



INDEX

A

- AAR (automatic alternate routing), 595
- access rate, 21
- acc-qos command, 612, 618
- acknowledgements
 - forward, 59
 - TCP, 59
- ACL (access control list)
 - configuring, 730, 741
 - IP extended matchable fields, 159–218
- actual debt (Da), 346
- actual queue depth, 435
- adaptation, traffic shaping, 337
- advanced integration modules (AIMs), 484
- Advanced Voice Busyout (AVBO), 573–575
- advertised windows, 429
- AF (assured forwarding), 124
- agents, SAA, 572, 664–680
 - ITU standards, 573
 - pings, 572
 - service, 572
- AIMs (advanced integration modules), 484
- algorithms
 - compression, 482–484
 - header compression, 485–486
 - Lemple-Ziv compression, 484
 - queue service, 91
 - service, 238
- alternate service, 874
- analog phones, calls between, 34
- analog voice gateways, 209
- applications
 - interactive, 7–9
 - NBAR, 185
 - QoS requirements, 32–33
 - TCP, 66
 - UDP error recovery, 65
- applying
 - traffic policing, 343–351
 - traffic shaping, 330–343
- architecture
 - Catalyst 3500 switches, 721–756
 - Catalyst 3524 switches, 722–723
 - Catalyst 4500/4000 switches, 717–755
 - Catalyst 6500 switches, 698–753
- ASN (autonomous system number), 837
- assignments, 262, 730
- associating ports, 726
- assured forwarding (AF), 124
- ATM (Asynchronous Transfer Mode), 168–222
- autofill, 51
- automatic alternate routing (AAR), 595
- autonomous system number (ASN), 837
- auxiliary VLANs, configuring for Catalyst OS switches, 725
- AVBO (Advanced Voice Busyout), 573–575
- average queue depth, 435
- avoidance, congestion, 96–97. *See also* congestion

B

- backward explicit congestion notification (BECN), 337
- bandwidth
 - CAC, 100–141
 - calculations, 548
 - per codec, 616
 - compression, 483
 - cRTP, 486
 - data, 63
 - engineering, 546–552
 - gatekeeper zone, 596–644
 - link efficiency, 97–99
 - optimizing, 7–13
 - SBM, 617
 - VAD, 38
 - video, 54–55, 673
 - voice, 35–36, 673
- bandwidth command, 11
- bandwidth interface subcommand, 280, 499
- Basic Rate ISDN (BRI), 546
- Bc (committed burst), 332
 - CAR policing, 398–420
 - CB policing, 390–398
- BE (best-effort) service, 136, 390–398
- Be (excess burst)
 - CAR, 343–347, 398–420
 - CB, 348–350
 - traffic shaping, 335–336
- bearer channel, 546
- BECN (backward explicit congestion notification), 337
- behavior, per-hop (DiffServ), 119–149
- best-effort (BE) service, 136, 390–398
- BGP (Border Gateway Protocol), 835–844
- bgp-policy interface subcommand, 840

bits

- CLP, 168
- DE, 168
- marking, 162
 - fields, 168–222
 - IP header fields, 163–165
 - LAN CoS, 166–168
- blocking, egress, 328
- boundaries, trust, 696, 728, 740
- branches, Frame Relay, 326
- BRI (Basic Rate ISDN), 546
- buffers
 - de-jitter delay, 44
 - Ethernet, 702
 - one-way video, 56
 - overflow, 690–691
- busy signals, 569–571. *See also* AVBO
- bytes, compression ratios, 482

C

- CAC (call admission control), 12, 51, 100–141, 544
 - bandwidth, 546–552
 - call rerouting, 545–546
 - local voice, 554
 - LVBO, 569–571
 - Max-Connections, 556–631
 - physical DS0 limitations, 554–629
 - trunking, 566–633
 - VoFR, 563–632
 - measurement-based, 571–638
 - mechanisms, 552–629
 - resource-based, 584–650
- caching, IP destination, 576
- calculations
 - bandwidth, 548
 - debt, 346
 - gateway resources, 585
 - propagation delay, 16
 - resources, 594
 - serialization delay, 15
 - WRED, 437–455
 - zone bandwidth, 602
- calendar queues, 863
- call admission control. *See* CAC
- call fallback command, 578
- call rerouting, 545–546
- call rsvp-sync command, 619
- CallManager, 35
- CAR (committed access rate), 193–200
 - with Be, 344–347
 - without Be, 343–344
 - classification, 388, 415
 - internals, 343
 - policing, 398–420
- cards
 - PFC, 698–701
 - RSP, 861
- CAS (channel-associated signaling), 546
- Catalyst OS, configuring, 724–735
- Catalyst switches, 698
 - 3500, 721–756
 - 3524, 722–723
 - 4500/4000, 717–755
 - 6500, 698–753
 - configuring, 723
 - catalyst OS, 724–735
 - IOS, 736–746
- CB marking (class-based marking), 175–184
 - NBAR, 185–189
 - show commands, 189–193
- CB policing (class-based policing), 390–398
 - with Be, 349–350
 - without Be, 348–349
 - classification, 388, 415
- CB shaping (class-based shaping), 357–369
- CBWFQ (CB Weighted Fair Queuing), 176, 272–288, 442
- CCS (common channel signaling), 546
- CDT (congestive discard threshold), 265
- CEF (Cisco Express Forwarding)
 - dCEF, 862
 - QPPB, 843
- cell loss priority (CLP), 168
- channel-associated signaling (CAS), 546
- CID (channel identification), 563
- CIR (committed information rate), 10, 94
- Cisco CallManager resource-based CAC, 591–641
- Cisco Service Agent (Assurance Agent), 664–680
- class class-default command, 284
- Class of Service (CoS), 166–168, 730
- class-based policing. *See* CB policing
- class-based shaping, 357–369
- Class-Based WFQ. *See* CBWFQ
- class-default queues, 274
- classes
 - CBWFQ, 442
 - GOCS classes-based QoS, 108–144

- classification, 86–89, 158–162, 170–175
 - CAR, 193–200, 388, 415
 - CB marking, 175–184
 - NBAR, 185–189
 - show commands, 189–193
 - CB policing, 388, 415
 - comparisons, 214–216
 - design, 170–175
 - GOCS class-based models, 109
 - LAN QoS, 691
 - PBR, 201–207
 - QPPB, 833–844
 - voice packets in LLQ, 615
 - VoIP dial peer, 207–214
 - WFQ, 258
- classifiers (DiffServ), 129–132
- class-map command, 176
- clock rate command, 11
- CLP (cell loss priority), 168
- CMs (Collection Managers), 667
- codecs
 - bandwidth per, 616
 - delay, 43
 - MPEG, 52
 - video, 54, 676
 - voice, 35
- Collection Managers (CMs), 667
- commands
 - acc-qos, 612, 618
 - bandwidth, 11
 - call fallback, 578
 - call rsvp-sync, 619
 - CB marking, 177
 - class class-default, 284

 - class-map, 176
 - clock rate, 11
 - commit qos acl, 730
 - compress, 486
 - compress stacker, 489
 - connection trunk, 566
 - cos-queue-group, 876
 - CQ, 854
 - custom-queue 6, 860
 - destination-pattern, 210
 - dial-peer, 210
 - DSCP, 211
 - flow-based dWFQ, 864
 - frame-relay fragment, 519
 - frame-relay traffic-shape, 371
 - frame-relay voice-bandwidth, 563

 - FRTS, 372, 412
 - GTS, 351
 - interface multilink 9, 514
 - ip nbar pdlm pdlm-name, 189
 - ip nbar protocol discovery, 188
 - ip policy route-map voip-routemap, 204
 - ip precedence, 211
 - ip qos dscp, 211–212
 - ip route-cache policy, 205
 - ip rsvp bandwidth, 612
 - IP RTP Priority, 297
 - ip rtp priority, 298, 508
 - load-interval, 193
 - map-class, 298
 - match ip rtp 16384 16383, 851
 - match protocol http, 854
 - max-conn, 556
 - max-reserved-bandwidth, 287
 - MDRR, 875
 - mls qos, 737
 - mls qos cos 3, 741
 - mls qos trust dscp, 740
 - multilink group 9, 514
 - multilink ppp, 514
 - NBAR, 185
 - PBR, 203, 228
 - police, 390
 - policy-map, 176
 - policy-map voip-and-be, 851
 - ppp multilink fragment-delay, 499, 514
 - ppp multilink interleave, 515
 - PQ, 846
 - precedence 0 random-detect-label 0, 877
 - priority, 288, 290, 295
 - priority-group 6, 851
 - priority-list, 849
 - priority-list 8 default low, 852
 - qos, 737
 - qos trust dscp, 740
 - QPPB, 835
 - queue-list 5 protocol ip 2 list 120, 857
 - queue-list 6 default 2, 860
 - random-detect flow, 463
 - rate-limit, 197, 399
 - req-qos, 612, 618
 - route-map, 204
 - rtr, 665
 - rtr responder, 574
 - rx-cos, 876
 - rx-cos my-sample, 877
 - SBM, 621

- service-policy, 176, 619
 - service-policy output, 280
 - set port auxiliaryvlan, 725
 - set port qos, 725
 - set port qos 2/1-48 vlan-based, 726
 - set qos acl, 730
 - set qos enable, 725
 - shape average, 358
 - shape peak, 358
 - show
 - CAR, 399
 - CB policing, 391
 - CB shaping, 358
 - CQ, 855
 - dWFQ, 864
 - Frame Relay fragmentation, 516
 - FRED, 459
 - FRTS, 371
 - GTS, 351
 - MDRR, 876
 - MLP interleaving, 507
 - payload compression, 487
 - RTP header compression, 491
 - TCP header compression, 491
 - WRED, 444
 - show access-lists, 357
 - show call rsvp-sync conf, 622
 - show compress, 487
 - show controllers, 245
 - show frame-relay ip rtp header-compression, 494
 - show interface, 270, 448, 515
 - show ip nbar protocol-discovery, 188
 - show ip policy, 207
 - show ip rsvp installed, 623
 - show ip rsvp installed detail, 623
 - show ip tcp header-compression, 493
 - show mls qos interface, 744, 745
 - show mls qos interface queueing, 743
 - show mls qos map cos, 746
 - show module, 699
 - show policy-map, 189, 280
 - show policy-map interface, 189, 455
 - show port capabilities, 703
 - show port qos, 732
 - show qos info routine, 733
 - show qos statistics I3stats, 734
 - show queue, 259, 849
 - show queue serial 0/0, 448
 - show queuing, 448
 - show queuing interface, 849, 858
 - show queuing priority, 849
 - show running-config, 455
 - show traffic-shape queue, 355
 - show traffic-shape statistics, 355
 - subcommands. *See* subcommands
 - switchport priority extend cos, 740
 - ToS-based WFQ, 867
 - trust-ext, 729
 - tx-cos, 876
- commit qos acl command, 730
 - committed access rate. *See* CAR
 - committed burst (Bc), 332
 - CAR policing, 398–420
 - CB policing, 390–398
 - committed information rate (CIR), 10, 94
 - common channel signaling (CCS), 546
 - Common Open Policy Service (COPS), 135
 - comparisons
 - CBWFQ, 288
 - classification and marking, 214–216
 - LLQ/IP RTP Priority, 297
 - queuing
 - interfaces/subinterfaces/VCs, 245–247
 - tools, 239
 - components
 - delay, 673, 683
 - of delay, 39
 - QPPB, 835
 - SMS, 667
 - compress command, 486
 - compress stacker command, 489
 - Compressed RTP (cRTP), 38, 486
 - compression, 11, 26
 - classification, 158–162
 - headers, 482–486
 - RTP, 490–494
 - TCP, 490–494
 - link efficiency, 97–99
 - MPPC, 484
 - payload, 482–490
 - conditioners
 - traffic, 129–132
 - trunks, 566–633
 - conferences, video, 52
 - configuration
 - ACL, 730, 741
 - adaptive traffic shaping, 338
 - CAR, 398–420
 - Catalyst switches, 723
 - Catalyst OS, 724–735
 - IOS, 736–746

- CB marking, 175–184
 - NBAR, 185–189
 - show commands, 189–193
 - CB shaping, 357–369
 - CBWFQ, 275
 - CQ, 854–861
 - devices, 663
 - DTS, 369–370
 - dWFQ, 861–870
 - FIFO Queuing, 250
 - FRED, 459
 - FRF.12, 515–527
 - FRTS, 370–388
 - gateways, 209
 - GTS, 351–357
 - IP RTP Priority, 297
 - IPM, 666
 - LLQ, 290
 - MLP, 506–515
 - NBAR, 185
 - payload compression, 486–490
 - PBR, 202, 227
 - PQ, 845–854
 - PSTN fallback, 578
 - QDM, 660–661
 - QoS
 - DSCP dial-peer, 212
 - management tools, 102–103
 - QPM, 662–664
 - QPPB, 835, 840
 - R4 voice gateways, 210
 - RAI, 589
 - RSVP, 612, 618
 - SAA, 664–680
 - ToS-based dWFQ, 867
 - trust boundaries, 728, 740
 - untagged frames, 729, 741
 - voice
 - gateway, 209
 - VLANs, 737
 - WFQ, 266
 - WRED, 437–455
 - zone bandwidth, 604
 - congestion
 - avoidance, 96–97
 - FRED, 456–465
 - RED, 428–437
 - WRED, 437–455
 - BECN, 337
 - FECN, 337
 - management, 845
 - CQ, 854–861
 - dWFQ, 861–870
 - MDRR, 871–877
 - PQ, 845–854
 - queuing, 90–93
 - windows, 429
 - congestive discard threshold (CDT), 265
 - conjugate-structure algebraic-code-excited linear-prediction (CS-ACELP), 547
 - connection trunk command, 566
 - connections
 - DLCI, 339
 - Max-Connections, 556–631
 - TCP starvation, 432–433
 - traffic
 - policing, 343–351
 - shaping, 330–343
 - trunking, 566–633
 - WAN, 731, 743
 - contracts, traffic, 323
 - controlled-load level of service, 607
 - COPS (Common Open Policy Service), 135
 - CoS (Class of Service), 166–168, 730
 - cos-queue-group command, 876
 - CoS-to-DSCP mappings, 727
 - CoS-to-egress queue mapping, 726, 738
 - CQ (Custom Queuing), 254–305, 845, 854–861
 - cRTP (Compressed RTP), 38, 486
 - CS-ACELP (conjugate-structure algebraic-code-excited linear prediction), 547
 - Customer Queuing. *See* CQ
 - customization
 - classification, 170–175
 - compression, 484–485
 - dWFQ, 861
 - marking, 170–175
 - custom-queue 6 command, 860
 - custom-queue interface subcommand, 857
- ## D
-
- D channel, 546
 - Da (actual debt), 346
 - data
 - bandwidth, 63
 - delay, 64
 - jitter, 64
 - loss, 65
 - traffic characteristics of, 32–33, 57–66
 - data terminal equipment (DTE), 10, 94
 - data-link connection identifier (DLCI), 95, 339
 - DBL (dynamic buffer limiting), 720
 - dCEF (distributed CEF), 862

- DE (discard eligibility), 168
- debt calculations, 346
- decreasing tail drop, 237
- deficits, MDRR, 873
- de-jitter buffer delay, 44
- delay
 - codec, 43
 - components, 39, 673, 68
 - compression, 483
 - data, 64
 - de-jitter buffer delay, 44
 - end-to-end voice, 675
 - forwarding, 20
 - maximum serialization, 498
 - network, 22–23
 - one-way budget guidelines, 41
 - optimizing, 7–9, 13–27
 - packetization, 42
 - propagation, 16–18
 - QoS tools, 24–27
 - queuing, 18–19, 237
 - serialization, 14–16
 - shaping, 20–21
 - traffic shaping, 93–96
 - video, 55, 673
 - voice, 39, 673
- deployment of QPM, 662–664
- depth of queues, 435
- design, 668–669. *See also* configuration
 - classification, 170–175
 - four-step process, 669–672
 - marking, 170–175
 - physical DS0 limitations, 554
 - QoS, 104
 - DiffServ, 114–119, 129–149
 - GOCS class-based, 108–144
 - GOCS flow-based, 105–108
 - IntServ, 133–136
 - SRND, 723
 - video/voice, 673–678
 - zone-per-gateway, 601
- designated subnetwork bandwidth manager (DSBM), 617
- destination-pattern command, 210
- detection, VAD, 38, 189
- devices
 - QDM, 660–661
 - QPM, 663
- dial peers, VoIP, 207–214
- dictionaries, 485
- Differentiated Services Code Point (DSCP), 114
- DiffServ (differentiated services), 85, 114
 - classifiers, 129–132
 - per-hop behaviors, 119–149
 - specifications, 114–119
- digital signal processor (DSP), 691
- discard eligibility (DE), 168
- discarding
 - logic, 436
 - packets (WRED), 437–455
- distributed CEF (dCEF), 862
- Distributed Services Shaping (DTS), 369–370
- distributed Weighted Fair Queuing (dWFQ), 861–870
 - DLCI (data-link connection identifier), 95, 339
 - drop thresholds, 695–696
 - DS0 limitation CAC evaluation criteria, 556
 - DSBM (designated subnetwork bandwidth manager), 617
 - DSCP (Differentiated Services Code Point), 114
 - commands, 211
 - fields, 163–165
 - QoS dial-peer configuration, 212
 - WRED, 448
 - DSP (digital signal processor), 691
 - DTE (data terminal equipment), 10, 94
 - DTS (distributed traffic shaping), 369–370
 - Dual FIFO queues, 237, 500
 - dual token buckets
 - CB policing, 349
 - refilling with CAR, 345
 - dWFQ (distributed Weighted Fair Queuing), 861–870
 - dynamic buffer limiting (DBL), 720

E

- echoes, ICMP, 664
- edge services router (ESR), 168
- EF (expedited forwarding), 124
- egress blocking, 328
- egress queue scheduling, 710
- EIGRP (Enhanced Interior Gateway Routing Protocol), 11
- EIR (excess information rate), 376
- ELMI (Enhanced LMI), 371
- enabling
 - PQ, 738
 - QoS, 737
 - RSVP with LLQ, 619

- traffic shaping, 340, 407
- trust, 729
- encapsulation, HDLC, 298
- encoding serialization delays, 14–16
- end-to-end voice delays, 675
- engineering bandwidth, 546–552
- engines, supervisor and switching, 698
- Enhanced Interior Gateway Routing Protocol, 11
- Enhanced LMI (ELMI), 371
- enterprise networks, RAI, 588
- error recovery
 - TCP, 60
 - UDP, 65
- ESR (edge services router), 168
- Ethernet
 - interfaces, 702
 - LAN CoS, 166–168
- excess burst (Be)
 - CAR, 343–347, 398–420
 - CB, 348–350
 - traffic shaping, 335–336
- excess information rate (EIR), 376
- expedited forwarding (EF), 124

F

- fair-queue interface subcommand, 270, 863
- fair-queue qos-group subcommand, 869
- fallback, PSTN, 578
- FECN (forward explicit congestion notification), 337
- feedback
 - Foresight Feedback, 337
 - PSTN, 575–638
- FIB (Forwarding Information Base), 843
- fields
 - classification, 388, 415
 - DSCP, 114, 163–165
 - IP ACL extended matchable, 159–218
 - marking, 162, 168–169, 215–222
 - IP header fields, 163–165
 - LAN CoS, 166–168
- FIFO (first in, first out), 236, 249–251
- fixed delay components, 673, 683
- flow
 - CAC, 100–141
 - FRED, 456–465
 - GOCS flow-based QoS, 105–108

- flow-based dWFQ, 862. *See also* dWFQ
- Flow-Based WRED (FRED), 433, 456–465
- Foreign Exchange Station (FXS), 189
- Foresight Feedback, 337
- formulas
 - propagation delay, 16
 - serialization delay, 15
- forward acknowledgements, 59
- forward explicit congestion notification (FECN), 337
- forwarding
 - AF, 124
 - EF, 124
- forwarding delay delay, 20
- Forwarding Information Base (FIB), 843
- four-step design process, 669–672
- fragile flows, 457. *See also* flow
- fragmentation
 - FRF, 371
 - LFI, 494–496
 - FRF.12, 499–506, 515–527
 - MLP, 506–515
 - multipoint PPP, 497–499
 - link efficiency, 97–99
 - optimum fragment sizes, 498
- Frame Relay
 - bandwidth, 9
 - branches, 326
 - fragments, 503
 - marking, 168–222
 - payload compression tools, 485
 - VoFR, 563–632
- Frame Relay Forum Implementation Agreement 12 (FRF.12), 499–506, 515–527
- Frame Relay Forum Implementation Agreement 9 (FRF.9), 485
- Frame Relay fragmentation (FRF), 371
- Frame Relay traffic shaping (FRTS), 298, 370–388
- frame-relay fragment command, 519
- frame-relay traffic-shape command, 371
- frame-relay voice-bandwidth command, 563
- frames, untagged, 729, 741
- FRED (Flow-Based WRED), 433, 456–465
- FRF (Frame Relay fragmentation), 371
- FRF.12 (Frame Relay Forum Implementation Agreement 12), 499–506, 515–527
- FRF.9 (Frame Relay Forum Implementation Agreement 9), 485
- FRTS (Frame Relay traffic shaping), 298, 370–388

functions. *See also* commands

- autofill, 51
- CBWFQ, 274
- CQ, 257
- dWFQ, 871
- MDRR, 874
- QoS Group-based dWFQ, 868
- ToS-based dWFQ, 865
- WFQ, 272, 308, 863

FXS (Foreign Exchange Station), 189

G

G.729 DSP, 691

gatekeeper zone bandwidth, 596–644

gateways

- configuration, 209
- RAI, 585–639

Gigabit Switch Routers (GSRs), 168, 845, 871–877

global synchronization, congestion-avoidance, 432–433

GOCS (Good-Old Commonsense) QoS model, 104

GSRs (Gigabit Switch Routers), 168, 845, 871–877

GTS (Generic Traffic Shaping), 351–357

guaranteed QoS level of service, 607

H

H.323 networks

- gatekeeper zone bandwidth, 596–644
- synchronization, 611

hairpinning, 546

HDLC (High-level Data Link Control), 298

headers, 490–494

- compression, 482–486
- IP fields, 163–165
- RTP compression, 490–494
- SNA, 169
- TCP/UDP, 61

High-level Data Link Control (HDLC), 298

hold-queue limits, 265

hold-queue x out interface subcommand, 250

hops, behavior (DiffServ), 119–149

I

ICMP (Internet Control Message Protocol), 298, 664

implementation

- policing, 323–330
- shaping, 323–330

ingress queue scheduling, 707

integrated services, 85, 133–136, 606–650

interactive applications, optimizing, 7–9

interactive video, 52. *See also* video

interface multilink 9 command, 514

interfaces

- CAR policing, 398–420

- CB shaping, 357–369

- commands, 11

- DTS, 369–370

- Ethernet, 702

- FRTS, 370–388

- GTS, 351–357

- IPM, 666

- MQC, 121, 176

- QDM, 660–661

- queuing, 236–239, 245–247

- traffic shaping, 338–340

- VIPs, 484, 861

interleaving, 494–496

- FRF.12, 499–506, 515–527

- MLP, 506–515

- multipoint PPP, 497–499

internals, CAR, 343

Internet Control Message Protocol (ICMP), 298, 664

Internetwork Performance Monitor (IPM), 103, 142, 666

IntServ (integrated services), 85, 133–136, 606–650

IOS

- Catalyst switches, 736–746

- QoS, 86–142

- queuing, 236–239

IP (Internet Protocol)

- destination caching, 576

- extended ACL matchable fields, 159–218

- header fields, 163–165

- physical DS0 limitations, 555

- Precedence, 120, 163–165

ip nbar pdlm pdlm-name command, 189

ip nbar protocol discovery command, 188

IP Phones, voice options, 33

ip policy route-map voip-routemap command, 204

ip precedence command, 211
 ip qos dscp command, 211–212
 ip route-cache policy command, 205
 ip rsvp bandwidth command, 612
 ip rsvp pq-profile, 619
 ip rsvp pq-profile command, 619
 IP RTP Priority, 296–298
 ip rtp priority command, 298, 508
 IPM (Internetwork Performance Monitor), 103, 142, 666
 ip-prec-map keyword, 840
 ISL trunking, 166–168

J-K

jitter

data, 64
 de-jitter buffer delay, 44
 optimizing, 7–9, 27–29
 queuing, 237
 video, 56, 673
 voice, 48, 673

keywords

ip-prec-map, 840
 low-latency, 876
 trust-ipprec port, 731
 weight, 877

L

LAN

CoS, 166–168
 QoS, 690
 buffer overflow, 690–691
 classification and marking, 691
 drop thresholds, 695–696
 Layer 2 queues, 694–695
 Layer 3-to-Layer 2 classification mapping, 693–694
 trust boundaries, 696
 large playout buffers, one-way video, 56
 Layer 2
 queues, 694–695
 switching engine, 709
 Layer 2-to-Layer 3 mapping, 739
 Layer 3 switching engines, 710
 layers, SNA, 169

left-to-right directional flow, 40
 legacy VoIP environments, 545
 Lempel-Ziv compression algorithm, 484
 length of queues, 243
 levels of service, RSVP, 607
 LFI (link fragmentation and interleaving), 25, 99, 494–496
 FRF.12, 499–506, 515–527
 MLP, 506–515
 multipoint PPP, 497–499
 links
 compression, 482–484
 efficiency, 97–99
 header compression, 485–486
 MLP, 506–515
 policing, 322–323
 propagation delay, 16–18
 serialization delay, 14–16
 LLQ (Low Latency Queuing), 288–296
 RSVP, 619
 voice classification for packets into, 615
 load-interval command, 193
 local-area network. *See* LAN
 local CAC mechanisms, 552
 Local Voice Busy-Out (LVBO), 569–571
 local voice CAC, 554
 LVBO, 569–571
 Max-Connections, 556–631
 physical DS0 limitations, 554–629
 trunking, 566–633
 VoFR, 563–632
 local zone statements, 601
 locations, Cisco CallManager resource-based CAC, 591–641
 logic
 discarding, 436
 QPPB, 839
 loss
 congestion avoidance, 96–97
 data, 65
 optimizing, 7–9
 packets (TCP/UDP), 428–431
 video, 57, 673
 voice, 49, 673
 Low Latency Queuing (LLC), 288–296
 low-latency keyword, 876
 LVBO (Local Voice Busy-Out), 569–573

M

management

- congestion, 845
 - CQ, 854–861
 - dWFQ, 861–870
 - MDRR, 871–877
 - PQ, 845–854
- LAN QoS, 690
 - buffer overflow, 690–691
 - classification and marking, 691
 - drop thresholds, 695–696
 - Layer 2 queues, 694–695
 - Layer 3-to-Layer 2 classification mapping, 693–694
 - trust boundaries, 696
- output queuing, 245–247
- SBM, 617
- tools, 660
 - IPM, 666
 - QDM, 660–661
 - QoS, 102–103
 - QPM, 662–664
 - SAA, 664–680
 - SMS, 666–667
- map-class command, 298
- mark probability denominator (MPD), 436
- marking, 86–89, 162, 170–175
 - CAR, 193–200
 - CB marking, 175–184
 - NBAR, 185–189
 - show commands, 189–193
 - comparisons, 214–216
 - design, 170–175
 - down packets with policing, 350–351
 - fields, 168–169, 215–222
 - GOCS class-based models, 109
 - IP header fields, 163–165
 - LAN CoS, 166–168
 - LAN QoS, 691
 - PBR, 201–207
 - QPPB, 833–844
 - voice payload traffic, 212
 - VoIP dial peer, 207–214
- match ip rtp 16384 16383 command, 851
- match protocol class-map subcommand, 185
- match protocol http command, 854
- match subcommand, 176
- max-conn command, 556
- Max-Connections, 556–631
 - maximum serialization delay, 498
 - maximum thresholds, 435
 - max-reserved-bandwidth command, 287
 - MDRR (Modified Deficit Round-Robin), 845, 871–877
 - measurement-based CAC mechanisms, 552
 - measurement-based voice CAC, 571–638
 - mechanisms (CAC), 552–629
 - local voice, 554
 - LVBO, 569–571
 - Max-Connections, 556–631
 - measurement-based, 571–638
 - physical DS0 limitations, 554–629
 - resource-based, 584–650
 - trunking, 566–633
 - VoFR, 563–632
 - Microsoft Point-to-Point Compression (MPPC), 484. *See also* compression
 - minimum thresholds, 435
 - MIR (minimum information rate), 338
 - MLP (multilink PPP interleaving), 506–515
 - mls qos command, 737
 - mls qos cos 3 command, 741
 - mls qos trust dscp command, 740
 - models (QoS), 104
 - DiffServ, 114–119, 129–149
 - GOCS class-based, 108–144
 - GOCS flow-based, 105–108
 - IntServ, 133–136
 - modification of queues, 243
 - Modified Deficit Round-Robin (MDRR), 845, 871–877
 - Modular QoS command-line interface (MQC), 121, 176
 - monitoring
 - IPM, 666
 - RSVP, 621
 - Moving Pictures Experts Group (MPEG), 52
 - MPD (mark probability denominator), 436
 - MPEG (Moving Pictures Expert Group), 52
 - MPPC (Microsoft Point-to-Point Compression), 484. *See also* compression
 - MQC (Modular QoS) command-line interface, 121, 176
 - multilink group 9 command, 514
 - multilink PP interleaving (MLP), 506–515
 - multilink ppp command, 514
 - multimedia
 - CAC, 100–141
 - traffic characteristics of, 32–33
 - multipoint PPP LFI, 497–499
 - multizone gatekeepers, 597

N

- names
 - marking fields, 169, 222
 - precedence, 120
- NBAR (Network-Based Application Recognition), 185–189
- Network File System (NFS), 65
- networks
 - bandwidth, 9
 - delay, 40
 - delay delay, 22–23
 - enterprise (RAI), 588
 - H.323
 - gatekeeper zone bandwidth, 596–644
 - synchronization, 611
 - PSTN, 12, 545
 - QoS management tools, 102–103
 - SP (RAI), 586
- NFS (Network File System), 65
- no fair-queue interface subcommand, 250
- no priority-group interface subcommand, 245
- noninteractive video, 52. *See also* video

O

- one-way delay budget guidelines, 41
- one-way video, 56
- OOS (out-of-service), 566
- optimization
 - IPM, 666
 - SAA, 664–680
 - SMS, 666–667
 - traffic, 7–9
 - bandwidth, 9–13
 - delay, 13–27
 - jitter, 27–29
- optimum fragment sizes, 498
- options, 170–175. *See also* configuration
 - DSCP command, 211
 - dWFQ, 861
 - LAN QoS, 690
 - buffer overflow, 690–691
 - classification and marking, 691
 - drop thresholds, 695–696
 - Layer 2 queues, 694–695
 - Layer 3-to-Layer 2 classification mapping, 693–694
 - trust boundaries, 696
 - point-to-point compression, 484–485

- out-of-service (OOS), 566
- output queues, 239–247
- overflow buffers, 690–691
- overrun, 690–691
- oversubscriptions, 522

P

- packet descriptor language modules (PDLMs), 189
- packetization delay, 42
- packets
 - CAR
 - internals, 343
 - with Be, 344–347
 - without Be, 343–344
 - CB policing, 390–398
 - classification, 86–89, 158–162
 - compression, 482–484
 - congestion avoidance, 96–97
 - flow (FRED), 456–465
 - forwarding delay, 20
 - header compression, 485–486
 - LFI tools, 496
 - loss (TCP/UDP), 428–431
 - network delay, 22–23
 - policing, 93–96, 322–323
 - implementing, 323–330
 - marking down, 350–351
 - QPPB, 838
 - queuing, 236–239
 - queuing delay, 18–19
 - reordering, 90–93
 - serialization delay, 14–16
 - shaping, 322–323
 - shaping delay, 20–21
 - traffic shaping, 93–96
 - voice, 549, 615
 - VoIP dial peers, 207–214
 - WRED, 437–455
- packets per second (pps), 550
- path messages, 608
- payloads
 - configuring, 486–490
 - compression, 482–485
 - link efficiency, 97–99
 - video, 54
 - voice, 35, 212
- PB Tents, 324, 328
- PBR (policy-based routing), 201–207
- PBXs (private branch exchanges), 544
- PCM (pulse code modulation), 546

- PDLMs (packet descriptor language modules), 189
- PDP (policy decision point), 135
- PEP (policy enforcement point), 135
- performance
- SAA, 664–680
 - SMS, 666–667
- traffic
- delay, 13–27
 - jitter, 27–29
 - optimizing, 7–13
- per-hop behaviors (DiffServ), 119–149
- permanent trunk connections, 566
- permanent virtual circuits (PVCs), 245
- PFC (Policy Feature Card), 698, 701
- physical DS0 limitations, 554
- ping IP connectivity, SAA probes, 572
- plain old telephone service (POTS), 545
- platforms, RAI, 590
- points of presence (POPs), 587
- point-to-point compression options, 484–485
- point-to-point network bandwidth, 9
- police command, 390
- policies
- QoS, 102–103
 - QPM, 662–664
 - QPPB, 833–844
- policing, 93–96
- CAR, 193–200
 - CB
 - with Be, 349–350
 - without Be, 348–349
 - packets, 350–351
 - traffic, 322–323
 - connections, 343–351
 - implementing, 323–330
 - tools, 388
- policy decision point (PDP), 135
- policy enforcement point (PEP), 135
- Policy Feature Card (PFC), 698, 701
- policy-based routing (PBR), 201–207
- policy-map command, 176
- policy-map voip-and-be command, 851
- POPs (points of presence), 587
- ports. *See also* connections
- associating, 726
 - CoS, 730
- POTS (plain old telephone service), 545
- PPP (Point-to-Point Protocol), 506–515
- ppp multilink fragment-delay command, 499, 514
- ppp multilink interleave command, 515
- pps (packets per second), 550
- PQ (Priority Queuing), 251–254, 738, 845–854
- precedence
- IP, 120, 163–165
 - WRED, 440
- precedence 0 random-detect-label 0 command, 877
- Predictor, 484
- PRI (Primary Rate ISDN), 546
- Primary Rate ISDN (PRI), 546
- priority command, 288, 290, 295
- Priority Queuing, 251–254, 738, 845–854
- priority-group 6 command, 851
- priority-list 8 default low command, 852
- priority-list command, 849
- private branch exchanges (PBXs), 544
- probes (SAA), 665, 680
- ITU standards, 573
 - measurement-based CAC, 571
 - pings, 572
 - service, 572
- profiles, voice-like, 624
- propagation
- delay delay, 16–18
 - QPPB, 833–844
- protocols
- cRTP, 38
 - EIGRP, 11
 - ICMP, 664
 - QPPB, 835
 - RSVP, 101, 606–650
 - RTP, 34
 - RTSP, 52
 - SNMP, 65
 - SSCP, 35
 - TCP, 58
 - packet loss, 428–431
 - starvation, 432–433
 - TFTP, 65
 - UDP, 58, 428–431
- PSTN (Public Switched Telephone Network), 12, 545–638
- pulse code modulation (PCM), 546
- PVCs (permanent virtual circuits), 245

Q

- QDM (QoS Device Manager), 102, 142, 660–661
- QoS (quality of service)
- bandwidth, 9–13
 - Catalyst 3500 switches, 721–756

- Catalyst 3524 switches, 722–723
- Catalyst 4500/4000 switches, 717–755
- Catalyst 6500 switches, 698–753
- Catalyst switches
 - Catalyst OS, 724–735
 - configuring, 723
 - IOS, 736–746
- delay, 13–27
- design, 668–669
 - four-step process, 669–672
 - video/voice, 673–678
- DSCP dial-peer configuration, 212
- jitter, 27–29
- LAN, 690
 - buffer overflow, 690–691
 - classification and marking, 691
 - drop thresholds, 695–696
 - Layer 2 queues, 694–695
 - Layer 3-to-Layer 2 classification mapping, 693–694
 - trust boundaries, 696
- management tools, 102–103, 660
 - IPM, 666
 - QDM, 660–661
 - QPM, 662–664
 - SAA, 664–680
 - SMS, 666–667
- models, 104
 - DiffServ, 114–119, 129–149
 - GOCS class-based, 108–144
 - GOCS flow-based, 105–108
 - IntServ, 133–136
- requirements, 32–33
- tools
 - data, 57–66
 - delay, 24–27
 - IOS, 86–142
 - jitter, 28
 - video, 52–57
 - voice, 33–52
- viewing, 732, 743
- qos command, 737
- QoS Device Manager (QDM), 102, 142
- QoS Group-Based dWfQ, 868
- QoS Policy Manager (QPM), 102, 142, 662–664
- QoS Policy Propagation with BGP (QPPB), 833–844
- qos trust dscp command, 740
- QPM (QoS Policy Manager), 102, 142, 662–664
- QPPB (QoS Policy Propagation with BGP), 833–844
- quality of service. *See* QoS
- quantum value (QV), 872
- queue service algorithm, 91
- queue-list 5 protocol ip 2 list 120 command, 857
- queue-list 6 default 2 command, 860
- queuing, 24, 90–93, 236–239, 845
 - bandwidth reservation with, 12
 - CBWFQ, 176
 - classification, 158–162
 - congestion avoidance, 96–97
 - CQ, 845, 854–861
 - delay delay, 18–19
 - depth, 435
 - dWFQ, 861–870
 - egress scheduling, 710
 - Ethernet, 702
 - ingress scheduling, 707
 - interfaces, 245–247
 - Layer 2, 694–695
 - length, 243
 - MDRR, 871–877
 - output, 239–245
 - PQ, 845–854
 - tools, 239, 248–249
 - CBWFQ, 272–288
 - CQ, 254–305
 - FIFO, 249–251
 - GTS, 351–357
 - IP RTP Priority, 296–298
 - LLQ, 288–296
 - PQ, 251–254
 - WFQ, 257–308
 - traffic shaping, 340–343
 - WFQ, 845
 - WRED, 437–455
- QV (quantum value), 872

R

- R4 voice gateways, configuration, 210
- RAC (resource availability confirmation), 585
- RAI (resource availability indication), 585–639
- Random Early Detection (RED), 30, 428–437, 720
- random-detect flow command, 463
- random-detect interface subcommand, 447
- rate-limit command, 197, 399
- rate-limit interface subcommand, 195
- ratios, compression, 482

RDT (RealNetworks Data Transport), 52
 RealNetworks Data Transport (RDT), 52
 Real-Time Streaming Protocol (RTSP), 52
 Real-Time Transport Protocol (RTP), 34
 receiver windows, 429
 RED (Random Early Detection), 30, 428–437, 720
 refilling dual token buckets
 with CAR, 345
 with CB policing, 349
 regions, Cisco CallManager resource-based CAC, 592
 reordering packets, 90–93
 req-qos command, 612, 618
 requirements
 bandwidth (CAC), 548
 QoS, 32–33
 video/voice, 673
 rerouting calls, 545–546
 reservation, bandwidth, 12
 resource availability confirmation (RAC), 585
 resource availability indication, 585–639
 Resource Reservation Protocol (RSVP), 101, 606–650
 resource-based CAC mechanisms, 552
 resource-based voice CAC, 584–650
 resources, calculations, 594
 Route Switch Processor (RSP), 861
 route-map command, 204
 routers
 ESR, 168
 forwarding delay, 20
 GSR, 168, 845, 871–877
 Max-Connections, 558
 network delay, 22–23
 payload compression, 484–485
 QPPB, 837
 queuing, 236–239
 queuing delay, 18–19
 shaping delay, 20–21
 routing
 PBR, 201–207
 RAI, 585–639
 RSP (Route Switch Processor), 861
 RSVP (Resource Reservation Protocol), 101, 606–650
 RTP (Real-Time Transport Protocol), 34, 490–494
 rtr command, 665
 rtr responder command, 574
 RTSP (Real-Time Streaming Protocol), 52
 rx-cos command, 876
 rx-cos my-sample command, 877

S

SAA (Cisco Service Assurance Agent), 103, 142, 572, 664–680
 ITU standards, 573
 pings, 572
 probes, 571
 service, 572
 SBM (subnet bandwidth management), 617
 scalability, PSTN fallback, 581
 scheduling, 24, 90–93
 CQ logic, 255
 egress queue, 710
 FIFO, 236
 ingress queues, 707
 PQ logic, 252
 strict, 874
 WFQ, 260
 schemes, queuing, 236–239
 Sender_Tspec path message, 609
 sequences
 ASN, 837
 WFQ, 262
 serialization
 delay, 14–16
 maximum delay, 498
 servers
 CallManager, 35
 COPS, 136
 QPM, 663
 service algorithms, 238
 service assurance agents. *See* SAA
 Service Management Solution (SMS), 103, 142, 666–667
 service provider (SP) networks, RAI, 586
 service-policy command, 176, 619
 service-policy output command, 280
 services
 BE, 136
 LLQ, 289
 RSVP, 607
 SAA, 572
 set port auxiliary vlan command, 725
 set port qos 2/1-48 vlan-based command, 726
 set port qos command, 725
 set qos acl command, 730
 set qos enable command, 725
 shape average command, 358
 shape peak command, 358
 shaping, 93–96

- CB, 357–369
- delay delay, 20–21
- DTS, 369–370
- FRTS, 370–388
- queues, 246
- traffic, 26, 322–323
 - connections, 330–343
 - implementing, 323–330
 - tools, 351
- show access-lists command, 357
- show call rsvp-sync conf command, 622
- show commands
 - CAR, 399
 - CB policing, 391
 - CB shaping, 358
 - CQ, 855
 - dWFQ, 864
 - Frame Relay fragmentation, 516
 - FRED, 459
 - FRTS, 371
 - GTS, 351
 - MDRR, 876
 - MLP interleaving, 507
 - payload compression, 487
 - RTP header compression, 491
 - TCP header compression, 491
 - WRED, 444
- show compress command, 487
- show controllers command, 245
- show frame-relay ip rtp header-compression command, 494
- show interface command, 270, 448, 515
- show ip nbar protocol-discovery command, 188
- show ip policy command, 207
- show ip rsvp installed command, 623
- show ip rsvp installed detail command, 623
- show ip tcp header-compression command, 493
- show mls qos interface command, 744
- show mls qos interface queueing command, 743
- show mls qos map cos command, 746
- show module command, 699
- show policy-map command, 189, 280
- show policy-map interface command, 189, 455
- show port capabilities command, 703
- show port qos command, 732
- show qos info runtime command, 733
- show qos interface command, 745
- show qos statistics l3stats command, 734
- show queue command, 259, 849
- show queue serial 0/0 command, 448
- show queueing command, 448
- show queueing interface command, 849, 858
- show queueing priority command, 849
- show running-config command, 455
- show traffic-shape queue commands, 355
- show traffic-shape statistics command, 355
- signaling
 - CAS, 546
 - CCS, 546
- simple FIFO queueing, 249
- Simple Network Management Protocol (SNMP), 65
- single FIFO queues, 236
- single-zone gatekeepers, 596
- sizes
 - fragments (Frame Relay), 503
 - optimum fragment, 498
- Skinny Station Control Protocol (SSCP), 35
- slamming the window shut, 430
- sliding windows, 60
- slow start threshold (SSTHRESH), 429
- SMS (Service Management Solution), 103, 142, 666–667
- SNA (Systems Network Architecture), 169
- SNMP (Simple Network Management Protocol), 65
- Solution Reference Network Design (SRND), 723
- SP (service provider) networks, RAI, 586
- specifications, DiffServ, 114–119
- speed mismatch, 329
- SRND (Solution Reference Network Design), 723
- SSCP (Skinny Station Control Protocol), 35
- SSTHRESH (slow start threshold), 429
- Stacker, 484
- starvation, TCP, 432–433
- statistics, QDM, 660–661
- strict scheduling, 874
- subcommands
 - bandwidth interface, 280, 499
 - bgp-policy interface, 840
 - custom-queue interface, 857
 - fair-queue interface, 270, 863
 - fair-queue qos-group, 869
 - hold-queue x out interface, 250
 - match, 176
 - match protocol class-map, 185
 - no fair-queue, 250
 - no priority-group interface, 245
 - random-detect interface, 447
 - rate-limit interface, 195
 - tx-cos my-sample interface, 877
 - tx-ring-limit 1 interface, 245

- subinterfaces
 - CAR policing, 398–420
 - queuing, 245–247
 - traffic shaping, 338–340
- subnet bandwidth management (SBM), 617
- supervisor and switching engines, 698
- Supervisor Engine I, 718
- Supervisor Engine II, 718
- Supervisor Engine III, 719
- Supervisor Engine IV, 719
- support platforms, RAI, 590
- switches
 - Catalyst, 698
 - 3500, 721–756
 - 3524, 722–723
 - 4500/4000, 717–755
 - 6500, 698–753
 - Catalyst OS configuration, 724–735
 - Catalyst OS IOS, 736–746
 - configuring, 723
 - GSR, 168
 - MDRR, 871–877
 - GSRs, 845
 - PSTN, 545
 - RSP cards, 861
- switchport priority extend cos command, 740
- synchronization
 - H.323 networks, 611
 - RSVP, 612
- Systems Network Architecture (SNA), 169

T

- tail drop, 11, 96–97
 - congestion-avoidance, 432–433
 - decreasing, 237
 - dWFQ, 863
 - WFQ, 258
- TCP (Transmission Control Protocol), 58
 - acknowledgements, 59
 - applications, 66
 - compression, 490–494
 - error recovery, 60
 - header compression, 490–494
 - packet loss, 428–431
 - starvation, 432–433
- TCP/IP (Transmission Control Protocol/Internet Protocol), 298
- TDM (time-division multiplexing), 259, 545
- Telnet devices, configuring, 663
- terminology, DiffServ, 114–119
- TFTP (Trivial File Transfer Protocol), 65
- three-headed policers, 96
- thresholds
 - CDT, 265
 - Ethernet, 702
 - drop, 695–696
 - logic, 436
- Time Exceeded ICMP message, 298
- time-division multiplexing (TDM), 259, 545
- token buckets
 - Be, 335–336
 - CAR, 343, 345
 - CB, 349
- toll-bypass environments, 545
- tools
 - CAC, 101
 - classification, 86–89, 158–162, 214–216
 - compression. *See* compression
 - congestion-avoidance
 - FRED, 456–465
 - RED, 428–437
 - WRED, 437–455
 - LFI, 494–496
 - FRF.12, 499–506, 515–527
 - MLP, 506–515
 - multipoint PPP, 497–499
 - management, 660
 - IPM, 666
 - QDM, 660–661
 - QPM, 662–664
 - SAA, 664–680
 - SMS, 666–667
 - marking
 - CB marking, 175–184
 - comparing, 214–216
 - NBAR, 185–189
 - show commands, 189–193
 - policing, 93–96
 - QoS
 - bandwidth, 11–13
 - delay, 24–27
 - IOS, 86–142
 - jitter, 28
 - management, 102–103
 - queuing, 239, 248–249, 845
 - CBWFQ, 272–288
 - CQ, 254–305, 854–861
 - dWFQ, 861–870

- FIFO, 249–251
- interfaces, 245–247
- IP RTP Priority, 296–298
- LLQ, 288–296
- MDRR, 871–877
- PQ, 251–254, 845–854
- WFQ, 257–308
- shaping, 93–96
- traffic policing, 388–390
 - CAR, 398–420
 - CB policing, 390–398
- traffic shaping, 351
 - CB shaping, 357–369
 - DTS, 369–370
 - FRTS, 370–388
 - GTS, 351–357
- topologies
 - multizone, 597
 - single-zone, 596
- ToS (type of service), 169
- ToS-based dWFQ, 865. *See also* dWFQ
- traffic
 - bandwidth, 9–13
 - CAC, 544
 - bandwidth, 546–552
 - call rerouting, 545–546
 - local voice, 554
 - LVBO, 569–571
 - Max-Connections, 556–631
 - measurement-based, 571–638
 - mechanisms, 552–629
 - physical DS0 limitations, 554–629
 - resource-based, 584–650
 - trunking, 566–633
 - VoFR, 563–632
 - CAR policing, 398–420
 - CB policing, 390–398
 - CB shaping, 357–369
 - classification, 158–162
 - conditioners, 129–132
 - contracts, 323
 - data (troubleshooting), 57–66
 - delay
 - components of, 39
 - optimizing, 13–27
 - DTS, 369–370
 - FRTS, 370–388
 - GTS, 351–357
 - jitter, 27–29
 - NBAR, 185
 - optimizing, 7–9
 - PBR, 201–207
 - policing, 93–96, 322–323
 - CAR, 193–200
 - connections, 343–351
 - implementing, 323–330
 - tools, 388
 - QoS requirements, 32–33
 - shaping, 26, 93–96, 322–323
 - connections, 330–343
 - implementing, 323–330
 - tools, 351
 - TCP starvation, 432–433
 - video, 52–57
 - voice
 - marking payloads, 212
 - troubleshooting, 33–52
- Transmission Control Protocol. *See* TCP
- Transmit Queue, 239–245
- Transmit Ring, 239–245
- Trivial File Transfer Protocol (TFTP), 65
- troubleshooting
 - congestion, 90–93. *See also* congestion
 - QoS
 - bandwidth, 11–13
 - data, 57–66
 - delay, 24–27
 - jitter, 28
 - video, 52–57
 - voice, 33–52
 - RSVP, 621
- trunking
 - CAS, 546
 - CCS, 546
 - conditioning, 566–633
 - ISL (LAN CoS), 166–168
- trust
 - boundaries, 171, 696, 728, 740
 - enabling, 729
- trust-ext command, 729
- trust-ipprec port keyword, 731
- two-headed policers, 96
- TX Queues (Transmit Queues), 239–245
- TX Rings (Transmit Rings), 239–245
- tx-cos command, 876
- tx-cos my-sample interface subcommand, 877
- tx-ring-limit 1 interface subcommand, 245
- type of service (ToS), 169

U-V

UDP (User Datagram Protocol), 58
 error recovery, 65
 packet loss, 428–431
 untagged frames, 729, 741

VAD (Voice Activation Detection), 38, 189
 values
 compression, 482
 CoS, 730
 DSCP-based WRED, 440
 precedence, 120
 QV, 872
 WFQ, 262

variable delay components, 673, 683

VC (virtual circuit), 10
 queuing, 245–247
 traffic shaping, 338–340

Versatile Interface Processors (VIPs), 484, 861

video
 bandwidth, 54–55
 codecs, 54, 676
 conferences, 52
 delay, 55
 design, 673–678
 jitter, 56
 loss, 57
 payloads, 54
 traffic characteristics of, 32–33, 52–57

viewing QoS, 732, 743

VIPs (Versatile Interface Processors), 484, 861

virtual circuit. *See* VC

VLANs (virtual LANs)
 auxiliary, 725
 IOS, 737

VoATM (Voice over ATM), 33

VoFR (Voice over Frame Relay), 33, 563–632

voice
 CAC, 544
 bandwidth, 546–552
 call rerouting, 545–546
 local voice, 554
 LVBO, 569–571
 Max-Connections, 556–631
 measurement-based, 571–638
 mechanisms, 552–629
 physical DS0 limitations, 554–629
 resource-based, 584–650
 trunking, 566–633
 VoFR, 563–632

delay, 39
 design, 673–678
 gateways, 209
 jitter, 48
 loss, 49
 packets, 549, 615
 payload traffic, 212
 traffic characteristics of, 32–52
 VLANs, 737

Voice Activation Detection (VAD), 38, 189

Voice over ATM (VoATM), 33

Voice over Frame Relay (VoFR), 33, 563–632

voice-like profile, 624

VoIP (Voice over IP), 33
 dial peer, 207–214
 physical DS0 limitations, 554

W-Z

WAN, 731, 743

weight keyword, 877

WFQ (Weighted Fair Queuing), 257–308, 845
 dWFQ, 861–870
 GTS, 354

windows, sliding, 60

WRED (Weighted Random Early Detection)
 CBWFQ, 273
 congestion-avoidance, 437–455

zone-per-gateway design, 601