**Numerics**

0.0.0.0/0 routes, 115-117

**A**

ABRs, 201, 208-210
access layer, 5
access lists, 18, 451. See also distribute lists
administrative distance, 305
applying, 457
descriptions, configuring, 456
dynamic access lists, 459-462
extended, 451-452, 463-465
named, 453-454
reflexive, 465-470
standard, 451-452
time-based, 454-456
accessibility, 20-21
acknowledgments
link-state (OSPF), 150
LSAs, 153
ACKs, EIGRP, 260
ACLs (access control lists), 18. See also access lists
active routes, 257
active state (BGP FSM), 345
adaptability, 20
adding
private AS numbers, 372-375
remarks to access lists, 456
special characters, 382
static routes, 104
addresses
allocation, 50-51
overloading, 71
adjacencies
EIGRP, 250-253
OSPF, 151
establishing, 160
Hello Protocol, 155
point-to-multipoint, 181
administrative distance, 110-111, 303-308
administrative states, 60
administrator tag (EIGRP), 259
advanced distance-vector routing protocols, 107. See also EIGRP
advertisements
customer routes, 339
directly connected static routes, 105
LSAs, 113-114, 202-204
aggregatable global unicast addresses, 54-55
aggregation, 19, 48-50, 59-60
EIGRP, 272-273, 286-288
OSPF, 211-212
AGGREGATOR attribute, 378
anycast addresses, IPv6 53
AppleTalk 108, 247
applets, 479-480
application layer inspection rules, CBAC, 478-480
applying
access lists, 457
administrative distance, 305
BGP route maps, 366-367
routing policies, 298-300, 381-382
Area ID field, OSPF packets, 158
areas, 149, 200
ABRs, 201
comparing, 205
OSPF, 204-209
NSSAs, 218-221
stub areas, 213-215
totally stubby areas, 213-215
AS_PATH attribute, 371-372
lab exercises, 399-402
private AS numbers, 372, 375
AS_SEQUENCE list, 371
ASBRs (autonomous system boundary routers), 202, 210
ASs (autonomous systems), 337
BGP symmetry, 429
IBGP, 362-363
imported routes, 308
number, 338
multihomed nontransit, 340
multihomed transit, 342
nontransit, 340
single-homed, 339, 430
multihomed, 431-433
assigning
IP addresses, 39-45
DHCP, 75-77
EasyIP, 79-80
point-to-point, 56-58
IP unnumbered, 74
loopback addresses, 168-170
neighbors, 183
priority values, 161
private IP addresses, 61-62
NAT, 63-71
point-to-point WAN links, 61
ATOMIC_AGGREGATE attribute, 376-378
attributes (BGP)
  AGGREGATOR, 378
  AS_PATH, 371-375
  ATOMIC_AGGREGATE, 376-378
  COMMUNITIES, 419-422
  LOCAL_PREF, 378
  MULTI_EXIT_DISC, 383
  NEXT_HOP, 368-371
  ORIGIN, 386
  WEIGHT, 382
authentication, 172-173
Authentication Data field, 158
Authentication Type field, 158
automatic summarization, 272
automatic updating of static routes, preventing, 117
autonomous system external link entry LSAs, 204

B
backbone
  areas, 204
  OSPF, 215-217
  routers, 201
bandwidth
  efficiency, 18-19
  field, 255
basic operation, BGP 342-344
BDRs (backup designated routers), 155, 161-162
election process, 179
priority value, 170-171
Bellman-Ford algorithm, 112
best path
  BGP, 364-365
  EIGRP, 266
  route of last resort, 114
BGP
  ASs, 337-340
  attributes
    AGGREGATOR, 378
    AS_PATH, 371-375
    ATOMIC_AGGREGATE, 376-378
    COMMUNITIES, 419
    LOCAL_PREF, 378
    MULTI_EXIT_DISC, 383-385
    NEXT_HOP, 368-371
    ORIGIN, 386
    WEIGHT, 382
    basic operation, 342-344
    border routers, 342
    configuring, 353-358
    default routing, 427-429
distribute lists, 414-415
dynamic injection, 434-437
FSM, 344
IBGP, 362-363
keepalive messages, 343
lab exercises, 391-393
load balancing, 430
multihomed ASs, 431-433
neighbors, 342
  negotiation, 344-353
relationships, 354
NLRI, 411
packets, 346-347
peer groups, 423
  configuring, 424-425
  lab exercises, 447-448
prefix lists, 415-419
redistribution, 434-437
redundancy, 426-429
route filtering, 411-419
routing policies
  decision process, 386
  implementing, 366-367, 421-422
routing process model, 364
RRs, 407-411
single-homed ASs, 430
speakers, 342
static injection, 434-437
symmetry, 429
synchronization, 362-363
update messages, 350-353
verifying, 358-359
withdrawn routes, 343
blocking Java applets, 480
BootP, 76
border routers, 342
boundary routers, 300, 303
bounded updates, 245
broadcast addresses, 39
broadcast multiaccess networks, 154
building
  EIGRP, 264
  OSPF, 163-164

calculating
  EIGRP metric, 243
  IGRP metric, 243
candidate routes, flagging, 118-122
case studies, RIP/OSPF redistribution, 315-320
CBAC (content-based access control), 470-472
collection example, 483-489
configuring, 473-475
global timeouts, 482
inspection rules, 477-482
thresholds, 482
verifying, 483
CEF (Cisco Express Forwarding), 6
characteristics of scalable networks
  accessibility, 20-21
  adaptability, 20
  availability, 12-14
  efficiency, 18-19
  reliability, 12-14
responsiveness, 15-17
checksum field, OSPF packets, 158
CIDR (classless interdomain routing), 48
address allocation, 50-51
network prefixes, 102
route aggregation, 48-50
Cisco Connection Online Web site, 471
Cisco IOS commands
clear ip bgp, 358
clear ip route, 306
debug ip ospf events, 152
debug ip routing, 111
default-information originate, 117
distance, 95 305
distribute-list, 296-297
EasyIP, 75, 79-80
helper addresses, 80-84
ip as-path access-list, 381-382
ip default gateway, 116
ip dhcp excluded-address, 78
ip dhcp pool room 12, 77
ip nat inside source, 66
ip ospf cost, 172
ip policy route-map, 300
ip route, 104, 298
ip subnet-zero, 46, 55
ip-default network, 118-122
maximum-paths, 430
metric maximum-hop, 112
neighbor, 177, 355
network, 166-167, 353-356
no synchronization, 363
passive-interface, 316
redistribute rip, 210, 308
redistribute static, 117, 122
route-map, 298
router ospf, 165-166
service dhcp, 77
show ip bgp neighbors, 359
show ip ospf, 222
show ip protocols, 166-297
show ip route, 101
show ip route summary, 302
traceroute, 11
variance, 244
switching modes, 6
Class A IP addresses, 38-39
Class B IP addresses, 40
Class C IP addresses, 40
Class D IP addresses, 41
Class E IP addresses, 42
classful boundaries, EIGRP, 272
classful IP addresses
broadcast addresses, 39
Class A, 38-39
Class B, 40
Class C, 40
Class D, 41
Class E, 42
classful, 39
dotted decimal notation, 36
depletion of, 46-47
host addresses, 39
loopback addresses, 38
subnet masking, 42-46
classless interdomain routing (CIDR), 48
clear ip bgp command, 358
clear ip route command, 306
client configuration, DHCP, 76-77
custers (RRs), 409
Codes legend, IOS routing tables, 108
commands
clear ip bgp, 358
clear ip route, 306
debug ip ospf events, 152
debug ip routing, 110-111
default-information originate, 117
default-metric, 314
default-router, 79
distance, 95, 305
distribute-list, 294-297
dns server, 79
domain-name, 79
ip as-path access-list, 381-382
ip default-gateway, 116
ip dhcp excluded-address, 78
ip dhcp pool room 12, 77
ip forwarded-protocol, 81
ip helper address, 80
ip nat inside source, 66
ip ospf cost, 172
ip policy route-map, 300
ip route, 104, 298
ip subnet-zero, 46, 55
ip-default network, 118-122
lease, 79
maximum-paths, 430
metric maximum-hop, 112
neighbor, 177, 355
netbios-name-server, 79
Index

542

network, 78, 166-167, 353-356
no synchronization, 363
passive-interface, 292-294, 316
redistribute rip, 210, 308
redistribute static, 117, 122
remark, 456
route-map, 298
router ospf, 165-166
service dhcp, 77
show ip bgp, 359
show ip bgp neighbors, 359
show ip dhcp, 79
show ip ospf, 297
show ip protocols, 166, 297
show ip route, 101
show ip route summary, 302
traceroute, 11
variance, 244
communicate, 317
COMMUNITIES attribute, 419-422
comparing
dynamic and static routing protocols, 103
EBGP and IBGP peer groups, 425
EIGRP and OSPF, 242
OSPF area types, 205
RIPv1 and RIPv2, 59
compatibility, EIGRP and IGRP, 242-246
configuring
access lists
descriptions, 456
reflexive, 467-470
BGP, 353-358
default routing, 427-429
distribute lists,
414-415
EBGP multihop,
356-358
lab exercises, 391-393
peer groups, 424-425
prefix lists, 415-419
CBAC, 473-477, 483-489
default routes, 115-122
default routing, 140-143
default static routes, 116
DHCP servers, 77-79
distribute lists, 323-329
dynamic NAT, 64-68
dynamic routing, 106
EIGRP, 269-271
lab exercises, 280-288
passive interfaces, 297
route summarization, 272-273
firewall guidelines, 475-476
floating static routes, 125-126
lab exercises, 144-146
helper addresses, 80-84
IGRP, 394-398
lab exercises, 138-140
maximum hop count, 112
lock-and-key, 461-462
multiarea OSPF, 207-209
ABRs, 210
ASBRs, 210
flooding LSUs, 208
NSSAs, 218-221
route summarization, 211-212
stub areas, 214-215
totally stubby areas, 214-215
updating the routing table, 209
verification, 222
multiple routing protocols, 300-306
NAT address overload, 71-72
OSPF
dlabor exercises, 189-194
process IDs, 165-168
single-area, 165-174
OSPF network types, 183
passive interfaces, 292-294, 323-329
policy routing, 298-300
redistribution
default-metric command, 314
one-way, 308-310
RIP/OSPF, case study, 315-320
two-way, 311-313
routes
filters, 294-296
maps, 329-331
redistribution, 306-307
reflection, 409-411
static NAT, 68-71
static routes on null0 interfaces, 489-490
static routing, 104-106
VLSM on routers, 57-58
congestion, controlling, 13
connect state (BGP FSM), 345
connected routes, 313
connection establishment, BGP, 344-350
connectivity
Internet, 46
loopback addresses, 38
content-based access control. See CBAC
controlling
congestion, 13
IPX RIP in EIGRP
- networks, 269-270
- routing updates, 291
  - passive interfaces, 292-294
  - route filters, 294-298
  - SAP updates in EIGRP networks, 270-271
-convergence, 13, 112, 126-127
  - EIGRP, 261, 264
  - link-state routing, 114
  - converting octets to dotted decimal notation, 36
-core layer, 4-8
-cost, OSPF, 150, 171-172
-counting hops, 11
-custom queuing, 17
-customer routes, advertising, 339

Data Structures, EIGRP, 250-259

Databases
- link-state, 113
- OSPF, 153
- DBD (database description), 150-152
- DDR (dial-on-demand routing), 19
-dead intervals
  - configuring, 174
  - PSPF hello packets, 159
-debug commands, EIGRP, 275
-debug ip ospf events command, 152
-debug ip routing command, 110-111
-decision process
  - BGP routing policy model, 386-387

time versus event-driven routing protocols, 128-129
-dedicated leased lines, accessibility, 20
-default routing, 114
-BGP, 427-429
- configuring,
  - lab exercises, 140-143
  - static routes, 115
  - configuring, 118-122
  - local domains, 122-124
  - quad-zero routes, 115
-default UDP forwarded services, 80
-default-free routers, 47-48
-default-information originate command, 117
-default-metric command, 314
-default-router command, 79
-defining
  - CBAC inspection rules, 477-482
  - NAT pools, 67
  - route maps, 298
  - demand caching, 6
  - depletion of IP addresses, 46-47
  - descriptions (access lists), 456
-devices
  - routers
    - access routers, 10
    - BGP speakers, 342
    - boundary routers, 300
    - CIDR-compliant, 49-50
    - configuring VLSM, 57
    - core routers, 5-8
    - default-free, 47-48
    - distribution routers, 8-9
    - passive interfaces, 292-294
-DHCP, configuring, 75-79
-dial backup, 14
dialup links, accessibility, 20
diffusing computation, 264
-Diffusing Update Algorithm (DUAL), 245
-Dijkstra algorithm, 113, 149, 163
directly connected routes, 313
disabling fast switching, 6
discontiguous subnets, 62
discovery
  - EIGRP, 248, 264
  - OSPF, 162, 163
discretionary well-known attributes (BGP), 376-378
-AGGREGATOR, 378
-LOCAL_PREF, 378-381
-WEIGHT, 382
displaying
  - link-state database, 222
  - NAT translation information, 73
  - TCP/IP routing table, 101
distance95 command, 305
distance-vector routing protocols, 18, 107, 112-113
distributed switching, 7
distribute-list command, 294-297
distribute lists, 298, 323-329
-BGP route filtering, 413-419
-configuring, 414-415
dns-server command, 79
documentation, RFCs, 35
domain-name command, 79
domains, 122-124. See also ASs
-DoS (denial of service) attacks, 472
dotted decimal notation, 36
Index

544

down state, OSPF interfaces, 151
DRs (designated routers), 154
electing, 161-162, 179
priority value, 170-171
DUAL (Diffusing Update Algorithm), 245-249, 257
dummy AS numbers,
  prepending to AS_PATH list, 375
dynamic access lists, 459-462
dynamic NAT
  configuring, 64-68
  monitoring, 73
dynamic queuing, WFQ, 17
dynamic redistribution, 434-437
dynamic route injection, BGP 434-437
dynamic routing, 102
  comparing to static, 103
  configuring, 106
  routing updates, 291
    passive interfaces, 292-294
    route filters, 294-298
basic operation,
  342-344
border routers, 342
COMMUNITIES, 419-422
configuring, 353-358
FSM, 344-347
load balancing, 430
LOCAL_PREF, 378-381
MULTI_EXIT_DISC, 383-385
neighbor negotiation, 344-347
NEXT_HOP, 368-371
ORIGIN, 386
peer groups, 423-425
redistribution, 434-437
redundancy, 426-429
symmetry, 429
synchronization, 362-363
verifying basic operation, 358-359
WEIGHT attribute, 382
policy routing, 298-300
EIGRP (Enhanced Interior Gateway Routing Protocol), 241
  best path, 266
  comparing to OSPF, 242
  compatibility with IGRP, 242-246
  configuring
    IP networks, 268
    IPX networks, 269-271
    lab exercises, 280-288
debbug commands, 275
DUAL, 248-249
feasible successors, 249
hold time, 251
metric, 243
neighbors
discovery/recovery, 248
table, 250-252, 264
packet types
  ACKs, 260
  hello, 260
  queries, 261
  replies, 261
  updates, 261
passive interfaces, 297
PDMs, 250
queue count, 251
routes, 264-266
routing table, 252-253
RTP, 248
successors, 249
summarization, 272-273
support for AppleTalk, 247
support for Novell IPX, 246
topology table, 253-259
  active routes, 257
  convergence, 261, 264
  feasible successors, 256
  passive routes, 257
  recomputation of routes, 257
  routes, 257-259, 266-267
unequal-cost load balancing, 244
verifying operation, 274
E
EasyIP, 75, 79-80
EBGP (External BGP), 342
  configuring, 356-358
  sessions, 354, 394-398
efficiency, 18-19
EGP3, precursor to BGP, 338
EGPs (exterior gateway protocols), 106, 337
BGP
  AGGREGATOR, 378
  AS_PATH, 371-375
  ASs, 337-342
  ATOMIC_AGGREGATE, 376-378
  basic operation, 342-344
  best path, 266
  comparing to OSPF, 242
  configuring, 353-358
  FSM, 344-347
  load balancing, 430
  LOCAL_PREF, 378-381
  MULTI_EXIT_DISC, 383-385
  next Hop, 368-371
  ORIGIN, 386
  peer groups, 423-425
  redistribution, 434-437
  redundancy, 426-429
  symmetry, 429
  synchronization, 362-363
  verifying basic operation, 358-359
  WEIGHT attribute, 382
  policy routing, 298-300
  EIGRP (Enhanced Interior Gateway Routing Protocol), 241
    best path, 266
    comparing to OSPF, 242
    compatibility with IGRP, 242-246
    configuring
      IP networks, 268
      IPX networks, 269-271
      lab exercises, 280-288
debbug commands, 275
DUAL, 248-249
feasible successors, 249
hold time, 251
establishing BGP connections
  FSM states, 344-347
  Keepalive message, 350
  Notification message, 348
  Open message, 347-348
  Update message, 350-353
neighbor relationships
  BGP, 354-355
  EIGRP, 248
router adjacencies (OSPF), 160
event versus time-driven routing protocols, 128-129
events
  CBAC, 483-489
  RIP/OSPF redistribution, 315-320
Exchange state, OSPF interfaces, 152
exhaustion of IP addresses, 46-47
ExStart state, 152, 162-163
extended access lists, 451-452
BGP policy routing, 366-367
dynamic access lists, 459-462
established argument, 463
syntax, 452
exterior gateway protocols.
  See EGP
external interfaces, configuring, 476
external routes
  OSPF, 206
  summarization, 211
fast switching, 6
fault tolerance
  BGP, 426-429
  EIGRP, 283-285
FD (feasible distance), 255
feasible successors, 246, 249
FIB (Forwarding Information Base), 6
fields
  BGP packets, 346-347
  IPv6 aggregatable global unicast addresses, 54-55
  OSPF packets, 157-159
FIFO (first in, first out) queuing, 16
firewalls, 451, 475-476
flagging candidate routes, 118-122
flapping links, 164
floating static routes, 111, 124
configuring, 125-126
lab exercises, 144-146
flooding LSUs to multiple areas, 208
forwarding databases, 149
packets to local domains, 122
Forwarding Information Base (FIB), 6
FP field, aggregatable global, 54
FSM (finite-state machine), 344
BGP, 344-347
DUAL, 248-249, 257
full adjacency states, 153-154
full-mesh Frame Relay, 177-178
gateway of last resort, 47-48, 118-122
global timeouts, CBAC, 482
guidelines for configuring firewalls, 475-476
header information, OSPF packets, 157-158
hello intervals, 260
configuring for single-area OSPF routers, 174
fields, 159
hello packets
  EIGRP, 260
  OSPF, 150, 159
Hello Protocol (OSPF), 155
helper addresses, 80-84
hexadecimal notation, IPv6, 53
hierarchical network design model, 3-5
hierarchical routing, 200
OSPF 201, 210
multiarea configuration, 207-209
protocols, 213-216
route summarization, 211-212
virtual links, 216-217
hold time, EIGRP, 251
hops, 11-12
hosts
  addresses, 39, 42-46
  groups, 41
hub-and-spoke topologies, 179
hybrid routing protocols, 114, 243
EIGRP, 107, 241
ACKs, 260
comparing to OSPF, 242
compatibility with IGRP, 242-246
configuring, 268-271
convergence, 261, 264
DUAL, 248, 249
feasible successors, 249
hello packets, 260
hold time, 251
neighbor discovery/recovery, 248
neighbor table, 250-252
PDMs, 250
queries, 261
queue count, 251
replies, 261
routes, 264-273
routing tables, 252-253
RTP, 248
successors, 249
support for AppleTalk, 247
support for Novell IPX, 246
topology table, 253-259
unequal-cost load balancing, 244
updates, 261
verifying operation, 274

IDA (Internet Assigned Numbers Authority), 338
IBGP (Internal BGP), 342
comparing to EBGP peer groups, 425
configuring, 424
peering, 362-363
sessions, 354, 394-398
idle state (BGP FSM), 344
IGPs (interior gateway protocols), 106, 337
IGRP
compatibility with EIGRP, 242-246
configuring, 138-140
gateway of last resort, 118-121
maximum hop-count, 112
implementing BGP routing policies, 366-367, 421-422
imported routes, seed metric, 308
inbound access lists, 457
incremental routing updates, 19
Init state, OSPF interfaces, 151
initiating routing updates, 128-129
injecting BGP routes inside an AS, 361-363
input policy engine, 365
inside global addresses (NAT), 64
inside local addresses (NAT), 64
inspection of packets. See CBAC
inspection rules, CBAC, 477-481
interarea route summarization, 211
interarea routing, 200-201
Interface ID fields, 55
interface identifier, IPv6 unicast addresses, 54
interface states (OSPF), 150-154
interfaces
access lists, 457
authentication, 172-173
external, 476
loopback. See loopback interfaces
null0, 489-490
passive
configuring, 292-294
EIGRP, configuring, 297
point-to-multipoint, 181-183
route flapping, 60
interior gateway protocols (IGPs), 106, 337
internal interfaces, CBAC, 477
internal routers, 201
Internet Assigned Numbers Authority (IANA), 338
Internet community value (BGP), 419
Internet routing table, 48
Internetwork Packet Exchange (IPX) 108
IP addresses
CIDR, 48-51
classful, 36-37
broadcast addresses, 39
Class A, 38-39
Class B, 40
Class C, 40
Class D, 41
dotted decimals, 36
destination addresses, 39
localhost, 38
loopback addresses, 38
network number, 39
subnet masking, 42-45
depletion of, 46-47
DHCP, 75-79
EasyIP, 79-80
EIGRP configuration, 268
gateway addresses, 80-84
private (NAT), 63-71
multicast addresses, 41
NAT, 71-73
point-to-point WAN links, 56
route summarization, 59-60
VLSM, 55-59
ip as-path access-list command, 381-382
ip default-gateway command, 116
ip dhcp excluded-address command, 78
ip dhcp pool room 12 command, 77
ip forward-protocol command, 81
ip helper-address command, 80
ip nat inside source command, 66
ip ospf cost command, 172
ip policy route-map command, 300
ip route command, 104, 298
IP routing protocols, 108-111
ip subnet-zero command, 46, 55
IP unnumbered, 74
ip-default network command, 118-122
IPv6, 53-55
IPX (Internetwork Packet Exchange), 108
EIGRP compatibility, 247
configuration, 269-271
SAP, 270-271
ISPs (Internet service providers)
customer routes, 339
routing domains, 48

J-L
Java applets, 479-480
Keepalive message, 343, 350
lab exercises
AS_PATH attributes, 399-402
BGP configuration, 392-394
peer groups, 447-448
route filters, 442-445
route reflectors, 442-445
configuring
default routing, 140-143
floating static routes, 144-146
IGRP, 138-140
OSPF, 189-194
point-to-multipoint OSPF over Frame Relay, 195-197
distribute lists, 323-329
EIGRP, 283-288
IBGP/EBGP sessions, 394-398
LOCAL_PREF attributes, 402-405
MED attributes, 402-405
migrating from RIP to EIGRP, 134-137
redistribution, 325-334
route map configuration, 329-331
layered models, 3-5
lease command, 79
legacy technologies, 108
Length field, BGP packets, 347
limitations of NAT, 72
link-state protocols, 222
link-state requests (OSPF), 150
link-state routing protocols, 107, 155
Dijkstra algorithm, 113
LSAs, 113-114
OSPF, 149
ABRs, 201, 210
adjacencies, 151
areas, 204-205
ASBRs, 202, 210
backbone, 201, 215-216
BDRs, 155
comparing to EIGRP, 242
cost, 150
creating multiple areas, 199-200
databases, 153
Dijkstra algorithm, 149
discovery process, 162-163
DRs, 154
external routes, 206
forwarding database, 149
hierarchical topology, advantages of, 200
interface states, 150-154
internal routers, 201
LSAs, 202-204
multiarea configuration, 207-212
network types, 154-155
NSSAs, configuring, 218-221
over nonbroadcast networks, 174-183
packets, 150
Index

548

process IDs, configuring, 165-168
router operation, 159-165
single-area configuration, 165-174
SPF algorithm, 163 stub areas, 213-215
totally stubby areas, 213-215
virtual links, 216-217
wildcard bitmasks, 167
link-state updates (OSPF), 150
load balancing, 13
BGP traffic, 430 unequal-cost (EIGRP), 244
load fields, 255
loading state, OSPF interfaces, 152
local computation, 263
local domains, 122-124
LOCAL_PREF attribute, 378-381
default primary routes, 427-428
lab exercises, 402-405
local-as community value (BGP), 419
localhost, 38
lock-and-key, 459-462
loopback addresses, 38
loopback interfaces
assigning router IDs, 158 configuring for single-area OSPF, 168-170
LSACKs (link-state acknowledgments), 153
LSAs (link-state advertisements), 113-114, 202-204
LSRs (link-state requests), OSPF 152
LSUs (link-state updates), OSPF 152, 208
M
maintaining
OSPF routing tables, 164-165
routes in EIGRP topology table, 266-267
mandatory well-known attributes
AS_PATH, 371-375
NEXT_HOP, 368-371
ORIGIN, 386
Marker fields, BGP packets, 347
maximum hop counting, 112
maximum-paths command, 430
MED attribute
BGP, 383-385
lab exercises, 402-405
messages
BGP
Keepalive, 350
Notification, 348
Open, 347-348
Update, 350-353
updates, 128-129
metric maximum-hop command, 112
metrics, 109
administrative distance, 303-306
EIGRP
best path, 266
calculating, 243
OSPF
cost, 150
eexternal routes, 206-207
reachability, 12
route calculation, 129
seed metric, 308
migrating RIP, 134-137, 315-320
modifying
cost on OSPF routers, 171-172
OSPF router priority, 170-171
modular design of EIGRP, 250
monitoring NAT, 73
more, 221
Moy, John, 150
MTU field, EIGRP topology table entries, 255
MULTI_EXIT_DISC attribute, 383-385
multiaccess networks, Type 2
LSAs, 203
multiarea configuration, OSPF, 214-217
multiarea OSPF, 201
ABRs, 210
ASBRs, 210
backbones, 201, 215-216
configuring, 207-209
creating multiple areas, 199-200
flooding LSUs, 208
internal routers, 201
NSSAs, 218-221
route summarization, 211-212
stub areas, 213
updating the routing table, 209
verifying operation, 222
multicast addresses, 41, 53
multicast groups, 41
multicast OSPF LSAs, 204
multihomed ASs, 340-342, 431-433
mutual redistribution, configuring 311, 313

N
named access lists, 453-454, 465-467
NAT (network address translation), 63
address overloading, 71
dynamic, 64-68
EasyIP, 79-80
limitations of, 72
monitoring 73
static, 69-71
translation information, 73
NBMA (non-broadcast multiaccess) networks, 174-183
neighbors
address fields, 159
BGP, 342, 423-425
command, 177, 355
EIGRP, 248
negotiation, 344-353
OSPF, 183
relationships, 151, 354-355
tables, 246, 250-252, 264
netbios-name-server command, 79
NetFlow switching, 7
NetWare Link Services Protocol (NLSP), 247
network command, 78, 166-167, 353-356
networks
addresses, 45-46
design models, 3-5
link entry LSAs, 203
local domains, 122-124
LSAs, 154
mask fields, 159
numbers, 39
OSPF, 154-155
prefixes, 102
subnet masking, 42-45
types, 174-183
next hops, advertising on static routes, 105
NEXT_HOP attribute, 368-371
NLA ID (Next-Level Aggregation Identifier) field
aggregatable global unicast addresses, 54
NLRI (network-layer reachability information), 350, 411
NLSP (NetWare Link Services Protocol), 247
no synchronization command, 363
NO_ADVERTISE community value, 419
NO_EXPORT community value, 419
nonbroadcast multiaccess, OSPF, 154
nonbroadcast networks, OSPF, 174-183
nontransit ASs, 340
Notification message (BGP), 348
Novell IPX, 108, 247
NSFNET (National Science Foundation Network), EGP3, 338
NSSAs (not-so-stubby areas), 205, 218-221
null0 interface, configuring, 489-490
O
octets, 221
one-way route redistribution, configuring, 308-310
Open message (BGP), 347-348
OpenConfirm state (BGP FSM), 346
OpenSent state (BGP FSM), 345
optimum switching 7
optional nontransitive attributes, 352, 383-385
optional transitive attributes, 352, 419-422
options field, OSPF hello packets, 159
ORIGIN attribute (BGP), 386
OSPF, 149, 220
adjacencies, 151, 160
areas, 199-205
BDRs, 155, 161-162
comparing to EIGRP, 242
configuring, 189-194
cost, 150
databases, 153
Dijkstra algorithm, 149
DRs, 154, 161-162
external routes, 206
forwarding database, 149
Hello Protocol, 155
hierarchical topologies, 200
interface states, 150
down, 151
Exchange, 152
Exstart, 152
full adjacency, 153-154
Init, 151
loading, 152
two-way, 151-152
link-state database, 222
multiarea, 201-202
configuration, 207-210, 215-216
flooding LSUs to multiple areas, 208
LSAs, 204
route summarization, 211-212
updating, 209
verifying, 222
network types, 154-155
over nonbroadcast
networks, 174-177
full-mesh Frame Relay, 177-178
partial-mesh Frame, Relay 178-183
packets, 150
header information, 157
LSAcks, 153
LSRs, 152
LSUs, 152
network LSAs, 154
process ID, configuring, 165-168
RIP redistribution case
study, 315-320
route discovery, 162-163
routing table
building, 163-164
maintaining, 164-165
single-area, 165-174
SPF algorithm, 163
stub areas, 214-215
totally stubby areas, 213-215
virtual links, 216-217
wildcard bitmasks, 167
outbound access lists, 457
output policy engine, BGP
routing process model, 365

DBD, 152
EIGRP, 260-261
forwarding to local
domains, 122-124
inspection of CBAC, 471-472
interarea traversal (OSPF), 207
OSPF, 150
header information, 157
hello, 155, 159
LSAcks, 153
LSRs, 152
LSUs, 152
network LSAs, 154
queuing, 16-18
parameters
ip nat inside source
command, 66
ip route command, 104
show ip bgp neighbors
command, 360
partial, bounded updates, 245
partial-mesh Frame Relay,
routing over OSPF, 178-183
passive interfaces
configuring, 292, 294
EIGRP, 297
lab exercises, 323-329
passive routes, 257
passive-interface command,
292-294, 316
PAT (port address translation),
71
path attributes
AS_PATH, 399-402
BGP
AGGREGATOR, 378
AS_PATH, 371-375
ATOMIC_AGGREGATE,
376-377
COMMUNITIES,
419-422
Update messages,
351-353
LOCAL_PREF, 378-381,
402-405
MED, 402-405
MULTI_EXIT_DISC,
383-385
NEXT_HOP, 368-371
ORIGIN, 386
weight, 382
PDMS (protocol-dependent
modules), 246, 250
peers, BGP, 362-363, 423-425,
447-448
per-destination load balancing,
14
performance
efficiency, 18-19
responsiveness, 15
per-packet load balancing, 13
point-to-multipoint networks
creating, 180-183
OSPF, 154, 195-197
point-to-point networks, OSPF,
154, 178
point-to-point WAN links,
56-61, 74
policies, 5
policy routing, 298-300
BGP
implementing,
366-367
regular expressions,
381-382
routes
filtering, 411-419
maps, 298
port address translation (PAT),
71
prefixes, 102
configuring, 415-419
summarizing routes, 49-50
prepending, 371, 375
priority queuing, 16

P
packet filtering, 18, 470-472
Packet Length field, OSPF
packets, 157
packets, 6
BGP fields, 346-347
private AS numbers, 372-375
private IP addresses, 61-62
discontiguous subnets, 62
NAT, 63
dynamic, 64-68
static, 68-71
process IDs, OSPF, 165-168
process switching, 6
properties of point-to-multipoint networks, 181
proprietary routing protocols, 108
protocol-dependent modules (PDMs), 246
public topology, IPV6 unicast addresses, 54

Q-R
quad-zero routes, 115-117
queries, EIGRP, 261
queuing, 16
custom, 17
EIGRP, 251
FIFO, 16
priority, 16
WFQ, 17-18
reachability, 12
  BGP withdrawn routes, 353
  NLRI, 350, 411
  OSPF Type 4 LSAs, 203
recomputation of routes, 257
recovery process, EIGRP neighbors, 248
redistribute rip command, 210, 308
redistribute static command, 117, 122
redistribution, 20, 109, 300, 306-307, 312
  BGP 434-437
configuring default-metric command, 314
directly connected routes, 313
external route
  summarization, 211
lab exercises, 325-334
multiarea OSPF, 202
one-way, 308-310
RIP/OSPF case study, 315-320
two-way, 307, 311-313
redundancy, 426-429
reflexive access lists, 465-467
configuring, 467-470
restrictions on use, 467
regular expressions, 381-382
reliability fields, EIGRP
topology table entries, 255
remark command, 456
replies, EIGRP, 261
reported distance (RD), 255, 262
Res (Reserved) fields, 54
responsiveness, 15
restrictions on reflexive access lists, 467
RFCs (Requests for Comments), 35
RIP (Routing Information Protocol), 269
  comparing versions of, 59
  migrating to EIGRP, 134-137
  OSPF redistribution, 315-320
route-map command, 298
Router ID field, OSPF packets, 157-158
router link entry LSAs, 203
router ospf command, 165-166
router priority field, OSPF
  hello packets, 159
routers
  ABRs, 201, 208-210
  access routers, 10
ASBRs, 202, 210
backbone (multiarea OSPF), 201
BDRs, 161-162
BGP speakers, 342
border routers, 342
boundary routers, 300-303
CIDR-compliant, 49-50
convergence, 126-127
core routers, 5-8
default-free, 47-48
distribution routers, 8-9
DRs, 161-162
der addressers, 80-84
IDs, 158
internal, 201
OSPF
  BDRs, 154
discovery process, 162
  DRs 154,
  priority value, 161, 170-171
  passive interfaces, 292-294
  VLSM, 57-58
VTYs, 457-459
routes
  aggregation, 48-50, 59-60
  directly connected,
    advertising, 105
  filtering, 411-419
  BGP, 442-445
  configuring, 294-298
  flapping, 60
maps
  administrator tags, 259
  BGP, 366-367
  configuring, 329-331
defining, 298
of last resort, 114-117
optimization, 291-298
recomputation (EIGRP), 257
Index

Index

redistribution, 20, 300-307, 312
directly connected routes, 313
lab exercises, 332-334
one-way, 308-310
RIP/OSPF, 315-320
two-way, 307, 311-313
route reflectors. See RRs
selection process, 365
source fields, 255
static in stub networks, 106
summarization, 19
EIGRP, 272-273
OSPF, 211-212
tagging, 257-259
routing, 102
default, 114
dynamic, 106
hierarchal, 200-201
interarea, 200
policies implementing, 366-367
models, 386-387
regular expressions, 381
protocols. See routing protocols
routing tables, 101
static, 102
configuring, 104-106
default routes, 115-124
floating routes, 124-126
tables, 101
Codes legend, 108
EIGRP, 246
OSPF, 163-165, 209
updates, 128-129
routing process model (BGP), 364-365
routing protocols, 101
adaptability, 20
administrative distance, 110
distance-vector, 112-113
Bellman-Ford algorithm, 112
convergence, 112
snapshot routing, 18
dynamic, 103
EGPs, 298-300
EIGRP, 241
ACKs, 260
compatibility with IGRP, 242-246
convergence, 261-264
DUAL, 248-249
feasible successors, 249
hello packets, 260
metric, calculating, 243
PDMs, 250
queries, 261
replies, 261
RTP, 248
successors, 249
summarization, 272-273
support, 246-247
unequal-cost load balancing, 244
updates, 261
hybrid, 114
IP, 108-109
link-state, 113
Dijkstra algorithm, 113
LSAs, 113-114
multiple, configuring, 300-306
OSPF, 149
ABRs, 201, 210
adjacencies, 151
areas, 204-205
ASBRs, 202, 210
backbones, 201, 215-216
BDRs, 155
cost, 150
creating multiple areas, 199-200
databases, 153
Dijkstra algorithm, 149
DRs, 154
external routes, 206
forwarding database, 149
Hello Protocol, 155
hierarchical topology, 200
interface states, 150-154
internal routers, 201
LSAs, 202-204
multiarea configuration, 207-212
network types, 154-155
NSSAs, 218-221
over nonbroadcast networks, 174-183
packets, 150
router operation, 159-165
single area, 165-74
stub areas, 213-215
totally stubby areas, 213-215
virtual links, 216-217
RIP, 59
route calculation, 128-129
scalability, 12
static, 103
support for VLSM, 58-59
RRs (route reflectors), 407-408
clusters, 409
configuring, 409-411
lab exercises, 442-445
RTP (reliable transport protocol), 248

S
SAP, compatibility with EIGRP, 247
scalability, 3
scalable networks
accessibility, 20-21
adaptability, 20
availability, 12-14
efficiency, 18-19
reliability, 12-14
responsiveness, 15-17
security
access lists, 451-452
descriptions, 456
named, 453-454
reflexive, 465-470
time-based, 454-456
authentication, 172-173
CBAC, 470-472
configuring, 473-477, 483-489
global timeouts, 48
inspection rules, 477-482
thresholds, 482
verifying, 483
controlling routing updates, 291
passive interfaces, 292
route filters, 294-298
firewalls, 451, 475-476
lock-and-key, 459-462
maintaining accessibility, 20
seed metric, 308
selection process
BGP routing policy model, 386-387
EIGRP routes, 264-266
semidynamic redistribution, 434-437
servers, configuring DHCP, 77-79
service dhcp command, 77
sessions, BGP, 354
show commands, EIGRP, 274
show ip bgp command, 359
show ip bgp neighbors command, 359-360
show ip dhcp command, 79
show ip ospf command, 221-222
show ip protocols command, 166, 297
show ip route command, 101
show ip route summary command, 302
single-area OSPF
authentication, 172-173
configuring, 165-174
cost, 171-172
loopback interfaces, 168-170
process ID, 165-167
router priority, 170-171	
timers, 174
single-homed ASs, 339, 430
site local use addresses, 55
site topology, IPv6 unicast addresses, 54
Site-Level Aggregation Identifier (SLA ID) field, 55
smooth round trip timer (SRTT), 251
snapshot routing, 18
source routes, configuring, 305-306
special characters, adding to regular expressions, 382
SPF algorithm, 163
SRTT (smooth round trip timer), 251
standard access lists, 366-367, 451-452
standard areas (OSPF), 204
standards, RFCs, 35
stateful packet filtering, 470-472
states (BGP FSM), 344-347
static NAT, 68-71
static routes
adding to routing table, 104
administrative distance, 111
configuring on null0, 489-490
injection, 434-437
in stub networks, 106
next-hops, 105
redistributing, 313
static routing, 102
comparing to dynamic, 103
configuring, 104-106
default routes, 115
counting, 118-122
local domains, 122-124
quad-zero routes, 115-116
floating static routes, 111, 124-126
stripping private AS numbers from AS_PATH list, 373-374
stub areas, 205, 213-215
stub networks, 339, 430
subinterfaces, 178
subnet masks, 42-46
subnets
  discontiguous, 62
subnetting, 55-59
successors, 246, 249
summarization, 19, 59-60
EIGRP, 272-273, 286-288
OSPF, 211-212
summary link entry LSAs, 203
supernetting, 50
switching modes, Cisco IOS, 6
symmetry, BGP, 429
SYN flood attacks, 472
synchronization, BGP, 472
syntax
access lists, 457
extended access lists, 452

TCP (Transport Control Protocol)
code bits, 463-465
load distribution, 69-71
UDP inspection rules (CBAC), 480-481
testing loopback addresses, 38
three-layer network design model
access layer, 5, 10
core layer, 4-8
distribution layer, 4-9
three-way handshake, TCP, 463-465
thresholds, CBAC, 482
time versus event-driven routing protocols, 128-129
time-based access lists, 454-456
timers
configuring, 174
EIGRP, 251
event-driven routing protocols, 129

TLA ID (Top-Level Aggregation Identifier) field, 54
Top-Level Aggregation Identifier (TLA ID), 54
topologies
convergence, 13, 126-127
full-mesh (Frame Relay), 177
hub-and-spoke, 179
partial-mesh, 178
tables
active routes, 257
convergence, 261, 264
feasible successors, 256
passive routes, 257
recomputation of routes, 257
route tagging, 257-259
routes, maintaining, 266
total delay field, 255
totally stubby areas, 205, 213-215
traceroute command, 11
traffic
BGP
load balancing, 430
symmetry, 429
EIGRP, 244
filtering, 18, 473-477
load balancing, 13
policies, 5
queuing, 16-18
transit areas, 204
translation (NAT)
address overloading, 71
dynamic, 64-67
EasyIP, 79-80
limitations of, 72
monitoring, 73
static, 68
tuning OSPF routers, 174
tunnels, 14
tuples, NLRI 350
two-way redistribution, 307, 311-313
two-way state, OSPF interfaces, 151-152
type 1 LSAs, 203
type 2 LSAs, 203
type 3 LSAs, 203
type 4 LSAs, 203
type 5 LSAs, 204
type 6 LSAs, 204
type 7 LSAs, 204
type fields
BGP packets, 347
OSPF packets, 157

UDP, default forwarded services, 80
unicast addresses, IPv6 levels of hierarchy, 53-54
Update message (BGP), 350-353
updates
BGP
AGGREGATOR attribute, 378
AS_PATH attribute, 371-375
ATOMIC_AGGREGATE attribute, 376-378
COMMUNITIES attribute, 419-422
LOCAL_PREF attribute, 378-381
MULTI_EXIT_DISC attribute, 383-385
NEXT_HOP attribute, 368-371
ORIGIN attribute, 386
WEIGHT attribute, 382
withdrawn routes, 343
controlling, 13, 291-296
EIGRP, 261
incremental, 19
LSUs, 208
OSPF link-state, 150
partial, bounded updates (EIGRP), 245
route calculation, 128-129
routing tables, OSPF 209

assigning private IP addresses, 61
wasted IP addresses in subnet masks, 45-46
Web sites
Cisco Connection Online, 471
RFCs, 35
WEIGHT attribute, 382
well-known attributes (BGP)
AS_PATH, 371-375
NEXT_HOP, 368-371
well-known community values (BGP), 419
well-known discretionary attributes, 351
AGGREGATOR, 378
ATOMIC_AGGREGATE, 376-378
LOCAL_PREF, 378-381
WEIGHT, 382
well-known mandatory attributes, 351, 386
WFQ (weighted fair queuing), 17-18
wildcards
bitmasks, 167
in regular expressions, 382
withdrawn routes, BGP, 343, 353

V

variance command, 244
verifying
BGP operation, 358-359
CBAC, 483
EIGRP operation, 274
OSPF multiarea operation, 222
Version field, OSPF packets, 157
versions of RIP, comparing, 59
viewing
link-state database, 222
NAT translation information, 73
TCP/IP routing table, 101
virtual links, 216-217
VLSM (variable-length subnet masks), 55-59
VTYs, applying, 457-459

W-Z

WANs (wide-area networks)
passive interfaces, 292-294
point-to-point links
assigning IP addresses, 36-58, 74