

INDEX

A

Ack (Acknowledgment) messages, RSVP, 48
Active Queue Management, 40–42, 121–126, 206
adaptive shaping, 111
adjacencies, forwarding, 172
administrative group, link attribute, 59–60
admission-control mechanisms, 206, 219, 234
AF (Assured Forwarding)
 PHBs, 17–18
 traffic, 227
affinities, tunnel, 157, 247
affinity command, 157–158
aggregate policies, 137
algorithms
 fair queuing, 4
 SPF, 60
 token bucket, 36
 WRED
 Cisco IOS XR, 125
 counters, 125
 description, 41, 121, 213–215
 ECN, 122
 queuing, 123
 thresholds, 121
 weighting fields, 121
alias configuration command, 156
AQM (Active Queue Management), 40–42, 121–126, 206
area-local scope LSA (link-state advertisement), 60
areas, OSPF, 60
Assured Forwarding
 See AF
ATM
 marking, 31
 policing profiles, 104
ATM Forum Traffic Management specification, 104
attachment points, 85, 132
attributes
 configuring, 150–152
 links, 60
 priority, 82
 See also specifically named link attributes

audio, streaming, 204
authentication, RSVP, 50
autoroute feature, 172, 253
Auto-tunnel feature, 253

B

BA (behavior aggregate) classifiers, 9
backbones
 designs, 260–261
 DS-TE, 240–248
 edge nodes, 210–212
 FRR, 251–260
 IS-IS, 240
 MPLS TE, 219–224, 251–260
 OSPF, 240
 performance
 application requirements, 201–204
 targets, factors affecting, 204–206
 QoS
 best-effort, 212–217
 DiffServ, 226–233
 DS-TE, 240–248
 FRR, 251–260
 MPLS TE, 219–224, 233–240, 251–260
 optimizing, 260–261
backup tunnels, 187, 259
backup commands
 backup-bw command, 187
 backup-path command, 184
bandwidth
 available, 59
 backup tunnels, 187, 259
 BDP, 213
 behavioral model, 83
 commands, 115–116, 132, 152, 157–158, 178–180
 congestion, 115–120
 constraint models, 68–71, 175, 243
 consumption, 202
 defaults, 157
 dequeueing, 82–83
 DS-TE, 179–180
 flooding link updates, 150
 FRR, 187–189

MAM/RDM, 68–71, 175–180, 240–243
 queuing, 115–118
 rates, percentage based, 132

bandwidth commands
 bandwidth percent command, 115, 132
 bandwidth qos-reference command, 132
 bandwidth remaining percent command, 115–116

bc keyword
 description, 100, 109
 bc0 keyword, 179–180
 bc1 keyword, 179

BDP (delay-bandwidth product), 213

be keyword, 101, 109

begin keyword, 156

behavior aggregate (BA) classifiers, 9

behavioral model
 bandwidth, 83
 classification, 80
 configuration, 84–87
 header compression, 128
 MQC, 84–87
 priority, 82
 queuing, 81
 dequeuing, 82–83
 enqueueing, 81
 post-queueing, 84
 pre-queueing, 80–81
 schedulers, 82
 TMN, 79–80

best-effort backbones, 213–217
 best-effort, 212–217
 DiffServ, 226–233
 DS-TE, 240–248
 FRR, 251–260
 MPLS TE, 219–224, 233–240, 251–260
 optimizing, 260–261

Bidirectional Forwarding Detection (BFD), 184

bit errors, 206

broadcast video, 203

buffering, 37, 215

Bundle messages, RSVP, 48

bursts, 133–135, 202, 229

burst keyword, 101

bw-protect keyword, 183

byte count, 118

C

capacity
 class, 226
 controlling, 213

CBTS (class-based tunnel selection), 173–174, 236, 246

child/parent policies, 130

CIR (committed information rate), 33

cir keyword, 100

Cisco IOS XR
 counters, clearing, 86
 formatting, 86
 headend nodes, 222–224
 interface commands, 163
 man command, 145
 MQC, 84
 policers, 107
 protocol marking
 description, 137
 queuing counters, 120
 shaping, 114
 tunnel configuration, 147
 WRED, 125, 217

Cisco QoS behavioral model
 See behavioral model

class-default command, 80, 88

classes
 capacity, 226
 CBTS, 173–174, 236, 246
 definitions, 85
 maps
 hierarchies, 129
 MCQ, 85
 priority, 116
 service, 202
 TE-Classes, 66, 176–177, 241–243
 See also CTs

classification/conditioning
 AQM, 40–42
 congestion, 37–39
 counters, 91–93
 description, 31
 DiffServ, 13–15
 header compression, 44
 LFI, 42–43
 marking, 31–32

- matching, 85–88
 - MQC hierarchies, 129
 - policing, 32, 35
 - shaping, 35–36
 - traffic, 80
 - See also traffic
- class-map command, 85, 88**
- Class Selector PHB (Per-Hop Behavior), 18**
- CLASSTYPE object, 68**
- Class-Types**
 - See CTs
- clear commands**
 - clear counters command, 86
 - clear ip rsvp command, 164
 - clear mpls traffic-eng command, 146
 - clear qos counters command, 86
 - MPLS TE, 146
 - RSVP, 164
- CLI (command-line interface) output filtering, 156**
- CLS (Controlled Load Service), 8**
- color-aware/blind policers, 33, 103,107**
- command parameters, 133**
- command/control traffic, 204**
- committed information rate (CIR), 33**
- compression, headers, 44, 128–129**
- compression command, 128**
- computation, paths, 60–62, 246**
- concatenating, performance parameters, 205**
- conditioning, traffic**
 - See classification/conditioning
- conferencing, multimedia, 203**
- conform action, policers, 102**
- conform-color command, 103**
- congestion**
 - bandwidth, 115–120
 - DiffServ, 233
 - DS-TE, 64
 - latency, 207
 - management
 - DRR*, 37–39
 - WFQ*, 38
 - traffic
 - differentiation*, 237
 - prioritizing*, 115
- constraintsbandwidth, 179–180, 240**
 - constraint-based routing, 58
 - CR-LDP, 63
 - CSPF, 61, 222
 - MAM/RDM, 68–71, 175–180, 240–243
- consumption, bandwidth, 202**
- Controlled Load Service (CLS), 8**
- control**
 - control-plane policies, 138–139
 - network, 202
- control-plane commands, 138**
- conversational voice traffic, 204**
- counters**
 - byte count, 118
 - Cisco IOS XR, 87, 120
 - classification, 91–93
 - color-aware/blind policers, 33, 103,107
 - drops, 124
 - marking, 99
 - policers, 33, 106–107
 - queuing, 118
 - random drops, 124
 - RSVP, 166
 - shaping, 113–114
 - tail drops, 124
 - transmitted, 124
 - WRED, 125
- Critic/ECP precedence, 18**
- CR-LDP (constraint-based routed Label Distribution Protocol), 63**
- cRTP (RTP header compression), 44**
- CS PHB (Class Selector Per-Hop Behavior), 18**
- CSPF (constraint-based, shortest path first), 61, 222**
- CTs (Class-Types)**
 - bandwidth-constraints
 - MAM*, 68–69
 - RDM*, 70–71
 - description, 175–180, 240–243
 - DS-TE, 176–177
 - See also TE-Classes

D

debug commands

- debug ip rsvp command, 164
- debug mpls traffic-eng command, 146
- description, 86
- DS-TE, 181
- MPLS TE, 146
- RSVP, 164

default

- command, 97
- PHB, 18

deficit round robin (DRR), 37–39

delay, 203–204, 229

delay-bandwidth product (BDP), 213

denial-of-service (DoS) attacks, 206

dequeueing, 82–83

destination

- command, 156
- routing, 58

DETOUR object, 73

Differentiated Services

- See DiffServ

Differentiated Services Code Points

- See DSCPs

differentiation, traffic, 237

DiffServ (Differentiated Services)

- backbones, 226–233
- class capacity, 226
- congestion, 233
- domains, 13
- DS-TE, 240–248
- fields, 9
- IP
 - architecture*, 9–11
 - domains*, 13
 - DSCPs*, 11
 - nodes*, 13
 - PHBs*, 15–18
 - regions*, 13
 - terminology*, 9–10
 - traffic classification/conditioning*, 13–15

MPLS

- E-LSPs*, 19–21
 - L-LSPs*, 22–24
 - tunneling models*, 25–29
- MPLS TE, 233–240

- policers, 229
- policies, 231
- queues, 228
- regions, 13

DiffServ-Aware traffic engineering

- See DS-TE

directions, I/O, 85

discard class, MQC, 96

distributed policies, 137

distribution, 206–207

domains, 9, 13

DoS (denial-of-service) attacks, 206

downloads, 204

drops

- counters, 124
- packets, 81
- priority, 32
- probabilities, 121
- profiles, 40, 96
- queues, 206

DRR (deficit round robin), 37–39

DSCPs (Differentiated Services Code Points)

- description, 9–11
- PHB mappings, 16

DS-TE (Differentiated Services traffic engineering)

- backbones, 240–248
- bandwidth constraints, 68, 179–180, 240–243
 - MAM*, 68–69
 - RDM*, 70–71
- CLASSTYPE object, 68
- commands
 - debug*, 181
 - ds-te bc-model command*, 180
 - ds-te mode ietf command*, 175–176
 - ds-te te-classes command*, 176

CTs, 66, 176–177, 241–243

debug, 181

description, 64, 175

E-LSPs, 65

link information distribution, verifying, 181

L-LSPs, 65

LSP signaling, verifying, 182

MPLS, 66, 176–177, 241–243

preemption, 66

prestandard, 175–176

signaling, 182

- standard, 175
- TE-Classes, 176–177
- tunnel interfaces, 177–178
- ds-te commands**
 - ds-te bc-model command, 180
 - ds-te mode ietf command, 175–176
 - ds-te te-classes command, 176
- dual-rate policers, 34**
- duration, flow, 202**

E

- ECN (explicit congestion notification), 42, 122**
- edge nodes, 210–212**
- EF (Explicit Forwarding)**
 - PHB, 17
 - traffic, 227
- egress nodes, 9**
- elastic traffic, 202**
- E-LSPs (EXP-inferred-class LSPs)**
 - description, 19–21
 - DS-TE, 65
 - L-LSPs, 24
- encapsulation, 128, 229**
- engineering, traffic**
 - bandwidth constraints, 68–71
 - FRR, 71–73
 - link attributes, 60
 - MPLS TE, 57–58
 - next-next hope, 74–75
 - path computation, 60–62
- enqueueing, 81**
- errors**
 - bits, 206
 - signaling, RSVP, 50
 - processing, nodes, 19–21
 - tolerance, 203
- Ethernet, 31, 214**
- events, shaping, 110**
- exceed action, policers, 102**
- exceed-color command, 103**
- exclude keyword, 156**
- EXP (Experimental) bits**
 - marking, 94
 - values, MPLS, 174

- Expedited Forwarding PHB (Per-Hop Behavior)**
 - See EF PHB
- EXP-inferred-class LSPs**
 - See E-LSPs
- explicit**
 - ECN, 42, 122
 - routing, 58
- EXPLICIT_ROUTE object, 63**
- explicit-path command, 157**
- extensions, 59**

F

- facility backup, FRR, 72**
- failures, network/routing, 206**
- fair-queuing algorithms, 4**
- Fast Ethernet, 214**
- fast reroute**
 - See FRR
- FAST_REROUTE object, 73**
- fast-reroute command, 183**
- fax traffic, 204**
- FIFO (first in, first out) queues, 37**
- filtering, 156**
- flags**
 - priority, 135
 - RRO, 193
- Flash Override precedence, 18**
- flooding**
 - controlling, 150
 - description, 59
 - IS-IS, 60
 - link updates, 150
 - mesh group memberships, 256
 - OSPF, 60
- flow**
 - duration, 202
 - flowspec, 5
- forwarding**
 - adjacencies, 172
 - TMN, 79–80
- fragmentation, 42–43**
- Frame Relay**
 - adaptive shaping, 111
 - header compression, 128
 - marking, 31
 - shaping, 110

frame-relay fragment command, 127**FRR (fast reroute)**

- backup, 72
- bandwidth protection, 187–189
- description, 182–183, 251–260
- facility backup, 72
- headend verification, 191–193
- label stacking, 72
- link/node protection, 183–186
- LSPs, 220
- MPLS TE, 71–73
- PLR verification, 193–196
- restoration, 73
- RSVP, 73

FTP, 204**G****Gigabit Ethernet, 214****global restoration, 73****graceful restart, RSVP, 51****grandparent policies, 132****groups**

- IDs, MQC, 96
- mesh groups, 256

Guaranteed Service (GS), 7–8**H****hardware, MQC, 87****hashing, microflows, 39****HDLC (High-Level Data Link Control), 128****headends**

- FRR, 191–193
- nodes, 222–224
- TE LSP, 147

headers

- compression, 44, 128–129
- IP, 88
- MPLS, 88

Hello messages, RSVP, 48, 51, 184**hierarchies, MQC**

- classification, 129
- policies, 130–131

high-throughput data, 203**IETF (Internet Engineering Task Force)****Transport Area working group, 202****IGPs (interior gateway protocols), 58, 236, 240****Immediate precedence, 18****imposition keyword, 94****include keyword, 156****ingress nodes, 9****input direction, 85****Integrated Services**

See IntServ

Integrity messages, RSVP, 48**interactivity, 203–204****interfaces**

- address, link attribute, 60
- commands, 146, 163, 256
- MPLS TE, 145–146
- logical, 85
- submodes, 151
- tunnels, 146–147, 177–178

interface Auto-Template1 command, 256**interior gateway protocols (IGPs), 58, 236, 240****interior nodes, 9****interleaving, 42–43, 127****Internet Engineering Task Force (IETF)****Transport Area working group, 202****Internetwork Control precedence, 18****IntServ (Integrated Services)****IP**

- architecture, 5*
- CLS, 8*
- description, 4*
- GS, 7–8*
- RSVP, 8*
- service model, 6–8*
- terminology, 5*

MPLS, 18–19**IP (Internet Protocol)****architecture, 3–4****commands**

- ip explicit-path command, 157*
- ip rsvp bandwidth command, 151*
- ip rsvp bandwidth interface command, 179*
- ip rsvp command, 144*
- ip rsvp prefix, 163*

destination-based routing, 58
 DiffServ
 architecture, 9–11
 domains, 13
 DSCPs, 11
 nodes, 13
 PHBs, 15–18
 regions, 13
 terminology, 9–10
 traffic classification/conditioning, 13–15
 headers, 88
 IntServ
 architecture, 4–5
 CLS, 8
 guaranteed service, 7–8
 RSVP, 8
 service model, 6–8
 terminology, 5
 marking, 94
 matching, 88
 Precedence field, 228
 signaling, RSVP, 45–51

ip commands

ip explicit-path command, 157
 ip rsvp bandwidth command, 151
 ip rsvp bandwidth interface command, 179
 ip rsvp command, 144
 ip rsvp prefix, 163

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

areas/levels, 60
 backbones, 240
 flooding, 60
 link information distribution, 148
 MPLS TE, 58

ITU-T Recommendations 203–205

J–L

jitter, 202, 206, 229

Label Distribution Protocol

See LDP

Label-inferred-class LSP

See L-LSP

LABEL object, 63

label stacking, FRR, 72

label switched paths

See LSPs

label switching routers

See LSRs

LABEL_REQUEST object, 63

labeled/unlabeled packets, 215

Label-inferred-class LSPs

See L-LSPs

latency

congestion, 207
 description, 42, 202–206
 link utilization, versus, 207–209

LDP (Label Distribution Protocol)

description, 220
 priority flags, 135

LFI (link fragmentation and interleaving), 42–43, 127

LFIB (LSP forwarding information base), 63

links

attributes
 bandwidth constraints, 68
 configuring, 150–152
 MPLS TE, 59
 See also specifically named link attributes

capacity, 213
 congestion latency, 207
 failure, 206
 FRR, 183–186
 groups, 74
 information distribution
 DS-TE, 181
 flooding, controlling, 150
 IS-IS, 148
 link attributes, configuring, 150–152
 OSPF, 149
 verifying, 153–156

latency, 207–209

LFI, 42–43, 127

LSAs, 60

protection, 74

utilization, 207–209

link-state

advertisements, LSAs, 60

protocols, 58

L-LSPs (Label-inferred-class LSP)

- description, 19–24
- DS-TE, 65
- E-LSPs, 24
- PHB mappings, 23

load distribution, 206**local**

- restoration, 73
- traffic, 135–139

lockdown keyword, 160**logical interfaces, 85****loss**

- packet, 206
- tolerance, 202

LSAs (link-state advertisements), 60**LSPs (label switched paths)**

- DS-TE, 182
- E-LSPs, 20–21
- extensions, RSVP, 63
- FRR, 71–73, 220
- full mesh, 220
- LFIB, 63
- L-LSPs, 22–24
- MPLS TE, 57
- RSVP, 63
- TE
 - description, 219*
 - full mesh, 251*
 - headends, 147*
 - paths, 156–159*
 - policing, 221*
 - signaling, 163–170*
- traffic selection, 64

LSRs (label switching routers)

- constraint-based routing, 59
- MPLS, 19
- MPLS TE, 57
- path computation, 60–62

M**MAM (maximum allocation model), 68–69, 175–180, 240–243****mam keyword, 179****man command, 145****management**

- See traffic management

map statements, 97**marking**

- ATM, 31
- Cisco IOS/IOS XR, 137
- counters, 99
- description, 10, 31–32, 94–99, 229
- Ethernet, 31
- EXP bits, 94
- Frame Relay, 31
- IP, 94, 135
- local traffic, 135
- MPLS, 94
- precedence, 94
- push operation, 96
- tunneling, 96

match commands

- match class-map command, 129
- match command, 88, 91
- match dscp command, 88, 91
- match frame-relay dlci command, 90
- match fr-dlci command, 90
- match ip dscp command, 88
- match ip precedence command, 88
- match mpls experimental topmost command, 88, 91
- match not command, 91
- match precedence command, 88
- match protocol command, 90
- match-all keyword, 91, 129
- match-any keyword, 91, 129

matching, IP/MPLS headers, 88**maximum allocation model (MAM), 68–69, 175–180, 240–243****maximum link bandwidth, link attribute, 60****max-reservable-bw command, 179–180****MCQ (modular QoS command-line interface), 84–87****memory units, MQC, 134****mesh group memberships, 256****message authentication, RSVP, 50****Message-Id-Ack object, 51****messaging traffic, voice/video, 204****metering, 10****metric-style wide command, 148****MFP (Multilink PPP), 85**

MFR (Multilink Frame Relay), 85

microflows, 9, 39

MLP

LFI, 127

MLP (Multilink PPP), 43

modular QoS command-line interface

See MCQ

modularity, RSVP, 47

MPLS (Multiprotocol Label Switching)

description, 58

DiffServ

E-LSPs, 19–21

L-LSPs, 22–24

pipe model, 25–26

short-pipe model, 26–27

tunneling models, 25–29

uniform model, 28–29

distribution, link information, 59

DS-TE, 64–65

EXP values, 174

explicit routing, 58

headers, 88

IntServ, 18–19

link information, 59

marking, 94

matching, 88

operation, 59

OSPF, 58

push operation, 96

routing, 58

shim headers, 19

signaling, 45–51

See also MPLS TE

mpls commands

mpls ldp tcp pak-priority command, 135

mpls traffic-eng administrative-weight command, 151

mpls traffic-eng area command, 149

mpls traffic-eng attribute-flags command, 151

mpls traffic-eng auto-tunnel backup command, 186

mpls traffic-eng backup-path command, 184

mpls traffic-eng command, 144–145, 148

mpls traffic-eng ds-te bc-model mam command, 179

mpls traffic-eng ds-te mode ietf command, 175–176

mpls traffic-eng ds-te mode migration command, 176

mpls traffic-eng ds-te te-classes command, 176

mpls traffic-eng link-management flood command, 150

mpls traffic-eng lsp attributes command, 157

mpls traffic-eng reoptimize events link-up command, 159

mpls traffic-eng reoptimize timers frequency command, 159

mpls traffic-eng router-id command, 149

mpls traffic-eng tunnels, 151

mpls traffic-eng tunnels command, 144

MPLS TE (Multiprotocol Label Switching Traffic Engineering)

admission control, 219, 234

attributes, links 59

bandwidth constraints

MAM, 68–69

RDM, 70–71

best-effort backbones, 219–224

BFD, 184

clear commands, 146

CSPF, 61, 222

debug commands, 146

description, 57–58

DiffServ, 233–240

DS-TE

CTs, 66

description, 64–65

TE-Classes, 66, 176–177

enabling, interfaces, nodes, 144–146

extensions, FRR, 73

FRR, 71–73

IS-IS, 58

link attributes, 59

link information distribution
flooding, controlling, 150

IS-IS, 148

link attributes, configuring, 150–152

OSPF, 149

verifying, 153–156

link protection, 74

link-state protocols, 58

LSPs, 57

LSRs, 57

next-next hop, 74–75

- node protection, 74
 - operation
 - description*, 59, 143
 - enabling*, 144–146
 - link information distribution*, 148–156
 - path computation*, 156–162
 - signaling TE LSPs*, 163–164
 - traffic selection*, 172–174
 - tunnel interfaces, defining*, 146–147
 - verifying RSVP*, 164–167
 - verifying TE LSP signaling*, 167–170
 - path computation
 - description*, 60–62, 156
 - reoptimization*, 159–160
 - TE LSP paths*, 156–159
 - verifying*, 160–162
 - RSVP, 73, 144
 - show commands, 146
 - signaling TE LSPs
 - description*, 63
 - RSVP*, 163–170
 - traffic selection
 - alternatives*, 172
 - description*, 64
 - CBTS*, 173–174
 - tunnel interfaces, defining, 146–147
- MQC (modular QoS command-line interface)**
- behavioral model, 84–87
 - Cisco IOS XR, 84
 - class maps, 85
 - discard class, 96
 - group ID, 96
 - hardware support, 87
 - hierarchical configurations
 - classification*, 129
 - policies*, 130–131
 - local traffic, processing, 135–139
 - memory units, 134
 - parameter units, 134–135
 - policies, configuring, 85
 - policy maps, 85
 - rate/burst parameters, 132–135
 - service policies, 85
 - time units, 134
- traffic management
 - AQM*, 121–126
 - bandwidth*, 115–120
 - classification*, 88–93
 - congestion*, 115–120
 - header compression*, 128–129
 - LFI*, 127
 - marking*, 94–99
 - policing*, 100–107
 - queuing*, 115–120
 - shaping*, 108–114
 - multifield (MF) classifiers, 9**
 - Multilink Frame Relay (MFR), 85**
 - Multilink PPP (MFP), 43, 85**
 - multimedia, 203**
 - Multiprotocol Label Switching Traffic Engineering**
 - See MPLS TE
-
- ## N
-
- neighbor address, link attribute, 60**
 - neighbor failures, RSVP, 51**
 - Network Control precedence, 18**
 - network**
 - control, 202
 - failures, 206
 - node-protect keyword, 183**
 - nodes**
 - DiffServ, 13
 - edge nodes, 210–212
 - egress 9
 - failure, 206
 - FRR, 183–186
 - headend nodes, 222–224
 - ingress, 9
 - interior, 9
 - IP, 13
 - mesh group memberships, 256
 - MPLS TE, 144–145
 - processing errors, 206
 - protection, 74
 - nonelastic traffic, 202**
 - Null Service, 7**

O

OAM (operations and maintenance), 203

OC transceiver models, 214–215

one-to-one backup, FRR, 72

ordered aggregates (OAs), 9

OSPF (Open Shortest Path First)

- areas/levels, 60
- backbones, 240
- distribution, link information 149
- flooding, 60
- link attributes, 60
- MPLS TE, 58

output

- direction, 85
- filtering, 156

P

Packet-over-SONET/SDH (POS) channels, 85

packets

- labeled/unlabeled, 215
- loss, 204–206, 229

parameters

- command, 133
- queue size, 134
- rate/burst, 132–135
- units, MQC, 134–135

parent/child policies, 130

path commands

- path-option command, 156
- path-selection command, 158

paths

- computation
 - description, 156, 246*
 - reoptimization, 159–160*
 - TE LSP paths, 156–159*
 - verifying, 160–162*
- configuring, 158
- messages
 - general, 63*
 - Path/PathErr/PathTear, RSVP, 48*

peaks

- commands, 101
- PIR, 34
- rates, 6

penultimate hop popping

See PHP

percent keyword, 101, 104

percentage-based rates, 132

performance

- backbones, 201
- application requirements, 202–204
- targets
 - concatenating, 205*
 - ITU-T, 204*

Per-Hop Behaviors

See PHBs

per-hop scheduling classes (PSCs), 66

permanent virtual circuits (PVCs), 85

PHB (Per-Hop Behavior) groups, 10

PHBs (Per-Hop Behaviors)

- AF, 17–18
- CS, 18
- Default, 18
- description, 10
- DiffServ, 15–17
- DSCP mappings, 16
- EF, 17
- L-LSP mappings, 23

PHP (penultimate hop popping)

- description, 26, 145
- short-pipe model, 27
- uniform model, 29

physical link errors, 206

piggy-backing, acknowledgments, 51

pipe

- mode, PHP, 26
- model, MPLS, 25–26
- operand, 156

PIR (peak information rate), 34

pir keyword, 101

point of local repair (PLR)

- description, 182
- FRR, 193–196
- next-next hop, 74–75

Poisson distribution, 207

police command, 94, 100, 132

police percent keyword, 102

police rate command, 101

policers

- actions, 102
- ATM, 104

- Cisco IOS XR, 107
- color-aware policers, 103
- counters, 106–107
- DiffServ, 229
- dual-rate policers, 34
- modes, 33
- policing
 - ATM*, 104
 - description*, 10, 100–107
 - percentage-based rates*, 132
 - TE LSP traffic*, 221
 - token buckets*, 100
 - traffic*, 32, 35
- priority command, 116
- single-rate policers, 33
- policies**
 - aggregate/distributed, 137
 - child/parent policies, 130
 - control plane, 138–139
 - DiffServ, 231
 - grandparent, 132
 - maps, 85
 - MQC
 - hierarchies*, 130–131
 - services*, *configuring*, 85
 - queuing, 117
 - tail drops, 81
- policing**
 - See policers
- policy commands**
 - policy cir command, 101
 - policy-map command, 85
- port channels, 85**
- POS (Packet-over-SONET/SDH) channels, 85**
- post-queuing, 84**
- PPP, 128**
- ppp commands, 127**
- precedence**
 - drop, 32
 - field, IP, 11, 228
 - IP vs. DiffServ, 18
 - marking, 94
 - See also specifically named preferences
- preemption, DS-TE, 66**
- pre-queuing, traffic, 80–81**
- prestandard DS-TE, 175–176**

- priority**
 - attributes, 82
 - classes, 116
 - command, 115–116, 157–158
 - flags, 135
 - priority percent command, 116, 132
 - precedence, 18
 - schedulers, 82
- probe-packet priority high command, 135**
- processing, 206**
- profiles, traffic, 10**
- propagation, 206**
- protocol messages, RSVP, 47–48**
- PSCs (per-hop scheduling classes), 66**
- pseudowire tunnel selection, 172**
- push operation, MPLS, 96**
- PVCs (permanent virtual circuits), 85**

Q

- QoS (quality of service)**
 - behavioral model. See behavioral model
 - design alternatives
 - best-effort backbone*, 212–224
 - DiffServ*, 226–233
 - DS-TE*, 240–248
 - MPLS TE*, 233–240, 251–260
 - optimizing*, 260–261
 - ITU-T categories/targets, 203–204
 - WRED, 213
- queue-limit command, 116**
- queues**
 - AQM, 121–126
 - behavioral model, 81–84
 - counters, 118
 - dequeuing, 82–83
 - DiffServ, 228
 - drops, 206
 - DRR, 38
 - enqueueing, 81
 - FIFO, 37
 - queue-limit command, 116
 - overview, 40, 115–118, 120, 206
 - policies, 117
 - post-queuing, 84
 - pre-queuing, 80–81

queue drops, 206
 random-detect command, 122
 RED, 40
 size parameters, 134
 TMN, 81
 dequeuing, 82–83
 enqueueing, 81
 post-queueing, 84
 weighting constant, 122
 WFQ, 37
 WRED, 41, 121–123, 213

R

random

drops, 124
 RED, 40

random-detect command, 121

rate keyword, 101, 109

rates

parameter units, 133–135
 percentage based, 132

RDM (Russian dolls model), 70–71, 175, 179, 240, 243

rdm keyword, 179

real-time

interactive, 203
 traffic, 228

Real-Time Transport Protocol (RTP), 44

Recommendations, ITU-T, 203–204

RECORD_ROUTE object, 63, 73

RED (random early detection), 40

refresh reduction messages, RSVP, 50–51

regions, 9, 13

reliable messages, RSVP, 50–51

reoptimization, paths, 159–160

reoptimize command, 159

request specification (RSpec), 5

reservable link bandwidth, link attribute, 60

Resource Reservation Protocol

See RSVP

restoration, FRR, 73

Resv messages, RSVP, 48–50

router isis mode, 148

router record object (RRO), flags, 191

router-id command, 148

Routine precedence, 18

routing

failures, 206
 types of, 58

RRO (route record object), flags, 191

RSpec (request specification), 5

RSVP (Resource Reservation Protocol)

clear commands, 164
 configuring, 163–164
 counters, 166
 debug commands, 164
 design principles, 46–47
 error signaling, 50
 FRR extensions, 73
 graceful restart, 51
 IntServ, 8
 LSPs, 63
 messages

authentication, 50

 Hello, 51, 184

 Path, 63

 protocol, 47–48

refresh reduction/reliable, 50–51

Resv messages, 48–50

modularity, 47

MPLS TE, 144

neighbor failures, 51

objects

CLASSTYPE, 68

DETOUR, 73

EXPLICIT_ROUTE, 63

FAST_REROUTE, 73

LABEL, 63

LABEL_REQUEST, 63

RECORD_ROUTE, 63, 73

SESSION_ATTRIBUTE, 63, 73

sessions, 46

setup, 49–50

show commands, 164

signaling, 45–51

soft state, 46

TE extensions, 63

TE LSPs, 63

verifying, 164–167

rsvp commands, 144

RTP (Real-Time Transport Protocol)

- description, 44
- header compression, 128

Russian dolls model (RDM), 68–71, 175–180, 240–243**S****scheduling**

- priority, 82
- traffic, 37

segmenting, performance targets, 204–206**self-similar traffic, 208****serialization, 206****service**

- classes, 202
- policies, MQC, 85
- RSpec, 5
- SLAs, 10, 13, 213
- SLS, 14

service-policy command, 85, 130**SESSION_ATTRIBUTE object, 63, 73****sessions, RSVP, 46****set commands**

- description, 94, 97, 131
- set dscp command, 94
- set dscp tunnel command, 96
- set ip dscp command, 94
- set ip precedence command, 94
- set mpls experimental imposition command, 94–96
- set precedence command, 94
- set precedence tunnel command, 96

shape commands

- description, 108, 115, 132
- shape adaptive command, 111
- shape average command, 109
- shape peak command, 109

shaping

- adaptive shaping, 111
- average vs. peak, 112
- Cisco IOS XR, 114
- counters, 113–114
- description, 10, 108–114
- events, 110

Frame Relay, 110–111

percentage-based rates, 132

token bucket algorithm, 36

traffic, 35–36

shared-risk link groups (SLRGs), 74**shim headers, 19****shortest path first (SPF) algorithm, 60****short-pipe model, MPLS, 26–27****show commands**

- show ip rsvp command, 164
- show ip rsvp counters command, 164
- show ip rsvp interface command, 164–165
- show ip rsvp reservation command, 182
- show ip rsvp reservation detail command, 170, 172, 191
- show ip rsvp sender detail command, 170, 172, 182, 191
- show mpls traffic-eng command, 146
- show mpls traffic-eng fast-reroute database command, 193–194
- show mpls traffic-eng link-management advertisements command, 153–154
- show mpls traffic-eng topology command, 154–156, 181
- show mpls traffic-eng topology path, 162
- show mpls traffic-eng tunnels, 160–162
- show mpls traffic-eng tunnels backup command, 196
- show mpls traffic-eng tunnels command, 167–168, 182, 191
- show mpls traffic-eng tunnels protection command, 194
- show policy-map command, 86–87, 91, 93, 99, 107
- show policy-map interface command, 99
- show policy-map interface command, 87, 120
- show rsvp reservation detail command, 182
- show rsvp counters command, 164, 166
- show rsvp counters messages command, 167
- show rsvp interface command, 165–166
- show rsvp sender detail command, 182

signaling

- description, 45, 203
- DS-TE, 182
- mechanisms, 51–52
- MPLS TE, 63

RSVP
design, 45–47
errors, 50
message authentication, 50–51
neighbor failures, 51
operation, 49–50
other mechanisms, 51
protocol messages, 47–48
 TE LSPs, 63, 163–170
single-rate policers, 33
size, packets, 202
SLAs (service level agreements), 10, 13, 213
SLRGs (shared-risk link groups), 74,
SLS (service level specification), 14
soft state, RSVP, 46, 50
SPF (shortest path first) algorithm, 60
Srefresh message, RSVP, 48
standard DS-TE, 175
STMs (Synchronous Transport Modules), 214–215
streaming
 audio/video traffic, 204
 multimedia, 203
sub-pool keyword, 177, 179
surges, traffic, 206

T

tail drops
 counters, 124
 policy, 81
targets, 203–205
TCP, 128, 202, 213
TE (traffic engineering)
 commands
 clear mpls traffic-eng command, 146
 debug mpls traffic-eng command, 146
 mpls traffic-eng administrative-weight command, 151
 mpls traffic-eng area command, 149
 mpls traffic-eng attribute-flags command, 151
 mpls traffic-eng auto-tunnel backup command, 186
 mpls traffic-eng backup-path command, 184
 mpls traffic-eng command, 144–145, 148
 mpls traffic-eng ds-te bc-model mam command, 179
 mpls traffic-eng ds-te mode ietf command, 175–176
 mpls traffic-eng ds-te mode migration command, 176
 mpls traffic-eng ds-te te-classes command, 176
 mpls traffic-eng link-management flood command, 150
 mpls traffic-eng lsp attributes command, 157
 mpls traffic-eng reoptimize events link-up command, 159
 mpls traffic-eng reoptimize timers frequency command, 159
 mpls traffic-eng router-id command, 149
 mpls traffic-eng tunnels, 151
 mpls traffic-eng tunnels command, 144
 show mpls traffic-eng command, 146
 show mpls traffic-eng fast-reroute database command, 193–194
 show mpls traffic-eng link-management advertisements command, 153–154
 show mpls traffic-eng topology command, 154–156, 181
 show mpls traffic-eng topology path, 162
 show mpls traffic-eng tunnels, 160–162
 show mpls traffic-eng tunnels backup command, 196
 show mpls traffic-eng tunnels command, 167–168, 182, 191
 show mpls traffic-eng tunnels protection command, 194
 traffic-eng router-id command, 148
 tunnel mpls traffic-eng affinity command, 157
 tunnel mpls traffic-eng autoroute command, 172
 tunnel mpls traffic-eng backup-bw command, 187
 tunnel mpls traffic-eng bandwidth command, 157, 177
 tunnel mpls traffic-eng command, 147
 tunnel mpls traffic-eng exp command, 173

- tunnel mpls traffic-eng fast-reroute*
 - command, 183*
- tunnel mpls traffic-eng path-option*
 - command, 156*
- tunnel mpls traffic-eng path-selection*
 - command, 157*
- tunnel mpls traffic-eng priority command, 157*
- LSPs, 219
 - full mesh, 251*
 - headends, 147*
 - paths, 156–159*
 - policing, 221*
 - signaling, 163–170*
- TE metric, link attribute, 60**
- TE-Classes, 66, 176–177, 241–243**
 - See also CTs
- telephony, 202**
- Telnet, 204**
- templates, 85, 256**
- thresholds, 121**
- throughput, 203**
- time units, MQC, 134**
- TMN (traffic-management node)**
 - bandwidth, 83
 - classification, 80, 85
 - description, 79–80
 - marking, 94
 - MCQ, 84–87
 - policing, 100
 - priority, 82
 - queuing
 - dequeuing, 82–83*
 - description, 81*
 - enqueueing, 81*
 - post-queuing, 84*
 - pre-queuing, 80–81*
 - schedulers, 82
- token buckets**
 - algorithm, 36
 - description, 6–7, 36
 - keywords, 100
 - policer actions, 102
 - policing, 100
 - shaping, 109
- tolerance**
 - errors, 203
 - loss, 202
- topmost keyword, 88**
- topology**
 - changes, 206
 - databases, 59
- TOS (Type-of-Service) octet, obsoleted, 11**
- traffic**
 - classification/conditioning
 - AQM, 40–42*
 - congestion, 37–39*
 - counters, 91–93*
 - description, 31, 80*
 - DiffServ, 13–15*
 - header compression, 44*
 - LFI, 42–43*
 - marking, 31–32*
 - matching, 85–88*
 - MQC hierarchies, 129*
 - policing, 32, 35*
 - shaping, 35–36*
 - differentiation, 237
 - elastic, 202
 - engineering
 - bandwidth constraints, 68–71*
 - FRR, 71–73*
 - link attributes, 60*
 - MPLS TE, 57–58*
 - next-next hope, 74–75*
 - path computation, 60–62*
 - local, 135–139
 - management
 - AQM, 40–42*
 - classification, 31*
 - congestion, 37–39*
 - description, 31*
 - header compression, 44*
 - LFI, 42–43*
 - marking, 31–32*
 - MQC, See MQC*
 - policing, 32, 35*
 - shaping, 35–36*
 - See also TMN*
 - nonelastic, 202
 - profiles, 10
 - real-time, 228

selection, 172–174
 self-similar, 20
 surges, 206
 types, 203

traffic-eng router-id command, 148

traffic-management node

See TMN

Transport Area working group, IETF, 202

TSpec (traffic specification), 5

tunnel commands

tunnel destination command, 156
 tunnel keyword, 147
 tunnel mode mpls traffic-eng command, 147
 tunnel mpls traffic-eng affinity command, 157
 tunnel mpls traffic-eng autoroute command,
 172
 tunnel mpls traffic-eng backup-bw command,
 187
 tunnel mpls traffic-eng bandwidth command,
 157, 177
 tunnel mpls traffic-eng command, 147
 tunnel mpls traffic-eng exp command, 173
 tunnel mpls traffic-eng fast-reroute command,
 183
 tunnel mpls traffic-eng path-option command,
 156
 tunnel mpls traffic-eng path-selection
 command, 157
 tunnel mpls traffic-eng priority command, 157

tunnels

affinities, 247
 backup, 187
 configuring, 158
 DS-TE interfaces, 177–178
 marking, 96
 MPLS models
 pipe, 25–26
 short-pipe, 26–27
 uniform, 28–29
 templates, 256

tunnel-te keyword, 147

U–V

uniform model, MPLS, 28–29

unlabeled/labeled packets, 215

unreserved bandwidth, link attribute, 60

updates, flooding link, 150

Usenet traffic, 204

verbatim keyword, 159

video, 203–204

violate action, policers, 102

virtual templates, 85

voice messaging traffic, 204

W

weighting

constant, 122

fields, 121

WFQ (weighted fair queuing), 38

WRED (weighted random early detection)

Cisco IOS XR, 125

counters, 125

description, 41, 121, 213–215

ECN, 122

queuing, 123

thresholds, 121

weighting fields, 121