
Index

Note: Italicized page locators refer to figures/tables.

- (* , G), 66
 - output of ip mroute command, 208
 - state, 7
- (* , G) Asserts, in Assert message format, 292
- (* , G) Join, 16, 111
 - and anycast RP, 74
 - messages, 12, 46, 75
 - and PIM-SM in SSM, 120
- (* , G) Join source list entry
 - and group set fragmentation, 290
 - in Join/Prune messages, 287
- (* , G) state, for PIM-SM, 25
- (* , * , RP) source list entry, in wildcard group set, 286

A

- ABRs. *See* Area border routers
- Access control, and SSM, 114
- Active peers, state transition for, 94
- Active SNMP, Web site for, 246
- Addresses, SSM, 112
- Address exhaustion, protecting against, 22

- Address family identifiers, 136, 139
- Addressing issues, 21–23
- Address mapping, of Layer 3 to layer 2, 17, 18, 19
- Addr Family
 - in Encoded-Group Address, 276
 - in Encoded-Source address, 277
- Addr Length, in PIM-Join/Prune message, 294
- Adjacencies
 - establishing on point-to-point links, 154
 - forming for M-ISIS, 160, 162
 - and IS-IS areas and levels, 150
 - in multiple-area IS-IS network, 151, 152
- Adjacency finite state machine, BGP, 130
- Administrative distance, 211, 213
 - in Cisco Internetwork Operating System, 127
- “Administratively Scoped IP Multicast” (RFC 2365), 86, 87
- Administrative scoping, 23
- Admin Scope [Z]one, in Encoded-Group Address, 276
- AESA. *See* ATM end-system addresses
- AFI. *See* Authority and format indicator

INDEX

- AFIs. *See* Address family identifiers
 - AGGREGATOR attribute, 132, 133, 135
 - ALLOW, 267
 - ALLOW_NEW_SOURCES record type, 118
 - ALLOW_NEW_SOURCES value, 266
 - ALL-PIM-ROUTERS group, 46, 82, 273, 274
 - ALL-ROUTERS link-local multicast group, mtrace query sent to, 250
 - ALL-SYSTEMS multicast group, 42
 - Andreessen, Marc, 28
 - Announce and mapping category, and auto-RP, 177, 206
 - Announce-only category, and auto-RP, 176, 178, 205
 - Anycast, 74
 - Anycast RP, 70, 74–75, 218
 - address router, 218
 - as example of intradomain MSDP, 91
 - and MSDP SA message, 95
 - primary goal of, 100
 - Anycast RP configuration
 - and Cisco System routers, 207–208
 - and Juniper Networks routers, 179–180
 - Any-Source Multicast, 109, 120, 217
 - and Internet applications, 110
 - Source-Specific Multicast versus, 20–21
 - Any-Source Multicast terminology, Source-Specific Multicast terminology compared to, 111
 - Any-to-any connectivity, 54
 - Application service providers, 32
 - Area border routers, 150
 - AS. *See* Autonomous system
 - ASM. *See* Any-Source Multicast
 - AS_PATH attribute, 132, 133, 141, 143
 - ASPs. *See* Application service providers
 - AS. *See* Autonomous system
 - Assert message format, 290–292
 - Assert messages, PIM, 83–86
 - Asynchronous Transfer Mode, 36, 149
 - ATM. *See* Asynchronous Transfer Mode
 - ATM end-system addresses, 149
 - ATOMIC_AGGREGATE attribute, 132, 133
 - Audio streaming, and RTP, 255
 - Authority and format indicator, 149
 - Autonomous system, 5, 39, 128
 - BGP, IGP and routing decisions between/within, 145
 - interconnected, 40
 - MBGP used for achieving incongruent routing across, 143
 - in topology with incongruent unicast and multicast paths, 122, 123
 - Auto-RP, 72, 73
 - anycast RP with, 75
 - and dynamic group-to-RP mapping, 70–71
 - and multicast scoping, 86
 - for PIM-SM, 66
 - RP learned through, 177, 206
 - Auto-RP configuration
 - and Cisco System routers, 204–206
 - and Juniper Networks routers, 175–179
 - Auto-RP leaking, preventing, 178
 - Aux Data Len field, in version 3 Membership Report message, 264
 - Auxiliary Data field, in version 3 Membership Report message, 264
 - Availability, of SSM applications, 115
- B**
- Backward compatibility, with M-ISIS, 159–160, 162
 - Bandwidth
 - limited, of “last mile,” 29
 - and multicast, 3
 - and TLV 22, 156
 - and TTL, 87
 - and unicast delivery, 2
 - Bell, Alexander, 28
 - Berners-Lee, Tim, 28
 - BGMP. *See* Border Gateway Multicast Protocol
 - BGP. *See* Border Gateway Protocol
 - BGP adjacency finite state machine, 130
 - BGP4, 123, 128, 129
 - BGP header, fields in, 130

- BGP Loc-RIB, 164
 - BGP next hops, 145, 166
 - recursive lookup for, 128
 - BGP Open messages, optional parameters field in, 137
 - BGP packets, format of, 130
 - BGP path attributes, examples and categories of, 132
 - BGP path selection algorithm, 166
 - BGP peering sessions, 93
 - BGP peers, 129, 130–131
 - BGP route selection, 134
 - BGP session, 130
 - BGP speaker, 129
 - BGP update message, 6, 134
 - fields in, 131–132
 - Bi-directional PIM (Bi-Dir PIM), 254–255, 276
 - Bit mask, slash notation for, 4
 - Blackholes, 105
 - and mtrace queries, 250
 - multicast, 123, 187, 211
 - BLOCK, 267
 - BLOCK_OLD_SOURCES record type, 118, 119
 - BLOCK_OLD_SOURCES value, 266
 - Bootstrap mechanisms, configuring in PIM-SM domain, 203–204
 - Bootstrap messages, 69
 - hash-masks in, 73
 - PIM version 2, 68
 - Bootstrapping, anycast RP with, 75
 - Bootstrap routers, 69
 - and Auto-RP, 73
 - filters, 175
 - load balancing provided by, 74
 - PIM, 72
 - Border bit (B), in Register Message Format, 282
 - Border Gateway Multicast Protocol, 107, 253–254
 - “Border Gateway Multicast Protocol (BGMP): Protocol Specification,” 253
 - Border Gateway Protocol, 6, 13, 58
 - and anycast RP, 74
 - capabilities negotiation, 137–140
 - functions separating IGP from, 129
 - message types with, 130
 - path attributes, 132
 - primary purpose of, 142
 - and routing decisions between autonomous systems, 145
 - Broadcast, 1
 - Broadcast delivery, 3
 - BSRs. *See* Bootstrap router
 - BSR messages, BSR filters for, 175
- C**
- Cable modems, 29, 36
 - Caching, SA, 92, 93, 209
 - Candidate BSRs, routers configured as, 174
 - Candidate-RP Advertisement messages, 68, 72
 - Candidate RPs, 70
 - routers configured as, 174
 - Capabilities negotiation, BGP, 137–140
 - Capabilities parameter, 138
 - Capability code, 138
 - Capability Code field, 138
 - Capability Length field, 138
 - Capability negotiation, use of, for MBGP, 138–140
 - Case study, service provider native deployment, 217–244
 - Cease subcodes, 306
 - Cerf, Vint, 28
 - CGMP. *See* Cisco Group Management Protocol
 - CHANGE_TO_EXCLUDE_MODE, 265, 267
 - CHANGE_TO_INCLUDE_MODE, 265
 - Channels, SSM, 111
 - Checksum, 155
 - in Assert message format, 290
 - in IGMP message format, 259
 - and IGMP messages, 293
 - in IGMP version 1 packet format, 271

INDEX

- Checksum, *continued*
 - in Join/Prune message format, 285
 - in Membership Query messages, 270
 - in PIM packet format, 274–275
 - in Register message format, 282
 - in Register-Stop message format, 283
 - in version 3 Membership Report message, 263
 - CIDR. *See* Classless interdomain routing
 - Cisco Group Management Protocol, 19
 - CISCO-RP-ANNOUNCE, 70
 - CISCO-RP-DISCOVERY, 71
 - Cisco Systems, 66, 76, 90, 93, 146
 - Auto-RP, 69, 70–71
 - conventions, 127
 - customer RP configuration, 239–240
 - customer without RP configuration, 235
 - implementation of PIM by, 67
 - ISP non-RP configuration, 231–232
 - ISP RP configuration, 225–227
 - MSDP implementations of, 96, 102
 - and PIM-SM in SSM, 120
 - router configurations, 217
 - and SSM addresses, 112
 - SSM-only configuration, 243–244
 - Cisco Systems routers, 24, 27, 65, 71, 145
 - and BGP next hop, 128
 - configurations for, 220
 - multicast routing on, 199–216
 - Class A networks, 5
 - Class B networks, 5
 - Class C networks, 5
 - Class D addresses, 22
 - Class D range, of IPv4 address space, 5
 - Classful allocation, 5
 - Classful networks, 5
 - Classless interdomain routing, 5
 - CLNP. *See* Connectionless Network Protocol
 - CLNS. *See* Connectionless Network Service
 - CNN, rebroadcasting of, as multicast feed, 37
 - Cocktail napkin protocol, MSDP as, 107
 - Codes, IGMP messages, 293,
 - Collisions, and oversubscription, 18
 - Communication, and Internet, 28
 - COMMUNITY attribute, 132
 - Complete Sequence Number PDU, 153–154
 - Conference model, 81
 - Configuration groups, and JUNOS software, 190–191
 - Congruent routing, MBGP and achieving of, 143
 - Connectionless Network Protocol, 146
 - Connectionless Network Service, 126, 168
 - Connectivity loss, 105, 245
 - CONNECT state, 94
 - Control bits, in Value field, 163
 - Control Information field, in TLV 135, 159
 - Control messages, for phase 3, 52
 - Control packets, 6, 106
 - Convergence, 30, 38, 73, 74
 - and anycast RP, 75
 - and distance-vector protocols, 125
 - Copyright laws, and Napster, 29
 - Core router, 10
 - Crossbar switching architecture, 26
 - CSNP. *See* Complete Sequence Number PDU
 - “Cube-cams,” 24
 - “Current-State Record,” 264–265
 - Customer router configurations, in service provider native
 - deployment case study, 232
 - Customer RP configuration
 - Cisco Systems, 239–240
 - Juniper Networks, 236–239
 - Customer without RP configuration
 - Cisco Systems, 235
 - Juniper Networks, 232–234
- D**
- Data delivery, methods of, 1
 - Data link layer, 17
 - Data packets, 6

- Debugging, for PIM BSR messages, 204
- Decapsulation
- and Juniper Networks routers, 170
 - and PIM Register messages, 171, 172
 - and routers, 76
- Dedicated RPF table configuration
- and Cisco Systems routers, 211–213
 - and Juniper Networks routers, 187–198
- Deering, Steve, 2, 18, 270, 292
- Default RPF peer, 100
- Delivery monitoring, with RTP over UDP, 255
- Denial-of-service attacks, 114
- and SSM, 114, 115
 - susceptibility to, 36
- Dense groups, 205
- and auto-RP, 176, 206
- Dense protocols, 60, 61–63, 109
- DVMRP, 62
 - PIM-DM, 63
 - primary difference between sparse protocols and, 63
 - shortcomings with, 110
- Designated intermediate system, 154
- Designated routers, 22, 44, 111, 112
- and Hello messages, 82–83
- Digital subscriber line, 29, 36
- Dijkstra's algorithm, 147
- DIS. *See* Designated intermediate system
- Disclaimers and fine print, 27–28
- Discovery category, and auto-RP, 176, 205
- Discovery-only routers, 70
- Distance Vector Multicast Routing Protocol, 6, 13, 61, 62
- codes, 293
 - configuration of, for providing RPF information to PIM, 197–198, 216
 - configuration of, in unicast-only mode on interface, 198
 - multicast RPF tables populated with, 125
 - and populating of inet.2 table, 126
- Distance-vector protocols, 100, 125
- Distribution tree construction and teardown, 77–81
- scenario 1: source comes online first, then receiver joins, 77–79
 - scenario 2: second receiver ends group membership, 81
 - scenario 3: receiver ends group membership, 81
 - scenario 4: conference model, 81
- Distribution trees, 3, 6, 7, 110
- building, for delivery of packets from source to RP, 48–50
 - and multicast routing, 45
- DNS. *See* Domain Name System
- Domain, 5
- Domain identifier, 149
- Domain Name System, 32
- “Domain-wide Prefix Distribution with Two-Level IS-IS,” 147, 155
- DoS attacks. *See* Denial-of-service attacks
- Downstream, 7
- DR Priority, 280, 281
- DRs. *See* Designated routers
- DSL. *See* Digital subscriber line
- Duplicate flow of packets, and multicast, 3
- Duplicate packets, forwarding to transit LANs, 84
- DVMRP. *See* Distance Vector Multicast Routing Protocol
- DVMRP routing table
- displaying contents of, 216
 - for RPF, 211
- Dynamic group-to-RP mapping, Cisco Systems Auto-RP, 70–71
- “Dynamic Hostname Exchange Mechanism for IS-IS,” 146
- Dynamic protocols, 254
- Dynamic routing protocols, multicast RPF tables populated with, 124–125
- E**
- EBGP. *See* External Border Gateway Protocol
- EGP. *See* Exterior gateway protocol

INDEX

- Emergency situations, and role of multicast, 37–38
- EMSDP. *See* External Multicast Source Discovery Protocol
- Encapsulation
 - of IGMP messages, 257, 268, 271
 - and Juniper Networks routers, 170
 - and PIM Register messages, 171
- Encoded-Group address, format of, 276
- Encoded-Source address, format of, 277
- Encoded-Unicast address, in PIM packet format, 275
- Encoding Type
 - in Encoded-Group Address, 276
 - in Encoded-Source address, 277
 - in PIM packet format, 275
- End system, 146
- End-to-end connectivity requirements, 34
- Enterprise networks, 13
 - and dense protocols, 61
 - and multicast, 38
 - unicast/multicast routing on, 13, 14
- Entry count, in IPv4 Source-Active TLV, 302
- Error codes, in Notification TLV, 305
- Error subcodes, in Notification TLV, 305–306
- ESTABLISHED state, 97
- Estrin, Deborah, 292
- Ethernet, 17, 36, 83
 - connections, 29
 - switches, 19
- Ethernet header, and layer 3 to layer 2 address mapping, 18
- Example network
 - Multicast Source Discovery Protocol in, 54–56
 - Multiprotocol Border Gateway Protocol in, 58–60
 - phase 1 on, 46–48
 - phase 2 on, 49–50
 - phase 3 on, 51–52
- Exclude mode, 42
 - and IGMPv3, 116
- Experimental MIBs, rooting of, 246
- Explicit join, 63
- Explicit leave, 42
- Export RIBs, and BGP route extraction for advertising to peers, 192
- Extended IP Reachability (TLV 135), 158
- Extended IS Reachability (TLV 22), 156
- Exterior gateway protocol, 5, 129
- External BGP connections, 164
- External Border Gateway Protocol, 39
- External links, 129
- External Multicast Source Discovery Protocol, 104
- External peer, 129
- F**
- Fanout, 25
- Farinacci, Dino, 292
- Federal Internet Exchange, 15
- Fenner, Bill, 268, 273, 299
- File transfer, and multicast, 29
- File Transfer Protocol, 6
- “Filter-Mode-Change Record,” 265
- Filter-Mode-Change Record, 266
- Financial networks
 - and multicast, 38
 - unicast/multicast routing on, 13, 14
- Finite State Machine Error subcodes, 306
- Firewall filter, 251
- Firewalls, less friendly, 36–37
- FIX. *See* Federal Internet Exchange
- Flexible PIC Concentrators, 167
- Flood-and-prune model, 62
- Flooding, 95, 96, 109
- Forwarding, and mask, 5
- Forwarding performance
 - and hardware, 26
 - and routers evaluated for multicast, 25
- Forwarding table, unicast, 135
- FPCs. *See* Flexible PIC Concentrators
- Frame relay, 36
- FTP. *See* File Transfer Protocol
- fxp0, 167, 168

fxp1, 167, 168
fxp2, 168

G

General Query, 259, 261
 within Membership Query messages (IGMPv2), 269
 and Number of Sources (N) field, 260
General Query messages, IGMPv3, 118
Generation ID option, 281
Generic routing encapsulation, 166, 170
Global configuration mode, 199
 and anycast RP configuration, 207, 208
 and auto-RP configuration, 205, 206
 and dedicated RPF table configuration, 212, 213
 and MSDP configuration, 209, 210
 and PIM sparse mode bootstrap mechanism configuration, 204
 and static RP configuration, 202, 203
GLOP, 22, 23, 113
GMI. *See* Group membership interval
GRE. *See* Generic routing encapsulation
G-RIB table, and MASC, 253
Group Address, 6, 270, 272
 in Assert message format, 291
 in IGMP message format, 259
 in IGMP messages, 293–294
 in IPv4 Source-Active Request TLV, 303
 in IPv4 Source-Active TLV, 302
 in Register-Stop Message format, 283
 in RP-Reachability message, 298
 and SA filtering, 105
 in SSM, 114
Group Address Mask, in RP-Reachability message, 298
Group-and-Source Specific Query, 259, 260–261
Group cache, IGMP, 42–43
Group membership interval, 43
Group Multicast Address, in Encoded-Group Address, 277

Group records
 format of (IGMPv3), 117
 notation for, 267
 in version 3 Membership Report message, 263, 264
Group set fragmentation, 289–290
Group set source list rules
 and combinations with valid interpretation, not generated by protocols described, 288–289
 and Join/Prune message, 286–289
Group set types, 286–289
Group-Specific Query, 259, 261
 within Membership Query messages (IGMPv2), 269
 and Number of Sources (N) field, 260
Group specific set, 287–289
Group-to-RP mapping, 69–74
 dynamic, 70–71
 dynamic RP mapping: PIM Bootstrap, 72–74
 static, 70
Gutenberg, Johannes, 28

H

Handley, Mark, 273
Hardware, and forwarding performance, 26
Hash algorithms, for electing active RP for group G, 73
Hash function, and load balancing, 74
Hash-masks, 73
Hash values, computing, 73
HDTV, 31
Head-of-line blocking, 26
Hello messages
 and designated routers, 82–83
 format for, 278–281
 PIM version 2, 68
Hello packets
 and adjacencies for M-ISIS, 160, 162
 and database synchronization, 154
Hello timer, 82

INDEX

- High severity problems, with RPF-peer rules
 - and internetworks
 - using MSDP, 102–103
- Holbrook, Hugh, 273
- Hold-time, 281
 - and Hello messages, 279
 - in Join/Prune Message Format, 285
 - value, 82, 83
- Hold Timer Expired subcodes, 306
- Hop count, with DVMRP, 62
- Hop-to-hop mode, and mtrace queries, 250
- Host, 42
- Host B, multicast traffic received from server A by, 40
- Host Membership Query messages, 41, 271, 272, 293
- Host Membership Report messages, 271, 272, 293
- HTTP. *See* Hypertext Transfer Protocol
- Hubs, 19
- Hypertext Transfer Protocol, 32
- I**
- IANA. *See* Internet Assigned Numbers Authority
- IBGP. *See* Internal Border Gateway Protocol
- ICD. *See* International code designator
- ICMP. *See* Internet Control Message Protocol
- IESG. *See* Internet Engineering Steering Group
- IETF. *See* Internet Engineering Task Force
- IGMP. *See* Internet Group Management Protocol
- IGMP Cache Table, in IGMP MIB, 248
- IGMP Code field, 68
- IGMP Connected Group Membership, 201
- IGMP Host Membership Report, 46
- IGMP-Host-Query message, group address field in, 293
- IGMP-Host-Query packet, 292
- IGMP-Host-Report message, group address field in, 293
- IGMP-Host-Report packet, 292
- IGMP Interface Table, in IGMP MIB, 248
- IGMP Leave-Group messages, 111
- IGMP Membership Queries, 258
- IGMP messages
 - format of, 268, 271
 - types of, 293
- IGMP MIB (igmpStdMIB), 248
- IGMP packet formats, 257–272, 292
 - version 1 packet formats, 270–272
 - version 2 packet formats, 268–270
 - version 3 membership report message, 262–267
 - version 3 packet formats, 257–262
- IGMP protocol number, for mtrace utility, 250
- IGMP Reports, 16
- IGMP snooping, 19
- IGMPv1
 - difference between IGMPv2 and, 42
 - packet formats, 270–272
 - Windows 95 support for, 16
- IGMPv2
 - difference between IGMPv1 and, 42
 - Windows 98 or 2000 support for, 16
- IGMPv2 packet formats, 268–270
 - checksum, 270
 - Group address field, 270
 - Max Response field, 269
 - other fields in, 270
 - types of messages, 268–269
- IGMPv3, 116–117, 257–258
 - exclude and include modes support from, 42
 - and IGMP version compatibility, 119
 - Membership Reports, 118, 258
 - message types supported by
 - implementation of, 258
 - packet formats, 257–262
 - and SSM, 110, 111, 115, 116–119
 - Windows XP support for, 16
- IGMP version compatibility, 119
- IGP. *See* Interior gateway protocol
- IIF (incoming interface), 7

- Import RIBs, for installing routes into routing tables, 192
- IMR. *See* Interdomain multicast routing
- IMSDP. *See* Internal Multicast Source Discovery Protocol
- INACTIVE state, 94
- In-band management, M-ISIS and support for, 145
- Include mode, 42, 116
- Incoming (or inbound) interface, 7
- Incongruent paths, for multicast and unicast routing, 59, 60
- Incongruent routing, MBGP and achieving of, 143
- Incongruent unicast and multicast paths, topology with, 122
- Incremental protocols, 254
- inet.0 routing table, 187
 - and BGP export/import policies, 193
 - and M-ISIS configuration, 194
 - OSPF configured place routes in, 196
- inet.2 routing table, 187
 - and BGP export/import policies, 193
 - and BGP next hops, 128
 - and M-ISIS configuration, 194
 - nondefault DVMRP RIB groups used to place routes in, 198
 - OSPF configured to place routes in, 196–197
 - OSPF RIB groups used to place routes in, 197
 - populating, 126
 - static routes added to, 189–190
- Interarea leaking, 155–156
- Interdomain connectivity, and MSDP, 89, 90
- Interdomain multicast
 - and anycast RP, 75
 - fundamentals of, 1–38
- Interdomain multicast routing, 13–15, 39, 217
- Interdomain source discovery, 91
- Interface configuration mode, 199
- Interface routes, RIB groups used for, 189
- Interfaces, enabling for IGMP and PIM, 200–201
- Interior gateway protocol, 5, 100, 128
 - functions separating BGP and, 129
 - and routing decisions within autonomous systems, 145
 - in service provider native deployment case study, 219
- Intermediate System to Intermediate System, 6, 13, 94, 125, 128
 - and anycast RP, 74
 - areas and levels, 150–151
 - background of, 146–148
 - and exchange of link-state information with neighbors, 155
 - and extending type length values, 156, 158–159
 - features provided by multitopology extensions to, 159
 - and interarea leaking, 155–156
 - and ISO addresses, 148–150
 - and mesh groups, 103
 - on multiaccess networks, 154–155
 - neighbor state machine on point-to-point links, 154
 - overview of, 146
 - packets, 153–154
 - specification documents for, 146–147
 - specifics of, 152–159
 - and type length values, 151–152
- Internal Border Gateway Protocol, 98
- Internal links, 129
- Internal Multicast Source Discovery Protocol, 104
- Internal peer, 129
- International code designator, 149
- International Organization for Standardization, 146
- Internet, 38, 128
 - and BGMP, 107
 - bidirectional communication with, 35
 - growth of, 28
 - multicast deployed/operated across, 14

INDEX

- Internet, *continued*
 - multicast feed over, 37
 - and one-to-many model, 110
 - and PIM-SM, 66
 - radio, television, and, 30
 - traffic trends for, 25
 - and unicast model for data delivery, 1
- Internet Address Families, 275
- Internet Assigned Numbers Authority, 21–22, 149, 275, 281
- Internet Control Message Protocol, 268, 271
- Internet-Drafts, IETF, 27
- Internet Engineering Steering Group, 27
- Internet Engineering Task Force, 107, 146
 - Internet-Drafts, 27
 - SSM Working Group, 110
- Internet Group Management Protocol, 16, 41, 61, 268, 270–272
 - Cisco Systems routers and configuration of, 200–201
 - JUNOS software and enabling interfaces for, 168–169
 - proxying, 17
- Internet service provider router configurations, 220–221
 - Cisco Systems, 225–227
 - Juniper Networks, 221–225
- Internet service providers, 13, 14, 15, 90, 146
 - and multicast deployment, 32
 - multicast-enabled, 31
- Internetwork base, 40
- Internetworking basics, 4–6
- Internetwork Operating System - IOS (Cisco), 127
 - and Cisco router platforms, 199
 - and PIM and IGMP configuration guidelines, 200–201
 - routing tables for RPF in, 211
- Internetwork Operating System software, technical documentation for configuring, 199
- Internetwork Packet Exchange (Novell), 135, 146
- IOS. *See* Internetwork Operating System
- IP (Internet Protocol) address ranges, and slash notation, 4
- IP datagrams, IGMP messages encapsulated in, 268, 271
- IP destination addresses
 - for queries, 261–262
 - for version 3 reports, 266
- IP header
 - and layer 3 to layer 2 address mapping, 18
 - TTL field in, 86
- IP-IP tunneling, 170
- ip mroute command, 208
- IP multicast
 - packets, 17
 - uses for, 255
- IPMulticastListen, and “Source-List-Change Record,” 265
- IP Multicast Route Table, in multicast routing MIB, 247
- IP Multicast Routing Interface table, in multicast routing MIB, 248
- IP Multicast Routing Next-Hop table, in multicast routing MIB, 248
- IP Multicast Scope Boundary table, in multicast routing MIB, 248
- IP Multicast Scope Name Table, in multicast routing MIB, 248
- IP Router Alert option, 257, 268
- IP Time-to-Live, and IGMP message, 257
- IP/TV (Cisco System), 24
- IPv4
 - scalability for IMR in, 107
 - subsequent address family identifiers for, 136
- IPv4 address space, Class D range of, 5
- IPv4 datagrams, IGMP messages encapsulated in, 257
- IPv4 multicast routing MIB, 247
- IPv4 multicast RPF routes, 192
- IPv4 Source-Active Request TLV, 302–303
- IPv4 Source-Active Response TLV, 303–304

- IPv4 Source-Active TLV, 301
- IPv6, 135
 - BGMP as IMR protocol for, 107
 - M-ISIS and support for, 145
- IPX. *See* Internetwork Packet Exchange
- IS_EX, 267
- IS_IN, 267
- IS-IS. *See* Intermediate System to Intermediate System
- IS-IS area number, 149
- IS-IS areas, OSPF areas compared to, 150
- “IS-IS Extensions for Traffic Engineering,” 147, 156, 158
- “IS-IS Intra-Domain Routing Information Exchange Protocol,” 146
- “IS-IS Mesh Groups,” 147
- ISO. *See* International Organization for Standardization
- ISO addresses, 148–150
- ISP non-RP configuration
 - Cisco Systems, 231–232
 - Juniper Networks, 228–231
- ISPs. *See* Internet service providers
- J**
- Jacobsen, Van, 292
- Join latency, 76
 - reducing, 92
- Join list, 287
- Join messages, 8, 53, 111
- Join/Prune messages, 46n.1
 - format of, 283–286
- Join Source Address 1..n
 - and Join/Prune Message format, 285
 - in PIM-Join/Prune message, 294
- Join Sources, 286
- Juniper Networks, 66, 76, 90, 93, 146
 - and Auto-RP, 70
 - conventions, 126–127
 - customer RP configuration, 236–239
 - customer without RP configuration, 232–234
 - implementation of PIM by, 67
 - ISP non-RP configuration, 228–231
 - ISP RP configuration, 221–225
 - MSDP implementations of, 96, 102
 - M-series, 26
 - and PIM-SM in SSM, 120
 - proprietary MIBs of, 246
 - public MIBs supported by, 246
 - router configurations, 217
 - and SSM addresses, 112
 - SSM-only configuration, 241–243
- Juniper Networks routers, 24, 27, 65, 71
 - and BGP next hops, 128
 - configurations for, 220
 - M-ISIS supported by, 145
 - multicast routing on, 167–198
 - RPT set up, no active sources, 180–181
 - source is active, host joins group later, 181–185
 - and SSM group range, 170
 - tunnel PIC and pe and pd interfaces, 170–172
- JUNOS operating system, 126, 127, 167
- JUNOS software
 - and configuration groups, 190–191
 - and configuring dedicated RPF table, 187–198
 - configuring/managing, to support multicast routing within domain, 168–185
 - and configuring MSDP, 185–187
 - and dense groups, 205
 - DVMRP configured to provide RPF information to PIM in, 197–198
 - and inet.0 routing table, 187
 - rp local command in, 202
 - technical documentation for configuring of, 167
- K**
- Keepalive message, with BGP, 130
- KeepAlive TLV, 304
- Kouvelas, Isidor, 273

INDEX

L

LAN Prune Delay, 280
 LAN_Prune_Delay option, in LAN Prune Delay, 280
 LANs. *See* Local area networks
 Last-hop router, 11
 Last mile technologies, unfriendly, 36
 Layer 2 switches, 19–20
 Layer 3 to layer 2 mapping, 17–19
 Leaking, 150, 203

- auto-RP and prevention of, 205, 206
- BSR filters and prevention of, 175
- interarea, 155–156
- and override keyword, 202
- prevention of auto-RP, 178
- SA filters and prevention of, 219

 Leave-Group messages, 42, 111
 Leave latency

- and Max Resp Code, 259
- reducing, 42

 Length field, 133, 141

- in BGP header, 130
- in Notification TLV, 305
- in TLV, 151

 Length x

- in IPv4 Source-Active Response TLV, 304
- in IPv4 Source-Active TLV, 301

 Length y, in IPv4 Source-Active TLV, 301–302
 Level 1

- Complete Sequence Number PDU (CSNP), 153
- IS-IS Hello PDU (IIH), 153
- link-state PDU (LSP), 153
- Partial Sequence Number PDU (PSNP), 153–154

 Level 1 (L1) routers, 150, 151

- and interarea leaking, 155–156
- link-state database, 155

 Level 1/Level 2 (L1/L2) routers, 150, 151, 155–156

Level 2

Complete Sequence Number PDU (CSNP), 153
 IS-IS Hello PDU (IIH), 153
 link-state PDU (LSP), 153
 Partial Sequence Number PDU (PSNP), 154
 Level 2 (L2) routers, 150, 151, 155
 Link color, and TLV 22, 156
 Link-state advertisement, 147
 Link-state database, 147
 Link-state information, exchanging with neighbors, 153, 155
 Link-state protocol data unit, 148
 Link-state protocols, 100, 125–126
 Listener, 6
 Load balancing, 73, 74

- and anycast RP, 75, 100, 179, 207, 218
- and MSDP, 89, 90, 91

 Local AFIs, 149
 Local area networks

- duplicate packets forwarded to, 84
- multicast on, 16–20

 LOCAL_PREF attribute, 132, 133, 141, 143
 Loc-RIB, BGP, 164
 Longest-match prefix, and RPF checks, 211
 Loopback addresses, 74, 75
 Loopback interface, 148, 207
 Loss of connectivity, identifying, 245
 Low severity problems, with RPF-peer rules and internetworks using MSDP, 102
 LSA. *See* Link-state advertisement
 LSDP. *See* Link-state database
 LSP. *See* Link-state protocol data unit

M

MAC address. *See* Media Access Control address
 Maddr Length, in PIM-Join/Prune message, 294
 Management Information Bases, 245

- Management tools for multicast networks, 245–255
 - MSDP traceroute facility, 252
 - mtrace facility, 249–252
 - SNMP MIBs, 245–249
- man mtrace, 251
- “Many-to-many” delivery model/
 - applications, 2, 14, 20, 21, 33, 110, 115, 116
- Mapping, Layer 3 to layer 2, 17, 18, 19
- Mapping agents, 70, 73
- Mapping-only category, and auto-RP, 177, 205
- Marker field, in BGP header, 130
- MASC. *See* Multicast Address Set Claim Protocol
- Mask, 5
- Mask length field
 - in Encoded-Group Address, 276–277
 - in Encoded-Source address, 278
 - in Multicast Group Address, 286
 - in Source Address format, 297
- Mask lengths, 5
 - with Cisco Systems, 126
 - with Juniper Networks, 126
- Max Resp Code, in IGMP message format, 259
- Max Response Time field, and Membership Query messages, 269
- Max Resp Time, 259
- MBGP. *See* Multiprotocol Border Gateway Protocol
- MBGP address family numbers, 136
- MBGP next hops, M-ISIS used for resolving, 165
- MBGP peering, 134, 191
- MBGP routing table
 - displaying contents of, 215–216
 - for RPF, 211
- MBone. *See* Multicast Backbone
- MCI, 146
- MD bit, in Source Address format, 296
- MED. *See* Multiple exit discriminator
- Media Access Control address, 17
- Membership Query message
 - additional data in, 261
 - in IGMP message format, 258
 - subtypes of, 269
- Membership Report, 43
- Membership Report messages, IGMPv3, 116, 118
- Mesh groups, 100, 103–104, 219, 220
- Message Header Error subcodes, 306
- Metric preference, in Assert message format, 291
- Metrics
 - in Assert message format, 291
 - with DVMRP, 62
 - and M-ISIS, 166
- Meyer, David, 299
- MIB browsing, 246
- MIBs. *See* Management Information Bases
- M-ISIS. *See* Multitopology Routing in IS-IS
- “M-ISIS: Multi Topology Routing in IS-IS,” 147
- MIX. *See* Multicast Internet Exchange
- Mobile phones, 35
- MODE_IS_EXCLUDE, 265, 267
- MODE_IS_INCLUDE, 118, 265
- MODULE_IDENTITY section, of MIB, 247
- Modulo (mod), 73
- Mosaic, 30
- MOSPF. *See* Multicast Extensions to OSPF
- MPLS. *See* Multiprotocol Label Switching
- MP_REACH_NLRI path attribute, 123, 135
- MP_UNREACH_NLRI path attribute, 123, 135
- MSDP. *See* Multicast Source Discovery Protocol
- MSDP mesh group, 103–104, 219, 220
- MSDP MIB (msdpMIB), 249
- MSDP packet formats, 299–306
 - defined TLVs, 300–301
 - IPv4 Source-Active Request TLV, 302–303

INDEX

- MSDP packet formats, *continued*
 - IPv4 Source-Active Response TLV, 303–304
 - IPv4 Source-Active TLV, 301–302
 - KeepAlive TLV, 304
 - MSDP TLV format, 300
 - Notification TLV, 304–306
- MSDP peer address, and SA filtering, 105
- MSDP peering paths, 97
- MSDP peer state machine, states for, 93
- MSDP Source-Active message, 91, 121
- MSDP TCP port 639, 93
- MSDP TLV format, 300
- MSDP traceroute facility, 252
- MT 0, 160, 162
- MT 3, 160
- MT ID, 163
- MT ID 0: IPv4 Unicast Topology, 164
- MT ID 1: Network Management Topology, 164
- MT ID 3: IPv4 Multicast RPF Topology, 164
- MT ID 8191: Experimental/Proprietary Features, 164
- MT prefix color, 164
- mtrace facility, 249–252
- mtrace man page, output from, 251–252
- mtrace queries, 250, 251
- mtrace response, 250
- MTs. *See* Multitopologies
- Multiaccess interfaces, PIM Hello messages sent on, 82
- Multiaccess networks, IS-IS on, 154–155
- Multicast, 1
 - and convergence, 30
 - description of, 1–4
 - end-to-end connectivity requirements for, 34
 - and “how do we charge for it?” syndrome, 31–32
 - location of, 15–16
 - need for, 37–38
 - outlook for, 38
 - performance in routers, 24–26
 - reasons for usage of, 28–30
- Multicast addresses, 5
 - and Ramen worm, 106
 - SSM and allocation of, 113
- Multicast Address field, in version 3
 - Membership Report message, 264
- Multicast Address Set Claim Protocol, 253, 254
- Multicast Backbone (MBone), 15, 62
- Multicast basics, 6–7
- Multicast “blackholes,” 187
- Multicast connectivity problems, mtrace
 - utility for assessment of IP, 249
- Multicast content, and multimedia content providers, 30–31
- Multicast data packets, 255
- Multicast delivery, 4
- Multicast distribution trees, 126
- Multicast-enabled Internet, 29
- Multicast-enabled Internet service providers, 31
- Multicast Extensions to OSPF, 126
- Multicast forwarding
 - Cisco Systems routers and monitoring of, 208–209
 - Juniper Networks routers and monitoring of, 180–185
 - layout of MP_REACH_NLRI for, 140
 - NLRI for, 136
 - state, 7
- Multicast group address
 - and Join/Prune Message format, 285
 - in PIM-Join/Prune message, 294
- Multicast group address mask, in PIM-Join/Prune message, 294
- Multicast Internet Exchange, 15, 122
- Multicast IP addresses, 114
- Multicast MAC addresses, 114
- Multicast messages, source address for (PIM), 273
- Multicast multimedia content, delivering, 24
- Multicast networks, management tools for, 245–255

- Multicast on LAN, 16–20
 - IGMP, 16
 - IGMP proxying, 17
 - layer 2 switches, 19–20
 - layer 3 to layer 2 mapping, 17–19
- Multicast packets, 6, 12, 15
- Multicast paths, 56, 57
 - path attributes manipulated for, 142
 - topology with incongruent, 122
- Multicast protocols, complexity of, and unicast networks, 32–33
- Multicast receivers, detection of: IGMP from perspective of router, 42–43
- Multicast routing, 7, 8
 - implementation of MBGP for, 135
 - incongruent paths, 59, 60
 - MGBP used for, 142–144
- Multicast routing MIB (ipMRRouteStdMIB), 247–248
- Multicast routing on Cisco Systems routers, 199–216
 - and dedicated RPF table configuration, 211–216
 - and MSDP configuration, 209–211
 - and PIM and IGMP configuration, 200–209
- Multicast routing on Juniper Networks routers, 167–198
 - and Anycast RP configuration, 179–180
 - and Auto-RP configuration, 175–179
 - and dedicated RPF table configuration, 187–198
 - and monitoring PIM Join state and multicast forwarding, 180–185
 - and MSDP configuration, 185–187
 - and PIM and IGMP configuration, 168–185
 - and PIM bootstrap mechanism configuration, 174–175
 - and static group-to-RP mapping configuration, 172–173
- Multicast routing protocols, 5, 61–66
 - dense protocols, 61–63
 - examples of, 6
 - sparse-dense mode, 66
 - sparse protocols, 63–66
- Multicast RPF routes, format of
 - MP_UNREACH_NLRI attribute, 141
- Multicast RPF table
 - DVMRP and populating of, 125
 - link-state protocols and populating of, 125–126
 - populating of, 121, 124
 - static routes and populating of, 124–125
- Multicast scoping, 86–87
- Multicast source, 6
- Multicast Source Discovery Protocol, 21, 52, 56, 61, 89–107
 - determining RPF peer, 95–103
 - in example network, 54–56
 - and inet.2 routing table, 187–188
 - mesh groups, 103–104
 - multicast traffic routed across multiple domains with, 53–56
 - operation, 90–93
 - original purpose of, 100
 - outlook for, 107
 - peering sessions, 93–94
 - policy, 105
 - problems related to RPF-peer rules and operating internetwork using, 102–103
 - rate limiting, SA storms, and ramen, 105–106
 - SA message, 94–95
 - in service provider native deployment case study, 219–220
- Multicast Source Discovery Protocol configuration
 - and Cisco Systems routers, 209–211
 - and Juniper Networks routers, 185–187
- Multicast Source Discovery Protocol mesh groups, 186, 210
- Multicast Source Discovery Protocol Source-Active cache, displaying, 210
- Multicast sources, 44, 92

INDEX

- Multicast traffic
 - generating, 43–44
 - reception of: IGMP from perspective of host, 41–42
 - routing across multiple domains with MSDP, 53–56
 - routing within domain using PIM-SM, 44–52
 - Multicast usage, addresses available for, 21–23
 - Multicast video, 35–36
 - MULTI_EXIT_DISC (MED) attribute, 132, 133
 - Multihoming, multicast, 122, 123
 - Multimedia, 29
 - Multiple-area IS-IS network, adjacencies in, 151, 152
 - Multiple exit discriminator, 60, 143
 - Multiprotocol Border Gateway Protocol, 52, 61
 - capability negotiation used for, 138–140
 - default RIB groups for, 193
 - example of using capability negotiation for, 140
 - in example network, 58–60
 - information flow for router running, 161 and M-ISIS, 145
 - multicast RPF routes learned via, 128
 - new path attributes in, 140–142
 - and populating of inet.2 table, 126
 - populating routing table dedicated to RPF with, 56–60
 - in service provider native deployment case study, 219
 - Multiprotocol Border Gateway Protocol configuration
 - and Cisco Systems routers, 214–216
 - and Juniper Networks routers, 191–194
 - Multiprotocol Extensions for BGP, 121–144
 - BGP and related terminology, 128–129
 - BGP internals and, 129–134
 - as extension of BGP, 134–135
 - internals, 135–142
 - for multicast routing, 142–144
 - overview of, 121–128
 - “Multiprotocol Extensions for BGP-4,” 123
 - Multiprotocol Extensions to Border Gateway Protocol, 13
 - Multiprotocol Label Switching, 168
 - Multiprotocol Reachable NLRI (MP_REACH_NLRI), 140–141
 - Multiprotocol Unreachable NLRI (MP_UNREACH_NLRI), 140, 141–142
 - Multitopologies, 159
 - Multitopology Intermediate Systems TLV (TLV 222), 162
 - Multitopology Reachable IPv4 Prefixes TLV (TLV 235), 162
 - Multitopology Routing in IS-IS, 13, 74, 126, 144, 145–166
 - adjacencies formed for, 160, 162
 - default RIB groups for, 195
 - examples of usage of, 164, 166
 - information flow for router running, 161
 - overview of, 159–160
 - for resolving MBGP next hops, 165
 - specifics of, 160–164
 - type length values, 162–164
 - Multitopology Routing in IS-IS configuration, and Juniper Networks routers, 194–195
 - Multitopology TLV (TLV 229), 162
- N**
- NAPs. *See* Network access points
 - Napster, 29
 - NASA Ames Research Center, Federal Internet Exchange at, 15
 - Native multicast routing, 15
 - NET. *See* Network entity title
 - NetWare Link Services Protocol, 146
 - Network engineers, 4
 - Network entity title, 150
 - Network layer, 17
 - Network layer reachability information field, 132, 133, 141

- Network management,
and multicast, 29
- Network management systems, 246
- Network Prefix field, 254
- Network service access point, 148
- NEXT_HOP attribute, 132, 133, 135, 142
- Nixon-Kennedy debates (1960), 28
- NLR, for unicast and multicast forwarding,
136
- NLRI attribute, 135
- NLRI field. *See* Network layer reachability
information field
- NLSP. *See* NetWare Link Services Protocol
- NMS. *See* Network management systems
- Nontransitive (BGP attribute), 132
- Notification message, with BGP, 130, 131
- Notification subcodes, 306
- Notification TLV, 304
- Not-so-stubby areas, OSPF, 155
- NSAP. *See* Network service access point
- n-selector, 150
- Null-Register bit (N), in Register Message
Format, 282
- Null-Register messages, 54, 55, 77
- Number of Group Records (M) field, in
version 3 Membership Report
message, 263
- Number of Groups, in PIM-Join/Prune
message, 294
- Number of Join Sources, in PIM-Join/Prune
message, 294
- Number of Prune Sources
and Join/Prune Message format, 286
in PIM-Join/Prune message, 294
- Number of Sources (N) field
and IGMP message format, 260–261
in version 3 Membership Report message,
264
- O**
- Object identifiers, 246
- Objects, MIB, 246
- OIDs. *See* Object identifiers
- OIL (or o-list: outgoing interface list), 7, 8,
12, 47, 62, 80
- One-to-many model/applications, 2, 14, 20,
21, 33, 110
- Online gaming, 20, 29, 116
- Open bit (O-bit), in Notification TLV, 305
- Open message, with BGP, 130
- Open Shortest Path First, 74, 128, 146,
196–197
and anycast RP, 74
IS-IS compared to, 147
not-so-stubby areas, 155
stubs, 155
totally stubby areas, 155
- Open Shortest Path First RIB groups, using to
place routes in
inet.2, 197
- Open Systems Interconnection, reference
model layers, 17
- Optional nontransitive path attributes, 132,
133, 140
- Optional transitive path attributes, 132, 133
- Option field, values in, in Hello message
format, 279
- OptionLength, in Hello message format, 279
- OptionType, in Hello message format, 279
- OptionValue, in Hello message format, 279
- ORIGIN attribute, 132, 133, 141
- OSI. *See* Open Systems Interconnection
- OSPF. *See* Open Shortest Path First
- OSPF areas, IS-IS areas compared to, 150
- OSPF designated routers, IS-IS DIS compared
with, 154
- Outgoing interface list, 7
- Override Interval, in LAN Prune Delay, 280
- Oversubscription, 18, 114
- P**
- Packet formats
IGMP, 257–272
MSDP, 299–306
MSDP SA message, 94
PIM, 273–298

INDEX

- Packet Forwarding Engine, 167
- Packets, IS-IS, 152, 153–154
- Packet-switching board, 167
- Parameter Value field, 138
- Partial Sequence Number PDU, 153
- Passive peers, 93, 94
- Path attributes
 - BGP, 132
 - manipulation of, 142–144
- Path attributes field, BGP, 132
- Payload type identification, with RTP over UDP, 255
- pd interface, and tunnel PIC, 171–172
- PDU. *See* Protocol data units
- Peering addresses, 75
- Peering sessions, MSDP, 93
- Peer-RPF flooding, 91, 96
- Peer Table, in MSDP MIB, 249
- pe interface, and tunnel PIC, 172
- PFE. *See* Packet Forwarding Engine
- PFE interfaces, 168
- Phase 1, on example network, 46–48
- Phase 2, on example network, 49–50
- Phase 3, 50–51
 - control messages for, 52
 - on example network, 51–52
- Physical Interface Cards (PICs), 167
- PIM
 - Cisco Systems routers and configuration of, 200–201
 - codes, 293
 - DVMRP configured to provide RPF information to, 197–198, 216
 - and inet.2 routing table, 187–188
 - JUNOS software and enabling interfaces for, 168–169
- PIM assert mechanism, situation requiring, 84, 85
- PIM Assert messages, 83–86, 294
- PIM bootstrap, as RP-set mechanism, 72
- PIM bootstrap mechanism configuration, and Juniper Networks routers, 174–175
- PIM Candidate RP Table, in PIM MIB, 249
- PIM Component Table, in PIM MIB, 249
- PIM control messages, IP protocol number for, 273
- PIM dense mode, 6, 13, 63
- PIM distribution trees, 77
- PIM-DM. *See* PIM dense mode
- PIM_DM, 61
- PIM (*,G) Joins, 170, 202
- PIM Interface Table, in PIM MIB, 248
- PIM IP Multicast Route Table, in PIM MIB, 249
- PIM-Join/Prune message, additional packet format for, 294, 295–296
- PIM Join state
 - Cisco Systems routers and monitoring of, 208–209
 - Juniper Networks routers and monitoring of, 180–185
- PIM MIB (pimMIB), 248–249
- PIM-Mode message, 294
- PIM Multicast Border Router, 281
- PIM Neighbor Table, in PIM MIB, 248
- PIM Next-Hop Table, in PIM MIB, 249
- PIM packet formats, 273–298
 - Assert Message format, 290–292
 - Encoded Source and Group Address formats, 275–278
 - group set fragmentation, 289–290
 - group set source list rules, 286–289
 - Hello message format, 278–281
 - Join/Prune message format, 283–286
 - PIM version 1 packet formats, 292–298
 - PIM version 2 packet formats, 273–292
 - Register message format, 281–282
 - Register-Stop message format, 282–283
- PIM Register messages, 48, 75, 76–77
- PIM Register (S,G) messages, 91
- PIM RP-Set Table, in PIM MIB, 249
- PIM RP Table, in PIM MIB, 249
- PIM (S,G) Join messages, 92
- PIM-SM. *See* PIM sparse mode
- PIM-SM/PIM-DM hybrid approach, limitations to, 89–90

- PIM-SM register process, 27
- “PIM snooping,” 20
- PIM sparse mode, 6, 13, 16, 17, 61, 63, 66, 67–87, 109
 - anycast RP, 74–75
 - designated routers and Hello messages, 82–83
 - distribution tree construction and teardown, 77–81
 - group-to-RP mapping, 69–74
 - multicast scoping, 86–87
 - phases of, 46–52
 - PIM Assert messages, 83–86
 - PIM register message processing, 76–77
 - PIM versions, 67–69
 - rendezvous point in, 10, 89
 - rendezvous point tree in, 12
 - routing multicast traffic within domain with, 44–52
 - and RP placement, 218
 - in service provider native deployment case study, 218
 - and Source-Specific Multicast, 110, 119–120
 - specifications, 67
- PIM sparse mode bootstrap mechanism configuration, and Cisco Systems routers, 203–204
- PIM sparse mode designated router
 - output on, to source after host joins group, 183–185
 - output on, to source for group with no members, 181–183
- PIM sparse mode domain, bootstrap mechanism configured in, 174
- PIM trace file, message sample, on router configured for
 - announce-only, 178
- PIM tracing, 174
- PIM types, 273
- PIM version
 - in Assert message format, 290
 - in Hello message format, 279
 - in Join/Prune Message Format, 285
 - in Register Message Format, 282
 - in Register-Stop Message format, 283
- PIM version 1, 203
 - message types, 67–68
- PIM version 2, 203
 - message types, 68–69
- PIM version 1 packet formats, packet types, 292–298
- PIM version 2 packet formats, PIM packet formats, 273–292
- Plen field, 254
- PMBR. *See* PIM Multicast Border Router
- Point-to-point, IS-IS neighbor state machine on, 154
- Point-to-Point Hello (IIH) PDU, 153
- Point-to-point interfaces, PIM Hello messages sent on, 82
- Point-to-point links, adjacencies established on, 152
- Point-to-point logical interfaces, 20
- Port densities, in routers, 25
- Port numbers, and BGP peers, 129
- Preference, in JUNOS operating system, 127
- Prefix color, MT, 164
- Prefixes, 58
 - aggregating, 135
 - and dynamic group-to-RP mapping, 71
- Prefix field, 133, 141
- Prefix length, and BGP next hops, 128
- Prefix range, for static RPF peer, 100
- Proprietary MIBs, 246
- Protocol data units, type length values for, 157
- Protocol independence, 63
- Protocol Independent Multicast-Dense Mode. *See* PIM dense mode
- Protocol Independent Multicast-Sparse Mode. *See* PIM sparse mode
- Protocol preference
 - and RPF checks, 211
 - terms for, 127

INDEX

- Prune lists, 286, 287
- Prune messages, 51, 62
- Prune Source Address 1..n
 - and Join/Prune Message format, 286
 - in PIM-Join/Prune message, 296
- Prune Sources, 286
- “Pseudo-header,” IPv6, 275
- Pseudonode, 154, 162
- PSTN. *See* Partial Sequence Number PDU
- PSTN. *See* Public switched telephone network
- Public MIBs, rooting of, 246
- Public multicast peering, 15
- Public switched telephone network, 35

- Q**
- QQIC. *See* Querier’s Query Interval Code
- QRV. *See* Querier’s Robustness Variable
- Queriers, 42
- Querier’s Query Interval Code, and IGMP message format, 260
- Querier’s Robustness Variable, and IGMP message format, 260
- Queries, IP destination addresses for, 261–262
- Query interval, 43
- Query message, variants of, 261
- Query response interval, 43

- R**
- Radio, 20, 35
 - and Internet, 30
 - and unicast, 2
- Ramen worm, 25, 105–106
- RAS. *See* Remote access server
- Rate limiting, MSDP, 106
- “Ratio of annoyance,” in ASM, 21
- RE. *See* Routing Engine
- Real-Time Transport Protocol, multicast data packets and, 255
- Receiver, 6
 - group membership ended by, 81
 - joining existing source, 79
 - PIM-SM DR for, 53
- Receiver’s DR, 46

- Record Type
 - of Current-State Record, 265
 - in version 3 Membership Report message, 264
- Recursive lookups, 126, 128
- Redundancy
 - and anycast RP, 179, 207, 218
 - and MSDP, 89, 90, 91
 - reducing, 142
- Register Message Format, in PIM packet format, 281–282
- Register messages, 53
 - and anycast RP, 74
 - PIM, 48
- Register packets, decapsulating, 76
- Register-Stop messages, 49, 76, 282–283
- Register-Stop timer, 76, 77
- Remote access server, 17, 62
- Rendezvous points, 10, 11, 12, 45, 110
 - building distribution tree for delivering packets from source to, 48–50
 - and load balancing, 74
 - and MSDP, 90
 - in PIM-SM, 89
 - placement of, in real network, 47
 - RPT and delivery of packets from, to interested listeners, 46–48
 - and sparse protocols, 63, 64
- Rendezvous point trees, 11, 12, 21, 46–48, 63
 - advantages with, 66
 - building, 47, 48
 - in Encoded-Source address, 278
 - with suboptimal routing, 64
 - tearing down, 80
- Report messages, 41
- Request for Comments, 27, 245–246
- Requests Table, in MSDP MIB, 249
- Reserved field, 139
 - in Assert message format, 290
 - in Encoded-Group Address, 276
 - in Encoded-Source address, 277
 - in IPv4 Source-Active Request TLV, 303

- in IPv4 Source-Active TLV, 302
 - in Join/Prune Message Format, 285
 - in MSDP SA message, 95
 - in PIM-Join/Prune message, 294
 - in Register Message Format, 282
 - in Register-Stop Message format, 283
 - in Source Address format, 296
 - in version 3 Membership Report message, 263
- Reserved2, in Register Message format, 282
- Resv (Reserved) field, and IGMP message format, 259
- Reverse path forwarding, 7, 9, 33, 48, 197–198
 - checks, 121, 124
 - in SSM, 112–113
- RFCs. *See* Request for Comments
- RFP-peer rules, from draft version 2, 102
- RIB. *See* Routing information base
- RIP. *See* Routing Information Protocol
- Robustness variable, 43, 260
- Route metrics, comparing, 127
- Router DVMRP Messages, 293
- Route reflection, 99
- Route reflectors, 99–100
- Router PIM Messages, 293
- Router-Querys, PIM version 1, 68
- Routers, 3, 42–43, 146
 - and decapsulation, 76
 - IS-IS area numbers shared by, 149
 - multicast performance in, 24–26
 - and multicast scoping, 86
- Routing Engine, 167
- Routing information base, 188
- Routing information base groups, interface routes and use of, 189
- Routing Information Protocol, 5–6, 128
- Routing loops, 158
- Routing policy, 84
- Routing preferences, default, for dedicated RPF table configuration, 211, 212
- Routing tables, 8, 12
 - Cisco Systems and implementation of, 127
 - Juniper Networks and implementation of, 126–127
- RPs. *See* Rendezvous points
- RP Address
 - in IPv4 Source-Active TLV, 302
 - in RP-Reachability message, 298
- RP Address field, of MSDP SA message, 95
- RP-Announcement message, 70
- RP bit, in Source Address format, 297
- RPF. *See* Reverse path forwarding
- RPF checks
 - with Cisco's IOS, 127
 - and longest-match prefix, 211
 - populating routing table dedicated to, with MBGP, 56–60
 - on unicast addresses, 12
- RPF interface, 8
- RPF peer, 97
- RPF peer determination, 95–103
 - avoiding pitfalls in, 102–103
 - current versions of RPF-peer rules, 96–101
 - RPF rules from draft version 2, 102
- RPF-peer failures, preventing, 219
- RPF-peer loop, 103
- RPF-peer rules, 98, 99, 101
 - current versions of, 96–101
 - network for explanation of, 97
 - problems related to, with internetwork using MSDP, 102–103
 - rule #1: if originating RP is peer, it is RPF peer, 97–98
 - rule #2: if BGP next hop toward originating RP is peer, it is
- RPF peer, 98
 - rule #3: if BGP peer advertised route toward originating RP is peer, it is RPF peer, 99–100
 - rule #4: MSDP peer with highest IP address is RPF peer, 100–101
 - rule #5: if static RPF peer is configured for originating RP, it is RPF peer, 101

INDEX

- RPF route-selection process, unicast routing
 - contrasted with, 211
- RPF tables
 - advantages with dedicated, 13
 - populating, 12–13
- RPF Type field, 213
- RP load, 26–27
- rp local command, 202
- RP-Mapping messages, 71
- RP-Reachability messages, 68, 297–298
- RP-set mechanism, PIM bootstrap used as, 72
- RPTs. *See* Rendezvous point trees
- RPT-bit (R), in Assert message format, 291
- RP-to-group mapping, and anycast RP, 74, 207
- RTP. *See* Real-Time Transport Protocol

- S**
- SA caching, 92, 93, 106
- SA filters
 - leakage prevented by, 219
 - and MSDP policy, 105
- SAFIs. *See* Subsequent address family identifiers
- SA flooding, mesh groups and reduction of, 103–104
- SA looping, avoiding, 104
- SA messages
 - and mesh groups, 104
 - MSDP, 94–95
 - and RPF peer determination, 96
- SA-Message/SA-Response Error subcodes, 306
- SAP/SDP. *See* Session Announcement Protocol/Session Description Protocol
- SA-Request Error subcodes, 306
- SAs, and problems related to RPF-peer rules, 102–103
- SA storms, 106
- Scoping, 23, 113
- SDP messages, 24
- SDR. *See* Session Directory Tool
- Sequence numbering, with RTP over UDP, 255
- Service models, 21
- Service provider native deployment case study, 217–244
 - customer router configurations, 232–240
 - ISP router configuration, 220–232
 - network architecture, 217
 - PIM-SM, 218–220
 - SSM-only domain, 241–244
- Session Announcement Protocol/Session Description Protocol, 22, 23
- Session Directory Tool, 22, 23
- S Flag (Suppress Router-Side Processing), and IGMP message format, 259–260
 - (S,G) Asserts, in Assert message format, 291
 - (S,G) Join, 16, 65, 111, 112
 - message, 8, 12, 51
 - and PIM Register message processing, 76
 - (S,G) PIM Join message, 48
 - (S,G,rpt) Prune source-list entry
 - and group set fragmentation, 290
 - in Join/Prune messages, 287
 - (S,G) source list entry, in Join/Prune messages, 287
 - (S,G) state, 7
 - output of ip mroute command, 208
 - for PIM-SM, 25
- Shared memory switching, 26
- Shared tree behavior, and SSM groups, 170
- Shared trees, 7
- Shortest path first algorithm, 147
- Shortest path trees, 8, 10, 12, 21, 50–52, 65, 110, 111, 112
 - and distribution tree construction and teardown, 77, 79, 80, 81
 - setting up, 80
 - switchover, 26
- show IGMP group command, 169
- show ip bgp ipv4 multicast command, 127

- show ip mroute command, 213
- show ip rpf source address command, 127
- show multicast rpf command, 127
- show pim join extensive command, 180
- show pim source command, 127
- show route table inet.2 command, 127
- Simple Network Management Protocol, 245
- Simple Network Management Protocol Management Information Bases, 245–249
 - IGMP, 248
 - MSDP, 249
 - multicast routing, 247–248
 - PIM, 248–249
- Slash notation, for bit mask, 4
- SNMP. *See* Simple Network Management Protocol
- Snooping switch, IGMP, 19
- Source
 - coming online, 78
 - PIM-SM DR for, 53
 - receiver joining existing, 79
- Source-Active cache, MSDP, 209, 210
- Source-Active Cache Table, in MSDP MIB, 249
- Source Active filters, and MSDP configuration, 186
- Source-Active messages, 25, 53, 54, 55, 91
- Source Address
 - in Assert message format, 291
 - in Encoded-Source address, 278
 - in IPv4 Source-Active TLV, 302
 - in Register-Stop Message format, 283
 - and SA filtering, 105
 - in Source Address format, 297
- Source Address field, in MSDP SA message, 95
- Source Address Format, 296–297
- Source Address [i] fields
 - and IGMP message format, 261
 - in version 3 Membership Report message, 264
- Source discovery, 20, 33, 110
 - and sparse and dense protocols, 63
 - and SSM, 111, 115
 - support for by dense protocols, 109
- Source-group tuple, and SSM channels, 113
- “Source-List-Change Record,” 265, 266
- Source-Specific Multicast, 5, 16, 23, 109–120, 217
 - addresses, 112
 - advantages and disadvantages of, 113–116
 - Any-Source Multicast versus, 20–21
 - IGMPv3 in, 116–119
 - overview of operation of, 111–112
 - PIM-SM in, 119–120
 - RPF in, 112–113
- Source-Specific Multicast terminology, Any-Source Multicast terminology compared to, 111
- Source to RP interaction, 49
- Sourcing, 6
- Sparse bit (S), in Encoded-Source address, 277
- Sparse-dense mode, 66
 - Cisco routers, Juniper Networks routers and, 71
- Sparse protocols, 60, 61, 63–66, 109, 110
- Speakers, MBGP, 135
- SPF algorithm. *See* Shortest path first algorithm
- Sprex Len field
 - in IPv4 Source-Active TLV, 302
 - in MSDP SA message, 95
- Sprint, 146
- SprintNAP, 15
- SPTs. *See* Shortest path trees
- SSM. *See* Source-Specific Multicast
- SSM channels, 111
 - and mtrace queries, 250
- SSM group range
 - and Cisco Systems routers, 202
 - and Juniper Networks routers, 170
- SSM-only configuration
 - Cisco Systems, 243–244
 - Juniper Networks, 241–243

INDEX

- Starr Hearings, webcasts of, 29
 - State, 6
 - refreshing, 41, 62
 - and routers evaluated for multicast, 25
 - RPTs and reduction of, 66
 - and SSM, 115
 - “State-Change Record,” 266
 - State explosion, 66
 - Static group-to-RP mapping, 70
 - anycast RP with, 179, 207
 - Static group-to-RP mapping configuration, and Juniper Networks routers, 172–173
 - Static mroutes, configuring, 213
 - Static mroute table, for RPF, 211
 - Static multicast addresses, 22, 23
 - Static routes, multicast RPF tables populated with, 124–125
 - Static RP, anycast RP with, 75
 - Static RP configuration, and Cisco Systems routers, 202–203
 - Static RPF peer, prefix range for, 100
 - Static RP mapping, 218
 - Stock tickers, 13
 - and multicast, 29
 - Storms, SA, 106
 - Stubs, OSPF, 155
 - Subnets
 - and designated routers, 82
 - masks for, 202
 - queriers for, 42
 - sparse distribution of, 63
 - Suboptimal routing
 - reducing potential for, 156, 218
 - with rendezvous point tree, 64
 - Subscribe, and SSM, 110, 111
 - Subsequent address family identifiers, 136, 139
 - Sub-TLVs, 152, 158
 - System identifier (sysID), 149
- T**
- T bit, in LAN Prune Delay, 280
 - TCP. *See* Transmission Control Protocol
 - Television, 2, 20, 30, 35
 - test msdp rpf-peer command, 127
 - Throughput, 25
 - Timeout, 43
 - Time stamping, with RTP over UDP, 255
 - Time-to-live, 42, 44, 86–87
 - TLV 22, format of, 156
 - TLV 128, 158
 - TLV 135, format for, 158
 - TLV 222, 162
 - TLV 229, 162, 163
 - TLV 235, 162
 - TLVs. *See* Type length values
 - TLV types, definitions of, 300–301
 - TNP. *See* Trivial Network Protocol
 - TO_EX, 267
 - TO_IN, 267
 - Totally stubby areas, OSPF, 155
 - Trace messages, 293
 - “Traceroute’ facility for IP Multicast, A,” 249
 - Transitive (BGP attribute), 132
 - Transmission Control Protocol, 37, 254
 - Traps, SNMP, 246
 - Trivial Network Protocol, 168
 - TTL. *See* Time-to-live
 - Tunnel interfaces, creating on Juniper router, 171–172
 - Tunnel PIC, and pe and pd interfaces, 170–172
 - Tunnels, 15
 - Tuples, 113
 - 12-bit MT ID value, values reserved for, 164
 - Type code, of MSDP SA message, 94
 - Type field
 - in Assert message format, 290
 - in BGP header, 130
 - in IPv4 Source-Active Request TLV, 303
 - in IPv4 Source-Active Response TLV, 303
 - in IPv4 Source-Active TLV, 301
 - in Join/Prune Message Format, 285
 - in Notification TLV, 304
 - in Register Message Format, 282
 - in Register-Stop Message format, 283

- RPF, 213
 - in TLV, 151
- Type length values, 94, 125, 151–152
 - extending, 156, 158–159
 - and IS-IS packets, 153
 - M-ISIS, 162–164
 - for protocol data units, 157
- U**
- UDP. *See* User Datagram Protocol
- Unicast, 1
- Unicast addresses, 75
 - in PIM packet format, 275
 - RPF checks on, 12
- Unicast bandwidth revenues, cannibalization of, 33–34
- Unicast connectivity problems, and IP traceroute, 249
- Unicast delivery, 2
- Unicast forwarding
 - and multicast performance, 25
 - NLRI for, 136
- Unicast forwarding table, 135
- Unicast messages, source address for (PIM), 273
- Unicast-multicast “gateways,” 34
- Unicast network, and complexity of multicast protocols, 32–33
- Unicast-only mode, 125, 216
- Unicast packets, 8, 15
- Unicast paths, 56, 57
 - path attributes manipulated for, 142
 - topology with incongruent, 122
- “Unicast-Prefix-based IPv6 Multicast Addresses,” 254
- Unicast routes, and RPF table, 12
- Unicast routing, 7
 - incongruent paths, 59, 60
 - protocols, 5
 - RPF route-selection process contrasted with, 211
- Unicast routing table, for RPF, 211
- Unicast Upstream Neighbor Address, in Join/Prune Message Format, 285
- UNIX hosts, 249, 251
- Unsubscribe, and SSM, 110, 111
- Unused field, in IGMPv1 packet format, 271
- Update messages, BGP, 6, 130, 131
- Up/down bit, 158
- Upstream, 7
- Upstream routers, 12
- “Use of OSI IS-IS for Routing in TCP/IP and Dual Environments,” 146
- User Datagram Protocol, 37, 255
- UUNet, 146
- V**
- Value field, 162, 163
 - format of, for multicast topology, 162, 163
 - format of, for unicast and multicast topologies, 163
 - in TLV, 151
- VAT. *See* Visual audio tool
- Version, IGMP packet format, 293
- Version 3 Membership Reports (IGMP), 262–267
 - additional data in, 264
 - Aux Data Len field in, 264
 - Auxiliary Data field in, 264
 - checksum field in, 263
 - format of, 262
 - Group Record in, 263
 - Group Record types in, 264–266
 - IP Destination Addresses for reports in, 266
 - membership report size in, 267
 - Multicast Address field in, 264
 - notation for group records in, 267
 - Number of Group Records (M) in, 263
 - Number of Sources in, 264
 - Record Type in, 264
 - Reserved field in, 263
 - Source Address [i] fields in, 264
- Version memo, in IGMPv1 packet format, 271
- VIC. *See* Video conferencing tool
- Victoria’s Secret fashion shows, webcasts of, 29

INDEX

- Video
 - lack of pervasiveness over Internet, 28–29
 - multicast, 35–36
 - Videoconference applications, 116
 - Videoconferencing, 20
 - Video conferencing tool, 24
 - Video streaming, and RTP, 255
 - Virtual interface, 50
 - Virtual LANs, 20
 - Virtual private networks, 31
 - Viruses, 106
 - Visual audio tool, 24
 - VLANs. *See* Virtual LANs
 - VPNs. *See* Virtual private networks
- W**
- WC bit, in Source Address format, 297
 - Web pages, 28
 - Web sites
 - free NMS software, 246
 - IANA assigned multicast addresses, 22
 - IETF Internet-Drafts, 27
 - public MIB versions on, 246
 - Well-known discretionary attributes, 132, 133
 - Well-known mandatory attributes, 132, 133
 - Wildcard Group set, 286
 - Wildcard masks, calculating, 202
 - Wildcards, 7, 296
 - Wildcard (WC), in Encoded-Source address, 277
 - Windows Media Player, 24
 - Withdrawn Routes field, of BGP UPDATE message, 135
 - WMP. *See* Windows Media Player
 - World Trade Center attack (2001), and role of multicast, 37–38
 - World Wide Web, 30, 38
 - Worms, 25, 105–106