

Index

Note to the Reader: Page numbers in **bold** indicate the principal discussion of a topic or the definition of a term. Page numbers in *italic* indicate illustrations.

Symbols and Numbers

> (angle bracket) in operational mode, 13
> (angle bracket) in set command, 32
- (minus sign) in candidate configurations, 33
+ (plus sign) in candidate configurations, 33
+ (plus sign) in set command, 32
(pound character) in configuration mode, 23
? (question mark) in help system, 15
* (asterisk) as wildcard, 86
2-Way state in OSPF, 238, 239, 534

A

ABRs. *See* area border routers
accept action, 446, 447–450, 534
access lists. *See* firewall filters
actions. *See* firewall filters; routing policies
activate (configuration) command, 79
active configurations, 33
active routes, 150, 534
Active state in BGP, 332
Address Family Identifiers, 207–208, 207, 208
address match conditions, 439–441, 534
Address Resolution Protocol. *See* ARP
addresses. *See also* IP addresses
 encoding in PIM protocol, 395–397, 395–396
 in multicast networks
 Ethernet addresses, 380–383, 381–382
 IP group addresses, 378–380, 378
 overview of, 377–378
 static RP addresses in PIM, 410–411
adjacencies
 defined, 284, 534
 forming in IS-IS, 284–285, 285
 forming in OSPF
 adjacency states, 238–239, 239
 Ethernet links and, 243–244, 243
 example, 239–240
 overview of, 238
 and troubleshooting, 241
 overview of, 277
Adjacency-RIB-In in BGP, 337, 534
Adjacency-RIB-Out in BGP, 338, 534
AFI (Authority and Format Indicator), 282, 283
aggregated routes. *See also* routing, protocol-independent
 attributes, 118–119
 in BGP, route policies and, 166
 configuration examples, 119–121
 contributing routes, 117
 defined, 116, 116–117, 534
 next-hop options, 118
aggregation, message, in RSVP, 489, 513–514, 553
all keyword, 503
AND operator in route filters, 168
angle bracket (>) in operational mode, 13
angle bracket (>) in set command, 32
area border routers (ABRs), 247, 535
area match condition (OSPF), 159
areas, 535. *See also* IS-IS; OSPF
ARP (Address Resolution Protocol)
 defined, 534
 multicast and, 380
 viewing ARP tables, 90
AS (Autonomous System)
 AS external LSAs, 250–255, 251–254, 256, 535
 AS Path attribute, 323, 331–332, 342–343, 535
 as-path match condition, 159
 assigning AS numbers, 346, 346
 defined, 323, 536
 GLOP addressing and, 379
ASBR (Autonomous System Boundary Routers), 247, 536

- ASBR summary LSAs, 251–254, 251–255, 256, 535
- ASICs (application-specific integrated circuits). *See also* Packet Forwarding Engine
 defined, 535
 Distributed Buffer Manager ASICs, 48–49
 I/O Manager ASICs, 48
 Internet Processor ASICs, 49, 139–140, 431
 MPLS creation and, 474
 overview of, 4, 47
 in packet flow, 50–51, 50
 PIC I/O Manager ASICs, 48, 557
- asterisk (*) as wildcard, 86
- ATM (Asynchronous Transfer Mode)
 networks
 cell tax, 478, 538
 configuring on routers, 76
 defined, 535
 in MPLS creation, 474
 versus MPLS networks, 478–479, 478–479
 as overlay network, 476–478, 476–477
 virtual circuit addressing, 72
 virtual circuits, versus LSPs, 487, 493
- Attempt state in OSPF, 238, 239, 535
- attributes. *See also* BGP
 of aggregated routes, 118–119
 configuring in dynamic LSPs, 507–510
 of static routes, 112–114
- authentication. *See also* firewall filters
 configuring in RIP, 216–217
 in OSPF, 232, 233
 in RIPv2, 209
 of RSVP messages, 514–515
- Auto-RP, 401–402, 411–415, 536
- Autonomous System. *See* AS
-
- B**
- backbone areas in OSPF, 246, 247, 536
- backbone routers in OSPF, 247, 536
- backup, 46, 536
- backup designated routers (BDRs), 244, 245, 536
- bandwidth
 defined, 537
 requests in RSVP, 493, 507, 508–510
 reservation limits in RSVP, 515–516
- Bellman-Ford algorithm, 196, 537
- BERT (Bit Error Rate Test), 96–97, 537
- BGP (Border Gateway Protocol), 322–371
 applying policies in, 174–176, 342, 353–354, 354, 362
 attributes
 in action, 344–345
 AS Path, 323, 331–332, 342–343
 categories of, 339
 Community, 344, 539
 Local Preference, 342
 Multiple Exit Discriminator, 343–344
 Next Hop, 339. *See also* Next Hop attribute
 Origin, 343
 TLV type bits in, 339
 default integration with dynamic LSPs, 516–520, 517
 default policies, 172
 defined, 537
 EBGp peer sessions
 assigning AS numbers, 346, 346
 configuring, 347–348
 defined, 327–328, 328, 544
 establishing over TCP, 327, 327
 Next Hop reachability, 339–340, 340, 357–359, 358
 relationship states, 332–333
 verifying, 350–353
 warning, 363
 exam essentials, 365–366
 goals of
 network connectivity, 322–323, 323
 policy control, 323–324
 routing table scalability, 325
 transport reliability, 324
 IBGP peer sessions
 Active state problem, 350
 assigning AS numbers, 346, 346
 avoiding routing loops, 328–329, 331–332, 342

- configuring, 348–350
- default route advertisement, 329–331, 330
- default route table integration, 517–520, 517
- defined, 328, 548
- establishing over TCP, 327, 327, 329
- IBGP full-mesh solution, 330, 331–332
- local-address solution, 350
- manual route table integration, 520–524, 520
- Next Hop unreachable, 340, 341, 359–361
- relationship states, 332–333
- resolving unreachability, 341–342, 362–365
- verifying, 350–353
- injecting other routes into, 353–354, 354
- Internet drafts for, 326
- key terms, 366
- loop creation and, 329, 331–332
- loops, preventing, 323, 329, 342
- messages
 - Keepalive messages, 337
 - message headers, 333–334, 333
 - Notification messages, 336–337, 336
 - Open messages, 334, 335
 - Update messages, 335–336, 336
- Next Hop attribute
 - default resolution process, 517–520, 527
 - defined, 339, 554
 - in manual routing table integration, 520–524, 520
 - next-hop match condition, 159
 - reachability in EBGp sessions, 339–340, 340, 357–359, 358
 - resolving unreachability, 341–342, 362–365
 - unreachability in IBGP sessions, 340, 341, 359–361
- overview of, 322, 325, 326, 365
- as path-vector protocol, 323, 556
- review question answers, 371
- review questions, 367–370
- RFCs for, 326

- routes
 - default assignment to LSPs, 516–520, 517
 - manually assigning to LSPs, 520–524, 520
 - match conditions and, 160, 166
 - selection process, 338–339
- Routing Information Bases
 - Adjacency-RIB-In, 337
 - Adjacency-RIB-Out, 338
 - defined, 337, 561
 - Local-RIB, 338
 - rib match condition, 159, 160, 438
- updates, 325
- viewing routing knowledge
 - advertised routes, 355
 - local routes, 355–357
 - overview of, 353, 354
 - received routes, 354–355
- bgp.12vpn.0 routing table, 135–136
- bgp.13vpn.0 routing table, 135
- Bit Error Rate Test (BERT), 96–97, 537
- bit field match conditions, 441–444, 537
- book, this. *See JNCIA Study Guide*
- broadcast networks. *See Ethernet broadcast networks*
- broadcasts, 537
- BSRs (bootstrap routers)
 - advertising RPs, 402–403
 - configuring, 415–417
 - defined, 537

C

- candidate configurations, 33–34, 538
- Candidate-RP-Advertisements, 402, 538
- cell tax in ATM, 478, 538
- certification programs. *See JNTCP*
- channel numbers, 64, 67
- chassisd (Chassis Daemon), 6, 538
- Cisco ATM Solutions: Master ATM Implementation of Cisco Networks* (Pildush), xxxi
- Cisco-RP-Announce messages, 402, 538
- Cisco-RP-Discovery messages, 402, 538

- clear (operational) command
 - clear firewall, 462
 - clear isis adjacency, 305
 - clear ospf database, 262–263
 - clear ospf neighbor, 261
 - defined, 13
 - CLI (command-line interface). *See* JUNOS software
 - command completion, 16–18, 26, 539
 - commit (configuration) command
 - commit and-quit, 41
 - commit check, 41–42
 - commit complete, 40
 - commit confirmed, 42–43
 - commit synchronize, 42–43
 - defined, 33, 39–40
 - community (in BGP), 159, 160, 344, 539
 - compare command, 33–34
 - configuration mode. *See* JUNOS software
 - configured routes, locally. *See* routing, protocol-independent
 - configuring router interfaces. *See* Juniper Networks routers; transient interfaces
 - Connect state in BGP, 332, 539
 - contributing routes
 - in aggregated routes, 117
 - defined, 540
 - for generated routes, 121–123, 121
 - count action modifier, 450
 - CSNPs (complete sequence number PDUs), 292–294, 293, 539
 - CSPF (Constrained Shortest Path First) algorithm, 504, 539
 - cutting and pasting configuration files, 38–39
-
- D**
- daemons, 6–7, 540
 - data link connection identifiers (DLCIs), 72–73, 540
 - data packets. *See* messages; packets; PDUs
 - dcd (Device Control Daemon), 6, 541
 - DD (Database Description) packets, 235, 235–236, 541
 - De Troch, Bruno, xxxiii
 - deactivate (configuration) command
 - deactivating interfaces, 78–79
 - defined, 541
 - versus disable command, 73
 - dead interval values, 233, 234, 245, 541
 - default policies in routing protocols, 171–173
 - default routes, 110, 541
 - delete (configuration) command, 24, 32–33
 - dense mode. *See also* multicast networks
 - configuring, 406
 - configuring sparse-dense mode, 407
 - defined, 541
 - forwarding data in, 386–387, 386–388, 393
 - Designated Intermediate System. *See* DIS election; DIS priority
 - designated routers. *See* DRs
 - destination-port match condition, 437
 - Differentiated Services Codepoint (DSCP), 437, 541
 - Diffie, Whitfield, 541
 - Diffserv (Differentiated Service) protocol, 437, 541
 - Dijkstra Algorithm, 231, 277, 278–279, 279. *See also* SPF algorithm
 - directly connected IP address next-hop, 111
 - directories in configuration mode, 26–28
 - directories, manipulating files in, 44–46
 - DIS (Designated Intermediate System) election, 289, 289–290
 - DIS priority, 290
 - disable (configuration) command
 - versus deactivate command, 73
 - defined, 542
 - disabling fxp0 interface, 79–80, 302–303
 - warning, 302
 - discard, 542
 - discard action, 434, 446
 - discard next hops, 111, 118
 - Distance Vector Multicast Routing Protocol (DVMRP), 387, 393, 542
 - distance-vector protocols. *See also* path-vector protocols; RIP
 - defined, 323, 542
 - routing policies and, 151, 151

Distributed Buffer Manager ASICs, 48–49, 50–51, 50, 542
 DLCIs (data link connection identifiers), 72–73, 540
 Down state in OSPF, 238, 239, 284, 542
 DRs (designated routers)
 defined, 244, 245, 541
 electing, 244–246, 245
 in IGMP, 390–391
 DSCP (Differentiated Services Codepoint), 437, 541
 DSP (Domain-Specific Part), 282, 283
 dynamic LSPs. *See* MPLS

E

EBGP (external BGP). *See* BGP
 edit (configuration) command
 defined, 24
 edit protocols, 26–28
 edit routing-options, 28
 edit system, 28–29, 31–32
 top edit, 28
 editor macros (Emacs), 19, 543
 EGP (Exterior Gateway Protocol), 322, 325, 543
 egress routers. *See also* MPLS
 defined, 483–484, 543
 dynamic LSPs and, 506–507
 static LSPs and, 497
 Embedded OS software, 47, 543
 encapsulation options, 69
 end systems, 276, 543
 EROs (explicit route objects). *See also* RSVP
 using both loose and strict hops, 491–492, 491
 configuring loose hops in, 507–508
 defined, 490, 543
 using loose hops, 490, 490
 as named path, 507, 554
 using strict hops, 490–491, 491
 warning, 491
 Established state in BGP, 333, 543
 Ethernet broadcast networks
 defined, xxvi

Internal Ethernet interface, 62–63, 545, 548
 IPv4 interfaces, configuring inet to, 75–76
 using LLC layer in, 292
 Management Ethernet interface, defined, 62, 545, 552
 Management Ethernet interface, disabling, 79–80, 302–303
 multicast addressing, 380–383, 381–382
 versus multicast networks, 374, 376, 376
 in OSPF networks, 243–246, 243, 245
 VLAN, virtual circuit addresses, 73
 exact match type keyword, 165, 167, 168, 543
 exams. *See* JNTCP
 except keyword, 437
 exception packets, 51–52, 543
 Exchange state in OSPF, 238, 239, 543
 explicit route objects. *See* EROs
 explicit-null command, 484
 export policies. *See also* routing policies
 applying in BGP, 174–176, 342, 353–354, 354, 362
 as RIP no export workaround, 212–214
 export (routes to routing tables), 177, 543
 ExStart state in OSPF, 238, 239, 543
 Exterior Gateway Protocol (EGP), 322, 325, 543
 external BGP. *See* BGP

F

families, protocol, 70. *See also* inet; inet6; iso; mpls
 FCS (frame check sequence) property, 69
 FEB (Forwarding Engine Board), 5, 545
 file (operational) command, 44
 file storage directories, 44–46
 filters, route. *See* routing policies
 firewall filters, 430–471
 actions
 accept action, 446, 447–450
 action modifiers, 449–452
 count modifier, 450
 default final actions, 434
 defined, 446, 534

- discard action, 434, 446
- flow-control actions, 447–449
- log modifier, 446, 448–449, 450–451
- next term action, 447, 449
- overview of, 432
- reject action, 446
- sample modifier, 451–452
- syslog modifier, 446, 452
- terminating actions, 446–447
- applying to router interfaces
 - overview of, 452–453
 - to remote in-band interfaces, 453
 - to Routing Engine (lo0 interface), 453–454, 454
 - to transit interfaces, 454, 454
 - warning, 454
- commands for modifying
 - clear firewall, 462
 - insert, 463–464
 - rename, 464
- commands for troubleshooting
 - show firewall, 460
 - show firewall log, 451, 460–461
 - show firewall log detail, 461
 - show interfaces filters, 462
 - show interfaces policers, 462–463
 - show log messages, 461–462
 - show policer, 463
- defined, 430, 544
- exam essentials, 465
- Internet Processor ASICs and, 431
- key terms, 465
- match conditions
 - absence of, 445–446
 - address conditions, 439–441
 - bit field conditions, 441–444
 - defined, 552
 - from syntax in, 434, 440
 - numeric range conditions, 434–439
 - overview of, 432, 434
- overview of, 430, 464
- processing, 432
- rate policing
 - bandwidth-limit, 455
 - burst-size-limit, 455–456
 - configuring filter policers, 456–458
 - configuring interface policers, 458–459
 - defined, 455, 557
 - overview of, 493
 - rate limits, 455–456
 - token-bucket algorithm, 455
- review question answers, 470–471
- review questions, 466–469
- versus stateful firewalls, 430
- terms
 - to accept TCP return packets, 444–445
 - defined, 433–434, 565
 - to drop known bad packets, 445–446
 - overview of, 432
 - reordering, 433, 463–464
- uses, 430, 455
- writing
 - actions, 432, 446–452
 - default final actions, 434
 - match conditions, 434–446
 - and naming, 432–433
 - overview of, 431–432
 - segmenting with terms, 433–434
- floating static routes, 111, 112, 544
- flood and prune, 386–388, 386–387, 544
- flow-control actions
 - defined, 544
 - in firewalls, 447–449
 - in routing policies, 170
- forwarding class, 455–456, 544
- forwarding data. *See* multicast; Packet Forwarding Engine
- Forwarding Engine Board (FEB), 5, 545
- forwarding table, 3, 545
- FPC (flexible PIC concentrator). *See also* PIC
 - defined, 5, 544
 - FPC slot numbers, 64, 65, 65–66
 - in naming interfaces, 63–68, 65–67
 - overview of, 4
- fragment-offset match condition, 437
- frame check sequence (FCS) property, 69
- Frame Relay, 72–73, 545
- from syntax in match conditions, 158–159, 434, 440, 545
- Full state in OSPF, 238, 239, 545
- fxp interfaces. *See* permanent interfaces

G

Garbage Collection timer, 204, 545
 Gateway Information Protocol (GWINFO), 196
 generated routes. *See also* routing,
 protocol-independent
 contributing routes, 121–123, 121
 defined, 121, 545
 primary contributing routes, 123–125, 558
 pros and cons of use, 125
 GLOP addressing scheme, 379
 group addresses in multicasting, 378, 378–380
 group addresses in PIM protocol, 395–396,
 396

H

Hammond, John L., xxxi
Handbook of Computer Communications Standards (Stallings), 292
 HDLC (High-Level Data Link Control) protocol, 69, 546
 Hellman, Martin, 541
 hello interval in OSPF, 233, 546
 hello interval timer in RSVP, 510–511
 hello mechanism in RSVP, 489, 546
 Hello messages in IS-IS, 277, 285, 285
 hello packets, OSPF, 232–234, 233, 556
 help, context-sensitive, 15–16, 540
 help (operational) command, 7–9
 hierarchy directories in configuration mode, 26–28
 Hold-Down timer, 203, 546
 hop counts (metrics), 198
 Host Membership Query messages, 391–392, 547
 Host Membership Report messages, 391, 547
 hosts, 276. *See also* end systems

I

I/O Manager ASICs, 48, 50–51, 50, 549
 IBGP (internal BGP). *See* BGP

ICMP (Internet Control Message Protocol)
 defined, xxvi–xxvii, 549
 icmp-code match condition, 437
 icmp-type match condition, 437–438
 messages
 overview of, 92
 reject options, 446–447
 traceroute, UDP and, 92
 Idle state in BGP, 332, 547
 IETF (Internet Engineering Task Force), 326, 402, 480, 549
 IGMP (Internet Group Management Protocol). *See also* multicast networks
 defined, 390–391, 549
 verifying, 404–406
 version 1, 391–392, 391
 version 2, 392–393, 392
 version 3, 393
 IGP (Interior Gateway Protocol), 548. *See also* IS-IS; OSPF; RIP
 IGP-based networks, 475–476, 475–476
 IIH (IS-IS Hello) PDUs. *See also* IS-IS; PDUs
 Hello messages, 277, 285, 285
 LAN Hello PDUs, 287–289, 287, 291
 overview of, 287
 point-to-point Hello PDU, 290–292, 290
 import, 214, 547
 inet protocol family, 70, 75–77
 inet routing tables. *See* routing tables
 inet6 protocol family, 70, 80–82
 infinity metrics, 198–199, 198–199, 547
 ingress routers. *See also* MPLS
 defined, 482, 547
 in dynamic LSPs, 503–506, 504
 in static LSPs, 497–498
 INI (Initial Domain Identifier), 282, 283
 Init state in OSPF, 238, 239, 547
 Initializing state in IS-IS, 284, 285
 insert (configuration) command
 defined, 24, 547
 to reorder firewall filter terms, 463–464
 to reorder routing policies, 177–178
 interface cost, 200, 548
 interface MTU property, 69, 72
 interface-group match condition, 438

- interfaces. *See* permanent interfaces; transient interfaces
- Interior Gateway Protocols (IGPs), 548. *See also* IS-IS; OSPF; RIP
- intermediate systems, 276, 548. *See also* routers
- internal BGP (IBGP). *See* BGP
- Internal Ethernet interface, 62–63, 548
- internal routers in OSPF, 247
- Internet , BGP and, 322–324, 323
- Internet Control Message Protocol. *See* ICMP
- Internet drafts
 - for BGP, 326
 - for bootstrap router process, 402
 - for MPLS, 480
- Internet Engineering Task Force (IETF), 326, 402, 480, 549
- Internet Group Management Protocol. *See* IGMP
- Internet Processor ASICs
 - defined, 49, 549
 - firewall filters and, 431
 - versus Internet Processor II ASICs, 139–140
 - in packet flow, 50–51, 50
- IP addresses. *See also* addresses
 - configuring in BGP, 350
 - defined, xxvi
 - firewall filter match conditions, 438–442
 - group addresses in PIM, 395–396, 396
 - multicast group addresses, 378–380, 378
 - multiple, on transient interfaces, 71
- IP (Internet Protocol), 549
- ip, using in operational mode, 18
- IPSec (Internet Protocol Security), 549
- IPv4 interfaces, configuring, 75–77
- IS-IS (Intermediate System to Intermediate System), 276–319
 - adjacencies, forming, 284–285, 285
 - adjacency states, 284
 - applying routing policies in, 174
 - area addresses, 279, 281, 281, 282, 283
 - area values, 278, 279, 282–283, 283
 - areas, defined, 535
 - commands for troubleshooting
 - clear isis adjacency, 305
 - overview of, 303, 303
 - show isis adjacency, 303–304
 - show isis adjacency detail, 304–305
 - show isis database, 308–309
 - show isis database detail, 309
 - show isis database extensive, 309–311
 - show isis hostname, 306–307
 - show isis interface, 306
 - show isis route, 308
 - show isis spf log, 307
 - show isis statistics, 307–308
 - comparing to OSPF, 311–312
 - configuring
 - disabling fxp0 interface, 302–303
 - iso protocol family, 82–84, 299
 - NET ID assignment, 298
 - network level, 300–303, 300
 - overview of, 298
 - physical interfaces, 299
 - warning, 302
 - default policies, 173
 - defined, 276, 548
 - Designated IS election, 289–290, 289
 - exam essentials, 312
 - key terms, 313
 - levels
 - defined, 278
 - design considerations, 280
 - Level 1, 278–279, 279, 280–281
 - Level 2, 278–279, 279, 280–281
 - level match condition, 159, 160
 - multilevel example, 281, 281
 - overview of, 282, 304
 - as link-state protocol, 277
 - NSAP addressing, 282–283, 283
 - overview of, 70, 276, 312
 - Protocol Data Units
 - common PDU header, 286–287, 286
 - CSNP PDUs, 292–294, 293
 - data-link MTUs and, 291–292
 - defined, 558
 - in forming adjacencies, 284–285, 285
 - Hello messages, 277, 285, 285
 - IS-IS Hello PDUs, 287–292, 287–290
 - LAN Hello PDUs, 287–289, 288
 - LSP PDUs, 295–297, 295

- overview of, 285
- point-to-point Hello PDU, 290–292, 290
- PSNP PDUs, 294–295, 294, 556
- triple format (TLVs), 287, 288, 288, 290, 290, 297
- types, listed, 286
- pseudonodes, 289–290, 289, 311
- reliability, 324
- review question answers, 318–319
- review questions, 314–317
- sample network, 276, 277

ISO (International Organization for Standardization), 548

iso protocol family, 70, 82–84, 299

J

- J-cells, 48–49, 549
- jbase package, 7, 549
- jbundle package, 7, 549
- jcrypto package, 7
- jdocs package, 7–9, 549
- kernel package, 7, 550
- JNCIA Study Guide* (this book)
 - authors/technical editors, xxx-xxxii
 - CD contents, xxx
 - how to use, xxix
 - overview of, xxv
 - scope of, xxvii
 - what it covers, xxvii-xxviii
 - what to know before starting, xxv-xxvii
- JNCIS Study Guide* (forthcoming), 441, 504
- JNTCP (Juniper Networks Technical Certification Program)
 - assessment test, xxxiii-xxxix
 - assessment test answers, xl-xlii
 - defined, xvii
 - ERX Edge Routers track, xvii
 - exam-taking tips, xxv
 - M-series Routers & T-series Routing Platforms track
 - Certified Internet Associate, xvii, xviii-xix
 - Certified Internet Expert, xvii-xviii, xx-xxi
 - Certified Internet Professional, xvii, xx
 - Certified Internet Specialist, xvii, xix-xx
 - overview of, xvii-xviii, xviii
 - nondisclosure agreement, xxiii
 - recertification requirements, xxii
 - registering for exams, xxi-xxii
 - resources
 - CertManager website, xxiii-xxiv
 - Groupstudy mailing list/website, xxiv
 - JNTCP website, xxiii
 - overview of, xxiii
 - Techcenter website, xxiv
 - technical documentation, xxiv
 - training courses, xxiv
- Join messages in PIM, 397, 397–398, 550
- jpfe package, 7, 550
- jrout package, 7, 550
- Juniper Networks router components, 2–60
 - exam essentials, 52–53
 - key terms, 54
 - overview of, 52
 - Packet Forwarding Engine. *See also* Packet Forwarding Engine
 - ASICs, 4, 47–49, 50–51, 50
 - defined, 4, 556
 - Embedded OS software, 47
 - flexible PIC concentrator, 4, 5, 63
 - general functions, 4, 47–52
 - packet flow, 49–52, 50
 - physical composition, 4–6
 - Physical Interface Card, 4, 6
 - switching control board, 4–5
 - review question answers, 59–60
 - review questions, 55–58
 - Routing Engine. *See also* JUNOS software
 - applying firewall filters to, 453–454, 454
 - defined, 3, 561
 - general functions, 3
 - JUNOS software, 3–4, 6–46
 - overview of, 2, 2
 - physical composition, 3–4
 - redundancy options, 42–43, 46–47
 - warning, 47

- Juniper Networks Routers: The Complete Reference* (Soricelli et al.), xxxi
- Juniper Networks routers. *See also* permanent interfaces; transient interfaces
- applying firewall filters to, 452–453
 - configuring on. *See also individual protocols*
 - BGP protocol, 346–353, 346
 - IS-IS protocol, 298–303, 300
 - OSPF protocol, 255–259, 256, 258
 - PIM protocol, 406–417
 - RIP protocol, 210–221, 211, 219
 - connecting to other vendor routers, 69
 - default routing table integration, 516–520, 517
 - verifying IGMP protocol, 404–406
- Juniper Networks Technical Certification Program. *See* JNTCP
- JUNOS software, 6–46. *See also individual commands*
- architecture, 6–7
 - boot sequence, 11–13, 12
 - CLI (command-line interface)
 - configuration mode, 23–43
 - defined, 539
 - operational mode, 13–23
 - overview of, 13
 - components, 7–9
 - configuration mode, 23–43
 - accessing, 23
 - accessing operational mode from, 24–26
 - active configurations, 33
 - candidate configurations, 33–34, 538
 - checking configurations, 41–42
 - command completion function, 26, 539
 - comparing configurations, 33–34
 - configuring routers, 28–33, 39–42
 - cutting/pasting configuration files, 38–39
 - defined, 539
 - exiting to operational mode, 41
 - hierarchy directories, 26–28
 - (more) prompt, 22, 26
 - navigating, 26–28
 - restoring previous configurations, 42–43
 - saving configuration files, 34–35
 - top-level command hierarchy, 23–26
 - warning, 43
 - configuration mode commands
 - commit, 33, 39–43
 - deactivate, 73, 78–79, 541
 - defined, 24
 - delete, 24, 32–33
 - disable, 73, 79–80, 542
 - discard, 542
 - for dynamic LSPs, 500–510, 504
 - edit, 24, 26–32
 - for firewall filters, 463–464
 - insert, 24, 177–178, 463–464
 - install (routes in tables), 520–524, 520
 - load, 24, 35–39
 - for PIM protocol, 406–417
 - rename, 24, 71, 177–180, 464
 - for RIP protocol, 210–221, 211, 219
 - rollback, 43
 - for routing policies, 176–179
 - for RSVP protocol, 510–516
 - run, 24–26
 - save, 24, 34–35
 - set, 24, 28–29, 31–32, 46
 - show, 24, 29–30, 32–34
 - for static LSPs, 494–500, 496
 - status, 24, 26
 - top, 24, 28
 - up, 24, 27
 - context-sensitive help, 15–16, 540
 - daemons, 6–7
 - decimal value conversion, 246
 - defining martian routes, 127
 - kernel, 6, 7, 550
 - load balancing, 137–140, 138
 - manipulating files on router, 44–46
 - match type syntax, 163, 165–166, 167
 - naming convention, 9–10
 - operational mode, 13–23
 - accessing, 13
 - command completion function, 16–18, 539
 - command history, 18–19

- command variables, 19–22
- defined, 555
- editing command-lines, 18–19
- using *ip* in, 18
- modifying command output, 22–23
- top-level command hierarchy, 13–14
- operational mode commands. *See also*
 - troubleshooting commands
- for BGP route knowledge, 354–361, 354, 358
- for BGP sessions, 346, 350–353
- clear firewall, 462
- defined, 13–14
- for dynamic LSPs, 506–507, 509–510
- file, 44–46
- for firewall filters, 460–463
- for IGMP, 404–406
- for interfaces, 85–91
- for IS-IS, 303–311, 303
- for multicast networks, 417–420
- for OSPF, 259–266
- request, 10–11, 13–14
- for routing policies, 180–183
- show, 13, 14–15
- for static LSPs, 499–500
- overview of, 3–4
- packages, 7, 9, 556
- upgrading, 10–11
- warning, 13

K

- keep-multiplier value in RSVP, 513
- keepalive mechanism, 69
- Keepalive messages in BGP, 337, 550
- kernel, 6, 7, 550
- keystroke shortcuts
 - editing command-lines, 19
 - modifying command output, 22–23
 - in *monitor interface* command, 89
 - stopping command output, 90

L

- Label Distribution Protocol (LDP), 493

- label objects, 492, 550
- label pop operation, 482, 550
- label push operation, 482, 550
- label request objects, 492, 550
- label switched paths. *See* MPLS
- label switching routers. *See* MPLS
- label values. *See also* MPLS
 - configuring in dynamic LSPs, 506
 - configuring in static LSPs, 496, 496
 - defined, 484, 484–485, 550
- LAN Hello PDUs, 287–289, 288
- levels. *See* IS-IS
- line loopback. *See* loopback testing
- link-state acknowledgment packets, 237, 237, 551
- Link-State Advertisements. *See* LSAs
- link-state databases, 230, 277, 551
- link-state protocols, 230–231, 277. *See also* IS-IS; OSPF
- link-state request list, 240, 551
- link-state request packets, 236, 236, 551
- link-state update packets, 237, 237, 551
- links, 551
- lo0 interface. *See* Routing Engine
- load balancing, 137–140, 138
- load (configuration) command
 - defined, 24
 - load merge common, 35, 36–37
 - load merge terminal, 38–39
 - load override common, 35–36
- Loading state in OSPF, 238, 239, 551
- Local Preference attribute in BGP, 342, 551
- local preference match condition, 159
- local significance, 484, 552
- local-address command, 349–350
- Local-RIB in BGP, 338, 552
- locally configured routes. *See* routing, protocol-independent
- log action modifier, 446, 448–449, 450–451
- logical interfaces. *See* transient interfaces
- logical operators, 443–444, 552
- logical unit numbers, 64, 67
- longer match type keyword, 165, 166, 167, 552
- loopback testing. *See also* transient interfaces
 - defined, 93, 551

- using local loopbacks, 93–94, 93
 - using remote loopbacks, 94–96, 95
 - loops
 - creating, 328–329, 331–332
 - detecting with RROs, 492
 - in multicast forwarding, 383–384, 384
 - preventing
 - with AS Path attribute, 323, 329
 - with poison reverse, 201–202, 202, 557
 - with reverse path forwarding, 384–385, 385, 560
 - loose hops, 490–491, 490–492, 507–508, 552
 - LSAs (Link State Advertisements)
 - AS external LSAs, 250–255, 251–254, 256
 - ASBR summary LSAs, 251–255, 251–254, 256
 - defined, 237, 237, 242
 - limiting flooding scope of, 246–255, 249–256
 - LSA Headers field, 235, 236
 - network LSAs, 244, 554
 - network summary LSAs, 246, 248–249, 249–250, 252–254, 252–254, 256
 - NSSA external LSAs, 255, 256
 - overview of, 242
 - router LSAs, 242, 243, 561
 - types, listed, 236
 - LSPs (label switched paths). *See* MPLS
 - LSPs (link-state PDUs), 295, 295–297, 551
 - LSRs (label switching routers). *See* MPLS
-
- M**
- MAC (Media Access Control), xxvi, 380–383, 381–382
 - Management Ethernet interface, 62, 545, 552
 - mapping agents in Auto-RP, 401–402, 552
 - martian routes, 126–131, 552
 - master, 46, 552
 - match conditions. *See also* firewall filters; routing policies
 - for firewall filters
 - absence of, 445–446
 - address conditions, 439–441
 - bit field conditions, 441–444
 - from* syntax in, 434, 440
 - numeric range conditions, 434–439
 - overview of, 432, 434
 - match,, defined, 552
 - for routing policies
 - absence of, 169
 - BGP routes and, 160, 166
 - defining multiple criteria, 160–161
 - using *from* or *to* keywords, 158–160
 - listed, 158–160
 - match, defined, 153
 - match type keywords, 163, 165–166, 167
 - overview of, 153, 155, 157–158
 - using route filters, 161–168
 - warning, 167
 - MED (Multiple Exit Discriminator) attribute, 343–344, 553
 - Media Access Control (MAC), xxvi, 380–383, 381–382
 - media types in naming interfaces, 64–65
 - messages. *See also* packets; PDUs
 - in BGP
 - Keepalive messages, 337
 - message headers, 333–334, 333
 - Notification messages, 336–337, 336
 - Open messages, 334, 335
 - Update messages, 335–336, 336
 - ICMP messages
 - reject* options, 446–447
 - traceroute, UDP and, 92
 - in IGMP protocol, 391–392, 547
 - in PIM protocol. *See also* multicast networks
 - Join messages, 394, 397–398, 397
 - message headers, 394–395, 394
 - Null Register messages, 399, 400
 - Prune messages, 386–387, 387–388, 389, 390, 394, 397–398, 397
 - Register messages, 398–399, 398, 559
 - Register Stop messages, 399, 399, 559
 - types, listed, 394–395
 - in RSVP protocol
 - authenticating, 514–515
 - defined, 488–489, 488
 - message aggregation, 489, 513–514, 553

- metrics
 - defined, 198, 208, 208
 - incoming, configuring in RIP, 215
 - infinity metrics, 198–199, 198–199, 547
 - metric match condition, 159
 - outgoing, configuring in RIP, 216
- mgd (Management Daemon), 6, 552
- minus sign (-) in candidate configurations, 33
- MMB (Memory Mezzanine Board), 5
- monitor (operational) command, 13, 88–90
- (more) prompt, 22, 26
- MOSPF (Multicast Open Shortest Path First), 387, 393
- MPLS (Multiprotocol Label Switching), 474–531
 - configuring dynamic (RSVP signaled) LSPs
 - advantage, 500
 - attributes, 507–510
 - defined, 561
 - egress routers and, 506–507
 - ERO loose hops, 507–508
 - ingress routers, 503–506, 504
 - interfaces, 500–501
 - label values, 506
 - MPLS protocol, 501–502
 - overview of, 500
 - RSVP bandwidth requests, 507, 508–510
 - RSVP protocol, 502–503
 - transit routers and, 506–507
 - and verifying operation, 506–507, 509–510
 - configuring static LSPs
 - egress routers and, 497
 - ingress routers, 497–498
 - interfaces, 494
 - label values, 496, 496
 - MPLS, 495–496
 - next-hop addresses, 499
 - overview of, 494
 - transit routers, 498–499
 - and verifying operation, 499–500
 - warning, 500
 - creation of, 474
 - defined, 554
 - exam essentials, 525
 - Internet drafts for, 480
 - key terms, 526
 - label values, 484–485, 484, 550
 - local significance, 484
 - LSPs (label switched paths)
 - versus ATM virtual circuits, 487, 493
 - configuring dynamic LSPs, 500–510, 504
 - configuring static LSPs, 494–500, 496
 - defined, 480–481, 551
 - dynamic LSPs, 487, 542
 - next-hop values, 111
 - overview of, 479
 - static LSPs, 486–487, 563
 - LSRs (label switching routers)
 - defined, 481, 481–482, 551
 - egress routers, 483–484
 - ingress routers, 482, 547
 - label pop operation, 482, 550
 - label push operation, 482, 550
 - penultimate hop popping, 483, 483, 484
 - penultimate routers, 482–483, 483
 - transmit routers, 482
 - overview of, 474, 480, 493, 524
 - packet processing, 485–486, 486
 - policing traffic in, 493
 - review question answers, 531
 - review questions, 527–530
 - RFCs for, 480
 - routing table integration
 - adding routes to inet.0, 523–524
 - adding routes to inet.3, 520–522, 520
 - default route assignment to LSPs, 516–520, 517
 - manual route assignment to LSPs, 520–524, 520
 - overview of, 516
 - RSVP protocol
 - bandwidth requests, 493, 507, 508–510
 - defined, 488, 560
 - Path messages, 488–489, 488, 556, 561
 - Resv messages, 488–489, 488, 560, 561
 - soft state, 488, 489
 - RSVP protocol, configuring
 - bandwidth limits, 515–516
 - hello interval timer, 510–511
 - keep-multiplier value, 513

- message aggregation, 513–514
- message authentication, 514–515
- overview of, 510
- soft state refresh timer, 512
- RSVP protocol extensions
 - explicit route objects, 490–492, 490–491, 543
 - hello mechanism, 489
 - label objects, 492
 - label request objects, 492, 550
 - loose hop EROs, 490, 490–491, 491–492
 - message aggregation, 489, 553
 - overview of, 489
 - record route objects, 492
 - session attribute objects, 492
 - strict hop EROs, 490–492, 491
 - tspec objects, 492
 - warning, 491
- shim headers, 484–485, 484, 562
- signaling protocols
 - Label Distribution Protocol, 493
 - overview of, 488
 - Resource Reservation Protocol, 488–492, 500–516
- traffic engineering history and
 - ATM overlay networks, 476–478, 476–477
 - defined, 475, 565
 - IGP-based networks, 475–476, 475–476
 - MPLS networks, 478–479, 478–479
 - overview of, 475
 - SONET networks, 478
- mpls protocol family, 70, 84–85, 494
- mpls.0 routing table, 134–135
- MTUs (maximum transmission units)
 - data-link MTUs, PDUs and, 291–292
 - defined, 553
 - interface MTU property, 69
 - overview of, 69
 - protocol MTU property, 71–72
- multicast forwarding cache, 132–133
- multicast networks, 374–428
 - addressing packets
 - Ethernet addresses, 380–383, 381–382
 - IP group addresses, 378–380, 378
 - overview of, 377–378
 - versus broadcast networks, 374, 376, 376
 - defined, 374, 377, 377, 553
 - exam essentials, 421–422
 - forwarding packets
 - dense mode forwarding, 386–387, 386–388, 393
 - loop problem, 383–384, 384
 - overview of, 383
 - pruning dense mode, 386–387, 387–388
 - pruning sparse mode, 389, 390
 - reverse path forwarding solution, 384–385, 385
 - sparse mode forwarding, 388–389, 389–390, 393
- IGMP protocol
 - defined, 390–391, 549
 - verifying, 404–406
 - version 1, 391–392, 391
 - version 2, 392–393, 392
 - version 3, 393
- key terms, 422
- overview of, 374, 403, 403, 421
- PIM protocol
 - configuring dense mode, 406
 - configuring sparse mode, 408–417
 - configuring sparse-dense mode, 407
 - defined, 393–394, 558
 - group addresses, 395–396, 396
 - Join messages, 394, 397–398, 397, 550
 - message headers, 394–395, 394
 - message types, listed, 394–395
 - Null Register messages, 399, 400
 - Prune messages, 394, 397–398, 397
 - Register messages, 394, 398–399, 398, 559
 - Register Stop messages, 399, 399, 559
 - source addresses, 396–397, 396
 - unicast addresses, 395, 395
 - verifying operation of, 417–420
- PIM sparse mode networks
 - Auto-RP, 401–402, 411–415
 - bootstrap routers, 402–403, 415–417
 - connecting to shared trees, 400

defined, 563
 establishing shortest path trees,
 400–401
 forwarding packets to RPs, 400
 overview of, 399–400
 rendezvous points, 401–403, 408–409,
 411
 static RP addresses, 401, 410–411
 review question answers, 427–428
 review questions, 423–426
 routing protocols
 Internet Group Management Protocol,
 393–393, 391–392
 overview of, 390
 Protocol Independent Multicast,
 393–403, 394–399
 source-specific multicasting, 379, 563
 versus unicast networks, 374, 375, 375, 380
 verifying/troubleshooting, 417–420
 Multicast Open Shortest Path First (MOSPF),
 387, 393
 multicast packet flow, 51
 multiplier value in RSVP, 513
 Multiprotocol Label Switching. *See* MPLS
 multiterm routing policies, 156, 156–157

N

N-selector (SEL) values, 283, 283, 555
 named paths. *See* EROs
 naming convention in JUNOS, 9–10
 naming firewall filters, 432–433
 naming routing policies, 155, 178–179
 naming structure for interfaces. *See also*
 transient interfaces
 defined, 63–64
 examples, 67–68
 FPC slot numbers, 64, 65, 65–66
 logical unit/channel numbers, 64, 67
 media types, 64–65
 PIC port numbers, 64, 66–67, 67
 PIC slot numbers, 64, 66, 66
 navigating configuration mode, 26–28
 neighbors. *See also* BGP; peers
 in BGP, 327, 327

defined, 554
 fields, in OSPF packets, 233, 234
 match condition, 159
 in OSPF, 238
 NET ID assignment, 298
 NET (Network Entity Title), 282–283, 283,
 554
 network connectivity, BGP and, 322–323, 323
 Network Layer Reachability Information
 (NLRI), 334, 336, 336, 554
 network LSAs, 244, 554
 network maps, routing policies and, 153
 network summary LSAs
 database size and, 252–254, 252–254, 256
 defined, 246, 248–249, 249–250, 554
 network transmission methods. *See*
 broadcast networks; multicast
 networks; unicast networks
 New state in IS-IS, 284, 285
 Next Hop attribute. *See also* BGP
 default resolution process, 517–520, 527
 defined, 339, 554
 in manual routing table integration,
 520–524, 520
 next-hop match condition, 159
 reachability in EBGp sessions, 339–340,
 340, 357–359, 358
 resolving unreachability, 341–342,
 362–365
 unreachability in IBGP sessions, 340, 341,
 359–361
 next term action, 447, 449
 next-hop options
 for aggregated routes, 118
 in configuring static LSPs, 499
 for static routes, 111
 NLRI (Network Layer Reachability
 Information), 334, 336, 336, 554
 notification cells, 49, 554
 Notification messages in BGP, 336, 336–337,
 554
 NSAP (Network Service Access Point), 282–
 283, 283, 554
 NSSA external LSAs, 255, 256
 NSSAs (not-so-stubby areas), 255, 256, 555
 Null Register messages in PIM, 399, 400, 555

numeric range match conditions, 434–439, 555

O

- One-Way state in IS-IS, 284
- Open messages in BGP, 334, 335, 555
- OpenConfirm state in BGP, 333, 555
- OpenSent state in BGP, 332–333, 555
- operational mode. *See* JUNOS software
- OR operations in route filters, 168
- Origin attribute in BGP, 343, 555
- origin match condition, 159
- orlonger match type keyword, 165, 167, 168, 555
- OSI (Open System Interconnection) model, xxvi, 555
- OSPF (Open Shortest Path First), 230–274
 - applying routing policies in, 174
 - area match condition, 159
 - areas, defined, 535
 - commands for troubleshooting
 - clear ospf database, 262–263
 - clear ospf neighbor, 261
 - show ospf database, 261–262
 - show ospf interface, 259–260
 - show ospf log, 263–264
 - show ospf neighbor, 260–261
 - show ospf route, 265
 - show ospf statistics, 264
 - show route protocol ospf, 265–266
 - warning, 263
 - comparing to IS-IS, 311–312
 - default policies, 173
 - defined, 230–231, 555
 - evolution of OSPF networks
 - designated routers, 244, 245, 541
 - DR elections, 244–246, 245
 - Ethernet networks, 243–246, 243, 245
 - network LSAs, 244, 554
 - overview of, 242
 - router LSAs, 242, 243, 561
 - scaling techniques, 246–255, 247, 249–254
 - exam essentials, 267
 - forming adjacencies
 - adjacency states, 238–239, 239
 - Ethernet links and, 243–244, 243
 - example, 239–240
 - overview of, 238
 - troubleshooting, 241
 - warning, 239
 - getting help from router on, 7–9
 - key terms, 268
 - as link-state protocol, 230–231
 - multiarea networks, 258–259, 258
 - overview of, 230, 266
 - packets
 - common packet header, 232, 233
 - Database Description, 235–236, 235
 - hello, 232–234, 233, 556
 - link-state acknowledgement, 237, 237
 - link-state request, 236, 236
 - link-state update, 237, 237
 - LSAs in, 237, 237, 242
 - overview of, 232
 - usage during adjacency formation, 238–241, 239
 - reliability, 324
 - review question answers, 273–274
 - review questions, 269–272
 - RFCs for, 231
 - scaling OSPF networks
 - ABR routers and, 247
 - altering area behavior, 252–255, 252–254, 256
 - AS external LSAs, 250–255, 251–254, 256
 - ASBR routers and, 247
 - ASBR summary LSAs, 251–255, 251–254, 256
 - defining area boundaries, 246–248, 247
 - design considerations, 248
 - limiting LSA flooding scope, 246–255, 249–256
 - network summary LSAs, 246, 248–249, 249–250, 252–254, 252–254, 256
 - non-OSPF routes, 250–251, 251
 - not-so-stubby areas, 255, 256, 555
 - NSSA external LSAs, 255, 256
 - overview of, 246

- reducing database size, 246, 252–255, 252–254, 256
- router types and, 247
- stub areas, 252–254, 253, 564
- totally stubby areas, 254, 254
- single-area networks, 255–258, 256
- transit areas, 565
- waiting on OSPFv3, 234
- WaitTimer, 245
- overlay networks, 477, 477–478, 479, 556

P

- packages, 7, 9, 556
- packet filters. *See* firewall filters
- Packet Forwarding Engine. *See also* Juniper Networks routers
 - application-specific integrated circuits
 - defined, 535
 - Distributed Buffer Manager ASICs, 48–49
 - I/O Manager ASICs, 48, 549
 - Internet Processor ASICs, 49, 139–140
 - overview of, 4, 47
 - in packet flow, 50–51, 50
 - PIC I/O Manager ASICs, 48, 557
 - defined, 4, 556
 - Embedded OS software, 47
 - general functions, 4, 47–52
 - packet flow
 - exception packets, 51–52, 543
 - multicast packets, 51
 - overview of, 49
 - unicast packets, 49–51, 50
 - physical composition
 - flexible PIC concentrator, 4, 5, 63
 - Physical Interface Card, 4, 6
 - switching control board, 4–5
- Packet Loss Priority (PLP), 556
- Packet Loss Priority (PLP) bit, 455–456, 557
- packets. *See also* messages; PDUs
 - filtering. *See* firewall filters
 - in OSPF
 - common packet header, 232, 233
 - Database Description, 235–236, 235
 - hello, 232–234, 233, 556

- link-state acknowledgement, 237, 237
- link-state request, 236, 236
- link-state update, 237, 237
- LSAs in, 237, 237, 242
- overview of, 232
- usage in forming adjacencies, 238–241, 239
- packet-length match condition, 438
- processing in MPLS, 485–486, 486
- in RIP
 - maximum size of, 206
 - request packets, 206
 - response packets, 206
 - in RIPv1, 207–208, 207
 - in RIPv2, 208, 208
- PARC Universal Protocol (PUP), 196
- pasting configuration files, cutting and, 38–39
- Path messages in RSVP, 488, 488–489, 556, 561
- path-vector protocols, 323, 556. *See also* BGP; distance-vector protocols
- payload scrambling property, 69
- PDUs (Protocol Data Units). *See also* IS-IS; messages; packets
 - common PDU header, 286–287, 286
 - CSNP PDUs, 292–294, 293
 - data-link MTUs and, 291–292
 - defined, 558
 - in forming adjacencies, 284–285, 285
 - IS-IS Hello PDUs
 - Hello messages, 277, 285, 285
 - LAN Hello PDUs, 287–289, 288
 - overview of, 287
 - point-to-point Hello PDU, 290–292, 290
 - LSP PDUs, 295–297, 295
 - overview of, 285
 - PSNP PDUs, 294–295, 294, 556
 - triple format (TLVs), 287, 288, 288, 290, 290, 297
- peers, 556. *See also* BGP; neighbors
- penultimate hop popping (PHP), 483, 483, 484, 556
- penultimate routers, 482–483, 483, 556
- permanent interfaces. *See also* transient interfaces
 - defined, 62–63

- fxp, overview of, 64, 65
 - fxp0 interface, disabling, 79–80, 302–303
 - fxp0 interface, overview, 62, 545
 - fxp1 interface, 62–63
 - fxp2 interface, 545, 548
 - warning, 63
 - permanent virtual circuits (PVCs), 72–73, 487, 557
 - pfed (Packet Forwarding Engine Daemon), 6
 - physical interfaces. *See* transient interfaces
 - PIC I/O Manager ASICs, 48, 50–51, 50, 557
 - PIC (Physical Interface Card). *See also* FPC
 - defined, 6, 63, 557
 - overview of, 4
 - port numbers, 64, 66–67, 67
 - slot numbers, 64, 66, 66
 - Pildush, Galina Diker, xxxi
 - PIM. *See* multicast networks
 - ping (operational) command, 13, 90–91, 499
 - PLP (Packet Loss Priority), 556
 - PLP (Packet Loss Priority) bit, 455–456, 557
 - plus sign (+) in candidate configurations, 33
 - plus sign (+) in set command, 32
 - point-to-point Hello PDUs, 290, 290–292
 - point-to-point links, xxvi
 - poison reverse, 201–202, 202, 557
 - policies. *See* routing policies
 - policing. *See* firewall filters
 - policy controls, BGP and, 323–324
 - port match condition, 438
 - pound character (#) in configuration mode, 23
 - PPP (Point-to-Point Protocol), 69, 557
 - precedence bits, 438, 557
 - preference. *See* protocol preference values
 - preferred addresses, 70–71, 558
 - prefix-length-range match type keyword, 165–166, 167, 558
 - prefix/prefix-length variables, 163, 165
 - primary addresses, 70–71, 558
 - primary contributing routes, 123–125, 558
 - protocol addresses, 70–71, 558
 - Protocol Data Units. *See* PDUs
 - protocol families, 70, 558. *See also* inet; inet6; iso; mpls
 - Protocol Independent Multicast (PIM). *See* multicast networks
 - protocol match condition, 159, 438
 - protocol MTU property, 71–72
 - protocol preference values
 - configuring in RIP, 217–218
 - defined, 136–137, 558
 - overview of, 150
 - preference match condition, 159
 - Prune messages. *See also* multicast networks
 - defined, 558
 - in dense mode forwarding, 386–387, 387–388
 - in PIM protocol, 397–398, 397
 - in sparse mode forwarding, 389, 390
 - pseudonodes in IS-IS, 289, 289–290, 311
 - PSNPs (Partial Sequence Number PDUs), 294, 294–295, 556
 - PUP (PARC Universal Protocol), 196
 - PVCs (permanent virtual circuits), 72–73, 487, 557
-
- Q**
- quad-wide PICs, 66, 559
 - qualified next hops, 111, 559
 - querier routers in IGMP, 391–392, 559
 - question mark (?) in help system, 15
-
- R**
- radix trees, 161–163, 162–164
 - rate policing. *See* firewall filters
 - record route objects (RROs), 492, 559
 - recursive lookups, 111, 559
 - redundancy options, Routing Engine, 42–43, 46–47
 - Register messages in PIM, 398, 398–399, 559
 - Register Stop messages in PIM, 399, 399, 559
 - reject action, 446, 559
 - reject next hops, 111, 118, 559
 - Reject state in IS-IS, 284
 - remote IP address next-hop, 111
 - remote loopbacks, 94–96, 95
 - rename (configuration) command
 - defined, 24, 179, 560

- rename address, 71, 180
- rename filter, 464
- rename policy-statement, 178, 179
- rename term, 179, 464
- rendezvous points. *See* RPs
- Request messages in RIP, 199–200, 201, 206, 560
- request (operational) command, 10–11, 13, 14
- resolve next hops, 111, 560
- Resource Reservation Protocol. *See* RSVP
- Response messages in RIP, 200–201, 206, 560
- restoring previous configurations, 42–43
- result cells, 48, 560
- Resv messages in RSVP, 488, 488–489, 560, 561
- reverse path forwarding (RPF), 384–385, 385, 560
- RFCs (Request for Comments)
 - for BGP protocol, 326
 - defined, 560
 - finding online, 197
 - for MPLS protocol, 480
 - for OSPF protocol, 231
- RIBs (Routing Information Bases). *See also* BGP
 - Adjacency-RIB-In, 337
 - Adjacency-RIB-Out, 338
 - defined, 337, 561
 - Local-RIB, 338
 - rib match condition, 159, 160, 438
- RIP (Routing Information Protocol), 196–228
 - applying routing policies in, 173–174
 - configuring
 - applying export policies, 212–214
 - applying import policies, 214
 - authentication, 216–217
 - incoming metrics, 215
 - minimum configuration, 210–212, 211
 - nonzero reserved fields and, 220–221
 - outgoing metrics, 216
 - overview of, 210
 - packet acceptance, 220–221
 - route advertisement, 212–214
 - route preference values, 217–218
 - update messages, 218–220, 219
 - default policies, 172
 - defined, 196, 561
 - exam essentials, 221–222
 - infinity metrics, 198–199, 198–199
 - input processing, 199–200
 - key terms, 222
 - limitations, 205–206
 - metrics, 198, 208, 208
 - output processing, 201
 - overview of, 196, 199, 221
 - packets
 - maximum size of, 206
 - with nonzero reserved fields, 220–221
 - for Request messages, 199–200, 201, 206
 - for Response messages, 200–201, 206
 - in RIPv1, 207–208, 207
 - in RIPv2, 208, 208
 - portability features, 197–198
 - using in real world, 212
 - review question answers, 227–228
 - review questions, 223–226
 - RIPv2 extensions, 209
 - stability features
 - hold-downs, 203
 - overview of, 201
 - poison reverse, 201–202, 202, 557
 - split horizon, 201, 563
 - triggered updates, 202, 566
 - standards, 197
 - timers
 - example of use, 204–205
 - Garbage Collection timer, 204
 - Hold-Down timer, 203
 - randomizing, 203
 - Timeout timer, 204
 - Update timer, 203, 567
- rollback (configuration) command, 43
- route redistribution, 152, 152, 561
- router IDs, 232, 233, 244–245, 245, 561
- router interfaces. *See* permanent interfaces; transient interfaces
- router LSAs, 242, 243, 561
- router priority values
 - assigning to bootstrap routers, 415–417
 - defined, 561
 - in OSPF, 244–245, 245
- routers. *See also* Juniper Networks routers
 - defined, xxvi, 150

- overview of, 276
- processes of, 150
- testing physical circuits between, 93–97, 93, 95
- Routing Engine. *See also* Juniper Networks router components; JUNOS software
 - applying firewall filters to, 453–454, 454
 - defined, 3, 561
 - general functions, 3
 - JUNOS software, 3–4, 6–46
 - overview of, 2, 2
 - physical composition, 3–4
 - redundancy options, 42–43, 46–47
 - warning, 47
- Routing Information Bases. *See* RIBs
- Routing Information Protocol. *See* RIP
- routing policies, 150–193
 - actions
 - action modifiers, 170–171
 - defined, 534
 - flow control actions, 170, 544
 - overview of, 169
 - terminating actions, 153, 155, 169
 - applying to
 - BGP protocol, 174–176, 342, 353–354, 354, 362
 - IGP protocols, 173–174
 - OSPF and IS-IS protocols, 174
 - overview of, 173
 - RIP protocol, 173–174, 212–214
 - warning, 156
 - BGP protocol and, 323–324
 - changing order of, 177–178
 - composing
 - actions, 169–171
 - default policies and, 171–173
 - example, 155
 - match conditions, 157–169
 - multiterm policies, 156–157, 156
 - overview of, 153
 - policy processing and, 153–155, 154
 - configuring multiple policies, 177
 - default policies in
 - BGP protocol, 172
 - IGP protocols, 172–173
 - IS-IS protocol, 173
 - OSPF protocol, 173
 - overview of, 171
 - RIP protocol, 172
 - defined, 150–151
 - effect on network maps, 153
 - exam essentials, 184
 - if-then-else loops and, 154
 - injecting routes into BGP with, 353–354, 354
 - key terms, 185
 - match conditions
 - absence of, 169
 - BGP routes and, 160, 166
 - defined, 552
 - defining multiple criteria, 160–161
 - using *from* or *to* keywords, 158–160
 - listed, 158–160
 - match type keywords, 163, 165–166, 167
 - overview of, 153, 155, 157–158
 - using route filters, 161–168
 - warning, 167
 - naming, 155, 178–179
 - overview of, 183–184
 - policy chains
 - changing policy order in, 177–178
 - complex, simplifying, 156–157, 156
 - defined, 557
 - evaluation order in, 153–154, 154
 - out-of-order, fixing, 155–156
 - review question answers, 192–193
 - review questions, 186–191
 - using route filters
 - AND* or *OR* operations in, 168
 - defined, 560
 - match type syntax, 163, 165–166, 167
 - multiple route filters, 166–168, 167
 - overview of, 161
 - radix trees, 161–163, 162–164
 - routers and, 150
 - routing tables and
 - defined, 150
 - inbound versus outbound routes, 153
 - purpose of modifying, 151–152, 151–152
 - selecting active routes, 136–137, 150

- uses
 - modifying default behavior of
 - protocols, 152
 - modifying default route selection, 151, 151
 - route redistribution, 152, 152
 - verifying, 180–183, 181
- routing, protocol-independent, 108–148
 - default routing tables
 - accessing, 131
 - bgp.12vpn.0, 135–136
 - bgp.13vpn.0, 135
 - inet.0, 131–132
 - inet.1, 132–133
 - inet.2, 133
 - inet.3, 133–134
 - inet.4, 134
 - inet6.0, 134
 - mpls.0, 134–135
 - overview of, 131
 - exam essentials, 140
 - key terms, 141
 - load balancing, 137–140, 138
 - locally configured aggregated routes
 - attributes, 118–119
 - in BGP, route policies and, 166
 - configuration examples, 119–121
 - contributing routes, 117
 - defined, 116, 116–117
 - next-hop options, 118
 - locally configured generated routes
 - contributing routes, 121–123, 121
 - defined, 121, 545
 - primary contributing routes, 123–125, 558
 - pros and cons, 125
 - locally configured routes, overview, 108
 - locally configured static routes
 - advantages, 109–110
 - attributes, 112–114
 - configuration examples, 114–116, 115
 - defined, 108–110, 109–110
 - disadvantages, 109–110
 - floating static routes, 111, 112
 - next-hop options, 111
 - martian routes, 126–131, 552
 - overview of, 108, 140
 - protocol preference values, 136–137
 - review question answers, 147–148
 - review questions, 142–146
- routing tables, 131–137, 516–524
 - default tables
 - accessing, 131
 - bgp.12vpn.0, 135–136
 - bgp.13vpn.0, 135
 - inet.0, 131–132, 547
 - inet.1, 132–133, 547
 - inet.2, 133, 547
 - inet.3, 133–134, 547
 - inet.4, 134, 547
 - inet6.0, 134, 547
 - mpls.0, 134–135
 - overview of, 131
 - defined, 150, 561
 - inbound versus outbound routes, 153
 - integration
 - adding routes to inet.0, 523–524
 - adding routes to inet.3, 520–522, 520
 - default integration, 516–520, 517
 - manual integration, 520–524, 520
 - overview of, 516
 - overview of, 3, 131
 - protocol preference values, 136–137
 - purpose of modifying, 151–152, 151–152
 - recursive lookups, 111, 559
 - scalability, BGP and, 325
 - selecting active routes, 136–137, 150
 - troubleshooting in BGP, 353–354, 354
- rpd (Routing Protocol Daemon), 6, 561
- RPF (reverse path forwarding), 384–385, 385
- RPs (rendezvous points). *See also* multicast networks
 - advertisement options, 401–403
 - Auto-RP option, 401–402, 411–415, 536
 - defined, 388, 389, 560
 - forwarding packets to, 400
 - local RPs, 408–409, 411
 - RP-Set messages, 402
 - static RP option, 401, 410–411
- RPTs (rendezvous point trees), 388, 389

- RROs (record route objects), 492, 559
- RSVP (Resource Reservation Protocol). *See also* MPLS
- bandwidth requests, 493, 507, 508–510
 - configuring
 - bandwidth limits, 515–516
 - hello interval timer, 510–511
 - keep-multiplier value, 513
 - message aggregation, 513–514
 - message authentication, 514–515
 - overview of, 510
 - soft state refresh timer, 512
 - defined, 488, 560
 - extensions
 - explicit route objects, 490–492, 490–491, 543
 - hello mechanism, 489
 - label objects, 492
 - label request objects, 492, 550
 - loose hops, 490, 490–491, 491–492
 - message aggregation, 489, 553
 - overview of, 489
 - record route objects, 492
 - session attribute objects, 492
 - strict hops, 490–492, 491
 - tspec objects, 492
 - warning, 491
 - Path messages, 488–489, 488, 556, 561
 - Resv messages, 488–489, 488, 560, 561
 - RSVP signaled LSPs. *See* MPLS
 - soft state, 488, 489
 - run (configuration) command
 - defined, 24–26
 - run show igmp interface, 405–406
 - run show interfaces, 25
 - run show route, 25–26
 - SEL (N-selector) values, 283, 283, 555
 - session attribute objects, 492, 562
 - set (configuration) command, 19, 24, 29, 31–32
 - SFM (Switching and Forwarding Module), 5, 564
 - shared trees, 388, 389, 400, 562
 - shim headers in MPLS, 484, 484–485, 562
 - Shortest Path First (SPF) algorithm, 562
 - shortest path trees (SPTs), 400–401, 562
 - show (configuration) command. *See also* JUNOS software
 - using with compare, 33–34
 - defined, 24, 29–30
 - show policy-options, 353–354, 354, 362
 - show system, 30, 32–33
 - show (operational) command. *See also* troubleshooting commands
 - defined, 13–15, 29–30
 - show chassis, 408
 - show chassis hardware, 431
 - show cli, 14, 17, 20–21
 - show interfaces, 14, 18, 21–22
 - show interfaces terse, 21–22, 74–75, 78–80
 - show route, 15, 17–18, 361
 - show route advertising-protocol, 180–183, 181, 355, 562
 - show route detail, 357, 359, 364–365
 - show route hidden, 340, 360–361
 - show route protocol static, 114–116, 115
 - show route receive-protocol, 180–183, 181, 355, 562
 - show route table, 131–136
 - show version, 10, 15
 - soft state refresh timer, 512
 - soft state in RSVP, 488, 489, 563
 - SONET (Synchronous Optical Network)
 - defined, 564
 - IPv4 interfaces, configuring inet to, 76–77
 - speeds, 478
 - Soricelli, Joseph M., xxxi
 - source addresses in PIM, 396, 396–397
 - source-based tree, 387, 388, 563
 - source-port match condition, 439
 - source-specific multicasting (SSM), 379, 563
 - sparse mode. *See* multicast networks
-
- S**
- sample action modifier, 451–452
 - save (configuration) command, 24, 34–35
 - SCB (System Control Board), 5, 564
 - scrambling property, 69
 - secondary addresses, 71
 - security, 430. *See also* authentication; firewall filters

- SPF (Shortest Path First) algorithm, 562. *See also* Dijkstra Algorithm
- split horizon feature
 defined, 201, 563
 overview of, 198
 with poison reverse, 201–202, 202, 557
- SPTs (shortest path trees), 400–401, 562
- SSB (System Switching Board), 5, 564
- Stallings, William, 292
- static IPv4 routes, 487
- static LSPs. *See* MPLS
- static routes. *See also* routing,
 protocol-independent
 advantages/disadvantages, 109–110
 attributes, 112–114
 configuration examples, 114–116, 115
 defined, 108–110, 109–110
 floating static routes, 111, 112
 next-hop options, 111
- static RP in PIM, 401, 410–411
- status (configuration) command, 24, 26
- strict hops in MPLS, 490–492, 491, 563
- stub areas. *See also* OSPF
 defined, 252–254, 253, 564
 not-so-stubby areas, 255, 256, 555
 totally stubby areas, 254, 254
- subnet masks, 208, 208, 564
- SVCs (switched virtual circuits), 487
- switches, xxvi
- switching control board, 4–5
- Switching and Forwarding Module (SFM), 5, 564
- synchronizing redundant Routing Engines, 42–43
- Synchronous Optical Network. *See* SONET
- syslog action modifier, 446, 452, 564
- System Control Board (SCB), 5, 564
- system IDs in IS-IS, 283, 283
- System Switching Board (SSB), 5, 564
- TCP sessions in BGP, 327–332, 327–328, 330
 tcpdump utility, 89, 565
- TED (Traffic Engineering Database)
 algorithm, 504
- terminating actions
 defined, 565
 in firewall filters, 446–447
 in routing policies, 153, 155, 169
- terms
 defined, 565
 in firewall filters
 to accept TCP return packets, 444–445
 defined, 433–434
 to drop known bad packets, 445–446
 overview of, 432
 reordering, 433, 463–464
 in routing policies, 156–157, 156
- test (operational) command, 14, 97
- testing physical circuits between routers
 with BERT tests, 96–97
 with loopback testing, 93–96, 93, 95
 overview of, 92
- tests. *See* JNTCP
- through match type keyword, 166, 167, 565
- timers. *See also* RIP
 example of use, 204–205
 Garbage Collection timer, 204, 545
 Hold-Down timer, 203, 546
 randomizing, 203
 Timeout timer, 204, 565
 Update timer, 203, 567
- TLV format in IS-IS PDUs, 287, 288, 288, 290, 290, 297
- TLV type bits in BGP, 339
- to keywords in match conditions, 158–160
- token-bucket algorithm, 455, 565
- top (configuration) command, 24, 28
- totally stubby areas in OSPF, 254, 254, 565
- traceroute (operational) command, xxvii, 14, 91–92, 499
- Traffic Engineering Database (TED)
 algorithm, 504
- traffic engineering history. *See also* MPLS
 ATM overlay networks, 476–478, 476–477
-
- T**
- TCP (Transmission Control Protocol)
 defined, xxvi, 565
 overview of, 324
 TCP port 179, 324, 565

- defined, 475, 565
 - IGP-based networks, 475–476, 475–476
 - MPLS networks, 478–479, 478–479
 - overview of, 475
 - SONET networks, 478
 - traffic specifier (tspec) objects, 492, 566
 - transient interfaces, 62–105. *See also* Juniper Networks routers; permanent interfaces
 - applying firewall filters to
 - overview of, 452–453
 - remote in-band interfaces, 453
 - Routing Engine (lo0 interface), 453–454, 454
 - transit interfaces, 454, 454
 - warning, 454
 - commands for troubleshooting
 - monitor interface, 88–89
 - monitor traffic, 89–90
 - ping atm, 91
 - ping (destination), 90–91, 499
 - show arp, 90
 - show interfaces extensive, 85–88, 97
 - traceroute, 91–92, 499
 - configuring
 - deactivating configurations, 73, 78–79
 - disabling configurations, 73, 79–80
 - in dynamic LSPs, 500–501
 - overview of, 74–75, 74
 - in static LSPs, 494
 - verifying configurations, 77–78
 - configuring inet family to IPv4 interfaces
 - ATM interfaces, 76
 - Ethernet interfaces, 75–76
 - overview of, 75
 - SONET interfaces, 76–77
 - configuring protocol families
 - inet6 to IPv6 interfaces, 80–82
 - iso to IS-IS interfaces, 82–84, 299
 - mpls to MPLS interfaces, 84–85
 - defined, 63, 565
 - exam essentials, 98
 - key terms, 99
 - logical interface properties
 - overview of, 68, 70
 - protocol addresses, 70–71
 - protocol families, 70
 - protocol MTUs, 71–72
 - virtual circuit addresses, 72–73
 - multiple IP addresses on, 71
 - naming structure
 - defined, 63–64
 - examples, 67–68
 - FPC slot numbers, 64, 65, 65–66
 - logical unit/channel numbers, 64, 67
 - media types, 64–65
 - PIC port numbers, 64, 66–67, 67
 - PIC slot numbers, 64, 66, 66
 - overview of, 62, 98
 - physical interface properties, 68–69
 - review question answers, 104–105
 - review questions, 100–103
 - testing physical circuits between
 - with BERT, 96–97
 - with loopbacks, 93–96, 93, 95
 - overview of, 92
 - viewing installed interfaces, 74–75
- transit areas in OSPF, 565
- transit routers. *See also* MPLS
- defined, 482, 565
 - in dynamic LSPs, 506–507
 - in static LSPs, 498–499
- transmission methods. *See* broadcast networks; multicast networks; unicast networks
- triggered updates, 198, 202, 566
- Triple-DES algorithm, 566
- triples. *See* TLV
- troubleshooting
- adjacency formation in OSPF, 241
 - BGP routing table limitation, 353–354, 354
 - IBGP peer sessions
 - Active state problem, 350
 - avoiding routing loops, 328–329, 331–332
 - with IBGP full-mesh, 330, 331–332
 - IP address configuration, 350
 - Next Hop unreachability, 340–342, 341, 359–365
 - local RP setup in PIM, 409–410
 - multicast Ethernet networks, 380, 383
 - multicast forwarding loops, 383–385, 384–385

- physical circuits between interfaces, 93–97, 93, 95
 - troubleshooting commands. *See also* show command
 - for BGP routes
 - show route advertising-protocol bgp, 355, 359–360, 363
 - show route detail, 357
 - show route protocol bgp, 355–357
 - show route protocol bgp terse, 358, 364
 - show route receive-protocol bgp, 355, 360, 363–364, 518
 - for BGP sessions
 - overview of, 346, 350
 - show bgp group, 352
 - show bgp neighbor, 352–353
 - show bgp summary, 351
 - for checking configurations, 41–42
 - for dynamic LSPs, 506–507, 509–510
 - for firewall filters
 - show firewall, 460
 - show firewall log, 451, 460–461
 - show interfaces filters, 462
 - show interfaces policers, 462–463
 - show log messages, 461–462
 - show policer, 463
 - for IGMP protocol, 404–406
 - for IS-IS networks
 - clear isis adjacency, 305
 - overview of, 303, 303
 - show isis, 14, 15–16
 - show isis adjacency, 303–305
 - show isis database, 308–309
 - show isis database extensive, 309–311
 - show isis hostname, 306–307
 - show isis interface, 306
 - show isis route, 308
 - show isis spf log, 307
 - show isis statistics, 307–308
 - for multicast networks
 - show multicast route, 420
 - show multicast rpf, 419
 - show multicast usage, 420
 - show pim join extensive, 418
 - show pim neighbors, 417
 - show pim source, 418–419
 - show route table inet.1, 132–133, 420
 - for OSPF networks
 - clear ospf database, 262–263
 - clear ospf neighbor, 261
 - show ospf database, 261–262
 - show ospf interface, 259–260
 - show ospf log, 263–264
 - show ospf neighbor, 260–261
 - show ospf route, 265
 - show ospf statistics, 264
 - show route protocol ospf, 265–266, 348
 - warning, 263
 - overview of, xxvii
 - for PIM protocol
 - show pim join extensive, 418
 - show pim neighbors, 417
 - show pim source, 418–419
 - for RIP, 211–212, 213–214
 - for router interfaces
 - monitor interface, 88–89
 - monitor traffic, 89–90
 - ping atm, 91
 - ping (destination), 90–91, 499
 - show arp, 90
 - show interfaces extensive, 85–88, 97
 - traceroute, 91–92, 499
 - show route (for routing policies), 180–183, 181
 - for static LSPs, 499–500
 - tspec (traffic specifier) objects, 492, 566
 - TTL (time-to-live) values, 92
 - 2-Way state in OSPF, 238, 239, 534
-
- U**
- UDP (User Datagram Protocol), xxvi, 92, 197, 567
 - ultimate hop popping, 483–484
 - unicast networks
 - addresses in PIM, 395, 395
 - defined, 566
 - versus multicast networks, 374, 375, 375, 380
 - packet flow, 49–51, 50
 - unit numbers, 64, 67

units, 70, 566
Unix tcpdump utility, 89, 565
up (configuration) command, 24, 27
Up state in IS-IS, 284, 285
Update messages in BGP, 335–336, 336, 567
Update messages in RIP, 218–220, 219
Update timer, 203, 567
upgrading JUNOS software, 10–11
upto match type keyword, 165, 167, 567

V

Van Meter, Thomas E., xxxi
variables in operational commands, 19–22
VCIs (virtual circuit identifiers), 72, 258, 567
VCs (virtual circuits)
 address property, 72–73
 ATM virtual circuits, 476–477, 476
 defined, 567
 permanent virtual circuits, 487
 switched virtual circuits, 487
VLANs (virtual local area networks), 73, 567
VPI (virtual path identifier), 72, 567
VPNs (virtual private networks), 73, 567
vt100 mode, 18–19

W

WaitTimer in OSPF, 245
WAN (wide area network) links, xxvi
Warble, Todd M., xxxi
WDM (wavelength-division multiplexing), 568
web addresses
 authors, xxx
 Boson, xxx
 cflowd, 452
 Core Routing, xxx
 finding RFCs, 197, 231
 IANA, 126
 IETF Internet drafts
 bootstrap router process, 402
 finding, 326, 480
 MPLS, 565
 Juniper ERX Edge Routers track, xvii
 reserved multicast addresses, 380
 test simulation software, xxx
Wong, Steven T.Y., xxxi–xxxii
WRR (weighted round-robin), 568

X

XNS RIP (Xerox Network System Routing Information Protocol), 196