

INDEX

A

**ABRs (area border routers),
214–215**

route summarization, 229–230

access layer, 16, 30

access routers, 16

address formats, IS-IS, 247–249

administrative distance, 134–135

**advanced distance vector routing
protocols, EIGRP**

configuring, 175–178

metrics, 178

neighbor discovery, 174–175

network summarization, 186–189

route update algorithm, 179–186

versus IGRP, 189–190

advertising (RIP), 133

aggregation, 25, 155–160

**Anycast RP, configuring PIM SM,
359–361**

areas

IS-IS, 249–250

*configuring single-area networks,
256–261*

Level 1 routing, 250

Level 2 routing, 250

*multiple-area networks, 250–251
configuring, 264–269*

virtual links, 230–234

areas (OSPF), 196–199

NSSAs, 222–226

stub areas, 220–221

totally NSSAs, 226–227

totally stubby areas, 221–222

**ARP (Address Resolution
Protocol), 78–79**

AS (autonomous system), 280

AS external LSAs, 239

AS_PATH attribute (BGP), 284–286

**ASBRs (autonomous system border
routers), 215–216**

summary LSAs, 239

asymmetrical routing, 236

attributes (BGP), 282–283

AS_PATH, 284–286

community, 292–294

LOCAL_PREF, 288

MED, 289–290

NEXT_HOP, 291

ORIGIN, 290–291

WEIGHT, 287–288

authentication, MD5, 154–155

**Auto-RP, configuring PIM SM,
356–357**

B

backbones, IS-IS, 250–253

bandwidth, 146–147

base 10 number system, 39

base 2 numbering system, 41

**BDR (backup designated router),
election process, 210**

BGP (Border Gateway Protocol)

AS, 280

attributes, 282–283

AS_PATH, 284–286

community, 292–294

LOCAL_PREF, 288

MED, 289–290

NEXT_HOP, 291

ORIGIN, 290–291

WEIGHT, 287–288

decision process, 332

EBGP

configuring, 294–298

*IP prefixes, injecting into routing
table*, 298–309

IBGP, scaling, 323–327

need for, 280–281

NOTIFICATION messages,
297–298

route summarization, 328–332

UPDATE messages, 297

BIAs (burned-in addresses), 79

binary numbering system, 40–43

converting to decimal, 43, 49

converting to dotted decimal, 49–50

converting to hexadecimal, 48

converting to octal, 48

dotted decimal notation, 47

least significant digits, 58

positional values, 42

**bitwise logical AND operations,
95–96**

broadcast addresses, 70

BSRs (bootstrap routers), 357

C

calculating IGRP metrics, 168–171

**CGMP (Cisco Group Management
Protocol), 345**

Class D addresses, 339

classful IP addressing, 72–74

classful protocols, 152

classless IP addressing, 94

bitwise logical AND operations,
95–96

masking, 94–95

subnetting, 96–103

classless routing protocols, 152

commands

passive-interface, 132

router rip, 131

show ip pim neighbor, 352–353

version 1, 131

**community attribute (BGP),
292–294**

comparing

IGRP and EIGRP, 189–190

IPv4 and IPv6, 113–115

IPv6 address format, 116

*IPv6 multicast addresses,
117–118*

IPv6 unicast addresses, 117

IS-IS and IP networks, 245–247

address formats, 247–249

IS-IS and OSPF, 273–274

unicast and multicast routing,
337–340

**confederations, scaling IBGP,
325–327**

configuring

BGP

EBGP, 294–298

IBGP, 309–320

EIGRP, 175–178

IS-IS

multiple-area networks, 264–269

single-area networks, 256–261

OSPF, 203–207

PIM DM, 350–352

PIM SM, 354

with Anycast RP, 359–361

with Auto-RP, 356–357

with PIM SM version 2, 357–358

with Static RP, 355–356

RIP, MD5, 154–155

convergence, 139–141

triggered updates, 141

converting

binary

to decimal, 43, 49

to dotted decimal, 49–50

to hexadecimal, 48

to octal, 48

decimal

to binary, 54–55

to hexadecimal, 56

to octal, 56

hexidecimal

to binary, 52

to decimal, 46, 53

dotted decimal, 54

to octal, 52–53

multicast IP addresses to multicast

Ethernet addresses, 341–343

octal

to binary, 50

to decimal, 45, 51

to dotted decimal, 52

to hexadecimal, 51

core layer, 22–30

cost metric (OSPF), 213–214

counting to infinity, 136

D

data flow through TCP/IP stack, 93

dead time, 212

debugging RIP, 131

decimal numbering system, 39

converting to binary, 54–55

converting to hexadecimal, 56

converting to octal, 56

decision process, BGP, 332

default gateway, 81

default routes, 19

delay (IGRP), 169

**distance-vector routing protocols,
135–136**

counting to infinity, 136

poison reverse, 138

split horizon, 137

distribution layer, 18–21, 30

dotted decimal notation, 47

DROTHER, 210

**DRs (designated routers), election
process, 210**

DSCP field (IP header), 89–90

**DUAL (diffusing update
algorithm), 179**

E

EBGP (External BGP)

configuring, 294–298

IP prefixes, injecting into BGP
routing table, 298–309

EGPs (exterior gateway protocols)

BGP

AS, 280

AS_PATH attribute, 284–286

attributes, 282–283

community attribute, 292–294

configuring, 294–298

decision process, 332

IBGP, configuring, 309–320

*IBGP, loopback interfaces,
320–323*

IBGP, scaling, 323–327

LOCAL_PREF attribute, 288

MED attribute, 289–290

need for, 280–281

NEXT_HOP attribute, 291

*NOTIFICATION messages,
297–298*

ORIGIN attribute, 290–291

route summarization, 328–332

UPDATE messages, 297

WEIGHT attribute, 287–288

**EIGRP (Enhanced Interior Gateway
Routing Protocol), 165**

configuring, 175–178

metrics, 178

neighbor discovery, 174–175

network summarization, 186–189

route update algorithm, 179–186

topology table, 181

versus IGRP, 189–190

electronic data delivery, 63–66

ES (end system), 246

Ethernet, 12, 67

resolving addresses to IP addresses,
76–77

external routes (OSPF), 219

summarization, 227–228

F

FD (feasible distance), 180

feasible successors, 181

fields of IP header, 86–88

DSCP, 89–90

IP Precedence, 87–88

flush time, 142

format of IPv6 addresses, 116

G-H

group management (IGMP)

CGMP, 345

IGMP snooping, 346

headers

IP, 85

DSCP field, 89–90

fields, 86–88

IP Precedence field, 87–88

TCP, 92–93

UDP, 92

hexidecimal numbering system, 45

converting to binary, 52

converting to decimal, 46, 53

converting to dotted decimal, 54

converting to octal, 52–53

holddown time, 142

hop count, 135

limitations, 146–147

hops, 135

host address, 69

I

IBGP (Interior BGP)

configuring, 309–320

loopback interfaces, 320–323

scaling, 323–324

with confederations, 325–327

with route reflectors, 324–325

IGMP (Internet Group Management Protocol), 343

group management, CGMP, 345

join messages, 343–344

IGMP snooping, 346

IGRP (Interior Gateway Routing Protocol), 165–166

limitations of, 172–174

metric, 165, 168

calculating, 168–171

versus EIGRP, 189–190

injecting IP prefixes into BGP routing table, 298, 307–309

network command, 299–305
redistribution, 305–307

Integrated IS-IS, 247**interarea routes (OSPF), 218****interfaces, bandwidth, 146–147****interior routing protocols, 165**

IGRP, 165–166
limitations of, 172–174
metric, 165, 168–171

inter-LAN communication, 81–84**internal routers (OSPF), 216–217****intra-LAN communication, 77–78****IP addressing, 68**

broadcast addresses, 70
classful, 72–74
classless, 94
bitwise logical AND operations, 95–96
masking, 94–95
subnetting, 96–103

default gateway, 81

header format, 85

DSCP field, 89–90

fields, 86–88

IP Precedence field, 87–88

inter-LAN communication, 81–84

intra-LAN communication, 77–78

IPv4 versus IPv6, 113–115

IPv6

address format, 116

multicast addresses, 117–118

unicast addresses, 117

network address, 69

private, 74–75

resolving, 75–77

ARP, 78–79

sockets, 92

structure, 69–70

supernetting, 113

IP networks, comparing to IS-IS, 245–249**IP Precedence field (IP header), 87–88****IP prefixes, 107–111**

injecting into BGP routing table, 298, 307–309

network command, 299–305

redistribution, 305–307

IP routing, 105–111**IPv4 versus IPv6, 113–115****IPv6**

address format, 116

multicast addresses, 117–118

unicast addresses, 117

IS-IS (Intermediate System-to-Intermediate System)

areas, 249–250

Level 1 routing, 250

Level 2 routing, 250

multiple-area networks, 250–251

backbones, 250–253

comparing with OSPF, 273–274

link states, 254
 LSPs, 254–255
 metrics, 261
 narrow, 262
 wide, 263–264
 multiple-area networks,
 configuring, 264–269
 NET, 258
 route leaking, 272–273
 route summarization, 270–271
 router types, 251–252
 single-area networks,
 configuring, 256–261
 versus IP networks, 245–249

J-K-L

join messages (IGMP), 343–344

leaf routers, 349

leaking IS-IS routes, 272–273

least significant digits, 58

Level 1 routing, 250

Level 2 routing, 250

limitations

of hop counts, 146–147
 of IGRP, 172–174

link-state protocols

IS-IS, 254–255

areas, 249–250
backbones, 250–253
comparing to IP networks,
 245–249
metrics, 261
multiple-area networks, 250–251
 configuring, 264–269
narrow metrics, 262
 NET, 258
route leaking, 272–273
route summarization, 270–271
router types, 251–252
single-area networks,
 configuring, 256–261
versus OSPF, 273–274
wide metrics, 263–264

OSPF, 198–199

ABRs, 214–215
areas, 196–198
ASBRs, 215–216
configuring, 203–207
external route summarization,
 227–228
external routes, 219
interarea routes, 218
internal routers, 216–217
LSAs, 238–239

metrics, 213–214
neighbor discovery, 209–212
NSSAs, 222–226

properties of, 200
route summarization, 229–230
router ID, 201–203
shortest path selection, 234–238
stub areas, 220–221
timers, 212–213
totally NSSAs, 226–227
totally stubby areas, 221–222
virtual links, 230–234

load (IGRP), 169

LOCAL_PREF attribute (BGP), 288

loopback addresses, 73

loopback interfaces, 201

IBGP, 320–323

LSAs (OSPF), 199, 238–239

M

MD5, 154–155

MED attribute (BGP), 289–290

metrics, 165, 168

EIGRP, 178

IGRP, calculating, 168–171

IS-IS, 261

narrow, 262

wide, 263–264

OSPF, 213–214

shortest path selection, 234–238

MSDP (Multicast Source Discovery Protocol), 360

multicast Ethernet addresses, 341

multicast forwarding

leaf routers, 349

RPF, 346–348

multicast IP addresses

converting to multicast Ethernet addresses, 341–343

IPv6, 117–118

multicast LSAs, 239

multicast routing

PIM DM, 349–350

configuring, 350–352

verifying neighbors, 352–353

PIM SM, 353–354

configuring, 354–361

RPs, 354

reserved addresses, 362

versus unicast, 337–340

multicast switching, 340

IGMP, 343

group management, 345

join messages, 343–344

IGMP snooping, 346

multiple-area networks, 195

IS-IS, 250–251

configuring, 264–269

OSPF, 196–198

N

narrow metrics (IS-IS), 262

neighbor discovery

EIGRP, 174–175

OSPF, 209–212

NET (network entity title), 258

network address, 69

network LSAs, 238

network summarization, EIGRP, 186–189

network summary LSAs, 239

next hops, 129

NEXT_HOP attribute (BGP), 291

NOTIFICATION messages (BGP), 297–298

NSAP addresses, 247–249

NSEL (NSAP selector), 248–249

NSSAs (not-so-stubby areas), 222–226

external LSAs, 239

O

octal numbering system, 44

converting to binary, 50

converting to decimal, 45, 51

converting to dotted decimal, 52

converting to hexadecimal, 51

open-standard documentation, 165

optional nontransitive attributes (BGP), 283

optional transitive attributes (BGP), 283

ORIGIN attribute (BGP), 290–291

OSPF (Open Shortest Path First), 195

ABRs, 214–215

areas, 196–198

NSSAs, 222–226

stub areas, 220–221

totally NSSAs, 226–227

totally stubby areas, 221–222

ASBRs, 215–216

comparing with IS-IS, 273–274

configuring, 203–207

external route summarization, 227–228

external routes, 219

interarea routes, 218

internal routers, 216–217

link states, 198–199

LSAs, 199

LSAs, 238–239

metrics, 213–214

neighbor discovery, 209–212

properties of, 200

route redistribution, 216

route summarization, 229–230

router ID, 201–203

shortest path selection, 234–238

timers, 212–213
virtual links, 230–234
wildcard bits, 206

P

packets, 84

IP header format, 85
 DSCP field, 89–90
 fields, 86–88
 IP Precedence field, 87–88

passive-interface command, 132

password authentication, RIPv2, 153

physical addresses, 79

PIM DM (Protocol Indendent Multicast Dense Mode), 349–350

configuring, 350–352
verifying neighbors, 352–353

PIM SM (Protocol Indendent Multicast Sparse Mode), 353–354

configuring, 354
 with Anycast RP, 359–361
 with Auto-RP, 356–357
 with PIM SM version 2, 357–358
 with Static RP, 355–356

RPs, 354
version 2, configuring, 357–358

poison reverse, 138

private IP addressing, 74–75

process ID (OSPF), 205

properties

of IS-IS networks, 255
of OSPF, 200

proprietary protocols, 165

protocols, 4

addressing, 6–8
message delivery, 8–18
 core layer, 22–29
 distribution layer, 18–21

public IP addresses, 74

R

redistribution, injecting IP prefixes into BGP routing table, 305–307

reliability (IGRP), 169

reported distance, 180

reserved multicast addresses, 362

resolving IP addresses, 75–77

ARP, 78–79

RIP (Routing Information Protocol), 130

administrative distance, 134–135
advertising, 133
convergence, 139–141
counting to infinity, 136
debugging, 131
MD5, configuring, 154–155
poison reverse, 138
route summarization, 155–160
split horizon, 137

RIPv1, 131

output algorithm, 147–148

RIPv2

security, 153

VLSMs, 150–151

route leaking, IS-IS, 272–273

route redistribution, OSPF, 216

route reflectors, scaling IBGP, 324–325

route summarization, 105–107, 155–160

BGP, 328–332

IP prefixes, 107–111

IS-IS, 270–271

route summarization (OSPF), 229–230

route update algorithm, EIGRP, 179–186

router ID (OSPF), 201–203

router LSAs, 238

router rip command, 131

routing protocols, 132

classless, 152

convergence, 139–141

distance-vector, 135–136

hop counts, limitations of, 146–147

RPF (Reverse Path Forwarding), 346–348

RPs (rendezvous points), 354

S

scaling

IBGP, 323–324

with confederations, 325–327

with route reflectors, 324–325

security

authentication, MD5, 154

RIPv2, 153

selecting OSPF shortest path, 234–238

shared delivery trees, 353–354

shortest path selection (OSPF), 234–238

show ip pim neighbor command, 352–353

SIA (stuck in active), 185

single-area IS-IS networks, 249

configuring, 256–261

Level 1 routing, 250

Level 2 routing, 250

sockets, 92

split horizon, 137

static routes, 129

Static RP, configuring PIM SM, 355–356

stub areas, 220–221

subnet masks, VLSMs, 142–145

RIPv2, 150–151

subnetting, 96–103

successors, 181

summarization, 155–160

BGP routes, 328–332

IP routes, 105–107

IP prefixes, 107–111

IS-IS routes, 270–271

OSPF routes, 229–230

*external routes, 228***supernetting, 113****T****TCP headers, 92–93****TCP/IP (Transmission Control Protocol/Internet Protocol)****model, 90–91**

data flow, 93

sockets, 92

TCP header, 92–93

UDP header, 92

timers, OSPF, 212–213**totally NSSAs, 226–227****totally stubby areas, 221–222****triggered updates, 141****U****UDP (User Datagram Protocol) headers, 92****unicast IPv6 addresses, 117****unicast routing versus multicast****routing, 337–340****UPDATE messages (BGP), 297****update times, 141****V****verifying PIM DM neighbors, 352–353****version 1 command, 131****virtual links (OSPF), 230–234****VLSPs (variable-length subnet masks), 142–145**

RIPv2, 150–151

W-Z**WEIGHT attribute (BGP), 287–288****well-known discretionary****attributes (BGP), 283****well-known mandatory****attributes (BGP), 282****wide metrics (IS-IS), 263–264****wildcard bits (OSPF), 206**