

Numerics

6Bone, 417, 446–447

6DISS, 448

6NET, 448

6PE routers

forwarding performance, 432–433

MPLS DiffServ, 191–194

overview, 135–139

RSVP-TE, 194–199

security, 347

6to4 addressing, 128–131

6VPE

forwarding in, 264–266

label stack, building, 262, 264

MP-BGP features, 272

MPLS DiffServ, 191–194

next hop, 261–262

router forwarding performance, 432–433

routing protocols, 260–261

RSVP-TE, 194–199

scaling, 270–271

virtual routing and forwarding, 267–269

A

AAA (authentication, authorization, and accounting), 360–361

AAAA records, 105

access

edge/core, 532–537

global IA (Internet access), 488–489

media types, 107–109

MPLS networks, 462–464

native access, 109

bridged, 109–110

PPP-encapsulated, 110–115

routed, 109

virtualized, 115–120

overview, 530–532

remote access

enterprise networks, 589

IPsec VPNs, 254–255

tunnels, 120–121

brokers, 122

ISATAP, 123–124

manually configured, 121–122

servers, 122

Teredo, 122–123

unauthorized, 334–336

WiFi access points, 443

access control lists. *See* **ACLs**

access layer

media types, 107–109

native access, 109

bridged, 109–110

PPP-encapsulated, 110–115

routed, 109

virtualized, 115–120

overview, 106–107

QoS for IPv6 deployment, 201

tunnels, 120

ACLs (access control lists)

example, 355–356

extended, 353

IP packet fragmentation, 354–355

MIPv6, 303–304

overview, 352

stateful filtering, 353–354

time-based, 354

addressing

6to4, 128–131

address-space allocation,
444–447

anycast, 446

architecture, 445

enterprise networks, 577, 592–594

global multicast, 446

IPv4, 6–8

loopback, 445

MPLS networks, 497–499

multicast, 208–215

NAT, 11–14

overview, 6, 526–528

policies, 444–447

public versus private, 8–9

registration, 444–447

renumbering, 10–11

RIRs, 446

SSM, 543

static vs. dynamic, 9–10

- unicast, 445, 528–530
- unspecified, 445
- VPNs, 18, 252–253
- address-resolution attacks, 341–342**
- ADVERTISE messages, 94**
- AF (Assured Forwarding) PHB, 183**
- AFRINIC, 445**
- aggregated home networks, 314**
- AH (Authentication Header), 12**
- Any Source Multicast. *See* ASM**
- anycast addresses, 446**
 - filtering traffic, 335
- application layer attacks, 346**
- application classification, 441–442**
- architecture**
 - addressing, 445
 - routers, 423–424
- ARIN, 445**
- ARPNIC, 445**
- AS_PATH attribute, 162**
- ASM (Any Source Multicast)**
 - intradomain versus interdomain, 231–232
 - multicast deployment example, 239–247
 - SSM, versus, 230–231
- Assured Forwarding (AF) PHB, 183**
- attachment router selection, 324**
- authentication**
 - AAA, 360–361
 - CHAP, 112
 - RADIUS, 112
- Authentication Header (AH), 12**
- autoconfiguration, stateless, 100**
- autonomous systems, 145**

B

- backbone networks**
 - 6PE, 135–139
 - 6to4, 128–131
 - GRE, 127–128
 - IPv4, 127
 - IPv6, 126
 - layer 2 circuits, 132–134
 - MPLS, 131–132
 - IPv4 tunnels over MPLS, 134*
 - native MPLS, 139–140*
 - overview, 125–126

- BE (Best Effort) PHB, 183**
- Bellman-Ford algorithm, 146**
- Best Effort (BE) PHB, 183**
- BGP (Border Gateway Protocol)**
 - configuring, 168–169
 - next hops, 166–168
 - overview, 161–165
 - peering, 165–166
- BGP-MPLS VPNs, implementing**
 - basic topology, 274–277
 - dual stack topology, 278–279
 - forwarding in, 264–266
 - hub-and-spoke topology, 280–282
 - Internet access topology, 282–284
 - interprovider topology, 285–289
 - label stack, building, 262–264
 - MP-BGP features, 272
 - next hops, 261–262
 - overview, 255–257
 - route reflector topology, 279–280
 - routing protocols, 260–261
 - routing table segregation, 257–260
 - scaling, 270–271
 - virtual routing and forwarding, 267–269
- Binding Acknowledgment message, 296**
- binding databases, 102**
- Binding Error message, 296**
- Binding Refresh Request message, 296**
- Binding Update message, 296**
- bindings, 294**
- black hole routes, 100**
- bootstrap router (BSR)**
 - configuring, 240–241
 - overview, 226–227
- Border Gateway Protocol. *See* BGP**
- bridged access, 109–110**
- broadcast-amplification attacks, 343**
- brokers, tunnel, 122**
- BSR (bootstrap router), 226–227**
 - configuring, 240–241
- business drivers, enterprise network deployments, 574–575**

C

- Care-of Test Init message, 296**
- Care-of Test message, 296**

CBTS (COS-based TE tunnel selection), 198–199

CE (customer edge)-based VPNs
 IPsec VPNs, implementing, 254
deploying, 255
example, 273–274
remote access, 254–255
routing protocols, 255
tunnel alternatives, 255
 overview, 251–252
 security, 253–254, 347–348

centralized forwarding routers, 424

CHAP (Challenge Handshake Authentication Protocol), 112

CIDR (Classless Inter-Domain Routing), 7

Cisco HSRP protocol, 599–601

Cisco IOS Firewall, 357–359

Cisco Learning Connection (CLC), 449

Cisco Network Registrar (CNR), 93

Cisco SAFE Blueprint, 20

classification, 176

Classless Inter-Domain Routing (CIDR), 7

CNR (Cisco Network Registrar), 93

communities of interest, 321, 519–520

Compressed Real Time Protocol (cRTP), 181

congestion avoidance, 176

congestion management, 176

connectivity
 continuous, 291
 Internet-to-campus, 587–589
 unicast, 6–14
 VPNs, 18

content delivery, 518

content distribution
 multicast, 542, 547–551
content management, 542–545
content transport, 545
customer interface, 545–547
 overview, 541–542

content hosting/storage, 517, 538

continuous connectivity, 291

control plane
 router forwarding, 417–419
 traffic rate limiting, 363–364

core layer, 201

correspondent nodes, 311

COS-based TE tunnel selection (CBTS), 198–199

cost analysis
 applications, 441–442
 hosts, 440–442
 network elements, 442–443
 operations, 443–444
 overview, 439

cRTP (Compressed Real Time Protocol), 181

customer edge-based VPNs
 IPsec VPNs, implementing
deploying, 255
example, 273–274
remote access, 254–255
routing protocols, 255
tunnel alternatives, 255
 overview, 251–252
 security, 253–254, 347–348

customer interfaces, 545, 547

D

DAD (Duplicate Address Detection), 94, 296

data plane, 419–420

Default Router Preferences (DRP), 597

Delegating Routers, 101–102

deployment
 addressing, 526–532
 edge core, 528–537
 content distribution, 541–551
 content hosting/storage, 538
 design, 520–521
 design options
dual stack, 523–525
PPP/L2TP, 521–523
 DNS, 538
 Internet access, 539–541
 network environment, 509–515
 plans, 515–516
 QoS, 551–555
 service rollout, 537–538
 targeted services
communities of interest, 519–520
content delivery, 518
content hosting/storage, 517
DNS services, 517
Internet access, 517
mail services, 517
MIPv6, 519–520

- unicast connectivity, 516
- VoIP, 517–518
- unicast, 89
- design goals**
 - dual stack options, 523–525
 - overview, 520–521
 - PPP/L2TP options, 521–523
- destination option, 297**
- DHAAD (Dynamic Home Agent Address Discovery), 295–298, 303**
- DHCP (Dynamic Host Configuration Protocol), 9, 94–95**
 - binding databases, 102
 - DHCP-PD, 96–98
 - DUID (DHCP Unique Identifier), 97
 - prefix pools, 101–102
 - protocol description, 96–98
 - provisioning, 93
 - RRs (Requesting Routers), 98–101
 - stateless, 103–104
- dialup, 509**
- DiffServ (differentiated services), 15, 176, 181–194**
- diffusing update algorithm (DUAL), 150**
- distance vector routing protocol, 146–147**
- distributed forwarding routers, 424**
- distributed home networks, 316–317**
- DNS (Domain Name System)**
 - AAAA records, 105
 - deployment, 538
 - enterprise networks, 583–584
 - ip6.arpa domain, 105
 - overview, 11, 103–104
 - query messages, 105–106
 - Resource Records, 105
- Doors protocol, 318**
- DoS attacks, 343**
- DRP (Default Router Preferences), 597**
- DSL (Digital Subscriber Line), 9**
- DUAL (diffusing update algorithm), 150**
- dual stack, 523–525**
- dual-stack networks**
 - enterprise networks, 594–595
 - managing, 605
 - overview, 103
 - VPNs, 278–279
- DUID (DHCP Unique Identifier), 97**
- Duplicate Address Detection (DAD), 94, 296**

- Dynamic Home Agent Address Discovery (DHAAD), 295–298, 303**
- Dynamic Host Configuration Protocol.**
See DHCP

E

- ECN (explicit congestion notification), 183**
- edge policies**
 - MPLS service provider networks
 - overview, 468–478
 - PE router design, 470–471
 - PE-CE interface design, 471–473
 - PE-CE routing design, 473–476
 - PE-PE routing design, 477–478
 - overview, 202
- edge/aggregation layer, 201**
- edge/core access, 532–537**
- education, 447–449**
- EF (Expedited Forwarding) PHB, 183**
- EGPs (exterior gateway protocols), 145**
- EIGRP (Enhanced Interior Gateway Protocol)**
 - configuring, 152–153
 - IPv6 support, 151–152
 - overview, 150–151
- embedded RP, 227–229, 244–247**
- Encapsulating Security Payload (ESP), 12**
- encryption, 442**
- Enhanced Interior Gateway Protocol. *See EIGRP***
- enterprise networks, IPv6 deployments**
 - addressing, 577, 592–594
 - business drivers, 574–575
 - default router, configuring, 597–598
 - DNS, 583–584
 - dual-stack approach, 594–595
 - equipment overview, 576
 - first-hop router redundancy, 596–601
 - future evolutions, 610–613
 - host configuration, 580–581
 - infrastructure, 571–574
 - Internet-to-campus connectivity, 587–589
 - IP Mobility, 606–609
 - ISATAP router configuration, 584–586
 - managing, 605
 - market expansion, 612–613
 - moving IPv6 to production, 590–591
 - multicast services, 602–605

QoS, 609–610
 remote site configuration, 589
 routing protocols, 595
 security, 601–602, 611–612
 troubleshooting, 610

ESP (Encapsulating Security Payload), 12
Ethernet MPLS, 133
Euro6IX, 448
Expedited Forwarding (EF) PHB, 183
explicit congestion notification (ECN), 183
extended home networks, 313–314
extension headers, 179
exterior gateway protocols (EGPs), 145

F

faster roaming, 323
filtering
 stateful, 353–354
 traffic, 334–335
firewalls
 Cisco IOS Firewall, 357–359
 overview, 356, 442
 PIX Firewall, 359–360
fish problem, 195
fleet in motion, 309–310
flooding attacks, 343, 346
flow label, 179
forwarding
 in BGP-MPLS IPv6 VPNs, 264–266
 multicast, 215–225
 router performance, measuring
 6PE/6VPE environments, 432–433
 black-box testing, 420–422
 centralized versus distributed forwarding, 424
 control plane, 417–419
 data plane, 419–420
 evaluation checklist, 433–435
 high-end routers, 429–432
 low-end routers, 425–426
 mid-range routers, 426–429
 overview, 415–417

software versus hardware forwarding, 423

fragmentation, IP packets, 337–338, 354–355

G

GARP (Generic Attribute Registration Protocol), 214
general prefixes, 98
global addresses, 253
global IA (Internet access), 488–489
global multicast, 446
GRE (Generic Routing Encapsulation), 127–128
group multicast addresses, 209–215

H

hardware
 forwarding routers, 423
 upgrade costs, 441
headers
 AH (Authentication Header), 12
 extension, 179
 Mobility, 295–297
 security threats, 336–337
high-end router forwarding performance, 429–432
home gateways, 306
home networks, 313
Home Test Init message, 296
Home Test message, 296
host-initialization attacks, 341–342
hosts
 cost analysis, 440–442
 deployment, 300–304
 mobility
 destination option, 297
 DHAAD, 297–298
 Mobility header, 295–297
 overview, 292–295
 route optimization, 298
 security, 299–300
hotspots, 305
hub-and-spoke topology, PE-based VPNs, 280–282

IANA, 446

IA-PD (Identity Association Prefix Delegation), 97

ICMP
traffic filtering and, 335–336

IGMP (Internet Group Management Protocol), 209

IGPs (interior gateway protocols), 145, 148

EIGRP
configuring, 152–153
IPv6 support, 151–152
overview, 150–151

IS-IS
configuring, 159–161
IPv6 support, 158–159
overview, 157

OSPFv3
configuring, 155–157
IPv6 support, 154–155
overview, 153–154

RIPng
configuring, 149–150
IPv6 support, 148–149
overview, 148

integrated services (IntServ)
IPv4, 176
overview, 15, 189–190

interdomain routing
BGP next hop, 166–168
BGP peering, 165–166
overview, 164–165

interior gateway protocols. See IGPs

Intermediate System-to-Intermediate System. See IS-IS

Internet Group Management Protocol (IGMP), 209

Internet-enabled cars, 307–308

interprovider VPNs, 285–289

Intra-Site automatic Tunnel Addressing Protocol (ISATAP), 123–124

Integrated Digital Services Network (ISDN), 9, 509

IntServ (integrated services), 189–190
IPv4, 176

IP Mobility, 606–609

IP packet fragmentation, 337–338, 354–355

ip6.arpa domain, 105

IPsec
communication, securing, 348–352
VPNs, implementing
deploying, 255
example, 273–274
remote access, 254–255
routing protocols, 255
tunnel alternatives, 255

IPSSs, 442

IPv4
addressing, 6–8
coexistence with IPv6, 204–205
mobility, 293
multicast, 17
QoS, 15, 179–181
services, 509–515

IPv6
coexistence with IPv4, 204–205
EIGRP support, 151–152
IS-IS support, 158–159
OSPFv3 support, 154–155
RIPng support, 148–149
See also MIPv6

IPv6 Form, 447

IPv6 Task Force, 448

ISATAP (Intra-Site Automatic Tunnel Addressing Protocol), 123–124
configuring routers for enterprise networks, 584–586

ISDN (Integrated Digital Services Network), 9, 509

IS-IS (Intermediate System-to-Intermediate System)
configuring, 159–161
IPv6 support, 158–159
overview, 157

L2TP networks, 521–523
access aggregation, 116–120

label stack, building for 6VPE, 262–264

LACNIC, 445

- layer 2**
 - circuits, 132–134
 - multicast protocols, 214
 - QoS, 180
- layer 3**
 - QoS, 179–180
 - spoofing attacks, 338–341
- layer 4 spoofing attacks, 338–341**
- LFI (link fragmentation and interleaving), 181**
- link-efficiency mechanisms, 180–181**
- link-local addresses, 498**
- link-state vector routing protocol, 147–148**
- load balancing servers, 322**
- load sharing, 169–170**
- Local Mobility Management (LMM), 301**
- loopback addresses, 445**
- low-end router forwarding performance, 425–426**

M

- mail services, 517**
- man-in-the-middle attacks, 346**
- marking, 176**
- MBGP (Multiprotocol BGP), 217–218**
- MDTs (multicast distribution trees), 215–216**
- MFIB (Multicast Forwarding Information Base), 225**
- mid-range router forwarding performance, 426–429**
- MIP (Mobile IP), 21–22, 292**
- MIPv4, 293**
- MIPv6, 21–22, 294–295, 519–520**
 - deployment, 300–304
 - destination option, 297
 - DHAAD, 297–298
 - Mobility header, 295–297
 - route optimization, 298
 - security, 299–300
- MLD (Multicast Listener Discovery) protocol, 209–214**
- mobile ad-hoc networking, 324**
- mobile home networks, 314–316**
- mobile network node (MNN), 311**
- mobile nodes, 292**
- mobile routers, 311**

- mobility**
 - deployment, 300–304
 - future
 - attachment router selection, 324*
 - faster roaming, 323*
 - integration with mobile ad-hoc networking, 324*
 - movement detection, 323*
 - multihoming, 325*
 - route optimization for NEMO, 325–326*
 - hosts
 - destination option, 297*
 - DHAAD, 297–298*
 - Mobility header, 295–297*
 - overview, 292–295*
 - route optimization, 298*
 - security, 299–300*
 - IPv4, 293
 - NEMO, 22
 - network
 - aggregated home networks, 314*
 - distributed home networks, 316–317*
 - enterprises on the move, 305*
 - extended home networks, 313–314*
 - fleet in motion, 309–310*
 - home gateways, 306*
 - home networks, 313*
 - Internet-enabled cars, 307–308*
 - mobile home networks, 314–316*
 - object model, 311*
 - operations, 311–313*
 - PANs, 306–307*
 - sensor networks, 308–309*
 - terminology, 311*
 - virtual home networks, 317*
 - nonmobile scenarios
 - community of interest, 321*
 - IPv4 to IPv6 transitioning, 318*
 - route projection, 321–322*
 - overview, 317–318*
 - server load balancing, 322*
 - topology hiding, 319–321*
- Mobility header, 295–297**
- mobiquity, 291, 327**
- Moonv6, 448**
- More-Specific Routes (MSR), 598**
- movement detection, 323**
- MP_REACH_NLRI attribute, 166**

MP-BGP (multiprotocol BGP) extensions

- next hop, 166–168
- overview, 164–165
- peering, 165–166
- VPNv6 features, 272

MPLS (Multiprotocol Label Switching), 131–132

- DiffServ, 190–194
- Ethernet, 133
- forwarder, 138
- IPv4 tunnels, 134
- multicast deployments, 233–234
- overview, 17, 139–140
- service provider deployments
 - access design, 462–464*
 - addressing, 497–499*
 - core design, 465–468*
 - CsC-CE configuration, 493*
 - design objectives, 453–460*
 - edge design, 468–478*
 - global Internet access design and implementation, 488–489*
 - inter-AS design, 484–487*
 - MTU discovery, 500*
 - POP design, 464–465*
 - QoS design, 493–496*
 - route reflector design, 479–481*
 - security, 500–501*
 - troubleshooting, 502–507*
 - VPN IA service design and implementation, 490–492*
 - VPN service design and implementation, 489–490*
 - VRF design, 482–484*
- traffic engineering, 195

MPLS-TE, 190**MSR (More-Specific Routes), 598****MTU discovery, 500****multicast distribution trees (MDTs), 215–216****Multicast Forwarding Information Base (MFIB), 225****Multicast Listener Discover (MLD) protocol, 209–214****multicast services, 16–17, 207–208**

- addressing, 208–215
- deployment, 225
 - ASM model, 230–232, 239–247*
 - domain control, 225–226*
 - enterprise networks, 602–605*

MPLS infrastructures, 233–234

RP mapping and redundancy, 226–229

service models, 229–232

SSM model, 213, 230–239

tunneling mechanisms, 232

filtering traffic, 336

implementation, 547–551

IPv4, 17

layer 2 protocols, 214–215

routing and forwarding, 215–225, 563–565

multicast VPN (MVPN), 17, 233**multihoming**

MPLS networks, 499

overview, 169–170, 325

multiprotocol BGP extensions (MP-BGP)

next hop, 166–168

overview, 217–218, 164–165

peering, 165–166

Multiprotocol Label Switching. See MPLS**MVPN (multicast VPN), 17, 233**

N

NAT (Network Address Translation)

elimination of, 348

NAP, versus, 12–13

overview, 7–14, 140

security, 12

NAT-PT (Network Address Translation–Protocol Translation), 140–143**Neighbor Discovery (ND), 291, 596****Neighbor Solicitation messages, 596****Neighbor Unreachability Detection (NUD), 596–597****NEMO (NEtwork MObility) standards, 22, 304****network access. See access****Network Architecture Protocol (NAP), 12–13****network mobility**

aggregated home networks, 314

distributed home networks, 316–317

enterprises on the move, 305

extended home networks, 313–314

fleet in motion, 309–310

home gateways, 306

home networks, 313

Internet-enabled cars, 307–308

mobile home networks, 314–316

- operations, 311–313
- PANs, 306–307
- sensor networks, 308–309
- terminology, 311
- virtual home networks, 317
- NETwork MObility (NEMO), 22, 304**
- next hops**
 - 6VPE, 261–262
 - BGP, 166–168
 - BGP-MPLS, 261–262
- NEXT_HOP attribute, 162**
- NUD (Neighbor Unreachability Detection), 596–597**

O

- operating systems, 440–441**
- operations cost analysis, 443–444**
- ORF (outbound route filtering), 270**
- OSPFv3 (Open Shortest Path First version 3)**
 - configuring, 155–157
 - IPv6 support, 154–155
 - overview, 153–154
- outbound route filtering (ORF), 270**

P

- PANs (personal-area networks), 306–307**
- Partner e-Learning Connection (PEC), 449**
- path vector routing protocol, 147**
- PE (provider edge)-based VPNs**
 - BGP-MPLS VPNs, implementing
 - basic topology, 274–277*
 - dual stack topology, 278–279*
 - forwarding in, 264–266*
 - hub-and-spoke topology, 280–282*
 - Internet access topology, 282–284*
 - interprovider topology, 285–289*
 - label stack, building, 262–264*
 - MP-BGP features, 272*
 - next hops, 261–262*
 - overview, 255–257*
 - route reflector topology, 279–280*
 - routing protocols, 260–261*
 - routing table segregation, 257–260*
 - scaling, 270–271*

- VRF (virtual routing and forwarding), 267–269*
- overview, 252
- security, 253–254, 347–348
- peering, BGP, 165–166**
- penultimate hop popping (PHP), 137, 266**
- performance, router forwarding**
 - 6PE/6VPE environments, 432–433
 - centralized versus distributed forwarding, 424
 - control plane, 417–419
 - data plane, 419–420
 - evaluation checklist, 433–435
 - high-end routers, 429–432
 - low-end routers, 425–426
 - measuring, 420–422
 - mid-range routers, 426–429
 - overview, 415–417
 - software versus hardware forwarding, 423
- PHP (penultimate hop popping), 137, 266**
- PIM traffic forwarding, 243–244**
- PIM-Bidir, 220, 225**
- PIM-SM, 220–229**
- PIM-SSM, 220, 224–225**
- Ping command, 581**
- PIX Firewall, 359–360**
- policy function, 176**
- POP design, 464–465**
- PPP (Point-to-Point Protocol), 521–523**
- PPP over ATM (PPPoA), 111–113**
- PPP over Ethernet (PPPoE), 113–115**
- PPP-encapsulated access**
 - overview, 110
 - PPPoA, 111–113
 - PPPoE, 113–115
- PPVPNs (provider-provisioned VPNs), 251**
- prefixes, 445**
 - delegation, 95–103
 - general, 98
 - pools, 101–102
 - RIR, 446
- private addresses**
 - public addresses, versus, 8–9
 - VPN IPv4 sites, 253
- protocols**
 - multicast, 207–208
 - routing
 - BGP-MPLS VPNs, 260–261*

enterprise networks, 595

IPsec VPNs, 255

See also specific protocols

provider edge (PE)-based VPNs. *See* PE

(provider edge)-based VPNs

provider-provisioned VPNs (PPVPNs), 251

provisioning, 91, 559–561

host addresses, 91–93

prefix delegation

Delegating Routers, 101–102

overview, 95–96

protocol description, 96–98

RRs, 98–101

stateful DHCP, 93–95

public addresses, 8–9

Q–R

QoS (quality of service), 14–15, 175–178, 551–552

enterprise network deployments,
609–610

implementation, 552–555

IPv4, 15

IPv6

deploying, 200–205

DiffServ-based deployment, 181–189

IntServ-based deployment, 189–190

IPv4, versus, 179–181

IPv6 over MPLS, 190–199

overview, 15, 178

MPLS, 493–496

radio technologies, 301

RADIUS authentication,

112, 360–361

Rapid Commit, 97

rate limiting, 363–364

RBE (Routed Bridged Encapsulation)

feature, 109

Real Time Protocol (RTP), 181

reconnaissance, 332–334

recursive name serves, 103

redundancy

first-hop router, 596–601

multihoming, 169–170

registration, addresses, 444–447

remote access

enterprise networks, 589

IPsec VPNs, 254–255

rendezvous points. *See* RPs

renumbering

addresses, 10–11

VPNs, 18

REPLY messages, 94

Requesting Routers (RRs), 96

resolvers, 104

Resource Records, 104–105

return on investment (ROI)

hosts, 440–442

network elements, 442–443

operations, 443–444

overview, 439

reverse routability, 298

reverse-path forwarding (RPF), 216–219

RGMP (Routing Group Management Protocol), 214

RIBs (Routing Information Bases), 149

RIPE, 445

RIPng

configuring, 149–150

IPv6 support, 148–149

RIRs (Regional Registries), 445

roaming, 323

rogue devices, 346

rollout, service, 537–538

route flapping, 343

route optimization, 295, 298

**route optimization for NEMO,
325–326**

route projection, 321–322

route reflectors

MPLS networks, 479–481

PE-based VPNs, 270–271, 279–280

route refresh, PE-based VPNs, 270–271

routed access, 109

Routed Bridged Encapsulation (RBE)

feature, 109

**Router Group Management Protocol
(RGMP), 214**

routers, 442

architecture, 423–424

first-hop redundancy, 596–601

forwarding performance

6PE/6VPE environments, 432–433

- centralized versus distributed forwarding*, 424
- control plane*, 417–419
- data plane*, 419–420
- evaluation checklist*, 433–435
- high-end routers*, 429–432
- low-end routers*, 425–426
- measuring*, 420–422
- mid-range routers*, 426–429
- overview*, 415–417
- software versus hardware forwarding*, 423

- mobile, 311
- VRF-aware commands, 269

routing, 14

- attacks, 343–344
- multicast, 215–225

Routing Information Bases (RIBs), 149

- Delegating Routers, 102

routing protocols, 145

- BGP-MPLS VPNs, 260–261
- deploying
 - network access*, 172–173
 - network core*, 170–172
 - network distribution/edge*, 172
- distance vector routing, 146–147
- enterprise networks, 595
- IPsec VPNs, 255
- link-state vector routing protocol, 147–148
- path vector routing protocol, 147
- See also* specific protocols

RPs (rendezvous points), 215

- embedded RP, 227–229, 244–247
- PIM-Bidir, 225
- PIM-SM, 224
- PIM-SSM, 224–225

RPF (reverse-pathforwarding), 216–219

RPs (Rendezvous Points), 17

RRs (Requesting Routers), 96–101

RSVP-TE, 194–199

RTP (Real Time Protocol), 181

S

- scaling PE-based VPNs, 270–271

- SEAMOBY (seamless mobility, for context and micro-mobility routing), 311

security

- 6PE, 347
- access, 556–558
- best practices, 364–365
- Cisco SAFE Blueprint, 20
- data center, 558–559
- edge, 558
- enterprise network deployments,
 - 601–602, 611–612
- MIPv6, 21, 299–300, 345
- MPLS, 500–501
- NAT, 12
- overview, 20–21, 329–332
- threats

- address-resolution attacks*, 341–342
- application layer attacks*, 346
- broadcast-amplification attacks*, 343
- flooding attacks*, 346
- header manipulation*, 336–337
- host-initialization attacks*, 341–342
- IP packet fragmentation*, 337–338, 354–355
- man-in-the-middle attacks*, 346
- reconnaissance*, 332–334
- rogue devices*, 346
- routing attacks*, 343–344
- sniffing*, 346
- spoofing*, 338–341
- transition-mechanism attacks*, 344–345
- unauthorized access*, 334–336
- viruses*, 344
- worms*, 344

tools

- AAA (*authentication, authorization, and accounting*), 360–361
- ACLs (*access control lists*), 352–356
- firewalls, 356–360
- IPsec, 348–352
- overview, 348
- traffic rate limiting, 363–364
- uRPF (*Unicast Reverse Path Forwarding*), 341, 361–363
- VPNs, 19, 253–254, 347–348

sensor networks, 308–309

server load balancing, 322

service level agreements, 15

service provider deployments (MPLS)

- access design, 462–464

- addressing, 497–499
- core design, 465–468
- CsC-CE configuration, 493
- design objectives, 453–460
- edge design, 468–478
- global Internet access design and implementation, 488–489
- inter-AS design, 484–487
- MTU discovery, 500
- POP design, 464–465
- QoS design, 493–496
- route reflector design, 479–481
- security, 500–501
- troubleshooting, 502–507
- VPN IA service design and implementation, 490–492
- VPN service design and implementation, 489–490
- VRF design, 482–484
- service providers, 16**
- services**
 - advanced, 541–542
 - multicast, 542–551
 - rollout, 537–538
 - targeted, 516–520
- shaping function, 176**
- shortest path trees (SPTs), 215–216**
- SIP (Session Initiation Protocol), 12**
- smurf attacks, 343**
- sniffing, 346**
- software**
 - forwarding routers, 423
 - upgrade costs, 441
- SOLICIT messages, 94**
- Source Specific Multicast. *See* SSM**
- spoofing attacks, 338–341**
 - uRPF (Unicast Reverse Path Forwarding), 341, 361–363
- SPTs (shortest path trees), 215–216**
- SSM (Source Specific Multicast)**
 - ASM, versus, 230–231
 - overview, 543
 - SSM mapping for MLDv1, 213
 - SSM mapping for MLDv2, 234–239
- Start Here manual, 442**
- stateful DHCP, 91–95**
- stateful filtering, 353–354**

- stateless autoconfiguration**
 - address renumbering, 92–93
 - operation, 92
- stateless DHCP, 103–104**
- static addresses, 9–10**
- storage, 443**
- switches, 442**

T

- TACACS+ (Terminal Access Controller Access Control System Plus), 361**

- targeted services**

- communities of interest, 519–520
- content delivery, 518
- content hosting/storage, 517
- DNS services, 517
- Internet access, 517
- mail services, 517
- MIPv6, 519–520
- overview, 516
- unicast connectivity, 516
- VoIP, 517–518

- Teredo tunnels, 122–123**

- TIB (Tree Information Base), 219**

- topology hiding, 319–321**

- Traceroute command, 581**

- traffic conditioning, 176**

- traffic engineering, 195**

- traffic filtering, 334–335**

- traffic forwarding, PIM, 243–244**

- traffic rate limiting, 363–364**

- training, 447–449**

- transitioning, 318**

- transition-mechanism attacks, 344–345**

- translation mechanisms, 140–143**

- Tree Information Base (TIB), 219**

- troubleshooting**

- enterprise network deployments, 610
- MPLS service provider networks, 502–507
- multicast routing/forwarding, 563–565
- overview, 555
- provisioning, 559–561
- securing networks
 - access, 556–558*

data center, 558–559
edge, 558
overview, 555–556
unicast routing/forwarding, 561–563

tunnels

6to4, 128–131
brokers, 122
GRE, 127–128
IPsec VPNs, 255
IPv4, 127, 134
ISATAP, 123–124
layer 2 circuits, 132–134
manually configured, 121–122
multicast deployments, 232
overview, 120–121
servers, 122
Teredo, 122–123

U

ULAs (unique local addresses), 253, 498–499

unauthorized access, 334–336

unicast, 6

access layer
media types, 107–109
native access, 109–115
virtualized, 115–120
address space, 445
addressing
IPv4, 6–8
NAT, 11–14
public vs. private, 8–9
renumbering, 10–11
static vs. dynamic, 9–10
connectivity, 516, 528–530
deployment mechanisms, 89
routing, 14, 561–563
forwarding, 561–563
service rollout, 537
tunnels
brokers, 122
ISATAP, 123–124
manually configured, 121–122
servers, 122
Teredo, 122–123

Unicast Reverse Path Forwarding (uRPF), 341, 361–363

unicast routing/forwarding, 561–563

unique local addresses (ULAs), 253, 498–499

unspecified addresses, 445

upgrade costs

hosts, 440–441
network elements, 442–443
operations, 443–444
overview, 439–442

uRPF (Unicast Reverse Path Forwarding), 341, 361–363

V

vendor-specific attributes (VSAs), 360–361

virtual home networks, 317

virtual routing and forwarding. *See* VRF

virtualized access layer

L2TPv2 access aggregation, 116–119
L2TPv3 access aggregation, 119–120
overview, 115

viruses, 344

VLSM (variable-length subnet mask), 7

VoIP, 517–518

VPNs (virtual private networks)

addressing, 18, 252–253
benefits, 18
cost savings, 18
extended connectivity, 18
overview, 18–19, 249–251
privacy, 19
renumbering, 18
security, 19, 253–254, 347–348
services, 18

VRF (virtual routing and forwarding)

associating to an interface, 269
configuring, 268
MPLS networks case study, 482–484
overview, 267
VRF-aware router commands, 269

VSAs (vendor-specific attributes), 360–361

W

websites, 449

WiFi access points, 443

worms, 344