Symbols

? (question mark), CLI help system 35

Numerics

10Base specifications 163
10Base2 Ethernet 151, 153
10Base5 Ethernet 151, 153
10BaseT Ethernet 153
    full-duplex 156
    half-duplex 153, 155
10-Mbps Ethernet 151–157
1900 series switches 179
    configuring, 179, 188, 196
    default settings 180
    ports, numbering 180
2-wire circuits 575
4-wire circuits 575
802.1Q, VLAN tagging 237, 250

A

access layer 573–574
access links 610
access lists 489
    controlling vty access 515–516
    deny statements 496, 517
    displaying details for all protocols 499, 504, 519
    extended IP 494, 497, 503–505, 512, 516
        displaying details of 499, 504, 519
        example 506–512
        filtering IPX traffic 715–718
        filtering logic 505–506
        matching options 505
        packet matching criteria 507–508
        placement of 507–508
    extended IPX 718
        matching parameters 715, 731
        socket parameter 716
    filtering logic 710
    functionality of 494
    hands-on lab exercises 842–844
    matching logic 496–497
    named IP 512–515
    named IPX 724
    permit statements 496, 517
    SAP filters 721, 733, 802
        configuration 767–768
        matching parameters 720, 733
        versus IPX packet filters 720
    standard IP 494, 503, 516
        configuring 498–503, 767–768
        controlling vty port access 516
        displaying details of 499, 504, 519
        features 495–496
        matching options 504
        planning 802
    standard IPX 707–715
        configuration 767–768
        filtering SAP traffic 718–720
        matching parameters 715, 731
    statements 505
    wildcard masks 497–498
access-class command 499
accessing CLI 32–34
access-list command 707, 722, 729, 733
ACK field, TCP connection establishment 283
acknowledgement numbers, error recovery 100
active configuration 44
Address Mask Request/Reply ICMP message 288
addresses, 107–108
    addressing schemes 119
    AppleTalk addresses
        grouping 118
        structure 120, 129
    broadcast addresses 128, 297, 375
    burned-in addresses 108, 127
    IP, 297–298, 375–376
        calculating 474, 485–486
        classes of 299–302
        displaying 179, 195
        format 309
        Frame Relay hybrid full/partial mesh networks 642
        grouping 118
        host portion 298, 309, 376
        hostnames, displaying 343, 380
        interfaces, displaying 343, 380

mapping to MAC addresses
network masks 298, 376
network portion 298, 309, 376
planning 797
prefix notation 339
setting 179, 195
structure 120, 129
subnet masks 298, 376
subnet portion 298, 306, 376
subnets, calculating 393, 398–399
translating for invalid hosts with NAT 342
wildcard masks 497, 518
IPX addresses 683, 725, 741, 751–752
displaying for neighboring routers 818
features 684, 725
Frame Relay hybrid full/partial mesh networks 642
grouping 118
node portion 697
secondary addresses 805
structure 120, 129
MAC addresses 157, 185–186
BIAs 158
broadcast addresses 158
components 158
dynamic 183
features 158, 189
functional addresses 158
LAN card addressing 158
mapping to IP addresses 286–287
multicast addresses 158
OUI 158
permanent 184
restricted-static entries 184
switches, setting permanent 179, 195
switches, setting restricted 179, 195
tables, displaying 180, 195
unicast 157
network layer 118–119
multicast addresses 128
network layer addresses 123, 136, 142
switch port violations186
unicast addresses 127
address-violation command 180, 186, 195
adjacent layer interaction (OSI model) 90–97
administrative distance 459–460
advanced RIP-2 features 443–446
advertisements, VTP 237–238
ANSI (American National Standards Institute) 162, 191
AppleTalk
addresses
grouping 118
structure 120, 129
cable ranges 118
application layer (OSI reference model) 84–85, 88, 124
applying access lists to vty ports 515–516
arbitration 106–107
Ethernet 106
Token Ring 106
architected field specifications 540
ARP (Address Resolution Protocol) 116, 272, 274, 286. *See also* Inverse ARP
broadcast 274
cache, displaying 343, 381
ARPA IPX Ethernet encapsulation 688, 726
asynchronous data links 539
asynchronous serial leased lines 539, 575
ATM (Asynchronous Transfer Mode)
CCNA exam coverage 572
strengths/weaknesses 573, 584
authentication
CHAP 557–558
PAP 557–558
auto summarization (IP routes) 452, 465
autonegotiation
Ethernet 162
switches 182
autosummarization 446–451
auxiliary ports 34

B

balanced hybrid routing protocols 414–416, 462
bandwidth command 628
BCRAN (Building Cisco Remote Access Networks) 6

BECN (backward explicit congestion notification) 611
behavior of distance vector routing protocols 416–417
BIAs (burned-in addresses) 158
binary conversion table 933–941
binary network numbers 301
binary values, converting to decimal and hexadecimal values 307–309, 933, 941
Blocking state (Spanning Tree) 229, 250
Boolean AND 309
boot field 54
boot sequence (Cisco IOS) 53–55, 57
boot system command 55
boot system flash command 55, 63
boot system rom command 55, 63
boot system tftp command 55, 63
BPDUs (bridge protocol data units) 220, 224
BRI (Basic Rate Interface), ISDN 548–549
    DDR 560–562, 583
    features 578
    information, displaying 583
bridging
    IDs 224
    transparent 165–169
broadcast addresses 108, 128, 297, 375
    MAC addresses 158
broadcast command 567
broadcast domains 173–174, 193
    VLANs 230, 232–233
        configuring 241–248
        implementing 233–234
        ISL trunking 235–236
        trunking 234
        VTP 237–238
broadcast firewalls 174, 177
broadcast handling, Frame Relay 625–626
BSCN (Building Scalable Cisco Networks) 6
buffering 103
Building Cisco Remote Access Networks (BCRAN) 6
burned-in addresses 108, 127
burst rate 611

C

cable ranges (AppleTalk) 118
cabling
    Fast Ethernet 161
    WANs 546–547
Can't Fragment code (Destination Unreachable ICMP message) 290
carrier sense multiple access collision detect. *See* CSMA/CD 106
CBPDUs (Configuration Bridge Protocol Data Units) 220, 224, 249
CCDA (Cisco Certified Design Associate) 6–7
CCDP (Cisco Certified Design Professional) 5–6
    prerequisite certification 5
    specialization certifications 7
    WAN certification 7
CCIE (Cisco Certified Internetworking Expert) 4
    prerequisite certification 5
    WAN certification 7
CCIP (Cisco Certified Internetworking Professional) 6
CCNA certification
    course associations 6
    exam requirements 6
    recommended training path 17–18
    topics covered 8–15
        cross reference to chapters 16–17
        study tips 19–21
    training path recommended for 16–17
CCNP (Cisco Certified Network Professional) 5–6
    prerequisite certification 5
    specialization certifications 7
    WAN certification 7
CDP (Cisco Discovery Protoco) 370–372, 779
cdp enable command 371
cdp run command 371
certification
    CCDP 7
    CCIE 4
        prerequisite certification 5
        WAN certification 7
    CCNA
        preparing for 22–24
        recommended training path 17–18
        topics covered 8–15, 19–21
        training path recommended for 16–17

CCNP
prerequisite certification 5
specialization certifications 7
reseller requirements 4
routing and switching 5
testing locations 3
WANs 7
Challenge Handshake Authentication. *See* CHAP
channels, ISDN 548–549
CHAP (Challenge Handshake Authentication) 543, 557–558, 578
CID (Cisco Internetwork Design) 7
CIDR (classless interdomain routing) 338–339
CIR (committed information rate) 611
Cisco Certified Design Associate. *See* CCDA
Cisco Certified Design Professional. *See* CCDP
Cisco Certified Internetworking Expert. *See* CCIE
Cisco Certified Network Professional. *See* CCNP
Cisco Discovery Protocol. *See* CDP
Cisco Internetwork Design (CID) 7
Cisco Internetwork Troubleshooting (CIT) 6
Cisco IOS
boot sequence 53–55, 57
CLI 32
accessing 32–34
configuration mode 39
help system 35–36
setup mode 46–50
configuration files
erasing from NVRAM 46
managing 44–45
updating 39
example configuration 40–42
privileged exec mode 34
user exec mode 34
Cisco Networking Academy, post-exam strategies 22–23
Cisco Systems training partners 17
CIT (Cisco Internetwork Troubleshooting) 6
Class A networks 302
IP addresses 300
masks 298, 376
network numbers 302
subnetting 306
Class B networks 302
IP addresses 300
IP subnet design 396, 399
masks 298, 376
network masks 303
network numbers 302
subnetting 306
Class C networks 302
IP addresses 300
IP subnet design 397, 402, 405
masks 298, 376
network masks 303
network numbers 302
subnetting 306
classes of networks 300–302
classful routers 368
classless interdomain routing. *See* CIDR
classless routers 368
CLI (command-line interface) 27, 39, 59, 179
1900 series switch, hands-on lab 831–836
accessing 33
commands, recalling 36
configuration mode 39–40
hands-on lab 827–831
help system 35–36
password recovery 56
privileged exec mode
commands 628
access-class 499
access-list 707, 722, 729, 733
address-violation 180, 186, 195
bandwidth 628
boot system 55
boot system flash 55, 63
boot system ROM 55, 63
boot system tftp 55, 63
broadcast 567
cdp enable 371
cdp run 371
clock rate 547
compress 541, 546, 577
configuration mode end 40
configure terminal 179, 182
confreg 57
context-sensitive help 795
copy 45, 60
copy nvram tftp 187–188, 196
copy running-config startup-config 188, 196
copy startup-config tftp 187–188, 196
copy tftp flash 51–53, 819

debug 37
output 435–437
debug dialer 562, 583
debug dialer events 571
debug dialer packets 571
debug ip icmp 353
debug ip igrp event 438–439
debug ip igrp transaction 437–439, 787, 795
debug ip packet 343, 350–351, 381
debug ip rip 430, 435, 440, 447–449, 464, 771, 778
debug ip rip event 770, 778
debug ipx routing 694, 729
debug ipx routing activity 698–700, 705–707, 769, 778, 786
debug ipx routing event 705–707, 769
debug ipx sap 694, 729
debug ipx sap activity 699–700, 706, 769, 778, 786, 807
debug ipx sap event 707, 769, 778
debug isdn q921 562, 583
debug isdn q931 562, 571, 583
delete nvram 188, 196
delete vtp 241, 251
dialer fast-idle 568
dialer idle-timeout 568
dialer in-band 565
dialer load-threshold 559, 567
dialer map 566–567
dialer string 561, 566, 582
dialer-group 561, 565, 582
editing in CLI 36
enable 795
enable secret 795
encapsulation 236, 541, 577
encapsulation hdlc 542
erase startup-config 46, 188, 196
frame-relay interface-dlci 628
frame-relay lmi-type 628
global commands 40
hostname 40
interface 40
interface ethernet 0 40
interface serial 628
ip access-group 499, 503, 513, 518–520
ip access-list extended 513, 520
ip access-list standard 513, 520
ip address 40, 179, 195, 343, 380
ip classless 343, 365–370, 380
ip default-gateway 179, 195
ip default-network 343, 368, 380
ip domain-lookup 343, 362, 380
ip domain-name 362
ip host 343, 362, 380
ip maximum-paths 452
ip mtu 361
ip name-server 343, 362, 380
ip netmask-format 343, 380
ip rip send version 445
ip route 367, 566
ip routing 343, 380
ipx access-group 708, 722, 730, 733
ipx access-list 708, 730
ipx access-list extended 722, 733
ipx access-list sap 722, 733
ipx access-list standard 722, 733
ipx delay 700
ipx input-sap-filter 708, 722, 730, 733
ipx maximum-paths 693, 700, 729
ipx network 693, 696, 703, 729
ipx output-sap-filter 708, 722, 730, 733
ipx per-host-load-share 701
ipx routing 693, 696–698, 703, 729
isdn answer1 560, 582
isdn answer2 560, 582
isdn spid1 560, 582
isdn spid2 560, 582
isdn switch-type 560–561, 569, 582
keepalive 628
key commands, Ctrl+z 40
line aux 33, 58
line console 33, 58
line vty 33–34, 58
logging buffered 37
logging host 38
logging synchronous 37
login 34
mac-address-table permanent 179, 184, 195
mac-address-table restricted 184
mac-address-table restricted static 179, 195
mtu 361
network 430–432, 464
no address-violation 186

no cdp enable 371
no cdp run 371
no debug all 37, 438
no ip classless 368
no ip domain-lookup 362
no keepalive 795
no router rip 439
output, comment lines 40
ping 275, 289, 350–355, 546, 694, 729, 776, 793
port secure 180, 185–186, 195
ppp multilink 559
recalling 36, 59
resume 365
router igrp 430, 464
router rip 430, 464
setup 47
show access-list 499, 708, 730, 769
show cdp entry 371
show cdp interface 372
show cdp neighbor 371
show cdp neighbor detail 371, 806
show compress 546, 577
show controllers bri 561, 583
show debug 353
show dialer interface bri 561, 569, 583
show flash 52
show frame-relay lmi 793, 813
show frame-relay map 791, 793, 815
show frame-relay pvc 791, 819–820
show hosts 343–344, 380–381
show interface 349, 772, 788
show interfaces 179, 182, 195, 343, 380
show interfaces bri 561–562, 569, 583
show ip 179, 182, 195
show ip arp 350, 775, 778, 792
show ip host 362
show ip interface 343, 348, 380, 499
show ip interface brief 343, 347, 380, 768, 786, 795, 806
show ip protocol 430, 438–439, 464, 773, 789, 795
show ip route 346–348, 351–352, 434, 437–439, 441, 447, 449, 460, 775–778, 792, 795
  options 453–459
show ipx access-list 708, 730
show ipx interface 693, 696–697, 708, 729–730
show ipx interface brief 773, 786, 789
show ipx route 693, 698–700, 729, 773, 778, 790, 795
show ipx servers 694, 698–700, 706, 729, 774, 778, 790, 793–795, 807
show ipx traffic 694, 729
show isdn 561, 583
show isdn active 570
show isdn status 570
show mac-address-table 180, 184–185, 195
show process 546
show running-config 179–181, 346–347, 350, 774, 791
show spantree 248
show trunk 247
show version 180, 188, 195–196
show vlan 243
show vlan-membership 241, 247, 251
show vtp 241, 247, 251
subcommands 40
telnet 362
terminal history size 36
terminal ip netmask 350
terminal ip netmask-format 343, 346, 381
trace 291, 776–778, 793
traffic-share 430, 464
traffic-share balanced 452
trunk 241, 244, 251
undebug all 769
variance 430, 452, 464
vlan 242
vlan-membership 242
vtp 241–242, 247, 251
vtp trunk pruning-disable 241, 251
write erase 46, 188, 196
write terminal 350
comment lines, command output 40
comparing
  distance vector routing protocols 428–429
  routing and routed protocols 122–123
  WAN options 571–574
  WAN protocols 540–541
compress command 541, 546, 577
compression
  data-link protocol configuration 544–546
  synchronous serial leased lines 544, 546

Configuration Bridge Protocol Data Units. *See* CBPDUs 220, 249
configuration files
copying 45–46
erasing from NVRAM 46
managing 44–45
routers
copying to TFTP servers 188, 196
erasing at reload time 188, 196
updating at reload time 188, 196
storing 44
switches
copying from TFTP servers 180, 195
copying to TFTP servers 187
displaying version information 180, 195
erasing at reload time 188, 196
managing 187–188, 196
saving to TFTP servers 180, 195
updating at reload time 188, 196
updating 39
configuration mode (Cisco IOS CLI) 39–40
configuration mode end command 40
configuration register 55–54, 63
configuration revision number, VTP advertisements 238
configure terminal command 179, 182
configuring
access lists
extended IP 503–505
extended IPX 718
hands-on lab exercises 842–844
named IP 515
named IPX 724
standard IPX 712, 715
CHAP 557
Cisco IOS, example 40–42
data-link protocols, compression 544–546
DDR
connection termination, determining 568
determining the subset of packets that trigger dialing 565
dialing 567
default routing 365–370
Frame Relay 203–206, 210, 257–258, 628–629
fully-meshed 629–636
hybrid 641–646
partial-meshed 637–641
with point-to-point subinterfaces 805
without subinterfaces 783–785
HDLC 541–542
IGRP 429–434
IP addresses 342–354
naming 361–362
with Frame Relay subinterfaces 357–360
IPX 693–701
access lists 709–710
Frame Relay networks with point-to-point subinterfaces 701–703
multiple Ethernet encapsulations 703–704
multiple networks 689–690
named access lists 721–724
standard access lists 711–714
IPX networks 802–805
ISDN 555–556, 569
authentication 557–558
DDR 560–562
legacy DDR 563, 567–568
sample configurations 568–571
signaling 565–567
triggering the dial 563–565
MAC address table entries 183, 186
named IP access lists 512–515
Novell IPX, hands-on lab exercises 848–849
point-to-point leased lines 597–603
routers
for ISL encapsulation 236
IGRP 459
IP 355, 471, 474, 480, 485, 783–785
IPX 707, 747–748, 752–754
RIP 429–432, 459, 767–768
RIP-2 443, 446
setup mode 46–50
secondary IP addressing 356–357
standard access lists 498–503
switches 179, 188, 196
as VTP client/servers 246
1900 series, default settings180
IP support 181–183
methods of 179
trunks 241, 247, 251
VLANs 241
multiple switch configuration 244–248
single switch configuration 242–244
VTP 247
WANs, hands-on lab exercises 844–848

confreg command 57
congestion avoidance 103–104
  buffering 103
  congestion avoidance 103–104
  flow control 102
  windowing 104
connectionless protocols 98–99, 126
connection-oriented protocols 98–99, 126
connections
  TCP 282–284
  telnet, suspsended 365
console ports, routers 34
contiguous networks 448
convergence 414, 462–463
  distance vector routing protocols 462–463
  STP 227–229
converting
  decimal to binary 933–941
  decimal to hex 933–941
copy command 45, 60
copy nvram tftp command 187–188, 196
copy running-config startup-config command 188, 196
copy startup-config tftp command 187–188, 196
copy tftp flash command 51, 53, 819
copying
  configuration files 45–46
  from TFTP servers 180, 195
  images into Flash memory 50–53
core layer 573–574
count-to-infinity 422, 426, 434
courses
  BCMSN 6
  BCRAN 6
  BSCN 6
  CID 7
  CIT 6
  DCN 6
  ICND 6, 17–18
  ITM 17
CRC (cyclical redundancy check) 109
creating subnet charts 316–320, 334–337
criteria
  for standard access lists 500–502
  for STP forwarding state activation 223–224
CSMA/CD 106, 152
Ctrl+z key sequence 40
cut-through processing 174–175

D

data connection process, FTP 295
data link layer (OSI reference model) 84–89, 105, 124
  addressing 107–108
  arbitration 106–107
  encapsulated data, identifying 109, 113
  encapsulation 94
  error detection 109
  error recovery 92
  functionality 114, 128
  identifying encapsulated data 109–114
  ISDN specifications 550
  summary of functions 113
Data Services Unit/Channel Services Unit. *See* DSU/CSU
datagrams 97
data-link encapsulation (IPX) 687
data-link protocols
  comparing 540–541
  compression 544–546
  configuring 541–542
  error-recovery 540
  LCP 542
  PPP
    error detection 543–544
    looped link detection 543–544
    LQM 544
    magic numbers 543
  Protocol Type field 540–541
DCE (data communications equipment) 609
DCN (Designing Cisco Networks) 6
DDR (dial-on-demand routing) 555
  configuring over ISDN BRI 560–562
  connection termination, determining 568
  dialing 567
    triggers 565
  legacy configuration 563
    connection termination 567–568
    sample configurations 568–571
    signaling 565–567
    triggering the dial 563–565
DE (discard eligibility) 611
debug command 37
  output 435–437
debug dialer command 562, 583

debug dialer events command 571
debug dialer packets command 571
debug ip icmp command 353
debug ip igrp event command 438–439
debug ip igrp transaction command 437–439, 787, 795
debug ip packet command 343, 350–351, 381
debug ip rip command 430, 435, 440, 447–449, 464, 771, 778
debug ip rip event command 770, 778
debug ipx routing activity command 698–700, 705–707, 769, 778, 786
debug ipx routing command 694, 729
debug ipx routing event command 705–707, 769
debug ipx sap activity command 699–700, 706, 769, 778, 786, 807
debug ipx sap command 694, 729
debug ipx sap event command 707, 769, 778
debug isdn q921 command 562, 583
debug isdn q931 command 562, 571, 583
decimal-to-binary conversion 307–309, 933–941
default port costs, STP 226
default routing 365–370
delay 690
delete nvram command 188, 196
delete vtp command 241, 251
deny statements (access lists) 496, 517
deploying networks
  configuration 766–768
  Frame Relay networks
    configuration 783–785
    planning phase 780–782
    verifying configuration 785–796
  IPX networks
    configuration 802–805
    planning phase 797–802
    planning phase 762–766
    verifying configuration 768–779, 806–820
designated bridge 223
designated port 223, 226
Designing Cisco Networks (DCN) 6
Destination Unreachable ICMP message 288, 290
Destination Unreachable messages 289–291
devices
  hubs 152–153
  TE2 552
  telnetting between 362–365
DF (Don' t Fragment) bits 354
dialer fast-idle command 568
dialer groups (ISDN), enabling 561, 582
dialer idle-timeout command 568
dialer in-band command 565
dialer load-threshold command 559, 567
dialer map command 566–567
dialer string command 561, 566, 582
dialer-group command 561, 565, 582
dial-on-demand routing. *See* DDR
Dijkstra SPF algorithm 414–415
directly connected routes, routing table updates 418
directly connected subnets 416
disabling debug options 37
discontiguous networks 448
discovering neighbor devices 370–372
displaying
  running configuration 46
  syslog messages 37
distance vector routing protocols 412–413, 416, 462–463
  administrative distance 459–460
  autosummarization 446–451
  comparing 428–429
  equal-cost routes 420–421
  IGRP
    configuring 429–433
    equal-cost routes 452
    metrics, configuring 434
  loop avoidance 419, 422 462–463
    count to infinity 422
    hold-down timers 426–428
    poison reverse 425
    route poisoning 428
    split horizon 423–425
    triggered updates 428
  RIP
    advanced features 443–446
    configuring 429–432
    debug command output 435–437
    hop count 418–419
    migration from RIP-1 to RIP-2 445
    migration to IGRP 437–439
  route aggregation 446–451
  routing behavior 416–417
  routing tables 417–418
  routing update timers 419
distance-vector routing protocols
distribute lists 718
distribution layer 573–574

DIX Ethernet 106
DLCI (data-link connection identifier) 109, 610–611, 616–620
  global addressing 618–620
  local addressing 617
DNS (Domain Name System), 274, 285
Domain Name System. *See* DNS
domains, broadcast 174, 193
Don't Fragment (DF) bits 354
DRAM (dynamic random-access memory) 43, 59. *See also* RAM
DSAP (destination service access point) 110
DSU/CSU (Data Services Unit/Channel Services Unit) 539 547, 575
DTE (data terminal equipment) 107, 609
DUAL (Diffusing Update Algorithm) 414–415
dynamic MAC addresses 183
dynamic random-access memory. *See* DRAM

E

E1 lines 539, 576
Echo ICMP message 288–289
Echo Request/Reply messages 289
editing commands in CLI 36
EIA/TIA 232 WAN cabling standard 547
EIA/TIA 449 WAN cabling standard 547
EIA/TIA 530 WAN cabling standard 547
EIGRP (Enhanced Interior Gateway Routing Protocol) 415–416, 462
  auto summarization 452, 465
  equal-cost routes 452
  equal-metric routes 452
  route aggregation 451–452, 465
electing root bridge (STP) 224–225
enable command 795
enable secret command 795
encapsulation 94–97
  data link layer processes 94
  forward acknowledgment 100–101
  identifying encapsulated data 113
  IPX 687, 783–785
  OSI layer processes 93
  switches
    802.10 237, 250
    802.1Q 237, 250
    ISL 236–237, 250
    LANE 237, 250
encapsulation command 236, 541, 577
encapsulation frame-relay command 628
encapsulation hdlc command 542
Enhanced IGRP. *See* EIGRP
enterprise network layers 573–574
equal-cost routes 420–421, 452
erase startup-config command 46, 188, 196
erasing configuration files 46
error detection 543–544
  at data-link layer 109
  PPP 543–544, 577–578
  versus error recovery 99–100
error recovery
  acknowledgement numbers 100
  at data link layer 92
  example 101
  LLC2 102, 127
  procedures 102, 127
  SPX 102, 127
  TCP 102, 127, 277, 280, 796
  versus error detection 99–100
  WAN protocols 540
E-series ISDN protocols 549, 578
EtherChannel 215
Ethernet 105, 108, 163
  10Base2 151, 153
  10Base5 151, 153
  10BaseT 153
    full-duplex 156
    half-duplex 153–155
  10-Mbps 152–157
  arbitration 106
  CSMA/CD 106, 152
  DIX Ethernet 106
  encoding 113
  Fast Ethernet 161–163
  Gigabit Ethernet 161–163
  hubs 153
  IEEE standards 162–163, 191
  IPX encapsulation 688–689, 726
  multicast addresses 108, 128
Ethernet_802.2 encapsulation 688
Ethernet_802.3 encapsulation 688
Ethernet_II encapsulation 688
Ethernet_SNAP encapsulation 688

evolution of OSI reference model 84–85
exam (CCNA), topics covered 8–15, 19–21
example configuration, Cisco IOS 40–42
extended IP access lists 494–505, 512, 516
  example 506–512
  filtering logic 505–506
  matching options 505
  matching packet filtering criteria 507–508
  placement of 507–508
extended IPX access lists 715–718
  configuring 715–718
  matching 715, 731
  socket paramet 716
exterior routing protocols 414

F

Fast Ethernet 161–162
  online resources 163
FCS (frame check sequence) 99,109, 540
FDDI (Fiber Distributed Data Interface)
  ANSI standards 162, 191
  IPX encapsulation 688–689, 727
FECN (forward explicit congestion notification) 611
filtering packets
  extended IP access lists 503–505
    example 506–512
    placement of 507–508
  named IP access lists 512–515
  SAP updates 718–720
  standard access lists 494
    configuring 498–503
    features 495–496
    matching logic 496–497
    wildcard masks 497–498
FIN field, TCP connection establishment 283
Flash memory
  read-only mode 53
  routers 43, 60
  storing IOS images 50–53
  verifying contents of 52
flow control 102–103
  buffering 103
  congestion avoidance 103–104
  TCP 281–282
  terminology 105
  windowing 104
forward acknowledgment 100–101
  TCP 280
Forward Delay Timer (Spanning Tree) 227, 250
forwarding state (Spanning Tree) 223–224, 229, 250
  lowest-cost hello, calculating 226
four-wire circuits 539
fragmentation 360–361
  SAR 572
FragmentFree processing 175
frame check sequence. *See* FCS
Frame Relay 572, 609
  broadcast handling 625–626
  configuration 203–206, 210, 257–258
    with point-to-point subinterfaces 805
    without subinterfaces 783, 785
  configuring 628–629
  DLCI 616–620
  encoding 113
  full-mesh, configuring 629–636
  hybrid full/partial mesh networks
    configuring 641–646
    IP addresses 642
    IPX addresses 642
  IP addressing, configuring 357–360
  Layer 3 addressing 621–625
    Layer 2 address mappings 632–636
  LMI 614–616
  maps, static 783, 785
  network deployment
    configuration 783–785
    planning 780–783
    verification 785–796
  partial-mesh, configuring 637–641
  Protocol Type field, lack of 615
  split horizon 626–627
  strengths/weaknesses 573, 584
  VCs 108, 610, 612–614
frame-relay interface-dlci command 628
frame-relay lmi-type command 628
frames 107, 158–160
  latency, decreasing with switch processing 174
framing 538
FTP 294–295
  control connections 294
  data connection process 295

full-duplex 10BaseT Ethernet 156
fully-meshed Frame Relay networks, configuring 613, 629–636
function groups, ISDN 551–555

G

gateway of last resort 368
gateways, setting default 179, 195
Gigabit Ethernet 161–163
global addressing 618–620
global commands 40
GNS (Get Nearest Server) requests 691–693, 728, 779
GOSIP (Government OSI Profile) 85
Government OSI Profile (GOSIP) 85
group addresses 158

H

half-duplex 10BaseT Ethernet 153–155
half-duplex switch ports 181–183
hands-on lab exercises 823
    access list configuration 842–844
    IP routing configuration 840–842
    Novell IPX configuration 848–849
    router CLI familiarization 827–831
    router IP configuration and management navigation 838–840
    switch CLI familiarization 831–836
    VLANs, trunks, and STP 836–838
    WAN configuration 844–848
HDLC 106–107, 541, 572, 576
    compression 544–546
    configuring 541–542
    encoding 113
    strengths/weaknesses 572, 583
headers
    encapsulation 93–97
    forward acknowledgment 100–101
    TCP 278
    trunking 234
hello BPDUs 224
Hello time timer (STP) 250
    Spanning Tree
    STP 227
help system, CLI 35–36, 59
hexadecimal values, converting to decimal and binary values 933–941
history buffer (CLI), recalling commands 36
hold-down timers 422–423, 426–428
home-based ISDN 554
hop count 418–419
host addresses. *See* IP addresses
Host Unreachable code (Destination Unreachable ICMP message) 290
hostname command 40
hostnames, mapping to IP addresses 362
hubs 152
    Ethernet 153
    full-duplex 10BaseT Ethernet 156
    half-duplex 10BaseT Ethernet 153–155
    shared Ethernet 153
"Hurry up and wait" 104
hybrid Frame Relay networks, configuring 641–646

I

ICMP (Internet Control Message Protocol) 272, 275–276, 287
    echo messages, sending/receiving 430, 464
    functions of 288
    messages
        Address Mask Request/Reply 288
        Code field 288
        Destination Unreachable 288–291
        Echo 288–289
        Echo Request/Reply 289
        Parameter Problem 288
        Redirect 288, 293
        Router Advertisment and Selection 288
        Source Quench 288
        Time Exceeded 288, 291–293
        Timestamp 288
        Type field 288

ICND 6, 17
course summary 17–18
identifying
encapsulated data at data link layer 109–114
IP address structure 311–315
IEEE 802.1Q, VLAN trunking 235
IEEE 802.3. *See* Ethernet
IEEE 802.5. *See* Token Ring
IEEE standards
group addresses 158
LANs 162, 191
IGRP (Interior Gateway Routing Protocol) 407, 416, 462
auto summarization 452, 465
CCNA exam coverage 415–416
configuring 429–433, 459
equal-cost routes 452
features 429, 463
metrics 434
migration from RIP 437–439
packets, displaying log messages 430, 464
route aggregation 452, 465
subnet masks 440–442
updates, displaying log messages 430, 464
versus RIP 429, 463
image files (IOS) 50
storing in Flash memory 50–53
upgrading into Flash memory 61
implementing VLANs with multiple switches 233–234
infinite-distance routes 424
interaction between OSI layers
adjacecent layers 90–93
same layers 93–94
interesting packets 564
interface command 40
interface ethernet 0 command 40
interface serial command 628
interfaces. *See also* ports
displaying information for 179, 195
IP parameters, displaying settings 343, 380
routers 43–44
statistics, displaying 343, 380
summary information, displaying 343, 380
switches, numbering 180
Interior Gateway Routing Protocol. *See* IGRP
interior routing protocols 414
internal switch processing 174–175
International Telecommunications Union. *See* ITU
Internetworking Technology Multimedia. *See* ITM
Inter-Switch Link. *See* ISL
Inverse ARP 634–636, 796
IOS 32
CLI 27, 179
accessing 33
configuration mode 40
privileged exec mode 39–40, 59
user exec mode 39, 59
configuration file
managing 44
storing 44
distribute lists 718
image files
storing in Flash memory 50–53
upgrading into Flash memory 61
IP access lists
extended 512
displaying details of 499, 504, 519
matching options 505
standard 494, 503
configuration 767–768
controlling vty port access 516
displaying details of 499, 504, 519
matching options 504
planning 802
IP addresses 297–298, 375–376
address classes 299–302
ARP cache, displaying 343, 381
calculating 474, 485–486
CIDR 338–339
configuring 342–355, 471, 474, 480, 485, 783–785
on switches 181–183
connectivity, verifying 818
displaying 179, 195
format 309

Frame Relay hybrid full/partial mesh networks 642
grouping 118
host portion 298, 309, 376
hostnames, displaying 343, 380
identifying address structure 311–315
interfaces, displaying 343, 380
naming configuration 361–362
NAT 338–342
network masks 298, 376
network numbers 300–301
network portion 298, 309, 376
planning
prefix notation 339
Private Addressing 338–340
secondary addresses 355–357
structure 120, 129
subnetting 303–306
binary conversion 307–309
deriving subnet broadcast address 327–333
deriving subnet number 321–327
masks 298, 376
practice questions 943–988
subnet chart, creating 316–320
Telnet sessions 694
test preparation 310
translating for invalid hosts with NAT 342
wildcard masks 497, 518
IP RIP
configuration 767–768
versus IPX RIP 690, 727
IP routes
aggregating 452, 465
auto summarization 452, 465
equal-cost 452
metrics, displaying 778
static routes 785
troubleshooting 460
IP routing protocols 412
interior 462
routing tables, displaying 430, 464
ip access-group command 499, 503, 513, 518–520
ip access-list extended command 513, 520
ip access-list standard command 513, 520
ip address command 40, 179, 195, 343, 380
ip classless command 343, 365–370, 380
ip default-gateway command 179, 195
ip default-network command 343, 368, 380
ip domain-lookup command 343, 362, 380
ip domain-name command 362
ip host command 343, 362, 380
ip maximum-paths command 452
ip mtu command 361
ip name-server command 343, 362, 380
ip netmask-format command 343, 380
ip rip send version command 445
ip route command 367, 566
ip routing command 343, 380
IPX (Internetwork Packet Exchange) 684
access lists, SAP filters 721, 733
addresses 741, 751–752
displaying for neighboring routers 818
features 684, 725
Frame Relay hybrid full/partial mesh networks 642
node portion 697
secondary addresses 805
structure 120, 129, 683, 725
addressing 683–687
configuring 693–701, 747–754, 783–785
hands-on lab exercises 848–849
multiple networks on same link 689–690
on Frame Relay networks with point-to-point subinterfaces 703
on networks with multiple Ethernet encapsulations 707
connectivity, verifying 818
enabling on routers 696
encapsulation 687, 783–785
accomodating multiple types 805
extended access lists, 718
configuring 715–718
filtering logic 710
matching parameters 715, 731
socket parameter 716
Frame Relay with point-to-point subinterfaces
configuring 701–702
GNS requests 691–693, 728, 779
interface parameter settings, displaying 693, 729
multiple Ethernet encapsulations, configuring 703–704
named access lists, configuring 721–724
network deployment
configuration 802–805

planning 797–802
verifying configuration 806–820
network numbers, creating 696
packets
filtering 707–709
sending to verify connectivity 694, 729
RIP 690–691
versus IP RIP 727
router configuration 707
routing 684–687
updates, displaying 694, 729
routing tables, displaying 693–694, 729
SAP 691–693
filters, configuring 718–720, 733, 767–768
tables, displaying 694, 729
updates, displaying 694, 729
secondary addressing 689–690
standard access lists
configuring 709–715, 767–768
filtering logic 710
matching parameters 715, 731
versus SAP filters 720
traffic, displaying statistics on 694, 729
ipx access-group command 708, 722, 730, 733
ipx access-list command 708, 730
ipx access-list extended command 722, 733
ipx access-list sap command 722, 733
ipx access-list standard command 722, 733
IPX addresses
grouping 118
ipx delay command 700
ipx input-sap-filter command 708, 722, 730, 733
ipx maximum-paths command 693, 700, 729
ipx network command 693, 696, 703, 729
ipx output-sap-filter command 708, 722, 730, 733
ipx per-host-load-share command 701
ipx routing command 693, 696–698, 703, 729
ISDN (Integrated Services Digital Network) 820
backup usage 555
BRI 548–549
DDR parameters, displaying 562, 583
features 578
information, displaying 583
channels 548
CHAP 557–558
configuring 555–556
DDR 555, 560–562
connection termination, determining 568
determining the subset of packets that trigger dialing 565
dialing 567
legacy configuration 563–569, 571
dial in/dial out capabilities, enabling 561, 582
dial strings, defining 582
dialer groups, enabling 561, 582
function groups 551–555
home-based 554
incoming call numbers, defining 560, 582
interesting packets 582–583
LAPD 550
Layer 2 messages, displaying 562, 583
Layer 3 messages, displaying 562, 583
modems 554
Multilink PPP, configuring 558–559
out-of-band signaling 550
PAP 557–558
PPP 551
PRI 548–549
protocols 549–551
reference points 551–555
SBus 554–555
SBus topology 554
signaling 562
specifications 551
SPIDs 551
defining 560, 582
subaddresses 555
status information, displaying 561, 583
switches
configuration 569
defining to router 560, 582
isdn answer1 command 560, 582
isdn answer2 command 560, 582
isdn spid1 command 560, 582
isdn spid2 command 560, 582
isdn switch-type command 560–561, 569, 582
I-series ISDN protocols 549, 578

ISL (Inter-Switch Link) 236
tagging
configuring routers for 236
VLANs 236–237, 250
trunking 235–236
VTP pruning 239–240
ITM (Internetworking Technology Multimedia) 17
ITU (International Telecommunications Union) 547–549

J-K-L

keepalive command 628
key sequences, Ctrl+z 40

LAN addresses. *See* MAC addresses
LAN Emulation. *See* LANE 237, 250
LANE (LAN Emulation) 237, 250
LANs
collision domains 154
Ethernet
10-Mbps 151–157
CSMA/CD 152
frames 158–160
segmenting
with bridges 165–169, 177
with routers 177
with switches 170–174, 177
switching, internal processing 174–175
VLANs 230, 232–233
configuring 241–248
implementing 233–234
ISL trunking 235–236
trunking 234
VTP 237–238
LAPB (Link Access Procedure Balanced) 541, 572, 576
HDLC 539
strengths/weaknesses 572, 583
LAPD (Link Access Procedure on the D channel) 541, 576
ISDN 550
LAPF (Link Access Procedure Frame Bearer Services) 611, 615
LAT (Local Area Transport) 121
latency, decreasing with switch processing 174
Layer 1. *See* physcial layer
Layer 2. *See* data link layer
Layer 3 addressing. *See also* network layer
Frame Relay 621–625
fully-meshed networks, Frame Relay configuration 629–632
hybrid networks, Frame Relay configuration 641–646
Layer 2 address mappings 632–636
partially-meshed networks, Frame Relay configuration 637–641
Layer 3 processes 97
Layer 3 protocols 97
Layer 4. *See* transport layer
layers of OSI model 85–88
concepts 89–90
data link layer 105
addressing 107–108
arbitration 106–107
error detection 109
identifying encapsulated data 109–114
encapsulation 94–97
interaction between 90–94
network layer
addressing 118–119
routing 114–118
Transport layer 98
LCP (Link Control Protocol) 542–543, 578
Learning state (Spanning Tree) 229, 250
leased lines
synchronous serial leased lines 546
versus packet-switching 572–573
legacy DDR configuration 563
connection termination 567–568
sample configurations 568–571
signaling 565–567
triggering the dial 563–565
line aux command 33, 58
line console command 33, 58
line vty comand 33–34, 58
Link Access Procedure on the D channel. *See* LAPD
Link Quality Monitoring. *See* LQM
link state routing protocols 414–415
link-state routing protocols 415–416, 462
Listening state, (Spanning Tree) 229, 250

LLC (Logical Link Control) Type 2 106, 109
error recovery 102, 127
LMI (Local Management Interface) 609, 611–616, 796
local addressing 617
logging buffered command 37
logging host command 38
logging synchronous command 37
Logical Link Control. *See* LLC 106
login command 34
loop avoidance
detecting with LCP 577
distance vector protocol features 419, 422, 462–463
hold-down timers 426–428
poison reverse 425
route poisoning 428
split horizon 423–425
triggered updates 428
split horizon over Frame Relay 626–627
STP 220–223
convergence 227–229
designated port 226
forwarding state 223–224
root bridge election 224–225
timers 227
troubleshooting 423
looped link detection, PPP 543–544
lower layers of OSI reference model 85–86, 88
LQM (Link Quality Monitoring) 543–544, 577

M

MAC (Media Access Control) 105, 157, 714
BIAs 158
broadcast addresses 158
components 158
dynamic 183
features 158, 189
functional addresses 158
LAN card addressing 158
mapping to IP addresses 286–287
multicast addresses 158
OUI 158
permanent 184
restricted-static entries 184
switches, 179, 195
tables, displaying 180, 195
unicast 157
mac-address-table permanent command 179, 184, 195
mac-address-table restricted command 184
mac-address-table restricted static command 179, 195
magic numbers 543
managing configuration files 44–45
masks 298, 376
Class A networks 298, 376
Class B networks 298, 303, 376
Class C networks 298, 303, 376
subnet masks 298, 306, 376
display types, setting 344, 381
RIP-1/IGRP issues 440, 442
matching packet filtering criteria
extended IP access lists 504–508
standard access lists 500–502
MaxAge timer (STP) 227, 250
maximum transmission unit. *See* MTU
MD5 (Message Digest 5) 557
Media Access Control. *See* MAC
memory 43
Flash 43
read-only mode 53
routers 60
storing IOS images 50–53
verifying contents of 52
NVRAM 43, 60
RAM 43, 59
ROM 43, 59
Message Digest 5. *See* MD5
messages, ICMP 287
Destination Unreachable 289–291
Echo Request/Reply 275, 289
Redirect 293
Time Exceeded 291–293
metrics 416
administrative distance 459–460
equal-cost routes 452
hop count 418–419
IGRP 434
IP routes, displaying 778
IPX routes, displaying 778
ticks 690

migrating to IGRP 437–439
modems, ISDN 554
MTU (maximum transmission unit) 160, 360–361
mtu command 361
multiaccess Frame Relay networks 609
  broadcast handling 625–626
  configuring 628–646
  DLCI 616–620
  Layer 3 addressing 621–625
  LMI 614–616
  MAC addresses 158
  split horizon 626–627
  VCs 610, 612–614
multicast addresses 108, 128
Multilink PPP 558–559
multiple IPX network configuration 689–690
multiple switch VLAN configuration 244–248
multiplexing 276–277
  TCP 278–280
  T1 mux 539
  UDP 285

N

named IP access lists 512–515
  comparing to numbered access lists 513–514
named IPX access lists 724
  configuring 721–724
  versus standard and extended IPX access lists 721–722, 733
naming
  IP addresses 361–362
  VLANs 241–242, 251
NAT (Network Address Translation) 338–342
NBMA (nonbroadcast multiaccess) 611, 796
neighboring devices, discovery 370–372
NetBEUI 121
NetBIOS 121
NetWare versus OSI and TCP/IP 97–98
Network Address Translation. *See* NAT
network address. *See* network numbers
network command 430–432, 464
Network File System. *See* NFS
network layer (OSI reference model Layer 3) 84–89, 124
  addressing 118–119, 123, 136, 142
  ISDN specifications 550
  routing 114–118
network masks 298, 376
network numbers 297, 300–301, 375
  aggregating with CIDR 338–339
  Class A networks 299–302
  Class B networks 299–302
  Class C networks 299–302
  IPX
    creating 696
    planning 797
network service access point. *See* NSAP
Network Unreachable code (Destination Unreachable ICMP message) 290
networks 375.*See also* subnets
  Class A 302
    IP addresses 300
    masks 298, 376
    network numbers 302
    subnetting 306
  Class B 302
    IP addresses 300
    IP subnet design 396, 399, 402
    masks 298, 303, 376
    network numbers 302
    subnetting 306
  Class C 302
    IP addresses 300
    IP subnet design 397, 402, 405
    masks 298, 303, 376
    network numbers 302
    subnetting 306
  contiguous 448
  Frame Relay 609
    broadcast handling 625–626
    configuring 628–646, 783–785
    DLCI 616–620
    IP addressing 357–360
    Layer 3 addressing 621–625
    LMI 614–616
    planning 780–783
    split horizon 626–627
    VCs 610, 612–614
    verifying configuration 785–796

IPX
configuring 802–805
planning phase 797–802
verifying configuration 806–820
planning 762, 766
private Internets 340
Next-Hop Routers, routing table entries 418
NFS (Network File System) 88, 285
no address-violation command 186
no cdp enable command 371
no cdp run command 371
no debug all command 37, 438
no ip classless command 368
no ip domain-lookup command 362
no keepalive command 795
no router rip command 439
nonroutable protocols 120–121
nonvolatile random-access memory (NVRAM) 43, 60
Novell IPX
addressing 683–684, 686–687
configuring 693–701
encapsulation 687
Frame Relay with point-to-point subinterfaces 701–702
GNS requests 691–693
multiple Ethernet encapsulations 703–704
multiple networks on same link, configuring 689–690
RIP 690–691
routing 684, 686–687
SAP updates 691
filtering 718–720
secondary addressing 689–690
standard access lists, configuring 709–714
Novell NetWare. *See* NetWare
Novell-ether IPX Ethernet encapsulation 688, 726
Novell-fddi encapsulation 688, 727
NSAP (network service access point) 79
NT1 (Network Termination Type 1) 796
ISDN function group 553, 580
NT1/NT2 (Network Termination Type 1/Network Termination Type 2) ISDN function group 553, 580
NT2 (Network Termination Type 2) ISDN function group 553, 580
numbered IP access list, versus named IP access lists 513–514
numbering
router interfaces 44
switch ports 180
NVRAM (nonvolatile RAM) 43, 60
configuration files, erasing 46
routers 43, 60

O

Open Systems Interconnection reference model. *See* OSI reference model
operating systems, categories of 54
ordered data transfer 284
Organizationally Unique Identifier. *See* OUI
OSI (Open Systems Interconnection) reference model 79
application layer 85, 88, 124
benefits of layered model 125
current usage 85
data link layer 85, 89, 105, 124
addressing 107–108
arbitration 106–107
error detection 109
identifying encapsulated data 109–114
ISDN specifications 550
encapsulation 94–97
evolution of 84–85
interaction between layers 90–94
justification for 79
layers 85–90
network layer 85, 89, 124
addressing 118–119
ISDN specifications 550
routing 114–118
origin/evolution 85
phyical layer 85, 89, 124
ISDN specifications 550
presentation layer 85, 88, 124
session layer 85, 88, 124
tranport layer 85, 89, 98, 124
versus NetWare and TCP/IP protocol suites 97–98

OSPF (Open Shortest Path First) 415–416, 462
    auto summarization 452, 465
    route aggregation 452, 465
OUI (Organizationally Unique Identifier) 108, 158, 127
out-of-band signaling, ISDN 550
output (commands), comment lines 40

P

packet filtering
    extended IP access lists 503–505
        example 506–512
        placement of 507–508
    named IP access lists 512–515
    standard access lists 494
        configuring 498–503
        features 495–496
        matching logic 496–497
        wildcard masks 497–498
packets 97. *See also* datagrams
    default routing 365–370
    encapsulation 94–97
    flow control 102
        buffering 103
        congestion avoidance 103–104
        windowing 104
    fragmentation 360–361
    IGRP log messages, displaying 430, 464
    interesting 564, 583
    IP
        filtering 494
        log messages, displaying 343, 381
    IPX
        encapsulation 687
        filtering 707–718
        sending to verify connectivity 694, 729
    MTU 360–361
    multiplexing 276–277
packet-switching
packet-switching services 572
    ATM, strengths/weaknesses 573, 584
    Frame Relay, strengths/weaknesses 573, 584
    versus leased line technologies 572–573
    X.25, strengths/weaknesses 573, 584
PAP (Password Authentication Protocol) 543, 557–558, 578
Parameter Problem ICMP message 288
partial mesh networks 613–614
    configuring 637–641
Password Authentication Protocol. *See* PAP
passwords
    accessing CLI 34
    recovery 56
periodic updates 417
permanent MAC addresses 184
permit statements (access lists) 496, 517
physical layer (OSI reference model) 84–89, 95, 124
    ISDN specifications 550
ping command 275, 289, 350–355, 546, 694, 729, 776, 793
placement of extended IP access lists 507–508
planning phase, network deployment 762–766
    IPX networks 797–802
point-to-point data link protocols 546
point-to-point leased lines 591, 597– 603
point-to-point serial links, compression 544–546
poison reverse 423
port secure command 180, 185–186, 195
Port Unreachable code (Destination Unreachable ICMP message) 290
ports 279. *See also* interfaces
    console ports 34
    switches
        address violations 186
        assigning to VLANs 241–242, 251
        full-duplex 181, 183
        half-duplex 181, 183
        IP configuration, verifying 182–183
        MAC addresses, limiting associations with 185–186
        numbering 180
        security, setting 180, 185–186, 195
        VLAN membership, displaying 241, 251
    vty ports, controlling access with IP access lists 515–516
    well-known numbers 280
PPP (Point-to-Point Protocol), 538–541, 572, 576
    compression 544–546
    configuration 768
    configuring 541–542
    error detection 543–544

ISDN 551
LCP 542–543, 578
looped link detection 543–544
LQM 544
magic numbers 543
strengths/weaknesses 572, 583
ppp multilink command 559
Predictor (compression software) 578
preparing for exam
guidelines 22–24
IP addressing 310
creating subnet chart 316–320
deriving subnet broadcast address 327–333
deriving subnet number 321–327
identifying address structure 311–315
presentation layer (OSI reference model Layer 6) 84–88, 124
preventing routing loops
hold-down timers 426–428
poison reverse 425
route poisoning 428
split horizon 423–425
STP 222–223
convergence 227–229
designated port 226
forwarding state 223–224
root bridge election 224–225
timers 227
triggered updates 428
PRI (Primary Rate Interface) 548–549
Private Addressing 338–340
private Internets 340
privileged exec mode (Cisco IOS) 34, 39, 59
processors 43
Protocol Type field 540–541
Protocol Unreachable code (Destination Unreachable ICMP message) 290
protocols
connectionless 99, 126
connection-oriented 99, 126
ISDN 549–551
MAC105
nonroutable protocols 121
routed 123, 412
routing123, 412
comparison of 413, 416, 462
definition of 413
distance vector routing protocols 412
goals of 413
troubleshooting 460
pruning
VLANs 241, 251
VTP trunks 239–240
PVCs (permanent virtual circuits) 610–620

Q-R

Q-series ISDN protocols 549, 578

R ISDN reference point 554, 580
RAM (random-access memory) 43, 59
routers 43, 59
random-access memory. *See* RAM
read-only memory. *See* ROM
read-only mode, Flash memory 53
recalling commands 36
recommended CCNA training path 17–18
recommended study guidelines 22–24
recovering passwords 56
Redirect ICMP message 288, 293
Rediret messages 293
redundancy. *See* routing loops
reference points, ISDN 551–555
reliability of TCP 280
removing configuration files from NVRAM 46
resellers, required certification 4
restricted-static MAC address entrie 184
resume command 365
RIP (Routing Information Protocol) 407, 415
CCNA exam coverage 415–416
configuration 460
configuring 429–432
debug command output 435–437
enabling on IPX networks 703
features 429, 463
hop count 418–419
IP
configuration 767–768
versus IPX 690, 727
IPX 690–691
migration to IGRP 437–439
subnet masks, absence of in routing updates 440–442
updates, displaying log messages 430, 464
versus IGRP 429, 463

RIP-1 416, 462
auto summarization 452, 465
migrating to RIP-2 445
route aggregation 452, 465
subnet mask issues 440–442
RIP-2 416, 443, 446, 462, 464
advanced features 443–446
auto summarization 452, 465
configuration 443, 446
migration from RIP-1 445
route aggregation 452, 465
ROM (read-only memory) 43, 59
root bridge election process 224–225, 249
root port 223–225, 249, 777
route aggregation 446–451
route poisoning 422–423, 426–428
routed protocols 412
versus routing protocols 122–123
Router Advertisment and Selection ICMP message 288
router igrp command 430, 464
router rip command 430, 464
routers 818
auxiliary connections33, 58
CLI
hands-on lab 827–831
versus switch CLI 179
configuration
for ISL encapsulation 236
IGRP 460
IP 355, 471, 474, 480, 485, 783–785
IP RIP 767–768
IPX 707, 747–748, 752–754, 783–785
RIP 460
RIP-2 443, 446
configuration files
copying 45–46, 188, 196
erasing at reload time 188, 196
updating at reload time 188, 196
configuration register 55, 63
configuring with setup mode 46–50
console connections, configuring 33, 58
interfaces 43–44
IPX
enabling 696
parameter settings, displaying 693, 729
ISDN backup connections 555
memory 43
Flash 43, 60
NVRAM 43, 60
RAM 43, 59
ROM 43, 59
multiple Telnet connections 34
neighboring devices, discovery 370–372
Next-Hop routing table entries 418
OS categories 54
ports 34
processors 43
running configuration, viewing 46
Telnet connections, configuration 33, 58
telnetting, suspend function 362–365
version information, displaying 188, 196
versus bridges and switches 177
routes
counting to infinity 434
IP
aggregating 452, 465
auto summarization 452, 465
equal-cost 452
static 785
troubleshooting 460
split horizon 434
troubleshooting multiple routes to the same subnet 420
routing
address resolution 118
at network layer 114–118
IPX 686–687
updates, displaying 694, 729
loops, troubleshooting 423
protocol flows 175, 177
routing and switching certifications 5
Routing Information Protocol. *See* RIP
routing loops (STP) 220–223
convergence 227–229
designated port 226
forwarding state 223–224
root bridge election 224–225
root ports 225
timers 227
routing protocols 120, 123, 412–414
balanced hybrid routing protocols 415–416, 462
comparison of 413, 416, 462
definition of 413

distance vector 412–413, 416, 462
autosummarization 446–451
comparing 428–429
convergence 422, 462–463
equal-cost routes 420–421
hold-down timers 426–428
IGRP 433–434
loop avoidance 419, 422, 462–463
poison reverse 425
route aggregation 446–451
route poisoning 428
routing behavior 416–417
split horizon 423–425
triggered updates 428
goals of 413
link-state protocols 415–416, 462
terminology 414
troubleshooting 460
versus routing protocols 122–123
routing tables 122–123, 137
displaying 343, 381
distance vector protocols 417–418
IP, displaying 430, 464
IPX, displaying 693, 729
routing updates
absence of subnet masks, troubleshooting 440–442
timers 419
running configuration 44
viewing 46

S

S ISDN reference point 554, 580
S/T ISDN reference point 554, 580
same-layer interaction (OSI model) 93–94
sample TCP/IP network 272–273
SAP (Service Advertisement Protocol) 110, 407, 691, 707, 718
enabling on IPX networks 703
encapsulation 688–689
filters 721, 733
configuration 767–768
matching parameters 720, 733
versus IPX packet filters 720
packets, internetwork transactions 718
tables, displaying 778
timers 718
updates, filtering 707–709, 718–721, 733
SAP IPX Ethernet encapsulation 688, 727
SAP IPX FDDI encapsulation 727
SAP IPX Token Ring encapsulation 727
SAR (segmentation and reassembly) 572
saving switch configuration files to TFTP servers 180, 195
SBus topology (ISDN) 554–555
scenarios, network deployment
configuration 766–768
planning phase 762–766
verification 768–779
SDLC (Synchronous Data Link Control) 540–541, 576
secondary addresses
IP 355–357
IPX 689–690
security
authentication
CHAP 557–558
PAP 557–558
extended IP access lists 497, 503–505
example 506–512
named IP access lists 512–515
passwords, accessing CLI 34
standard access lists 494
configuring 498–503
features 495–496
hands-on lab exercises 842–844
matching logic 496–497
wildcard masks 497–498
switch ports, setting 180, 195
segmenting LANs
with transparent bridges165–169
with switches 170–174
sending syslog messages 38
serial WAN cabling 546–547
servers (TFTP), copying switch configuration files from 180, 195
Service Advertising Protocol. *See* SAP
session layer (OSI reference model) 84–88, 124
setup command 47
setup mode, router configuration 46–50
shared Ethernet 153
show access-list command 499, 708, 730, 769

show cdp entry command 371
show cdp interface command 372
show cdp neighbor command 371
show cdp neighbor detail command 371, 806
show compress command 546, 577
show controllers bri command 561, 583
show debug command 353
show dialer interface bri command 561, 569, 583
show flash command 52
show frame-relay lmi command 793, 813
show frame-relay map command 791–793, 815
show frame-relay pvc command 791, 819–820
show hosts command 343–344, 380–381
show interface command 349, 772, 788
show interfaces bri command 561–562, 569, 583
show interfaces command 179, 182, 195, 343, 380
show ip arp command 350, 775, 778, 792
show ip command 179, 182, 195
show ip host command 362
show ip interface brief command 343, 347, 380, 768, 786, 795, 806
show ip interface command 343, 348, 380, 499
show ip protocol command 430, 438–439, 464, 773, 789, 795
show ip route command 346, 348, 351–352, 434, 437, 439, 441, 447, 449, 460, 775, 778, 792, 795
    options 453–459
show ipx access-list command 708, 730
show ipx interface brief command 773, 786, 789
show ipx interface command 693, 696–697, 708, 729–730
show ipx route command 693, 698, 700, 729, 773, 778, 790, 795
show ipx servers command 694, 698, 700, 706, 729, 774, 778, 790, 793, 795, 807
show ipx traffic command 694, 729
show isdn active command 570
show isdn command 561, 583
show isdn status command 570
show mac-address-table command 180, 184–185, 195
show process command 546
show running-config command 179–181, 346–347, 350, 774, 791
show spantree command 248
show trunk command 247
show version command 180, 188, 195–196
show vlan command 243
show vlan-membership command 241, 247, 251
show vtp command 241, 247, 251
signaling, ISDN 562–567
single switch VLAN configuration 242–243
sliding windows 281
SNAP (Subnetwork Access Protocol) 110
SNAP IPX Ethernet encapsulation 688–689, 727
SNAP IPX FDDI encapsulation 727
SNAP IPX Token Ring encapsulation 727
sockets 278–280
Source Quench ICMP message 288
Spanning Tree 220–223
    blocking state 224, 249
    building initially 249
    CBPDUs 224, 249
    configuration status
        displaying for switches 248
    convergence 227–229
    designated port 224–226, 249
    election process 777
    features of 230
    forwarding state 223–226, 249, 778
    functions of 229–230
    hands-on lab exercises 836–838
    learning state 778
    listening state 778
    port states 226
    root bridges, electing 224–225, 249
    root ports 225, 777
    timers
        Forward Delay 227, 250
        Hello time 227, 250
        MaxAge 227, 250
    VLAN information, displaying 241, 251
SPF (shortest path first) algorithm 415
SPIDs (service profile identifiers) 551
    defining 560, 582
    subaddresses 555
split horizon 422–425, 434
    over Frame Relay 626–627
    with poison reverse 422, 425
SPX (Sequence Packet Exchange), error recovery 102, 127
STAC 543, 578
standard IP access lists 494, 503, 516
    applying to vty ports 515–516
    configuring 498–503, 767–768
    displaying 499, 504, 519

features 495–496
matching logic 496–497, 504
planning 802
standard IPX access lists 715
configuring 711–714, 767–768
matching 715, 731
startup configuration 44
static Frame Relay maps 783, 785
static IP routes 785
store-and-forward processing 174–175, 193
storing IOS images in Flash memory 50–53
subaddresses, ISDN SPIDs 555
subcommands 40
subinterfaces 624
subnet masks 298, 306, 308–309, 376
binary conversion 314
display types, setting 344, 381
RIP-1/IGRP issues 440, 442
subnet numbers 297, 375
displaying 818
subnets 118, 303–306, 375
absence of in routing updates, troubleshooting 440–442
binary conversion 307–309
contiguous 448
deriving from IP address information 474, 485–486
deriving subnet broadcast address 327–333
deriving subnet number 321–327
designing for Class B IP networks 396, 399, 402
designing for Class C IP networks 397, 402, 405
directly connected 416
equal-cost routes 420–421, 452
list chart, creating 316–320, 334–337
practice questions 943–988
supernetting 451
suspend function (Telnet) 362–365
SVCs (switched virtual circuits) 610–613
switches
1900 series 179
address violations 180, 195
autonegotiation 182
CLI 179
hands-on lab 831–832, 834–836
versus router CLI 179
configuring 179, 188, 196
as VTP clients 246
as VTP servers 246
duplex 181, 183
IP support 181, 183
methods of 179
configuration files
copying from TFTP servers 180, 195
copying to TFTP servers 187
displaying version information 180, 195
erasing at reload time 188, 196
managing 187–188, 196
saving to TFTP servers 180, 195
updating at reload time 188, 196
cut-through processing 174–175, 193
encapsulation
802.10 237, 250
802.1Q 237, 250
ISL 236–237, 250
LANE 237, 250
fragment-free processing 174–175, 193
internal logic 171
ISDN
configuration 569
defining to router 560, 582
ISL trunks 235
LANs 170–175
logic behind 170
MAC address tables
configuration 183, 186
displaying contents 183, 186
neighboring devices
discovery 370–372
learning about via CDP 372
ports
address violations 186
assigning to VLANs 241–242, 251
duplex settings, verifyin 182–183
full-duplex 181, 183
half-duplex 181, 183
IP configuration, verifying 182–183
MAC addresses, limiting associations with 185–186
numbering 180
security, setting 180, 185–186, 195
VLAN membership, displaying 241, 251
Spanning Tree configuration status, displaying 248
store-and-forward processing 174–175, 193
system files, managing 187–188, 196
trunks, hands-on lab 836–838

version information, displaying 188, 196
VTP configuration information 237, 247
SYN field, TCP connection establishment 283
Synchronous Data Link Control. *See* SDLC
synchronous serial data-link protocols, comparing 540–541
synchronous serial leased lines 538, 572, 575
clock source 575
compression 544, 546
HDLC 540, 572, 583
LAPB 540, 572, 583
PPP 540, 572, 583
syntax
extended IP access lists 507
named IP access lists 513–514
standard access lists 499–500
syslog messages 37
sending 38
viewing 37

T

T ISDN reference point 554, 580
T/1 lines 539, 575
T1 mux 539, 575
TA (Terminal adapter) ISDN function group 553, 580
TCP (Transmission Control Protocol) 98, 272, 277, 819
connections 282–284
error recovery 102, 127, 280, 796
features of 277
flow control 281–282
forward acknowledgment 280
functions of 284, 374
headers 278
multiplexing 278–280
ordered data transfer 284
sockets, connections 278–280
versus UDP 284–286
well-known port numbers 279
TCP/IP (Transport Control Protocol/Internet Protocol) 98, 267
ARP 286
ARP Broadcast 274
DNS 274
FTP 294–295
ICMP 287–288
Address Mask Request/Reply message 288
Code field 288
Destination Unreachable messages 288–291
Echo message 288–289
Echo Request/Reply messages 289
Parameter Problem message 288
Redirect message 288, 293
Router Advertisement and Selection message 288
Source Quench message 288
Time Exceeded messages 288, 291–293
Timestamp message 288
Type field 288
IP addressing 299
address classes 299–302
CIDR 338–339
configuring 342–354
deriving subnet broadcast address 327–333
deriving subnet number 321–327
identifying address structure 311–315
naming configuration 361–362
NAT 340–342
network numbers 300–301
over Frame Relay subinterfaces 357–360
private addressing 339–340
secondary addresses 355–357
subnet chart, creating 316–320
subnet list chart, creating 334–337
subnets 303–309
test preparation 310
sample network 272–273
TCP 277, 819
connection establishment/termination 282–284
error recovery 280
features of 277
flow control 281–282
forward acknowledgement 280
functions of 284, 374
headers 278
multiplexing 278–280

ordered data transfer 284
sockets 278–280
versus UDP 284, 286
TFTP 295–296
UDP 819
data transer 285
DNS 285
functions of 285, 374
multiplexing 285
NFS 285
versus TCP 284, 286
versus OSI and NetWare 97–98
TE1 (Terminal Equipment 1) ISDN function group 553, 579–580
TE2 (Terminal Equipment 2) ISDN function group 553, 579
TE2 (Terminal Equipment 2) devices 552
telco 539, 575
Telnet sessions
router connections, configuring 33–34, 58
multiple, resuming 365
suspend function 362–365
telnet command 362
terminal history size command 36
terminal ip netmask command 350
terminal ip netmask-format command 343, 346, 381
terminating TCP connections 283
terminology, routing protocols 414
testing locations 3
TFTP (Trivial File Transfer Protocols) 180, 195, 295–296
TIA (Telecommunications Industry Association), WAN cabling standards 547
ticks 690
Time Exceeded ICMP message 288, 291–293
timers
routing update timers 419
SAP 718
STP 227
Timestamp ICMP message 288
Token Ring 105–108
arbitration 106
encoding 113
functional addresses 128, 158
IEEE standards 162, 191
IPX encapsulation 688–689, 727
topics covered on CCNA 8–15
cross reference to chapters 16–17
study tips 19–21
trace command 291, 776, 778, 793
traffic
filtering with access lists 494–496
IP 494
SAP updates 707–720
flow control 102
buffering 103
congestion avoidance 103–104
windowing 104, 281–282
interesting 582
IPX, displaying statistics on 694, 729
traffic-share balanced command 452
traffic-share command 430, 464
trailers 93
training path for CCNAs 17–18
Transmission Control Protocol. *See* TCP
transparent bridging 165–169
transparent VTP mode, enabling 239, 242
Transport Control Protocol/Internet Protocol. *See* TCP/IP
transport layer (OSI reference model Layer 4) 84–89, 124
connection-oriented/connectionless protocols 98, 126
error recovery 99, 127
flow control 102, 105
triggered updates 422, 428
troubleshooting
distance vector routing protocols 453–460
IP routes 460
multiple routes to the same subnet 420
non-transmission of subnet masks 440–442
routing protocols 460
trunk command 241, 244, 251
trunks 215, 234
configuration 241, 247, 251
hands-on lab exercises 836–838
ISL 235–236
status, displaying 241, 251
verifying configuration 248
VTP 237–238
two-wire circuits 539

U

U ISDN reference point 554, 580
UAAs (Universally Administered Addresses)158
UDP (User Datagram Protocol) 272, 284, 819
  data transfer 285
  DNS 285
  functions of 285, 374
  multiplexing 285
  NFS 285
  versus TCP 284–286
undebug all command 769
unicast addresses 127
unicast MAC addresses 157
Universally Administered Addresses (UAAs) 518
unreachable codes (ICMP) 290
updating configuration files 39
upgrading images into Flash memory 50–53
upper layers of OSI reference model 85–86, 88
User Datagram Protocol. *See* UDP
user exec mode, IOS CLI 34, 39, 59

V

V.35 WAN cabling standard 547
variance command 430, 452, 464
VCs (virtual circuits)108, 610–620
verifying IPX network configuration 806–820
viewing
  running configuration 46
  syslog messages 37
virtual LANs. *See* VLANs
vlan command 242
vlan-membership command 242
VLANs (virtual LANs) 230–233, 243
  configuring 241
    for multiple switches 244–248
    for single switch 242–243
  defining 241, 251
  hands-on lab exercises 836–838
  implementing 233–234
  membership, displaying 241, 251
  naming 241–242, 251
  numbering 242
  parameters, verifying 243
  pruning 239–241, 251
  Spanning Tree information, displaying 241, 251
  summary information, displaying 241, 251
  switch ports, assigning to 241–242, 251
  tagging 234
    802.10 237, 250
    802.1Q 237, 250
    ISL 236–237, 250
    LANE 237, 250
  trunking 235–236
    configuration 241, 247, 251
    status, displaying 241, 251
    verifying configuration 248
  VTP 237
    advertisements 237–238
    client mode 238–239, 251
    clients, configuring switches as 246
    configuring 247
    mechanics of 237–239, 251
    modes of operation 238
    parameters, resetting to defaults 241, 251
    pruning 239–240
    server mode 238–239, 251
    servers, configuring switches as 246
    status, displaying 241, 251
    transparent mode 238– 242, 251
VLSM (variable-length subnet mask) 315
VTP (VLAN Trunking Protocol) 215, 237
  advertisements 237–238
  client mode 238–239, 251
  configuration, displaying 247
  mechanics of 237, 239, 251
  modes of operation 238
  parameters, resetting to defaults 241, 251
  pruning 239–240
  server mode 238–239, 251
  servers 237
  status, displaying 241, 251
  transparent mode 238–242, 251
vtp command 241–242, 247, 251
vtp trunk pruning-disable command 241, 251
vty ports
  access lists, applying 515–516
  controlling access with IP access lists 515–516

W

WANs
- 2-wire circuits 575
- 4-wire circuits 575
- asynchronous serial leased lines 539, 575
- cabling standards 546–547
- comparing 571–574
- data-link protocols
  - comparing 540–541
  - configuring 541–542
  - Protocol Type field 540–541
- DSU/CSU 575
- error recovery 540
- four-wire circuits 539
- Frame Relay 609
  - broadcast handling 625–626
  - configuring 628–646
  - DLCI 616–620
  - Layer 3 addressing 621–625
  - LMI 614–616
  - split horizon 626–627
  - VCs 610, 612–614
- HDLC protocol, compression 544, 546
- ISDN 548
  - channels 548
  - CHAP 557–558
  - configuring 555–556
  - DDR 560–562
  - function groups 551–554
  - home-based 554
  - legacy DDR configuration 563–571
  - multilink PPP 558–559
  - out-of-band signaling 550
  - PAP 557–558
  - protocols 549–550
  - reference points 551–554
  - SPIDs 551
- LAPB protocol, compression 544, 546
- layers 573–574
- packet-switching services 572
- PPP 541
  - compression 544–546
  - error detection 543–544
  - LCP 542–543, 578
  - looped link detection 543–544
  - protocols
    - HDLC 539, 576
    - LAPB 539, 576
    - LAPD 541, 576
    - PPP 539, 576
    - SDLC 540–541, 576
  - synchronous links 538
  - synchronous serial leased lines 538, 572, 575
  - two-wire circuits 539

well-known port numbers 279–280

wildcard masks 497–498
- extended IPX access list concerns 717
- IP addresses 497, 518
- standard IPX access lists 713–714

windowing, TCP flow control 281–282

write erase command 46, 188, 196

write terminal command 350

X-Y-Z

X.21 WAN cabling standard 547

X.25 572–573, 584