35
- gateway address, 214
- Generic Flow Control (GFC)
  - field, ATM, 813
- generic routing encapsulation (GRE), 282, 792
- giga (G)
  - binary system, 52–53
  - decimal system, 53
- Gigabit Ethernet (GigE)
  - 1000BASE-T, 191
  - implementing on LANs, 78
  - over fiber-optic cabling, 71–73
  - over twisted-pair cabling, 70–71
  - overview, 75
  - STP path cost, 393

- gigabytes, defined, 56
- GigE. *See* Gigabit Ethernet (GigE)
- G/L (Global/Local) bit, data link frames, 76
- global address
  - defined, 766–767
  - LMI, 859
- global configuration mode
  - boot command, 340–341
  - function of, 332–333
  - overview, 118–119
- global configuration prompt, 119
- global NAT addresses, 766–767
- Global/Local (G/L) bit, data link frames, 76
- GRE (generic routing encapsulation), 282, 792
- Group Authorization and Group Policy Lookup screen, SDM, 799–800
- Group Authorization and User Group Policies window, SDM, 800

---

## H

---

- half-duplex transmission
  - 10-Mbps Ethernet, 66–67
  - defined, 191
  - Fast Ethernet, 68–69
  - overview, 65, 378
  - setting switch transmission mode, 379
- handler, 724
- hardware
  - best practices for, 114
  - defined, 111
  - differentiating, 114

- hardware (MAC) broadcast, defined, 223
- Hash Message Authentication Code (HMAC), 788–789
- HCC (horizontal cross-connect), 79
- HDLC (High-Level Data Link Control)
  - authentication, 843
  - configuring, 826
  - frames, 824–825
  - links, 823–824
  - monitoring, 827–828
  - overview, 812
  - SLARP, 825
- header
  - ATM, 813
  - Cisco ISL frame-tagging method, 421
  - encapsulation process, 181–182
  - information exchange between layers, 189
  - MAC layer, 194
- Header Error Control (HEC) field, ATM, 814
- hello packets
  - EIGRP, 609–610, 612–613
  - hybrid routing, 582
  - link-state routing, 581
  - OSPF, 626–627
- hello timer
  - defined, 619
  - EIGRP, 613
  - OSPF, 627
- help (?) command
  - function of, 124–127, 129–130, 347
  - switch: boot prompt, 345, 362
- helper option, 340
- helper-config-file option, 340
- hexadecimal system. *See also* colon hexadecimal notation
  - bits, 56–57
  - bytes, 56–57
  - compared to binary and decimal systems, 55
  - configuration register, 545
  - converting binary to, 57–58
  - converting to binary, 58, 250
  - nibbles, 56–57
  - notation, 56
  - overview, 53–55
- hierarchical logical (IP) addressing, 34–36, 506–507, 512
- high availability, defined, 7
- High-Level Data Link Control. *See* HDLC (High-Level Data Link Control)
- high-modal-bandwidth fiber-optic cabling, 72
- high-order bits, defined, 215
- High-Speed Serial Interface (HSSI), 810
- HMAC (Hash Message Authentication Code), 788–789
- hold-down timer
  - default setting, 600
  - distance vector routing, 580
  - error mitigation, 591
  - preventing reactivation of failed links, 593
- holdtime parameter, cdp run command, 492
- Home screen, SDM, 149–150
- hop count
  - defined, 36, 198
  - distance vector routing, 578
  - EIGRP, 608
  - overview, 574
  - RIP, 590
- horizontal cross-connect (HCC), 79
- host address
  - IPv6, 266
  - overview, 214–215
  - subnetting, 241–243
- host configuration file, 542
- host device (computer host device)
  - backing up and recovering router configuration, 551–552
  - backing up and recovering switch running configuration, 348–349
- CSMA/CD, 64
  - defined, 5–6
  - effect on size of collision domain, 78
  - hub networks, 293
  - IP addresses, 35, 507
  - MAC addresses, 75
- host ID
  - defined, 220
  - overview, 220–221
  - subnetting, 231, 233, 235, 236
- host keyword
  - ACLs, 746, 748
  - function of, 750
- host name, defined, 207
- Host Unreachable message, 737

hostname command, 331, 533

hosts file, 8

host-to-host transport layer (TCP/IP), 208

HSSI (High-Speed Serial Interface), 810

HTTP (Hypertext Transfer Protocol)

- application layer, 16, 206
- function of, 26
- overview, 170
- port for, 206
- TCP/IP port, 33
- Web authentication process, 708

HTTPS (Hypertext Transfer Protocol Secure)

- TCP/IP port, 33
- WLAN security, 669–670

hub

- compared to bridges, 294
- compared to switches, 665–666
- defined, 9
- LANs, 63
- purpose of, 7, 293–294

hybrid routing. *See also* EIGRP (Enhanced Interior Gateway Routing Protocol)

- convergence, 582
- protocols, 582
- route updates, 582

HyperTerminal terminal emulation application, 80

Hypertext Transfer Protocol. *See* HTTP (Hypertext Transfer Protocol)

Hypertext Transfer Protocol Secure. *See* HTTPS (Hypertext Transfer Protocol Secure)

## I

---

IANA (Internet Assigned Numbers Authority)

- ASNs, 589
- function of, 214
- IPv6 address assignment, 266
- port definitions, 33

ICANN (Internet Corporation for Assigned Names and Numbers), 214, 266

ICC (intermediate cross-connect), 79

ICMP (Internet Control Message Protocol)

- ACLs, 727, 737
- gathering network information, 486–490
- network layer, 34, 202
- overview, 173
- Ping of Death, 724

ICMPv6 (Internet Control Message Protocol version 6), 275

icons used in book, 2

ID. *See* interface identifier (ID)

idle state

- PVCs, 857
- SVCs, 857

IDS. *See* intrusion detection system (IDS)

IEEE (Institute of Electrical and Engineers)

- LAN technology standards, 191
- wireless standards, 649

IEEE 802.1d standard, 386. *See also* STP (Spanning Tree Protocol)

IEEE 802.1p standard. *See* CoS (class of service), VoIP

IEEE 802.1q frame-tagging standard (dot1q encapsulation method), 422, 429, 447

IEEE 802.1w standard, 405. *See also* RSTP (Rapid Spanning Tree Protocol)

IEEE 802.3 standards. *See also* EtherChannel; LACP (Link Aggregation Control Protocol)

- 802.3ab, 70–71, 75, 191
- 802.3ad, 408
- 802.3an, 75
- 802.3u, 68, 69, 70, 75
- 802.3y, 68
- 802.3z, 71–73, 75

cabling standards, 191

overview, 63, 74–75

IEEE 802.11 standards

- 2.4-GHz band, 657–661
- 5-GHz band, 660–661
- 802.11a, 655–656, 660
- 802.11b, 654, 659–660
- 802.11g, 654, 656, 660
- 802.11i, 96
- 802.11n, 654–657, 660–661

configuring for WLANs, 703

- overview, 657–659
- wireless bands, 649
- IETF (Internet Engineering Task Force), 262
- IFS. *See* Cisco IOS File System (IFS)
- I/G (Individual/Group) bit, data link frames, 76
- IGPs (interior gateway protocols), 275. *See also* OSPF (Open Shortest Path First); RIP (Routing Information Protocol)
- IGRP (Interior Gateway Routing Protocol)
  - administrative distance, 589
  - EIGRP, 608
  - limitations of, 608
  - network layer, 199–200
  - split horizon, 592
- IKE. *See* Internet Key Exchange (IKE)
- IKE Proposals screen, SDM, 799
- IMAP (Internet Message Access Protocol), 174
- implicit deny statement, ACLs, 726
- inbound ACL
  - multiple, 741
  - overview, 739
- inbound mapping, NAT, 764
- ! include boot suffix, 543
- incoming terminal
  - connection banner, 336, 538
- %Incomplete command error message, 123
- independence of layer functionality, 41, 43
- Individual/Group (I/G) bit, data link frames, 76
- Industrial, Scientific, Medical (ISM) radio bands, 650
- informational messages, ICMPv6, 275
- InfraRed, 658
- infrastructure mode
  - defined, 675
  - WLANs, 679–688
- inherent (channel) attenuation, defined, 79
- initial configuration dialog, IOS
  - function of, 324
  - routers, 527, 530–533
  - switches, 326–331
- Initial Sequence Number (ISN), 725
- initialization vector (IV)
  - WEP, 667
  - WPA, 668
- inside global address
  - defined, 766
  - NAT operational flow, 767
- inside local address
  - defined, 766
  - NAT operational flow, 767
- Institute of Electrical and Electronics Engineers. *See* IEEE (Institute of Electrical and Electronics Engineers)
- int loopback command, 634
- Integrated Services Digital Network. *See* ISDN (Integrated Services Digital Network)
- Integrated Services Router (ISR), 709
- interface <fastethernet 0/0> (int <fa 0/0>) command, 307
- interface <interface#> (int <interface#>) command, 307, 379
- interface command
  - function of, 120, 333
  - short forms of, 122
- interface configuration mode, 332–333
- interface fastethernet0/0 command, 534
- interface identifier (ID) address
  - autoconfiguration, 273
  - defined, 263
  - IPv6, 266
- interface port-channel 1 command, 409, 431
- interface port-channel command, 409, 425–426, 431
- interface range command, 333, 426, 535
- interface range configuration mode, 333
- interface range fastethernet 0/3 - 4 command, 409, 432
- Interface Selection screen, SDM, 800
- interface vlan1 command, 332
- interior gateway protocols (IGPs), 275. *See also* OSPF (Open Shortest Path First); RIP (Routing Information Protocol)

- Interior Gateway Routing Protocol. *See* IGRP (Interior Gateway Routing Protocol)
- intermediate cross-connect (ICC), 79
- Intermediate System-to-Intermediate System. *See* IS-IS (Intermediate System-to-Intermediate System)
- internal attack, 722
- internal connection, Cisco IP phone, 447–448
- internal log buffer
  - displaying size of, 471
  - logging system events and alerts to, 469, 471
- internal router, 719
- International Organization for Standardization. *See* ISO (International Organization for Standardization)
- International Telecommunication Union, Radiocommunication Sector (ITU-R), 650
- International Telecommunication Union, Telecommunication Standardization Sector (ITU-T), 814
- International Telecommunications Union (ITU), 860
- Internet Assigned Numbers Authority. *See* IANA (Internet Assigned Numbers Authority)
- Internet Connection Sharing, Windows, 679
- Internet Control Message Protocol. *See* ICMP (Internet Control Message Protocol)
- Internet Control Message Protocol version 6 (ICMPv6), 275
- Internet Corporation for Assigned Names and Numbers (ICANN), 214, 266
- Internet Engineering Task Force (IETF), 262
- Internet Key Exchange (IKE)
  - best practices for, 790
  - overview, 794
- Internet layer (DoD model), 179–180
- Internet layer (TCP/IP), 208
- Internet Message Access Protocol (IMAP), 174
- Internet Protocol. *See* IP (Internet Protocol); IP (logical) address; TCP/IP (Transmission Control Protocol/Internet Protocol)
- Internet Protocol Security. *See* IPsec (Internet Protocol Security)
- Internet Protocol version 4. *See* IPv4 (Internet Protocol version 4); NAT (Network Address Translation)
- Internet Protocol version 6. *See* IPv6 (Internet Protocol version 6); NAT (Network Address Translation)
- Internet Security Association and Key Management Protocol (ISAKMP), 796
- Internet service provider (ISP), 214
- Internet Small Computer Systems Interface. *See* iSCSI (Internet Small Computer Systems Interface)
- Internet Stream Protocol, 262
- Internetwork Operating System. *See* Cisco Internetwork Operating System (IOS)
- Internetwork Packet Exchange (IPX). *See* IPX (Novell Netware Internetwork Packet Exchange)
- interrupting switch boot process
  - with Ctrl+Break, 343–345, 361–362
  - by enabling manual boot option, 342–343, 361
  - with Mode button, 342–345, 361
  - overview, 341–342
- inter-VLAN routing
  - advantages of, 418
  - network switch, 440–441
  - one large router with one port per VLAN, 439–440
  - one router per VLAN, 438–439
  - one subinterface per VLAN, 440
  - overview, 417, 438–439

- Intra-Site Automatic Tunnel Addressing Protocol (ISATAP), 283
- intrusion detection system (IDS)
  - Cisco IOS Firewall, 729
  - defined, 730
  - WLAN security, 671
  - WLCs, 694
- intrusion prevention system (IPS)
  - defined, 730
  - WLAN security, 671
  - WLCs, 694
- %Invalid input error message, 123, 357, 560
- invalid timer, 600
- Inventory menu, CNA, 141–142
- Inverse ARP (Inverse Address Resolution Protocol), 862–863
- inverse subnet mask. *See* wildcard (inverse subnet) mask
- IOS. *See* Cisco Internetwork Operating System (IOS)
- IOS File System. *See* Cisco IOS File System (IFS)
- IP (Internet Protocol). *See also* IP (logical) address; TCP/IP (Transmission Control Protocol/Internet Protocol)
  - EIGRP, 609
  - network layer, 34, 202, 506
  - overview, 169
  - packet header, 170
  - transport layer, 29
- IP (logical) address. *See also* ARP (Address Resolution Protocol); CIDR (classless interdomain routing); DNS (Domain Name System); NAT (Network Address Translation); RARP (Reverse Address Resolution Protocol); subnet mask ACLs, 726–727
  - broadcast, 223–225
  - configuring default routes, 570
  - configuring for routers, 534–535
  - configuring for switches, 332–333
  - defined, 18
  - disabling validation, 601
  - format of, 197
  - function of, 213, 226
  - hierarchy of, 34–36, 214–221
  - IPv6, 263, 264–273
  - logging system events and alerts to more than one Syslog server, 469
  - network layer, 33–34, 198, 505–506
  - optimizing with VLSMs, 253
  - private, 222
  - purpose of, 7–8, 213–214
  - remote router connections, 522–523
  - wildcards, 635–636, 743–744
- IP access control list (ACL). *See* access control list (ACL)
- ip access-group command
  - editing ACLs, 742
  - function of, 746, 749, 752
- ip access-list command, 751–752
- IP ACL. *See* access control list (ACL)
- ip address command, 332, 534
- IP Address field
  - RIPv1, 595
  - RIPv2, 596
- IP Addresses screen, CNA, 481–482
- IP Cisco IOS image, 561
- ip default-gateway command, 332, 534–535
- ip domain-name silange.com command, 358
- IP header manipulation, 724
- IP masquerading, 727–728
- ip nat allow-static-host command, 780
- ip nat create command, 780
- ip nat enable command, 780
- ip nat inside command, 772, 773, 780
- ip nat inside source static command, 771
- ip nat log command, 780
- ip nat outside command, 773, 780
- ip nat outside source static command, 771
- ip nat piggyback-support command, 780
- ip nat pool command, 772–773, 780
- ip nat portmap command, 780

- ip nat service command, 780
- ip nat sip-sbc command, 780
- ip nat source command, 780
- ip nat stateful id command, 780
- ip nat syslog command, 780
- ip nat translation command, 780
- ip nat translation tcp-timeout command, 773
- ip nat translation timeout command, 773
- ip nat translation udp-timeout command, 773
- ip nat translations command, 780
- ip ospf cost value command, 639
- ip ospf priority value command, 633, 638
- IP packet sniffing (man-in-middle attack), 679, 725
- ip rip receive version command, 600
- ip rip send version command, 600
- ip route command, 569–570, 774
- ip split horizon command, 867
- IP spoofing, 724–725
- ip ssh authentication-retries 2 command, 359
- ip ssh time-out 60 command, 359
- ip subnet-zero command line syntax, 241
- IP-EIGRP, 610
- IP/IPX/APPLETALK Cisco IOS image, 560
- IPng (“Next Generation Internet Protocol”), 262
- IPS. *See* intrusion prevention system (IPS)
- IPsec (Internet Protocol Security)
  - best practices for, 790
  - IPv4 versus IPv6, 263
  - network layer, 34
  - overview, 173
  - RIPng, 597
  - VPNs, 787–790, 793–801
- IPv4 (Internet Protocol version 4). *See also* NAT (Network Address Translation)
  - compared to IPv6, 262–263
  - migrating to IPv6, 279–285
  - number of allowable IP addresses, 214
- IPv4-compatible IPv6 address, 283
- IPv4-mapped IPv6 address, 283
- IPv6 (Internet Protocol version 6). *See also* NAT (Network Address Translation)
  - addresses, 264–270
  - benefits of, 263–264
  - configuring, 270–275
  - migrating to, 279–285
  - overview, 261–262
  - routing with, 275–279
- ipv6 enable command, 271
- IPv6 prefix field, RIPng, 598
- ipv6 route command, 276
- ipv6 unicast-routing command, 270
- IPX (Novell Netware Internetwork Packet Exchange)
  - EIGRP, 609
  - network layer, 202
- IRC, 33
- ISAKMP (Internet Security Association and Key Management Protocol), 796
- isakmp policy command, 797
- ISATAP (Intra-Site Automatic Tunnel Addressing Protocol), 283
- iSCSI (Internet Small Computer Systems Interface)
  - application layer, 207
  - session layer, 28
- ISDN (Integrated Services Digital Network)
  - circuit-switched connections, 87
  - Dial on Demand Routing, 845–846
  - LREs, 819
  - UTP cabling, 816
- ISDN Dial on Demand Routing. *See* DDR (Dial on Demand Routing)
- IS-IS (Intermediate System-to-Intermediate System)
  - administrative distance, 589
  - network layer, 199–200
  - OSPF, 625
- ISM (Industrial, Scientific, Medical) radio bands, 650

ISN (Initial Sequence Number), 725  
 ISO (International Organization for Standardization)  
 HDLC, 823  
 OSI reference model, 174  
 ISP (Internet service provider), 214  
 ISR (Integrated Services Router), 709  
 ITU (International Telecommunications Union), 860  
 ITU-R (International Telecommunication Union, Radiocommunication Sector), 650  
 ITU-T (International Telecommunication Union, Telecommunication Standardization Sector), 814  
 IV. *See* initialization vector (IV)

---

## J

jitter reduction, 813

---

## K

K. *See* kilo (K)  
 keepalive message, SLARP, 825  
 keepalive value, LMI, 859  
 key (certificate), IPsec, 788, 790  
 keylogger, 723

kilo (K)  
 binary system, 52–53  
 decimal system, 53

---

## L

L (Length) field, data link frames, 76–77  
 L2F (Layer 2 Forwarding), 792  
 L2TP (Layer 2 Tunneling Protocol), 792  
 LACNIC (Latin American and Caribbean Internet Addresses Registry), 266  
 LACP (Link Aggregation Control Protocol)  
 overview, 408, 424  
 selecting, 409–410, 432  
 LAG (controller link aggregation), WLCs, 694  
 LAN (local-area network). *See also* VLAN (virtual local-area network); WLAN (wireless local-area network)  
 defined, 807  
 Ethernet, 63–80  
 first-generation, 292–293  
 NAT, 727–728  
 overview, 63  
 sending frames within, 369–371, 374  
 setting up and verifying for WLAN connection, 701, 703  
 STP priority, 392  
 zoning, 718–722  
 LAN configuration form, SDM Express, 156

LAN item, SDM Express, 155  
 LAN LITE package, 358  
 LAN LITE W/O Crypto package, 358  
 LAN LITE W/O CRYPTO with Web-Based DEV MGR package, 358  
 latency, inter-VLAN routing, 439–440  
 Latin American and Caribbean Internet Addresses Registry (LACNIC), 266  
 Launch Telnet Console link, Device Manager, 137  
 Layer 1. *See* network access layer (TCP/IP); physical layer (OSI reference model)  
 Layer 2. *See* data link layer (OSI reference model); Internet layer (TCP/IP)  
 Layer 2 Forwarding (L2F), 792  
 Layer 2 switch. *See* switch  
 Layer 2 Tunneling Protocol (L2TP), 792  
 Layer 3. *See* host-to-host transport layer (TCP/IP); network (routing) layer (OSI reference model)  
 Layer 3 (network) switch. *See* switch  
 Layer 3 router. *See* router  
 Layer 3 Trace Route screen, CNA, 485–486  
 Layer 4. *See* application layer (TCP/IP); transport layer (OSI reference model)

- Layer 5. *See* session layer (OSI reference model)
- Layer 6. *See* presentation (syntax) layer (OSI reference model)
- Layer 7. *See* application layer (OSI reference model)
- LCP (Link Control Protocol)
  - options, 837–838
  - overview, 836
  - PPP, 812, 833, 834–836
  - purpose of, 837
- learning port, defined, 400
- LED, access point, 706–707
- Length (L) field, data link frames, 76–77
- Length or Type field, data link frames, 195
- licensed radio bands, 649–650
- Lightweight Access Point Protocol. *See* LWAPP (Lightweight Access Point Protocol)
- lightweight access points (LWAP), 705–706
- lightweight mode, WLANs, 681–683
- limited (flooded) broadcast, 223–225
- line ? command, 130
- line <first\_arg> ? command, 130
- line command, 121
- line configuration mode, 127–128, 129
- line console 0 command, 334, 353, 355, 536, 556, 558
- line vty 0 ? command, 335, 354, 537, 556
- line vty 0-15 command, 335, 354, 359–360
- line vty 0-4 command, 537–538
- link aggregation, 407, 423. *See also* EtherChannel; trunking; VLAN (virtual local-area network)
- Link Aggregation Control Protocol. *See* LACP (Link Aggregation Control Protocol)
- link authentication phase, PPP, 835
- link configuration frames, LCP, 836
- Link Control Protocol. *See* LCP (Link Control Protocol)
- link dead phase, PPP, 834
- link establishment phase, PPP, 834
- link maintenance frames, LCP, 836
- link negotiator, 837. *See also* LCP (Link Control Protocol)
- Link Network Layer Protocol phase. *See* NLP (Link Network Layer Protocol) phase
- link quality determination phase, PPP, 835
- link quality monitoring (LQM), PPP, 848
- link termination frames, LCP, 836
- link termination phase, PPP, 835
- link-local address
  - address
    - autoconfiguration, 273
    - IPv6, 269–271
- link-state advertisement (LSA)
  - OSPF, 626–627, 630, 632, 634
  - OSPFv3, 279
- link-state routing. *See also* IS-IS (Intermediate System-to-Intermediate System); OSPF (Open Shortest Path First); RIP (Routing Information Protocol)
  - convergence, 581
  - overview, 580–581
  - protocols, 582
  - route updates, 581
- link-state table
  - EIGRP, 613
  - OSPF, 626–627
- LIR (Local Internet Registry), 214
- listening port, defined, 400
- LLC (Logical Link Control) header, 77
- LLC (Logical Link Control) layer, 179, 193–194
- LMI (Local Management Interface)
  - configuring interfaces for Frame Relay, 868–870
  - defined, 859
  - link status control using, 859–860
- load, 575–576

- load balancing
    - EtherChannel, 408, 424
    - WLCs, 694
  - local address, defined, 766–767
  - local connection
    - routers, 519–522
    - switches, 315–318
  - Local Internet Registry (LIR), 214
  - Local Management Interface. *See* LMI (Local Management Interface)
  - local-area network. *See* LAN (local-area network); WLAN (wireless local-area network)
  - Log buffer field, 471
  - log keyword, 756–757
  - logging [<IP address>]
    - command, 469
  - logging buffer, 756
  - logging buffered [<level>]
    - command, 469
  - logging command, 468–469
  - logging console [<level>]
    - command, 469
  - logging console command, 756–757
  - logging file
    - [flash:<filename>]
      - command, 469
  - logging level
    - defined, 469
    - description of, 470, 756
  - logging monitor [<level>]
    - command, 469
  - logging on command, 468
  - logging trap [<level>]
    - command, 469
  - logical address. *See* ARP (Address Resolution Protocol); CIDR (classless interdomain routing); DNS (Domain Name System); IP (logical) address; NAT (Network Address Translation); RARP (Reverse Address Resolution Protocol); subnet mask
  - logical communication channels (sessions), 17
  - Logical Link Control (LLC)
    - header, 77
  - Logical Link Control (LLC)
    - layer, 179, 193–194
  - login, Device Manager, 131
  - login banner, 336, 538
  - login command, 124, 333–334, 352–355, 535–536, 538, 555, 557
  - login local command, 359
  - login page, Web
    - authentication, 709–710
  - login tacacs command, 359
  - login Web form, CNA, 140
  - logs
    - ACL, 750, 756–757
    - switch, 467–473, 496
    - traffic, 764
  - Long Range Ethernet (LRE), 819
  - long-wavelength fiber-optic cabling
    - Fast Ethernet, 69–70
    - Gigabit Ethernet, 71
  - loopback address
    - defined, 219
    - IPv6, 269–270
    - zero compression, 267
  - loopback interfaces,
    - creating, 633–634
  - loops. *See* routing loops
  - low-modal-bandwidth fiber-optic cabling, 72
  - LQM (link quality monitoring), PPP, 848
  - LRE (Long Range Ethernet), 819
  - LSA. *See* link-state advertisement (LSA)
  - LWAP (lightweight access points), 705–706
  - LWAPP (Lightweight Access Point Protocol)
    - access point discovery, 705–706
    - lightweight mode wireless networking, 681–682
    - overview, 695–696
    - WLCs, 702
- 
- ## M
- M. *See* mega (M)
  - MAC (hardware) broadcast,
    - defined, 223
  - MAC (Media Access Control) layer, 179, 193–194
  - MAC (Media Access Control; physical)
    - address. *See also* ARP (Address Resolution Protocol)
    - data link layer, 36–37, 75–76, 291–292
    - electing root bridge, 389
    - filtering, 96
    - filtering based on, 307
    - format of, 197

- MAC (Media Access Control; physical)
  - (*continued*)
  - function of, 226, 291
  - learning, 296–300
  - MAC-to-EUI64 conversion, 273
  - network layer, 197–198
  - purpose of, 7–8
  - sending frames to remote networks, 370–375
  - sending frames within LAN, 369–370
  - sticky, 308
  - switches, 296–303
  - VLANs, 416
  - VMPS, 420–421
- MAC address filtering, 96, 670, 694
- MAC address table
  - displaying data regarding, 467
  - Layer 2 switches, 297–303
- MAC address table thrashing
  - cause of, 380
  - defined, 306, 388
  - example of, 305, 387
- MAC-to-EUI64 conversion, 273
- Magic-Number option, LCP, 838
- main cross-connect (MCC), 79
- main distribution frame (MDF), defined, 818
- Maintenance menu, CNA, 143–144
- MAN (metropolitan-area network)
  - defined, 807
  - relation to WANs, 85
  - wireless, 648
- management access, WLAN security, 672
- Management Interface, WLCs, 693
- man-in-middle attack (IP packet sniffing), 679, 725
- manual boot option (boot manual command), 342–343, 361
- manual option, 340
- manual tunneling, 282–283
- MAP (Mesh Access Point), 697
- map-class dialer command, 846
- max age timer
  - convergence duration, 401
  - defined, 400
  - overview, 405–406
- maximum transmission unit (MTU), 78, 576
- Maximum-Receive-Unit (MRU), LCP, 838
- MCC (main cross-connect), 79
- MD5 (message digest algorithm 5)
  - CHAP, 840–841
  - IPsec, 789
  - RIPv2, 595
- MDF (main distribution frame), defined, 818
- Media Access Control (MAC) address. *See* MAC (Media Access Control; physical) address
- Media Access Control (MAC) layer, 179, 193–194
- mega (M)
  - binary system, 52–53
  - decimal system, 53
- megabytes, defined, 56
- merge mode, PACLs, 754–755
- Mesh Access Point (MAP), 697
- mesh topology
  - defined, 12
  - figure of, 12
  - Frame Relay, 864
- message collision. *See* collision domain; CSMA/CD (carrier sense multiple access collision detect) protocol; frame (message) collision
- message digest algorithm 5. *See* MD5 (message digest algorithm 5)
- message of the day banner. *See* MOTD (message of the day) banner
- Metric field
  - RIPng, 598
  - RIPv1, 595
  - RIPv2, 596–597
- metrics. *See also* hop count; reliability
  - bandwidth, 575
  - cost, 576, 628, 639
  - delay, 575
  - EIGRP, 609, 613
  - IGRP, 608
  - load, 575–576
  - MTU, 78, 576
  - offsets, 599
  - routing protocol, 572–573, 574–576
  - routing tables, 513

- metropolitan-area network. *See* MAN (metropolitan-area network)
- MIME (Multipurpose Internet Mail Extensions), 27
- MIMO (multiple-in, multiple-out), 656–657, 661
- MLD (Multicast Listener Discovery) Protocol, 275
- mls command, 451
- MMF optic cabling. *See* multimode fiber-optic cabling (MMF optic cabling)
- Mode button, Cisco switch interrupting switch boot process with, 342–345, 361
- resetting switches, 338
- modulating, defined, 652
- modulus number, number of bits in, 359
- Monitor button, SDM, 150–151
- Monitor logging field, 471
- Monitor menu, CNA, 141–142
- MOTD (message of the day) banner
- configuring, 337, 539
  - defined, 336, 538
- MRU (Maximum-Receive-Unit), LCP, 838
- MTU (maximum transmission unit), 78, 576
- Multicast Listener Discovery (MLD) Protocol, 275
- multicast transmission
- compared to broadcasting, 223
  - defined, 309
  - EIGRP, 612
  - IPv4 versus IPv6, 263
  - IPv6 addresses, 269, 270
  - LMI, 859
  - overview, 308–311
- multilinking
- LCP, 838
  - PPP, 833
- multimode fiber-optic cabling (MMF optic cabling)
- 10 Gigabit Ethernet, 73–74
  - Fast Ethernet, 69–70, 75
  - Gigabit Ethernet, 71–73, 75
- multiple access, defined, 658
- multiple-in, multiple-out (MIMO), 656–657, 661
- multiplexing
- defined, 203
  - port, 765, 769
- multipoint topology
- Frame Relay, 868, 870–873
  - HDLC, 824
- Multipurpose Internet Mail Extensions (MIME), 27
- multitasking, RIPv2, 595

---

## N

---

- NACL (named access control list) mode, 751
- name resolution, 207. *See also* DNS (Domain Name System)
- name server. *See* DNS (Domain Name System)

- named access control list (NACL) mode, 751
- named ACL
- configuring, 755
  - creating, 751–753
  - overview, 739
- nameif command, 797
- naming
- routers, 533–534
  - switches, 331
- NAT (Network Address Translation)
- commands, 780
  - configuring, 770–776
  - distribution layer, 104
  - local and global addresses, 766–767
  - managing, 776–780
  - migrating to IPv6, 283–285
  - operational flow of, 767–770
  - overview, 727–728
  - private IP addressing, 222
  - purpose of, 763–767
  - SSL, 791
  - traffic control, 737
  - types of, 764–766
- NAT configuration
- summary screen, SDM, 779
- NAT Configuration Wizard, SDM, 779
- NAT item, SDM Express, 157
- NAT overload. *See* PAT (Port Address Translation; overloading)
- NAT-PT (Network Address Translation–Protocol Translation), 283–285
- NBAR (Network-Based Application Recognition), 801

- NBMA (nonbroadcast multiple access), 867
- NCP (Network Control Protocol)
  - overview, 838–839
  - PPP, 812, 833
- NDP (Neighbor Discovery Protocol)
  - address auto-configuration, 273
  - ICMPv6, 275
  - neighbor discovery/recovery, EIGRP, 610
  - neighbor solicitation message, 273
  - neighbor table
    - EIGRP, 611, 613
    - OSPF, 626–627
  - nesting PDUs, 43
  - netmask parameter, ip nat pool command, 773
  - network (Layer 3) switch. *See* switch
  - network (routing) layer (OSI reference model)
    - broadcast IP addresses, 223–225
    - compared to data link layer, 505
    - distance vector and link-state routing protocols, 198–202
    - encapsulation process, 16, 180–182
    - hierarchical IP addresses, 34–36
    - information exchange between layers, 175–177, 188
    - overview, 18, 33, 178, 197–198, 505–508
    - placement in stack, 174–176
    - routing versus routed protocols, 198
    - TCP/IP protocols at, 34
  - network access layer (DoD model), 179–180
  - network access layer (TCP/IP), 208
  - network address
    - IPv6, 266
    - overview, 214–215
  - Network Address Translation. *See* NAT (Network Address Translation)
  - Network Address Translation–Protocol Translation (NAT-PT), 283–285
  - network command
    - function of, 598
    - wildcards, 635–636
  - network configuration file, 542
  - Network Control Protocol. *See* NCP (Network Control Protocol)
  - network devices
    - defined, 5–6
    - physical addresses, 75
    - Network File System. *See* NFS (Network File System)
  - network ID
    - defined, 220
    - overview, 220–221
    - subnetting, 236
  - network int\_IP command, 616
  - network int\_IP wildcard\_mask area area\_id command, 635
  - network interface card. *See* NIC (network interface card)
  - network layer protocols. *See* NLPs (network layer protocols)
  - network routes. *See also* router
    - default, 570
    - defined, 567
    - dynamic, 571
    - overview, 567–568
    - static, 568–570
  - Network Service Provider (NSP), 818
  - Network Stumbler, 670–671
  - Network Time Protocol. *See* NTP (Network Time Protocol)
  - network zoning, 718–722
  - Network-Based Application Recognition (NBAR), 801
  - networks. *See also names of specific types of networks*
    - applications using, 6–7
    - Cisco hierarchical design model, 99–107
    - operation flow of, 7–10
    - purpose of, 5–7
    - “Next Generation Internet Protocol” (IPng), 262
    - Next Hop field, RIPv2, 595, 597
    - {next-hop | interface} syntax, ip route command, 569

- next-hop router
  - EIGRP, 612, 619
  - OSPF, 640
- NFS (Network File System)
  - application layer, 206
  - function of, 26
  - overview, 173
- nibble
  - configuration register, 545
  - defined, 56–57
- NIC (network interface card)
  - 10BASE2, 67
  - MAC address filtering, 306
  - physical addresses, 75
  - WEP, 95
  - WPA, 96
- NLP (Link Network Layer Protocol) phase
  - NCP, 838
  - PPP, 835
- NLPs (network layer protocols)
  - NCP, 839
  - PPP, 835
- NNI interface, ATM, 813
- no access-list command, 741
- no auto-summary
  - command, 614–615
- no boot enable-break
  - command, 344, 362
- no boot manual option, 361
- no cdp enable command, 492
- no debug eigrp command, 620
- no debug ip ospf command, 641
- no encapsulation hdlc
  - command, 826
- no ip access-group
  - command, 741
- no ip nat inside source
  - static command, 771
- no ip route command, 569
- no ip split horizon
  - command, 867
- no ip subnet-zero command
  - line syntax, 241
- no logging [<IP address>]
  - command, 469
- no logging buffered
  - command, 469
- no logging console
  - command, 469
- no logging file command, 469
- no logging monitor
  - command, 469
- no logging on command, 468
- no logging trap command, 469
- no login command, 334, 353, 536, 556–558
- no prefix, 124
- no service password-recovery command, 362
- no shutdown command
  - EIGRPv6, 277–278
  - function of, 332, 534, 797, 817
  - PPP, 842
  - short forms of, 123
- noise
  - effect on full-duplex transmission, 66
  - radio frequency signal, 685
- nonbroadcast multiple access (NBMA), 867
- noncontiguous port assignment, 739
- nonegotiate port mode,
  - DTP, 430
- nonroot bridge, 380, 388
- nontrusting PC port, Cisco IP phone, 451
- nonvolatile random-access memory. *See* NVRAM (nonvolatile random-access memory)
- normal response mode (NRM), HDLC, 825
- Novell Netware
  - Internetwork Packet Exchange. *See* IPX (Novell Netware Internetwork Packet Exchange)
- NRM (normal response mode), HDLC, 825
- NSP (Network Service Provider), 818
- NTP (Network Time Protocol)
  - overview, 173
  - TCP/IP port, 33
  - time-oriented ACLs, 753
- numbered ACL
  - compared to named ACLs, 751
  - editing, 753
- numbering systems
  - binary, 51–53
  - converting, 57–58, 250
  - decimal, 50–51
  - hexadecimal, 53–57
  - overview, 49
- NVRAM (nonvolatile random-access memory)
  - amount of, 324
  - inspecting contents of
    - with Cisco IFS, 464–466
  - purpose of, 114

NVRAM (nonvolatile random-access memory) (*continued*)  
 router running configuration, 549–550  
 router startup configuration, 548  
 specifying size of, 340  
 switch running configuration, 346–347  
 switch startup configuration, 325–328, 331, 336–337, 345–347  
 VLAN configuration, 435  
 nvram: directory, 351, 465, 553

## O

octet, defined, 214–215  
 OFDM (Orthogonal Frequency Division Multiplexing), 656, 660–661  
 on demand routing, 589  
 Open Shortest Path First version 3. *See* OSPFv3 (Open Shortest Path First version 3)  
 Open Systems Interconnection (OSI) reference model, 15  
 advantages of, 175  
 application layer, 16–17, 205–207  
 benefits of, 19–20  
 communication between layers, 175  
 compared to DoD and TCP/IP models, 207–208  
 data link layer, 18–19, 75–78, 193–197, 223

figure of, 174  
 information exchange through, 188–190  
 mnemonic for remembering layers, 175  
 network layer, 18, 197–202, 223–225  
 overview, 15–16, 174–179  
 physical layer, 19, 78–80, 190–193  
 PPP, 832  
 presentation layer, 17, 205  
 session layer, 17, 204–205  
 TCP/IP implementation of, 26, 168  
 transport layer, 17–18, 202–204  
 operation flow of computer networks, 7–10  
 STP, 393–401  
 operational flow  
 Frame Relay, 865–866  
 NAT, 767–770  
 PPP, 834–836  
 Operational mode field, 477  
 Organizational Unique Identifier (OUI), 76  
 Orthogonal Frequency Division Multiplexing (OFDM), 656, 660–661  
 OSI reference model.  
*See* Open Systems Interconnection (OSI) reference model  
 OSPF (Open Shortest Path First)  
 administrative distance, 573–574, 589  
 characteristics of, 626–627  
 configuring, 634–639  
 convergence, 627

cost metric, 576, 628  
 maximum hop count, 578  
 monitoring, 639–640  
 network layer, 199–200  
 overview, 173, 625–626  
 route updates, 627–628  
 routing hierarchy, 628–634  
 routing tables, 626  
 troubleshooting, 641  
 OSPF cost, 639  
 OSPF priority defined, 633  
 overview, 638  
 selecting designated router, 633  
 OSPFv3 (Open Shortest Path First version 3)  
 IPv6, 279  
 overview, 279  
 OTAP (over-the-air provisioning), 706  
 OUI (Organizational Unique Identifier), 76  
 outbound ACL  
 overview, 740  
 placing, 750  
 outbound gateway, 510  
 outside global address defined, 766  
 NAT operational flow, 767  
 outside local address defined, 766  
 NAT operational flow, 767  
 overhead  
 cell-switched connections, 90  
 defined, 90  
 HDLC frames, 825  
 PPPoE, 818  
 UDP, 32  
 overloading. *See* PAT (Port Address Translation; overloading)

over-the-air provisioning (OTAP), 706  
 Overview screen, SDM Express, 154

---

**p**

---

packet (datagram). *See also* access control list (ACL); UDP (User Datagram Protocol)  
 defined, 169  
 EIGRP, 612  
 encapsulation process, 181  
 filtering, 104, 728–729, 736  
 network layer, 16, 18, 505  
 PDUs, 44–45  
 processing by routers, 509  
 processing by switches, 509  
 purpose of IP addressing, 213  
 RIPng, 597  
 RIPv1, 594–595  
 RIPv2, 595–597  
 routed protocols, 36, 511  
 routing, 513  
 SDUs, 189  
 VoIP, 446  
 packet header, 262–263  
 packet sniffer, defined, 94  
 packet-switched  
   connection  
     advantages of, 88  
     defined, 811  
     disadvantages of, 89  
     origin of, 168–169  
     protocols, 89  
 packet-switching exchange (PSE), 815

PACL (port ACL), creating, 754–755  
 PAgP (Port Aggregation Protocol)  
   overview, 408, 424  
   selecting, 409–410, 432  
 PAP (Password Authentication Protocol)  
   overview, 839–840, 844–845  
 PPP, 835  
 PAR (positive acknowledgment and retransmission) process, 31  
 parallel processing, defined, 7  
 partial mesh topology  
   defined, 12  
   Frame Relay, 864, 866, 871–872  
 passenger protocol, 792  
 passive destination  
   network, defined, 618–619  
 password  
   access points, 671–672  
   console, 121  
   encrypting, 330  
   forgotten, 322, 341, 546  
   PAP, 839–840  
   PPP, 842–843  
   privileged EXEC mode, 117–118  
   router, 522–523, 531, 535–538, 555–559, 562  
   switch, 317, 319, 329, 333–336, 352–357, 360, 362–365  
   Telnet, 122

types of, 333, 535, 555  
 VTP, 437  
 WLAN security, 671–672  
 password attack, 723  
 Password Authentication Protocol. *See* PAP (Password Authentication Protocol)  
 password command, 333, 535  
 password guessing, 723  
 password my\_password command, 334, 353, 355, 536, 556, 558  
 password my\_telnet\_password command, 335, 354, 537, 557  
 PAT (Port Address Translation; overloading)  
   configuring, 775–776  
   defined, 222  
   operational flow, 769–770  
   overview, 765  
 patch panel, 473–485  
 path MTU discovery, 275  
 Payload Type (PT) field, ATM, 814  
 Payment Card Industry (PCI), 667  
 PBX (private branch exchange), 819  
 PC (10/100 PC) connection, Cisco IP phone CDP, 450–451  
   purpose of, 447–450  
 PCI (Payment Card Industry), 667  
 PCMCIA card, 114

- PDU (protocol data unit)
  - defined, 42
  - encapsulation process, 42–43
  - information exchange
    - between layers, 189
  - perimeter (border) router
    - ACLs, 736
    - overview, 718
  - period, defined, 651–652
  - permanent virtual circuit (PVC)
    - overview, 856–857
    - purpose of, 814
  - permission level\_15\_
    - access, CNA, 140
  - permit any any statement, 740–741
  - permit statement
    - ACLs, 726–727, 740
    - defined, 750
  - phase, defined, 651–652
  - physical address. *See* ARP (Address Resolution Protocol); MAC (Media Access Control; physical) address
  - physical layer (OSI reference model)
    - cabling standards, 191
    - encapsulation process, 180–182
    - Ethernet in, 78–80
    - information exchange
      - between layers, 175–177, 188
    - overview, 19, 37, 178–179, 190
  - PDU, 45
  - placement in stack, 174–176
  - wiring standards, 192–193
- piggybacking, WLANs, 94–95
- ping command
  - example of, 484, 487
  - ICMP, 173, 202, 486–487
  - PPP, 848
  - testing connectivity with, 482–484
  - using in CNA, 484, 490
- Ping item, SDM Express, 159
- Ping of Death, The, 724
- Ping screen, CNA, 484
- ping sweep, 723
- pipe (|) sign, 569
- PKI (public key infrastructure), 790
- PoE (Power over Ethernet)
  - port
    - lightweight mode wireless networking, 682
  - WLCs, 693
- Point-to-Point Protocol. *See* PPP (Point-to-Point Protocol)
- Point-to-Point Protocol over Ethernet (PPPoE), 818
- point-to-point topology
  - dedicated leased line connections, 86
  - defined, 10
  - Frame Relay, 867–870
  - HDLC, 823
- Point-to-Point Tunneling Protocol (PPTP), 792
- poison reverse
  - distance vector routing, 580
  - error mitigation, 592
- POP3 (Post Office Protocol 3)
  - application layer, 207
  - overview, 173
  - port for, 207
  - TCP/IP port, 33
- port. *See also* names of specific ports; static (port-based) VLAN membership
  - assigning STP, 389, 393–396
  - configuring speed, 379
  - DTP, 430–431
  - FTP, 206
  - HTTP, 32, 206
  - IANA definitions, 33
  - monitoring configuration, 410–411
  - POP3, 207
  - RSTP, 405
  - security, 307–308, 317, 319, 352, 522–523
  - SMTP, 32, 206
  - SNMP, 206
  - STP, 393–400
  - switch, selecting, 379
  - TCP/IP, 32–33
  - Telnet, 206
  - verifying status of, 474–482
  - VLANs, 416, 420, 434
- port ACL (PACL), creating, 754–755
- Port Address Translation. *See* PAT (Port Address Translation; overloading)
- Port Aggregation Protocol. *See* PAgP (Port Aggregation Protocol)
- port multiplexing, 765, 769
- port number, setting
  - designated ports
  - according to, 396–398
- port scans, 723

- Port Settings item, Device Manager, 132
- Port Settings screen, CNA, 480
- Port Settings Web form, Device Manager, 133
- Port Statistics menu, CNA, 141–142
- Port Statistics screen, CNA, 482–483
- Port Status menu, Device Manager, 135–136
- Port Status screen, Device Manager, 479
- Port Status Web form, Device Manager, 136
- port trunking. *See also* EtherChannel; trunking; VLAN (virtual local-area network)
  - defined, 407, 423
  - displaying data regarding, 467
- port-based (static) VLAN membership, 420, 434
- PortFast option. *See also* RTF (Rapid Transitioning to Forwarding)
  - overview, 401–402
  - using with BPDUFILTER option, 403
  - using with BPDUGuard option, 402
- positive acknowledgment and retransmission (PAR) process, 31
- POST (power-on self test)
  - defined, 113
  - routers, 525, 541
  - switches, 321–322, 324, 339
- Post Office Protocol 3.
  - See* POP3 (Post Office Protocol 3)
- Power over Ethernet port.
  - See* PoE (Power over Ethernet) port
- power-on self test. *See* POST (power-on self test)
- PPP (Point-to-Point Protocol)
  - CHAP, 840–841
  - configuring, 841–846
  - dedicated leased line connections, 86–87
  - LCP, 836–838
  - monitoring, 847–851
  - NCP, 838–839
  - operational flow of, 834–836
  - overview, 812, 831–834
  - PAP, 839–840
  - troubleshooting, 847–851
- ppp callback accept command, 846, 851
- ppp callback request command, 851
- ppp chap hostname command, 844
- ppp compress command, 851
- ppp multilink command, 851
- ppp pap sent-username command, 844
- ppp quality command, 851
- PPPoE (Point-to-Point Protocol over Ethernet), 818
- PPTP (Point-to-Point Tunneling Protocol), 792
- Pre field, data link frames, 76–77
- preamble (synchronization bit), data link frames, 195
- prefer port mode, ACLs, 754–755
- prefix delegation, DHCPv6, 274
- prefix length, defined, 237
- Prefix Length field, RIPng, 598
- prefix-length /24 syntax, ip nat pool command, 773
- presentation (syntax) layer (OSI reference model)
  - encapsulation process, 180–182
  - information exchange between layers, 175–177, 188
  - overview, 17, 177–178, 205
  - PDUs, 43–44
  - placement in stack, 174–176
  - TCP/IP applications at, 28
  - TCP/IP protocols at, 27–28
- presentation layer (TCP/IP), 27
- Pre-Shared Key (PSK)
  - WLAN security, 705
  - WPA, 668
- priming access points, 706
- priority queuing, 736
- private branch exchange (PBX), 819
- private configuration files, 340
- private IP address
  - ACLs, 742
  - overview, 222
- private TCP/IP ports, 33

private-config-file option, 340

private-config.text file, 461–462, 465

private-config.text.renamed file, 461–462

privileged EXEC mode

- boot command, 341
- CDP configuration commands, 492
- defined, 116
- interrupting automatic boot process, 342–343, 345, 361
- listing commands in, 126–127, 129
- overview, 117–118
- security, 352, 555

privileged EXEC prompt, 118

privileged password

- defined, 333, 352, 535, 555
- routers, 558–559
- switches, 355–356

process\_id value, 634

processing delay, defined, 575

propagation delay, defined, 575

protocol data unit. *See* PDU (protocol data unit)

Protocol field

- HDLC frames, 824
- PPP frames, 833

protocol parameter, show cdp entry \* command, 494

protocol-dependent modules, 610

Protocol-Reject frame, LCP, 836

proxy ARP, 226

proxy server, 222

PSE (packet-switching exchange), 815

PSK. *See* Pre-Shared Key (PSK)

PT (Payload Type) field, ATM, 814

public key cryptography, 788

public key infrastructure (PKI), 790

PVC. *See* permanent virtual circuit (PVC)

## Q

Q Cnt (Queue Count), 619

Q933A LMIs, 860

QoS (quality of service)

- enabling in IPsec VPNs, 800–801
- enabling on upstream switch, 451
- IPv6, 263
- packet-switched connections, 88
- VoIP, 446–447

QoS Policy Generation screen, SDM, 801

QoS Wizard, SDM, 800

quality of service. *See* QoS (quality of service)

Quality-Protocol option, LCP, 838

queries, EIGRP, 612

Queue Count (Q Cnt), 619

queuing delay, 575

## R

RA. *See* router advertisement (RA)

radio frequency channels. *See* RF (radio frequency) channels

Radio Resource Management (RRM), 703

RADIUS (Remote Authentication Dial-In User Service)

- MAC address filtering, 670
- WLCs, 703

RAM (random-access memory). *See also* NVRAM (nonvolatile random-access memory)

- inspecting contents with Cisco IFS, 464–466
- purpose of, 115

random-access memory. *See* NVRAM (nonvolatile random-access memory); RAM (random-access memory)

RAP (Rooftop Mesh Access Points), 697

Rapid Spanning Tree Protocol. *See* RSTP (Rapid Spanning Tree Protocol)

Rapid Transitioning to Forwarding (RTF), 406–407

- RARP (Reverse Address Resolution Protocol)
  - data link layer, 37, 196
  - function of, 196
  - overview, 173, 226
- RC4 (Rivest Cipher 4)
  - stream cipher, 667
- RCP (remote copy)
  - protocol, 737
- read-only connection, 140
- read-only memory. *See* ROM (read-only memory)
- read/write connection, 140
- receiving host
  - encapsulation process, 42–44
  - TCP connections, 30–31
- Recommended Action:
  - field, CNA, 472–473
- reconnaissance attack, 722–723
- recovering passwords
  - routers, 562
  - switches, 360–365
- redundant link
  - disadvantages of, 386
  - utilizing to send data, 407
- reflection, defined, 685
- reflexive access list, 739
- regional Internet registry. *See* RIR (regional Internet registry)
- registered TCP/IP port, 33
- reliability
  - core layer, 100
  - dedicated leased line connections, 86
  - frame collisions, 64
  - full-duplex transmission, 66
  - full-mesh topologies, 12
- IGRP, 200
  - overview, 575
  - packet-switched connections, 88–89
  - parallel processing, 7
  - WLANs, 94
- Reliable Transport Protocol (RTP), 610
- reload command
  - function of, 341, 544
  - interrupting automatic boot process, 342–343, 361
- REM statement, 746
- remark command, 742
- Remote Authentication Dial-In User Service. *See* RADIUS (Remote Authentication Dial-In User Service)
- remote connection
  - routers, 522–524
  - switches, 318–320
- remote control, defined, 6
- remote copy (RCP)
  - protocol, 737
- remote management
  - computer host
    - connecting to routers, 524
    - connecting to switches, 318–319
- remote network
  - sending frames to, 370–375
  - sending frames within LAN, 369–370
- remote shell (RSH), 737
- remote-access VPN, 787
- remote-procedure call (RPC) protocol, 28
- repeater, defined, 9
- replay protection, IPsec, 789–790
- replies, EIGRP, 612
- requests, EIGRP, 612
- Réseaux IP Européens Network Coordination Centre (RIPE NCC), 266
- reserved IP address
  - IPv6, 269–270
  - overview, 219
- Reset to Factory Default
  - form, SDM Express, 159
- Reset to Factory Default
  - item, SDM Express, 159
- resetting
  - routers, 539–540
  - switches, 337–338
- response message, CHAP, 840
- Restart the switch radio
  - button, Device Manager, 135
- Restart/Reset menu, Device Manager, 134–135
- Restart/Reset option, CNA, 144
- Restart/Reset Web form, Device Manager, 135
- Retransmission Timeout (RTO), 619
- Reverse Address Resolution Protocol. *See* RARP (Reverse Address Resolution Protocol)
- reverse routing, 797
- RF (radio frequency)
  - channels
    - 2.4-GHz band, 653–654, 657–661
    - 5-GHz band, 655, 660–661
  - modulating, 655–657
  - WLANs, 685
- RID (router ID), 633

- ring topology
  - defined, 10
  - figure of, 11
- RIP (Routing Information Protocol)
  - administrative distance, 573–574
  - configuring, 598–601
  - convergence, 592–593
  - core layer speed, 102
  - hop count, 574, 578, 590
  - as interior gateway protocol, 588–589
  - limitations of, 608
  - network layer, 199
  - overview, 587–588
  - packets, 513
  - routing error mitigation
    - methods, 590–592
  - routing tables, 590
  - routing updates, 590
  - split horizon, 592
  - TCP/IP port, 33
  - timers, 592–593
  - verifying, 601–603
- RIPE NCC (Réseaux IP Européens Network Coordination Centre), 266
- RIPng (Routing Information Protocol Next Generation), 276–277, 597–598
- RIPv1 (Routing Information Protocol version 1), 593–595
- RIPv2 (Routing Information Protocol version 2), 573, 595–597
- RIR (regional Internet registry)
  - ASNs, 589
  - function of, 214
  - IPv6 address assignment, 266
- Rivest Cipher 4 (RC4)
  - stream cipher, 667
- RJ-45 (8 Position 8 Contact [8P8C]) connector
  - 10BASE-T, 67
  - Ethernet standards, 191
  - T568B and T568A UTP
    - termination standards, 79
- RJ-45 cabling, 815–816
- RJ-45-to-DB-9 adapter, 816
- RJ-45-to-DB-9 cable, 815
- RJ-45-to-DB-25 adapter, 816
- rlqr failure message, 850
- rogue AP detection, 694
- rollover cable
  - connecting to routers, 520–521
  - connecting to switches, 315–317
  - defined, 324
  - overview, 80, 815
- ROM (read-only memory)
  - Cisco software in, 113
  - purpose of, 114
- ROMMON (ROM monitor), 113
- rommon > (ROMMON)
  - prompt
    - accessing ROM Monitor, 113, 115
    - configuration register, 115, 544, 546–547
- Rooftop Mesh Access Points (RAP), 697
- root bridge
  - defined, 380, 388
  - electing, 389–393
- root port
  - defined, 393
  - setting, 394–395
- route aggregation. *See* summarization (route aggregation; supernetting)
- route metrics, 567
- route poisoning, 579–580
- route summarization. *See* summarization (route aggregation; supernetting)
- Route Table Entries field, RIPng, 598
- Route Tag field
  - RIPng, 598
  - RIPv2, 595, 596
- route update packets, 36, 511
- route updates
  - distance vector routing, 577
  - EIGRP, 609, 612, 613
  - error mitigation, 590–591
  - hybrid routing, 582
  - link-state routing, 581
  - OSPF, 627–628
  - permitting, 599
  - preventing, 599
  - reducing, 736
  - RIP, 587, 590
  - triggered, 593
- routed protocols. *See also names of specific routed protocols*
  - function of, 36, 511
  - ICMP, 202
  - IP, 202
  - IPX, 202
  - overview, 572
  - routing tables, 572

- router. *See also* EIGRP (Enhanced Interior Gateway Routing Protocol); OSPF (Open Shortest Path First); RIP (Routing Information Protocol)
  - authentication, 554–562
  - best practices for, 114, 517–519
  - compared to switches, 295, 508–509
  - configuring, 528–554
  - connecting to, 519–524
  - functions of, 511–513
  - host names, 842
  - network layer, 505–508
  - network routes, 567–571
  - purpose of, 508–511
  - routed protocols, 572
  - routing decision criteria, 572–576
  - routing methods, 576–582
  - routing protocols, 571–572, 582
  - startup process, 525–528
- router advertisement (RA)
  - address
    - autoconfiguration, 273
  - ICMPv6, 275
  - IPv6, 263
- router eigrp as\_id command, 615
- router ID (RID), 633
- router ospf process\_id command, 634
- router rip command, 598
- Router> prompt, 527
- router-id command, 277, 633
- router-on-stick, 440
- routing, defined, 33, 505
- Routing configuration form, SDM Express, 157–158
- routing domain ID (as\_id), 615
- Routing Information Protocol. *See* RIP (Routing Information Protocol)
- Routing Information Protocol Next Generation (RIPng), 276–277, 597–598
- Routing Information Protocol version 1 (RIPv1), 593–595
- Routing Information Protocol version 2 (RIPv2), 573, 595–597
- Routing item, SDM Express, 157
- routing layer. *See* network (routing) layer (OSI reference model)
- routing loops. *See also* STP (Spanning Tree Protocol)
  - avoiding, 304–307, 379–380, 388
  - distance vector routing, 577–580
  - RIP, 591–592, 601
- routing protocols. *See also* metrics; names of specific routing protocols
  - configuring, 582
  - distance vector, 198–200
  - function of, 36, 511
  - link-state, 198–200
  - managing, 512
  - overview, 571–572
- routing table. *See also* route updates
  - BGP, 200
  - building, 513
  - EIGRP, 610–611, 617–618
  - OSPF, 626, 639
  - overview, 35, 510–511
  - purpose of, 571–572
  - RIP, 587–588, 590
- RPC (remote-procedure call) protocol, 28
- RRM (Radio Resource Management), 703
- RS232 parameters. *See* serial communications (RS232) parameters
- RS-232 straight-through cable, 816
- RSH (remote shell), 737
- RSTP (Rapid Spanning Tree Protocol)
  - alternate port, 406
  - backup port, 406
  - enabling on switches, 407
  - max age timer, 405–406
  - RTF, 406–407
- RTF (Rapid Transitioning to Forwarding), 406–407
- RTO (Retransmission Timeout), 619
- RTP (Reliable Transport Protocol), 610
- rumor routing. *See* BGP (Border Gateway Protocol); distance vector routing (rumor routing); EIGRP (Enhanced Interior Gateway Routing Protocol); IGRP (Interior Gateway Routing Protocol); RIP (Routing Information Protocol)

running configuration  
 defined, 321, 339, 525, 541  
 overview, 115–116  
 RAM, 115  
 routers, 549–552  
 switches, 346–349  
 troubleshooting, 496–498  
 running-config file, 351  
 Rx-boot image, 113, 321, 525  
 Rx-boot prompt. *See*  
 (boot)> (Rx-boot)  
 prompt

## S

SA (security association),  
 790  
 SAN (storage area  
 network), 207  
 SAP. *See* service access  
 point (SAP)  
 Save Running Config to  
 Router's Startup Config  
 check box, SDM, 779  
 scalability  
   Cisco hierarchical design  
   model, 106–107  
   dynamic routes, 571  
   IGRP, 200  
   IPsec, 789  
   static routes, 569  
 scattering, defined, 685  
 SDM. *See* Cisco Security  
   Device Manager (SDM);  
   Cisco Security Device  
   Manager (SDM) Express  
 SDU (service data unit), 189  
 Secure Hash Algorithm  
 (SHA-1), 789  
 Secure Shell. *See* SSH  
 (Secure Shell)

Secure Shell (SSH) ACL,  
 creating, 749–750  
 Secure Socket Layer. *See*  
 SSL (Secure Socket  
 Layer)  
 security. *See also* access  
 control list (ACL);  
 IPsec (Internet  
 Protocol Security);  
 NAT (Network  
 Address Translation);  
 SSH (Secure Shell);  
 VPN (virtual private  
 network)  
 access ports, 427  
 console port and auxiliary  
 port connections, 317,  
 319, 352, 522–523, 555  
 IPv4 versus IPv6, 263, 280  
 network zoning, 718–722  
 overview, 717  
 packet-switched  
 connections, 89  
 port filtering, 307–308  
 RIP, 600–601  
 RIPv2, 595  
 risk mitigation methods,  
 725–730  
 risks, 722–725  
 static routing, 276, 568  
 VLANs, 418  
 wireless network, 94–96  
 WLANs, 704–705  
 WLCs, 694  
 security association (SA),  
 790  
 Security configuration form,  
 SDM Express, 157–158  
 Security Device Manager.  
*See* Cisco Security  
 Device Manager (SDM);  
 Cisco Security Device  
 Manager (SDM) Express

Security item, SDM Express,  
 157  
 security zone, defined, 718  
 segment (data segment)  
 access layer, 99, 105  
 broadcasting, 223  
 cell-switched connections,  
 90  
 defined, 16, 28  
 encapsulation process,  
 181  
 PDUs, 44–45  
 router before and after  
 segmentation, 200–201  
 SDUs, 189  
 sequencing, 29, 30–31  
 segmenting  
   data link layer, 197  
   defined, 417  
   overview, 9  
 SEM (system error  
 message), 471  
 sending host  
   encapsulation process,  
   42–44  
   TCP connections, 30–31  
 SEQ (TCP “Sequence”)  
   message, 30  
 sequencing, 29–31  
 serial communications  
   (RS232) parameters  
   connecting to routers, 521  
   connecting to switches,  
   316  
 serial interfaces  
   Cisco, 809–810  
   DCE, 810  
 Serial Line Internet Protocol  
 (SLIP), 812  
 Serial Link Address  
   Resolution Protocol  
   (SLARP), 823, 825

- serial/USB port adapter
  - connecting to routers, 521
  - connecting to switches, 317
- Server Message Block (SMB), 33
- server mode, VTP
  - switches, 435
- service access point (SAP)
  - defined, 188–189
  - LLC layer, 194
- service data unit (SDU), 189
- service password-encryption command, 357, 559, 843
- service password-recovery command, 362
- Service Port, WLCs, 693
- service provider class
  - device, 100
- service provider (layer), 188
- service set
  - basic, 684
  - extended, 684
  - overview, 683–684
- service set identifier. *See* SSID (service set identifier)
- service user (layer), 188
- service-config command, 542–543
- Service-Port Interface, WLCs, 693
- session layer (OSI reference model)
  - communications, 204–205
  - encapsulation process, 180–182
  - information exchange between layers, 175–177, 188
  - overview, 17, 28, 177–178, 204–205
  - PDUs, 43–44
  - placement in stack, 174–176
- sessions (logical communication channels), 17
- setup mode
  - defined, 116
  - overview, 117
  - routers, 530
  - switches, 325
- setup mode commands, IOS
  - configuring routers, 533–539
  - configuring switches, 331–338
- Severity column, CNA, 472–473
- SHA-1 (Secure Hash Algorithm), 789
- shared key authentication, 668
- shared network storage, defined, 7
- shared secret, 668
- shielded twisted-pair (STP) cabling, 79
- “ships in the night”
  - integrated parallel routing, 279
- short-wavelength fiber-optic cabling, 70
- show access-list [list #] command, 749
- show access-list ACL\_name detail command, 756
- show access-list command, 741, 752–753, 755
- show access-lists
  - command, 749
- show boot command, 341
- show cdp command, 491–493
- show cdp entry \*
  - command, 494
- show cdp interface command, 494
- show cdp neighbors
  - command, 493
- show cdp neighbors detail command, 494
- show clock command, 466
- show command
  - configuration mode, 345
  - function of, 272
  - short forms of, 122
- show controllers command
  - compared to show interfaces command, 466
  - function of, 817, 827–828, 851
- show dialer command, 851
- show env all command, 467
- show etherchannel
  - summary command, 467
- show flash command, 461–462, 465
- show frame-relay lmi command, 874
- show frame-relay map command, 875
- show frame-relay pvc command, 875–876
- show frame-relay route command, 876
- show frame-relay traffic command, 876

- show interface command, 827
- show interface serial command, 874
- show interfaces command, 466, 847, 851
- show interfaces serial command, 851
- show interfaces status command, 467, 474, 476
- show interfaces status err-disabled command, 467, 474
- show interfaces switchport command, 467, 474–475, 476–478
- show interfaces trunk command, 467, 475
- show ip access-list command, 749, 756
- show ip eigrp neighbors command, 619
- show ip eigrp topology command, 618
- show IP interface command, 214
- show ip interface command, 475, 478–479, 749, 756
- show ip nat statistics command, 777–778, 780
- show ip nat translations command, 777, 780
- show ip ospf database command, 640
- show ip ospf interface command, 640
- show ip ospf neighbor command, 640
- show ip protocols command, 602, 618, 640
- show ip rip database command, 603
- show ip route command, 602–603, 617, 639, 777, 780, 851
- show ip ssh command, 359, 360
- show logging command
  - function of, 467, 756
  - inspecting switch logs and system messages, 468
  - output of, 470–472
  - verifying port status, 475
- show mac-address-table command, 467
- show ppp multilink command, 851
- show process cpu command, 843
- show resource usage command, 756
- show running-config access-list command, 756
- show running-config command
  - editing ACLs, 741
  - function of, 356, 559, 749, 843, 851
  - global configuration mode, 119
  - inspecting current switch configuration, 462–463
  - interface configuration mode, 121
- show running-configuration command, 543
- show spanning-tree backbonefast command, 410
- show spanning-tree command, 410, 467
- show spanning-tree interface fastethernet 0/1 bpduguard command, 411
- show spanning-tree interface fastethernet 0/1 bpduguard command, 411
- show spanning-tree interface fastethernet 0/1 portfast command, 411
- show spanning-tree uplinkfast command, 410
- show ssh command, 360
- show startup-config command
  - function of, 356, 559
  - inspecting switch startup configuration, 463–464
- show tech-support command
  - function of, 497
  - inspecting switch technical parameters, 466–467
- show time-range command, 754
- show version command, 457–458
- show vlan command
  - function of, 467
  - verifying port status, 475, 478
- show vtp command, 438
- show vtp status command, 438

- shutdown command, 332, 534
- signals. *See also* wireless network
  - modulating, 652–653
  - overview, 651–652
- SIIT (Stateless IP/ICMP Translation) Algorithm, 284
- Simple Mail Transfer Protocol. *See* SMTP (Simple Mail Transfer Protocol)
- Simple Network Management Protocol. *See* SNMP (Simple Network Management Protocol)
- single routing domain. *See* autonomous system (AS; single routing domain)
- single-mode fiber-optic cabling (SMF optic cabling)
  - 10 Gigabit Ethernet, 74
  - Fast Ethernet, 69
  - Gigabit Ethernet, 71–73, 75
- site survey, 685
- site-to-site VPN, 787
- SLARP (Serial Link Address Resolution Protocol), 823, 825
- sleeptime timer, 600
- sliding window protocol, 31–32, 203
- SLIP (Serial Line Internet Protocol), 812
- S-M, 387
- S-MAC. *See* source MAC address (S-MAC; S-M)
- SmartPort feature
  - interswitch connectivity, 437
  - overview, 428
- Smartports item, Device Manager, 131–132
- SMB (Server Message Block), 33
- SMF optic cabling. *See* single-mode fiber-optic cabling (SMF optic cabling)
- Smooth Round-Trip Timer (SRTT), 619
- SMTP (Simple Mail Transfer Protocol)
  - application layer, 206
  - Cisco IOS Firewall, 729
  - e-mail, 27
  - function of, 26
  - overview, 174
  - port for, 206
  - TCP/IP port, 33
- SNMP (Simple Network Management Protocol)
  - application layer, 206
  - function of, 26
  - ports for, 206
  - TCP/IP port, 33
  - software, defined, 111
- Software Update item, SDM Express, 159–160
- Software Upgrade menu, Device Manager, 137–138
- Software Upgrade option, CNA, 143–144
- Software Upgrade screen, Device Manager, 458–459
- Software Upgrade Web form, Device Manager, 138
- solicited-node multicast group, 270
- source IP address, defined, 750
- source MAC address (S-MAC; S-M) MAC address table
  - thrashing, 306, 387
  - overview, 76–77
- source mask, defined, 750
- Source Service Access Point (SSAP) LLC layer, 194
  - overview, 77
- Spanning Tree Protocol. *See* STP (Spanning Tree Protocol)
- specific configuration mode, 119–120
- specific configuration prompt, 120–121
- speed
  - bridges, 295–296
  - cell-switched
    - connections, 89
  - circuit-switched
    - connections, 87
  - console line, 547
  - core layer, 100, 101–102
  - determination by physical layer, 190
  - full-duplex transmission, 65
  - hubs, 296
  - inter-VLAN routing, 439–441
  - packet-switched
    - connections, 88

- speed (*continued*)
  - parallel processing, 7
  - port, configuring, 379
  - switches, 295–296
- Speed column
  - Port Settings Web form, Device Manager, 133
  - Port Status Web form, Device Manager, 136
- speed command, 379
- SPF (Dijkstra shortest path first) routing algorithm, 628–629
- split horizon
  - distance vector routing, 579
  - Frame Relay, 866–868
  - RIP, 592, 601
- Split MAC function, 696
- split tunneling, 793
- splitter, 818
- SQNs (TCP sequence numbers)
  - Cisco IOS Firewall, 729
  - IP spoofing, 725
- SRTT (Smooth Round-Trip Timer), 619
- SSAP. *See* Source Service Access Point (SSAP)
- SSH (Secure Shell)
  - enabling for routers, 560–562
  - enabling for switches, 357–360
  - logging to sessions, 469, 471
  - purpose of, 722
  - as replacement for Telnet, 171
  - TCP/IP port, 33
  - WLAN security, 669–670
  - loading, 321, 339
  - monitoring, 347
  - overview, 345–346
  - troubleshooting, 494–496
- startup configuration
  - (config.text) file
  - copying configurations to, 352, 554
  - erasing, 461
  - hiding, 495
  - saving configurations to, 352
  - verifying presence of, 461, 465
- startup process
  - routers, 525–528
  - switches, 321–324
- Startup Wizard, WLC, 702
- startup-config keyword, 346, 549
- stateful packet inspection, 728–729
- stateless autoconfiguration, IPv6, 263, 272–273
- Stateless IP/ICMP Translation (SIIT) Algorithm, 284
- stateless packet inspection, 728–729
- static (port-based) VLAN membership, 420, 434
- static IP address, 702
- static NAT
  - configuring, 770–772
  - operational flow, 767–768
  - overview, 764–765
- static packet filtering, 728–729
- static routes
  - administrative distance, 573–574, 589
  - advantages of, 568
- SSH (Secure Shell) ACL, creating, 749–750
- SSID (service set identifier)
  - basic, 684
  - configuring, 704
  - extended, 684
  - hiding, 670–671
  - overview, 95, 683–684
- SSL (Secure Socket Layer) VPNs, 787, 790–791
- WLAN security, 669–670
- standard ACL
  - creating, 745–747
  - naming, 748
  - overview, 726–727, 738
  - placing, 740, 748
- star topology
  - defined, 10
  - EIA/TIA-568-B cabling standard, 79
  - figure of, 11
  - Frame Relay, 863
- Start of Frame Delimiter, data link frames, 195
- starting sequence number, 30
- startup configuration
  - NVRAM, 114
  - OSPF, 634
  - overview, 115
- routers
  - backing up, 540, 550
  - creating, 529–539
  - deleting, 540, 550
  - loading, 525, 541
  - monitoring, 550
  - overview, 548
- switches
  - backing up, 338, 347
  - creating, 325–331
  - deleting, 325, 338, 347–348

- Cisco SDM Express, 157
- configuring, 569–570
- defined, 275
- disadvantages of, 569
- IPv6, 275–276
- overview, 198
- Status column, Port Status
  - Web form, Device Manager, 136
- sticky MAC address, 308
- storage area network (SAN), 207
- store-and-forward
  - switching mode, 375–377
- STP (shielded twisted-pair)
  - cabling, 79
- STP (Spanning Tree Protocol)
  - avoiding loops with, 379–380
  - Cisco options for, 401–405
  - debugging, 497–498
  - displaying data regarding, 467
  - EtherChannel, 407–410
  - fault tolerance, 424
  - function of, 305, 388
  - monitoring, 410–411
  - operation flow, 389–401
  - overview, 197, 385–388
  - RSTP, 405–407
- STP path cost
  - overview, 393
  - setting designated ports according to, 395–396
- STP priority
  - Cisco hierarchical design model, 391–393
  - decreasing convergence duration, 401
  - default, 389
  - overview, 389–391
  - setting, 389–390
- straight-through cable
  - overview, 80
  - RJ-45, 815
  - RS-232, 816
- structured attack, 722
- stub domain
  - defined, 764
- dynamic NAT, 768–769
- PAT, 769
- static NAT, 767–768
- subinterface, Frame Relay, 867, 870–873
- subnet (subnetwork)
  - broadcast IP addresses, 236
  - broadcasting, 223
  - CIDR, 236–238
  - Class A, 245–250
  - Class B, 243–245
  - Class C, 240
  - creating, 235–236
  - defined, 232
  - determining number of, 220
  - host addresses, 241–243
  - host IDs, 236
  - network IDs, 236
  - overview, 220–221, 231–232
  - planning, 239–250
  - purpose of, 232–234
  - subnet zero, 240–241
  - summarization, 253–256
  - VLSMs, 250–253
  - wildcard masks, 744
- subnet ID, 232–233
- subnet mask. *See also* VLSM (variable-length subnet mask)
  - bit positions, 234–235
  - compared to inverted subnet masks, 743
  - function of, 214, 221
- IGRP, 608
- OSPF route
  - summarization, 631–632, 636–637
- overview, 220–221, 234–236
- Subnet Mask field, RIPv2, 596–597
- subnet syntax, ip route
  - command, 569
- subnet zero, 240–241
- subnetwork. *See* subnet (subnetwork)
- successor route
  - EIGRP, 612, 614
  - topology table, 611, 618
- summarization (route aggregation; supernetting)
  - classful routing protocols, 614–615
  - disabling, 601
  - EIGRP, 200
  - OSPF, 630–632, 636–637
  - overview, 253–255
  - VLSMs, 255–256
- supernetting. *See* summarization (route aggregation; supernetting)
- SVC. *See* switched virtual circuit (SVC)
- switch. *See also* STP (Spanning Tree Protocol); VLAN (virtual local-area network)
  - authentication, 352–365
  - best practices for, 114, 313–314

- switch (*continued*)
  - broadcast transmission, 308–311
  - compared to bridges, 295
  - compared to hubs, 665–666
  - compared to routers, 295, 508–510
  - configuring, 324–352
  - connecting to, 315–320
  - data link layer, 291–292
  - defined, 9
  - duplex modes, 378–379
  - functions of, 296–307, 379–380
  - LANs, 63
  - monitoring configuration, 410
  - multicast transmission, 308–311
  - overview, 9
  - physical addresses, 10
  - purpose of, 295–296
  - remote networks, 369–375
  - security, 307–308
  - startup process, 321–324
  - switching modes, 375–377
  - troubleshooting, 455–498
  - unicast transmission, 308–311
  - VoIP, 445–452
- Switch Information frame, Device Manager, 458
- switch: manual boot
  - prompt, 340, 345, 362, 495
- switch port ACL. *See* port ACL (PACL), creating
- switched virtual circuit (SVC)
  - overview, 857
  - purpose of, 814
- switchport access vlan
  - <vlan #> command, 434
- switchport access vlan command, 420
- switchport mode access command, 430
- switchport mode
  - command, 426, 428
- switchport mode dynamic auto command, 431
- switchport mode dynamic desirable command, 431
- switchport mode trunk
  - command, 426, 430, 433
- switchport nonegotiate command, 430, 433
- .switchport port-security mac-address <MAC> command, 306
- switchport portsecurity mac-address sticky command, 307
- switchport port-security maximum <max#> command, 307
- switchport port-security violation <action> command, 307
- switchport portsecurity violation shutdown command, 307
- switchport trunk encaps dot1q command, 422, 433
- switchport trunk encapsulation command, 429
- symmetric cryptography, 788
- SYN flooding
  - Cisco IOS Firewall, 729
  - IP spoofing, 725
- synchronization bit (preamble), data link frames, 195
- syntax layer. *See* presentation (syntax) layer (OSI reference model)
- Syslog (System Logging Process) server, 33, 469, 471
- Syslog logging field, 471
- SYSLOG protocol
  - configuring, 469
  - defined, 471
- SYST (System LED), 342, 344, 361
- system: directory, 351, 465, 553–554
- system error message (SEM), 471
- System LED (SYST), 342, 344, 361
- System Logging Process (Syslog) server, 33, 469, 471
- System Messages
  - Monitoring tool, CNA, 472
- system messages, switch inspecting, 468, 470–473, 496
- managing logging system, 468–470
- overview, 467–468
- system option, 340, 543

---

## T

- T (Type) field, data link frames, 76–78
- T adapter, 67

- T568A UTP termination
  - standard, 79
- T568B UTP termination
  - standard, 79
- TACACS (Terminal Access Controller Access Control System) server
  - login tacacs command, 359
  - storing privileged
    - password on, 356, 558–559
- tagging frames, 421–422
- TA/NT1 (terminal adapter/network termination 1), 808
- tar file. *See* Cisco IOS software image (tar file)
- Tc (Committed Rate Measurement Interval), 859
- TCN (topology change notification) BPDU, 399
- TCP (Transmission Control Protocol)
  - Cisco IOS Firewall, 729–730
  - compared to UDP, 32
  - overview, 169
  - packet header, 170
  - TCP/IP ports, 32–33
  - transport layer, 18, 29, 203
  - UDP versus, 170, 203–204
- TCP (Transmission Control Protocol) Intercept feature, ACLs, 737
- TCP flag, ACLs, 739
- TCP sequence numbers. *See* SQNs (TCP sequence numbers)
- TCP “Sequence” (SEQ) message, 30
- TCP session hijacking (man-in-the-middle attack), 679, 725
- TCP sliding window, 31–32
- TCP socket, defined, 204
- TCP/IP (Transmission Control Protocol/Internet Protocol)
  - applications, 27–28
  - ARP, 37
  - communication, 167–169
  - compared to DoD and OSI models, 207–208
  - components of, 169–182
  - connectionless transport, 29
  - connection-oriented transport, 29
  - flow control, 29–32
  - hierarchical IP addresses, 34–36
  - layers of, 207–208
  - origin of, 168–169
  - overview, 25–26
  - ports, 32–33
  - protocols, 26–29, 34, 37
  - UDP, 32
  - WLANs and security, 94
- TCP/IP ports, 32–33
- telecom
  - (telecommunication company; service provider), 85
- Telnet (Terminal Emulation Protocol)
  - ACLs, 736
  - application layer, 206
  - logging to sessions, 469, 471
  - overview, 171
  - port for, 206
  - remote router
    - connections, 523
    - session layer, 28
    - TCP/IP port, 33
- Telnet ACL, creating, 749–750
- Telnet item, SDM Express, 159–160
- Telnet menu, Device Manager, 136–137
- Telnet option, CNA, 144
- Telnet password
  - configuring, 335–336
  - routers, 537–538, 556–557
  - switches, 353–354
- Telnet Web form, Device Manager, 137
- Temporal Key Integrity Protocol. *See* TKIP (Temporal Key Integrity Protocol)
- terabytes, defined, 56
- Terminal Access Controller Access Control System server. *See* TACACS (Terminal Access Controller Access Control System) server
- terminal adapter/network termination 1 (TA/NT1), 808
- terminal emulation
  - application
    - rollover cables, 80
  - Telnet applications
    - supporting, 315–316, 521
- Terminal Emulation Protocol. *See* Telnet (Terminal Emulation Protocol)
- terminal monitor
  - command, 877
- Terminate-ACKs frame, LCP, 835–836

- Terminate-Request frame, LCP, 835–836
- TFTP (Trivial File Transfer Protocol) server, 113
- Thicknet (10BASE5), 66–67, 75
- Thinnet (10BASE2), 67, 75
- three-legged firewall, 720
- three-way handshake (call setup; virtual circuit setup)
  - CHAP, 840–841
  - flow control, 30
  - TCP connections, 30–31
- time range, defined, 753
- time-oriented ACL, creating, 753–754
- timeout value, NAT table entries, 772–773
- timer parameter, cdp run command, 492
- time-range command, 754
- timers. *See also names of specific timers*
  - adjustments to, 600
  - backup controller, 707
  - RIP, 592–593
- timers basic command, 600
- Timestamp column, CNA, 472–473
- Time-To-Live value. *See* TTL (Time-To-Live) value
- TKIP (Temporal Key Integrity Protocol)
  - WLAN security, 705
  - WPA, 668
  - WPA-1, 96
- TLS (Transport Layer Security), 669–670
- topologies
  - Frame Relay, 863–865, 868–873
  - overview, 10–12
  - topology change
    - notification (TCN) BPDU, 399
  - topology table, 611, 618–619
  - Topology View, CNA, 141, 490–491
  - trace route (traceroute) tool, 485
    - example of, 488–489
    - ICMP, 486–487
    - testing connectivity with, 482
    - using in CNA, 485, 490
  - traceroute mac tool, 485
  - traceroute tool. *See* trace route (traceroute) tool
  - tracert command, 489–490
  - traffic control, switches
    - avoiding loops with STP, 379–380
    - duplex modes, 378–379
    - remote networks, 369–375
    - switching modes, 375–377
  - traffic logging, NAT, 764
  - trailer
    - Cisco ISL frame-tagging method, 421
    - information exchange between layers, 189
    - MAC layer, 194
- Transform Set screen, SDM, 799
- Transmission Control Protocol. *See* TCP (Transmission Control Protocol); TCP/IP (Transmission Control Protocol/Internet Protocol)
- Transmission Control Protocol (TCP) Intercept feature, ACLs, 737
- Transmission Control Protocol/Internet Protocol. *See* TCP/IP (Transmission Control Protocol/Internet Protocol)
- transmission delay, defined, 575
- transparent mode, VTP switches, 435
- transport input ssh telnet command, 360
- transport layer (DoD model), 179–180
- transport layer (OSI reference model)
  - connectionless transport, 29
  - connection-oriented transport, 29
  - encapsulation process, 16, 180–182
  - flow control, 29–32
  - information exchange between layers, 175–177, 188
  - overview, 17–18, 28–29, 178, 202–204
  - PDU, 43–44
  - placement in stack, 174–176
  - TCP/IP ports, 32–33
  - TCP/IP protocols at, 29
  - UDP, 32
- Transport Layer Security (TLS), 669–670
- transport mode, IPsec, 794–796
- transport protocol, 792
- Trap logging field, 471
- triggered update, 580
- Triple DES (3DES), 788

- Trivial File Transfer Protocol (TFTP) server, 113
  - Trojan horse attack, 723
  - Troubleshoot menu, CNA, 143
  - troubleshooting
    - access control lists, 755–758
    - Cisco hierarchical design model, 107
    - EIGRP, 620
    - Frame Relay, 873–877
    - NAT, 776–777
    - OSPF, 641
    - PPP, 851
    - switches
      - connectivity, 473–485
      - gathering network information, 485–494
      - gathering switch information, 456–473
      - overview, 455
      - running configuration, 496–498
      - startup configuration, 494–496
    - VTP, 438
  - trunk mode, DTP, 430
  - trunk port
    - DTP, 426
    - managing, 429–434
    - overview, 428–429
    - PACLs, 755
  - trunking
    - EtherChannel, 423–432
    - overview, 422–423
    - port types, 426–429
    - VLAN, 425–426, 429–432
    - VTP, 434–438
  - trust exploitation attack, 724
  - trusting PC port, Cisco IP phone, 451
  - TTL (Time-To-Live) value
    - extended ACLs, 739
    - ICMP, 202
    - limiting hop count, 590
    - poison reverse, 592
  - tty keyword, line <first\_arg> ? command, 130
  - tunnel mode, IPsec, 794–796
  - tunnel mode ipv6ip
    - command, 283
  - tunnel-group command, 798
  - tunneling
    - defined, 728, 786
    - migrating to IPv6, 281–283
    - PPPoE, 818
    - VPNs, 792–793
  - twisted-pair cabling. *See also* UTP (unshielded twisted-pair) cabling
    - 10 Gigabit Ethernet, 73
    - Fast Ethernet, 68–69
    - full-duplex transmission, 65
    - Gigabit Ethernet, 70–71
    - half-duplex transmission, 65
    - star topology, 10
  - Type (T) field, data link frames, 76–78
- 
- ## u
- 
- UDP (User Datagram Protocol)
    - Cisco IOS Firewall, 729–730
    - compared to TCP, 32, 170, 203–204
    - overview, 169
    - TCP/IP ports, 32–33
    - transport layer, 29, 32, 203
  - unencrypted privileged mode password
    - routers, 531
    - switches, 329
  - UNI interface, 813
  - unicast transmission
    - compared to broadcast, 223
    - defined, 309
    - EIGRP, 610, 612
    - IPv6 addresses, 268
    - overview, 308–311
    - RIP, 599
  - Unicode, 28
  - U-NII (Unlicensed National Information Infrastructure), 650
  - Unlicensed Personal Communications Services (UPCS), 650
  - unlicensed radio bands, 649–650
  - Unrecognized command error, 730
  - unshielded twisted-pair cabling. *See* crossover cable; rollover cable; straight-through cable; twisted-pair cabling; UTP (unshielded twisted-pair) cabling
  - unspecified address, IPv6, 269–270
  - unstructured attack, 722
  - UPCS (Unlicensed Personal Communications Services), 650
  - update timer, 600

updates, VTP, 436. *See also* route updates

Upgrade button, Device Manager, 459

uplink (10/100 SW)  
connection, Cisco IP phone, 447–449

UplinkFast option, 403–405

Use a Custom Application Security Policy button, SDM, 757

User Datagram Protocol.  
*See* UDP (User Datagram Protocol)

user EXEC mode  
defined, 116  
listing commands in, 125–126, 129  
overview, 117

user EXEC prompt, 117

username command, 528

UTP (unshielded twisted-pair) cabling. *See also* crossover cable; rollover cable; straight-through cable; twisted-pair cabling

10 Gigabit Ethernet, 73, 75, 191

10-Mbps Ethernet, 66–67, 75, 191

common uses for, 816

difference between categories of, 79, 192–193

effect of number of hosts, 78

Fast Ethernet, 68–69, 75, 191

Gigabit Ethernet, 70–71, 75, 191

overview, 815

T568A and T568B termination standard, 79

verifying connectivity of, 474

## V

V.35 connector, 810

variable-length subnet mask. *See* VLSM (variable-length subnet mask)

VCI (Virtual Channel Identifier) field, ATM, 813

vendor-assigned part, MAC address, 76

Version Number field  
RIPng, 597  
RIPv1, 595  
RIPv2, 596

version parameter, show cdp entry \* command, 494

video over IP, 6

Virtual Channel Identifier (VCI) field, ATM, 813

virtual circuit  
Frame Relay, 856–859  
permanent, 814, 856–857  
switched, 814, 857

virtual circuit setup. *See* three-way handshake (call setup; virtual circuit setup)

Virtual Interface, WLCs, 693

virtual local-area network.  
*See* VLAN (virtual local-area network)

Virtual Path Identifier (VPI) field, ATM, 813

virtual private network. *See* VPN (virtual private network)

virtual type terminal line.  
*See* VTY (virtual type terminal) line; VTY (virtual type terminal) line password

VLAN (virtual local-area network)  
benefits of, 418  
displaying data regarding, 467  
identifying, 419  
managing, 418–421  
overview, 415–418  
routing traffic between, 104, 438–441  
STP priority, 390  
tagging frames with VLAN ID, 421–422  
trunking, 422–433  
VoIP, 450, 452  
VTP, 434–438

VLAN 1 (administrative VLAN)  
access ports, 427  
configuring switches, 330, 332  
overview, 419

VLAN column, Port Status Web form, Device Manager, 136

vlan command, 419

VLAN ID  
access ports, 427  
defined, 421  
ranges of, 436–437  
tagging frames with, 421–422

- VLAN Membership Policy Server. *See* VMPS (VLAN Membership Policy Server)
- VLAN Trunking Protocol. *See* VTP (VLAN Trunking Protocol)
- vlan.dat file, 461
- VLANs screen, CNA, 481
- VLSM (variable-length subnet mask)  
design guidelines, 252  
DUAL, 614  
EIGRP, 200  
optimizing IP addressing with, 253  
OSPF, 200, 626  
purpose of, 250–251  
RIPv2, 595
- VMPS (VLAN Membership Policy Server)  
automatic port membership assignment, 434  
function of, 420
- VoIP (Voice over IP)  
access ports, 427  
CDP, 450–451  
Cisco IP phone, 447–450  
configuring, 451–452  
CoS, 447  
defined, 6  
overview, 445–446  
QoS, 446–447
- VPI (Virtual Path Identifier)  
field, ATM, 813
- VPN (virtual private network)  
defined, 785  
implementation methods, 787–793  
IPsec VPNs, 793–801  
overview, 728  
purpose of, 785–787  
static routes, 568  
types of, 787  
WLAN security, 668–669
- VTP (VLAN Trunking Protocol)  
benefits of, 434  
client, 434–435  
domain, 434–435, 437  
dynamic membership, 420–421, 423  
enabling, 437–438  
functions of, 434  
monitoring, 438  
operating modes, 435–436, 438  
pruning, 436  
requirements for, 437  
server, 435–437  
static membership, 420, 434  
troubleshooting, 438  
updates, 436  
VLAN ID range, 436–437
- VTP client, 435–436
- VTP domain, 434–435, 437
- VTP domain controller (VTP server), 435–437
- vtp mode client command, 435
- vtp mode server command, 435
- vtp mode transparent command, 435
- VTP pruning, 436
- VTP revision number, 436
- VTP server (VTP domain controller), 435–437
- VTY (virtual type terminal)  
line  
ACLs, 736  
defined, 333–334, 352, 535, 555  
logging to sessions, 469, 471  
number of, 335, 354, 537, 556–557
- VTY (virtual type terminal)  
line password  
overview, 122  
routers, 531, 535, 555  
switches, 329, 333, 335–336, 352  
vty keyword, line <first\_arg> ? command, 130

---

## W

---

- WAN (wide area network).  
*See also* Frame Relay;  
PPP (Point-to-Point Protocol)
- cable connections, 815–817
- cell-switched  
connections, 89–90
- circuit-switched  
connections, 87–88
- Cisco serial interfaces, 809–810
- connection types, 811
- connectors, 809–810
- DCE, 808–810
- dedicated leased line  
connections, 86–87  
defined, 807
- DSL connections, 817–819
- DTE, 808–809

- WAN (wide area network)
  - (continued)
  - encapsulation, 811–815
  - HDLCL, 823–828
  - layers, 179
  - overview, 85–86, 807–808
  - packet-switched
    - connections, 88–89
    - purpose of, 808
  - wireless, 93, 648–649
- WAN configuration form, SDM Express, 156
- WAN item, SDM Express, 155–156
- WAN Wizard, SDM
  - configuring Frame Relay, 873
  - configuring PPP, 846
- WAP (wireless access point) device
  - MAC address filtering, 96
  - WEP, 95
  - WPA, 96
- WCS (Wireless Control System), 695
- Web authentication
  - process, 708–709
- Web browsers
  - application layer, 27
  - presentation layer, 27–28
- well-known TCP/IP ports
  - examples of, 33
  - range, 33
- WEP (Wired Equivalent Privacy)
  - ad hoc mode wireless networking, 677
  - overview, 95
- WLAN security, 667–668, 704
- wide area network. *See* WAN (wide area network)
- Wi-Fi. *See* IEEE 802.11 standards
- Wi-Fi Alliance
  - defined, 95–96
  - wireless standards, 650
- Wi-Fi Protected Access. *See* WPA (Wi-Fi Protected Access)
- wildcard (inverse subnet) mask
  - compared to subnet masks, 743
  - defined, 726
  - OSPF, 635–636
  - overview, 742–745
- Wired Equivalent Privacy, WEP (Wired Equivalent Privacy)
- wireless access point device. *See* WAP (wireless access point) device
- Wireless Control System (WCS), 695
- Wireless LAN Controller. *See* WLC (Wireless LAN Controller)
- wireless local-area network. *See* WLAN (wireless local-area network)
- wireless mesh device
  - ad hoc mode, 676
  - AWPP, 697
- wireless metropolitan-area network (WMAN), 648
- wireless network, 93–96.
  - See also* WLAN (wireless local-area network)
  - benefits of, 94
  - classes of, 648–649
  - costs of, 94
  - purpose of, 647
  - RF channels, 653–657
  - security, 94–96
  - sharing airwaves, 649–650
  - signals, 651–653
  - wireless WANs, 93, 648–649
- Wireless Network
  - Connection Properties dialog box, Windows XP, 676–678
- wireless personal-area network (WPAN), 648
- wireless wide-area network (WWAN), 93, 648–649
- wiring standards, 192–193
- WLAN (wireless local-area network)
  - configuring, 701–711
  - managing, 691–697
  - operation modes, 675–683
  - overview, 93, 648
  - planning, 685–688
  - security, 665–672
  - service set, 683–684
  - standards, 657–661
- WLANA (WLAN Association), 650
- WLC (Wireless LAN Controller)
  - configuring, 702–704
  - functions of, 696

- GUI, 709–710
  - lightweight mode wireless networking, 682–683
  - overview, 692–694
  - purpose of, 692–693
  - tuning access points, 688
  - WMAN (wireless metropolitan-area network), 648
  - workgroup layer.  
*See* distribution (workgroup) layer (Cisco hierarchical model)
  - World Wide Web, defined, 6
  - WPA (Wi-Fi Protected Access)
    - overview, 95–96
  - WLAN security, 667–668, 704
  - WPA-1, 96
  - WPA-2, 96, 667–668
  - WPAN (wireless personal-area network), 648
  - wrapping/unwrapping PDUs, 43–44
  - WWAN (wireless wide-area network), 93, 648–649
- 
- X**
- 
- X Windows, 207
  - X.25, 89, 814–815. *See also* Frame Relay
- 
- Z**
- 
- zero compression, defined, 267–268
  - Zero/Unused field
    - RIPng, 597
    - RIPv1, 595
    - RIPv2, 596
  - zombie (agent), 724



# Wiley Publishing, Inc.

## End-User License Agreement

---

**READ THIS.** You should carefully read these terms and conditions before opening the software packet(s) included with this book “Book”. This is a license agreement “Agreement” between you and Wiley Publishing, Inc. “WPI”. By opening the accompanying software packet(s), you acknowledge that you have read and accept the following terms and conditions. If you do not agree and do not want to be bound by such terms and conditions, promptly return the Book and the unopened software packet(s) to the place you obtained them for a full refund.

- 1. License Grant.** WPI grants to you (either an individual or entity) a nonexclusive license to use one copy of the enclosed software program(s) (collectively, the “Software”) solely for your own personal or business purposes on a single computer (whether a standard computer or a workstation component of a multi-user network). The Software is in use on a computer when it is loaded into temporary memory (RAM) or installed into permanent memory (hard disk, CD-ROM, or other storage device). WPI reserves all rights not expressly granted herein.
- 2. Ownership.** WPI is the owner of all right, title, and interest, including copyright, in and to the compilation of the Software recorded on the physical packet included with this Book “Software Media”. Copyright to the individual programs recorded on the Software Media is owned by the author or other authorized copyright owner of each program. Ownership of the Software and all proprietary rights relating thereto remain with WPI and its licensors.
- 3. Restrictions on Use and Transfer.**
  - (a)** You may only (i) make one copy of the Software for backup or archival purposes, or (ii) transfer the Software to a single hard disk, provided that you keep the original for backup or archival purposes. You may not (i) rent or lease the Software, (ii) copy or reproduce the Software through a LAN or other network system or through any computer subscriber system or bulletin-board system, or (iii) modify, adapt, or create derivative works based on the Software.
  - (b)** You may not reverse engineer, decompile, or disassemble the Software. You may transfer the Software and user documentation on a permanent basis, provided that the transferee agrees to accept the terms and conditions of this Agreement and you retain no copies. If the Software is an update or has been updated, any transfer must include the most recent update and all prior versions.
- 4. Restrictions on Use of Individual Programs.** You must follow the individual requirements and restrictions detailed for each individual program in the “About the CD” appendix of this Book or on the Software Media. These limitations are also contained in the individual license agreements recorded on the Software Media. These limitations may include a requirement that after using the program for a specified period of time, the user must pay a registration fee or discontinue use. By opening the Software packet(s), you agree to abide by the licenses and restrictions for these individual programs that are detailed in the “About the CD” appendix and/or on the Software Media. None of the material on this Software Media or listed in this Book may ever be redistributed, in original or modified form, for commercial purposes.

## 5. Limited Warranty.

- (a) WPI warrants that the Software and Software Media are free from defects in materials and workmanship under normal use for a period of sixty (60) days from the date of purchase of this Book. If WPI receives notification within the warranty period of defects in materials or workmanship, WPI will replace the defective Software Media.
- (b) WPI AND THE AUTHOR(S) OF THE BOOK DISCLAIM ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WITH RESPECT TO THE SOFTWARE, THE PROGRAMS, THE SOURCE CODE CONTAINED THEREIN, AND/OR THE TECHNIQUES DESCRIBED IN THIS BOOK. WPI DOES NOT WARRANT THAT THE FUNCTIONS CONTAINED IN THE SOFTWARE WILL MEET YOUR REQUIREMENTS OR THAT THE OPERATION OF THE SOFTWARE WILL BE ERROR FREE.
- (c) This limited warranty gives you specific legal rights, and you may have other rights that vary from jurisdiction to jurisdiction.

## 6. Remedies.

- (a) WPI's entire liability and your exclusive remedy for defects in materials and workmanship shall be limited to replacement of the Software Media, which may be returned to WPI with a copy of your receipt at the following address: Software Media Fulfillment Department, Attn.: *CCNA Certification All-in-One For Dummies*, Wiley Publishing, Inc., 10475 Crosspoint Blvd., Indianapolis, IN 46256, or call 1-800-762-2974. Please allow four to six weeks for delivery. This Limited Warranty is void if failure of the Software Media has resulted from accident, abuse, or misapplication. Any replacement Software Media will be warranted for the remainder of the original warranty period or thirty (30) days, whichever is longer.
- (b) In no event shall WPI or the author be liable for any damages whatsoever (including without limitation damages for loss of business profits, business interruption, loss of business information, or any other pecuniary loss) arising from the use of or inability to use the Book or the Software, even if WPI has been advised of the possibility of such damages.
- (c) Because some jurisdictions do not allow the exclusion or limitation of liability for consequential or incidental damages, the above limitation or exclusion may not apply to you.

## 7. U.S. Government Restricted Rights.

Use, duplication, or disclosure of the Software for or on behalf of the United States of America, its agencies and/or instrumentalities "U.S. Government" is subject to restrictions as stated in paragraph (c)(1)(ii) of the Rights in Technical Data and Computer Software clause of DFARS 252.227-7013, or subparagraphs (c) (1) and (2) of the Commercial Computer Software - Restricted Rights clause at FAR 52.227-19, and in similar clauses in the NASA FAR supplement, as applicable.

## 8. General.

This Agreement constitutes the entire understanding of the parties and revokes and supersedes all prior agreements, oral or written, between them and may not be modified or amended except in a writing signed by both parties hereto that specifically refers to this Agreement. This Agreement shall take precedence over any other documents that may be in conflict herewith. If any one or more provisions contained in this Agreement are held by any court or tribunal to be invalid, illegal, or otherwise unenforceable, each and every other provision shall remain in full force and effect.