

Numerics

- 1+1 protection (APS), 91–92
- 10 Gigabit Ethernet, 17
- 12xxx Series DPT line cards, 387
- 200-GHz filters, channels, 273
- 2-fiber BLSR, 192
- 802.3X flow control, 226

A

- A1 byte (SOH), 73
- access services, MANs, 6
- ADMs (add/drop multiplexers), SONET, 81
- aggregate to per channel power conversions,
 - DWDM networks, 418–420
- AIC (alarm indicator cards), 150
- ais-shut interface configuration command, 319
- alarms
 - PoS (Packet over SONET), 305–306, 319–320
 - SONET, 126
 - error-causing events, 126–127
 - error-event propagation, 127–129
 - performance event collection, 129–130
- A-Law, 41–42
- algorithms, SRP-fa (SRP fairness algorithm), 360
 - congestion, 364–365
 - monitoring, 365
 - packet handling, 360–363
- Alternate Mark Inversion, 35
- American National Standards Institute (ANSI), 47
- amplification, analog signals, 30
- amplifiers. *See* regenerators
- analog signals, 29
 - amplification, 30
 - attenuation, 30
 - distortion, 30, 32
 - FDM (frequency-division modulation), 34
 - PCM (pulse code modulation), 34
 - regenerators, 31

- ANSI (American National Standards Institute), 47
- application-specific integrated circuit (ASIC)-based queuing, PoS line cards, 313
- APS (automatic protection switching)
 - 1+1 protection, 91–92
 - bidirectional protection switching, 94–95
 - BLSRs (bidirectional line-switched rings), 104–122
 - four-fiber BLSRs, 122–124
 - two-fiber BLSRs, 104–122
 - commands, (PoS), 323
 - nonrevertive protection, 95–96
 - revertive protection, 96
 - SONET, 89–124
 - UPSR (unidirectional path-switched ring), 93–104
- APS 1+1 protection scheme (SONET), 298–299
- aps protect command (PoS), 323
- arming keys, OC-48 ELR optics cards, 279
- ARP, DPT rings, 356
- ATM (Asynchronous Transfer Mode), 6
 - PoS (Packet over SONET), 288
 - switches, 288
- attenuation, 31
 - analog signals, 30
 - calculating, 414
- automatic protection switching (APS). *See* APS

B

- B1 bytes (SOH), 74
- B2 bytes (SOH), 76
- B3 byte (POH), 78
- Bell, Alexander Graham, 29
- bidirectional layer switched rings (BLSRs). *See* BLSRs
- bidirectional protection switching, 94–95
- BIP (bit interleaved parity) errors, 305

- bit stuffing, eliminating, SONET, 59–60
- BLSRs (bidirectional layer switched rings), 104–122, 182, 331
 - four-fiber BLSR rings, 122–124, 192
 - creating, 197–198
 - protection, 110–122
 - provisioning, 196
 - SONET, 125
 - two-fiber BLSR rings, 104–110, 192
 - creating, 195

C

- C2 signal label byte (POH), 78
- calculating attenuation, 414
- campus LANs, DPT (Dynamic Packet Transport), 337
- CAR (committed access rate), 206, 288
- Card view (CTC), 158
- card-mode configuration, metro Ethernet circuits, 236–239
- cards, activating, 189
- CEF tables, Cisco PoS line cards, 313
- cell taxes, 285
- channel spacing, 262–263
- channels, 200-GHz filters, 273
- Circuit Attributes dialog box, 242
- Circuit Destination dialog box, 245
- Circuit Routing Preferences dialog box, 246
- Circuit Source dialog box, 244
- Circuit VLAN Selection dialog box, 246
- circuits, metro Ethernet
 - configuring, 144–160, 235–241
 - creating, 242–249
 - troubleshooting, 251
 - verification, 249–250
- Cisco 12000 Series line cards, PoS, 312–315
- Cisco 12000 Series routers, PoS networks, 312
- Cisco Transport Controller (CTC). *See* CTC
- Cisco Transport Manager (CTM), 131
- Cisco WAN Quick Start, 35
- clock source internal command, 327
- clocking, PoS interfaces, 318
- coarse wavelength division multiplexing (CWDM), 6
- commands
 - clock source internal command, 327
 - DPT (Dynamic Packet Transport), 393–394
 - debug commands, 400–404
 - show commands, 394–400
 - loopback command, 327
 - ping command, 327
 - PoS
 - ais-shut interface configuration command, 319
 - APS commands, 323
 - show commands, 324–326
 - show interface pos slot/interface, 317
 - committed access rate (CAR), 206, 288
 - committed information rate (CIR) services, 285
 - companding digital voice signals, 34
 - composite channels, 264
 - configuration
 - DPT (Dynamic Packet Transport), 392–394
 - automatic configurations, 357–358
 - commands, 393–394
 - ONS optical platforms, 165
 - entering node information, 168–176
 - initial configuration, 165–184, 189–195
 - rings, 190–198
 - SONET timing, 177–189
 - PoS
 - interfaces, 315–323
 - physical fiber configuration, 314–315
 - verification, 327
 - VLANs, 239–241
 - congestion, SRP-fa (SRP fairness algorithm), 364–365
 - containment, high-order containment, PoS (Packet over SONET), 290–293
 - control cards
 - ONS 15327 optical platform, 156
 - ONS 15454 optical platform, 148–149
 - AIC cards, 150
 - TCC+ cards, 148

- XC cards, 149–150
- XC-10G cards, 150
- XC-VT cards, 149
- control messages, IPS, 367
- control packets, SRP packets, 342
- convergence time, PoS (Packet over SONET), 302–303
- cores, MANs, 5–7
- corporate network transmission requirements, 12–13
- CPE (customer premises equipment)
 - metropolitan Ethernet, 209–212
 - SONET Ring hierarchy, 210
- Create BLSR dialog box, 196
- cross-connecting, 83
- CTC (Cisco Transport Controller), 157, 167, 217
 - alarms, displaying, 170
 - hardware requirements, 165
 - node configuration and management, 158–160
 - troubleshooting, 167–168
 - views, 158
- CTM (Cisco Transport Manager), 131
- customer premises equipment (CPE). *See* CPE
- CWDM (coarse wavelength division multiplexing), 6

D

- D4 frame format, 39
- data networking, MAONs, 11
- data services (layer 2), 12
- DCEF (Distributed Cisco Express Forwarding), 313
- DCSs (digital cross-connects), 83–84
- debug commands, DPT (Dynamic Packet Transport), 400–404
 - debug srp ips command (DPT), 402
 - debug srp nodename command (DPT), 402
 - debug srp packet command (DPT), 402
 - debug srp periodic activity command (DPT), 403
 - debug srp protocol error command (DPT), 401
 - debug srp topology command (DPT), 403–404
- degradation, signals, DPT, 375–378
 - dense wavelength division multiplexing (DWDM). *See* DWDM
- dialog boxes
 - Circuit Attributes, 242
 - Circuit Destination, 245
 - Circuit Routing Preferences, 246
 - Circuit Source, 244
 - Circuit VLAN Selection, 246
 - Create BLSR, 196
 - Ring Creation, 197
 - Route Review and Edit, 248
- digital cross-connects (DCSs). *See* DCSs, 83–84
- digital hierarchies, 36–47
 - international markets, developing in, 40–44
 - international digital hierarchies, 41
 - North America, 40
- digital loop carriers (DLCs), 85
- digital signal level 0 (DS0), 37
- digital subscriber line (DSL), 6
- digital system, samples, 32
- digital voice transmissions, 33–35
- distance, calculating, formulas, 421
- distortion, analog signals, 30–32
- Distributed Cisco Express Forwarding (DCEF), 313
- DLCs (digital loop carriers), SONET, 85
- DPT (Dynamic Packet Transport), 3, 22–23, 331–335, 385
 - 12xxx Series DPT line cards, 387
 - campus LANs, 337
 - commands
 - debug commands, 400–404
 - show commands, 394–400
 - configuring, 392–394
 - failures, signal degradation, 375–378
 - hierarchical ring structures, 338
 - IP encapsulation, 339
 - IPS (intelligent protection switching), 366–368
 - line cards, benefits, 389
 - Metro IP access ring, 386–391
 - node states, 369–378
 - ONS SONET rings, 386–391, 404–407

- Pass-through mode, 369
 - platforms, 385–386
 - QoS (Quality of Service), 359
 - SRP-fa (SRP fairness algorithm), 360–365
 - queues, 352
 - reconfiguring automatically, 366–368
 - rerouting automatically, 366–368
 - ring operations, 369–378
 - ring transporting, 334
 - rings, 354
 - ARP, 356
 - automatic configurations, 357–358
 - creating, 390–391
 - Ethernet, 355–357
 - SRP ring selection, 354
 - routers, 335
 - single-fiber failures, 371–374
 - SONET, 389
 - internetworking, 335–338
 - SRP (Spatial Reuse Protocol), 338–339
 - packets, 340–354
 - protection, 339–340
 - troubleshooting, 394–404
 - two-fiber failures, 375
 - verification, 394–404
- drop and continue nodes, SONET, 85
- DS0 (digital signal level 0), 37
- DS1 (digital signal level 1), 37
- DSL (digital subscriber line), 6
- DWDM (dense wavelength division multiplexing), 3, 24, 206, 261
 - architecture, 267
 - components, 263
 - filters, 264
 - mid-span amplifiers, 265
 - OADM (optical add/drop multiplexer), 266
 - O-E-O (optical-electrical-optical), 266
 - optical amplifiers, 264
 - OXC (optical cross-connect), 266
 - post amplifiers, 265
 - pre-amplifiers, 265
 - receivers, 264
 - transmitters, 263
 - transponders, 263
- EoDWDM (Ethernet over DWDM), 217
- equipment, 269
- frequencies, 257
- infrastructure, building, 276–278
- limitations, 267
 - linear, 267–268
 - nonlinear, 268–269
- LTE (line termination equipment), 266
- MANs
 - challenges, 255–268, 273–280
 - network requirements, 278–279
- OC-48 ELR ITU optics cards, 270–272
 - provisioning, 279–280
- ONS 15216 filters, 273–274
- optical signals, multiplexing, 257–261
- per-channel power, 420
- power conversion, 418–420
- Dynamic Packet Transport (DPT). *See* DPT

E

- E1 circuits, 37
- E1 orderwire bytes (SOH), 74
- E1 voice transmissions, 42
- E1000-2/E1000-2-G cards, 225
- E100T-12/E100T-12-G cards, 224
- E2 orderwire bytes (SOH), 77
- Edge Service Router (ESR), 312
- electrical cards
 - ONS 15327 optical platform, 156
 - ONS 15454 optical platform, 150–152
- encapsulation, PoS interfaces, 317
- end-to-end Ethernet link integrity, 227
- Enterprise Systems Connection (ESCON), 6, 17
- EoDWDM (Ethernet over DWDM), 217
- EoMPLS (Ethernet over MPLS), 206

EoS (Ethernet over SONET), 216
 error-event propagation, SONET, 127–129
 ESCON (Enterprise Systems Connection), 6, 17
 ESF (extended super frame), 38–40
 ESR (Edge Service Router), 212
 Ethernet, 13–14

- 10 Gigabit Ethernet, 17
- advantages, 14
- cost, 15
- DPT rings, 355–357
- end-to-end Ethernet link integrity, 227
- EoDWDM (Ethernet over DWDM), 217
- EoMPLS (Ethernet over MPLS), 206
- EoS (Ethernet over SONET), 216
- ESCON (Enterprise Systems Connection), 17
- Fibre Channel, 17
- flexibility of, 15
- Gigabit Ethernet, 17
- iSCSI (Internet Small Computer System Interface), 17
- metro mirroring, 18
- metropolitan Ethernet, 203–206
 - architectures, 206–215
 - transporting, 215–216
- Priority Queuing support, 223
- remote mirroring, 18
- SANs (storage-area networks), 15–16
- simplicity of, 15
- speed, 15
- storage service providers, 16–17

 Ethernet cards

- ONS 15327 optical platform, 157
- ONS 15454 optical platform, 154

 Ethernet over MPLS (EoMPLS), 206
 Ethernet over SONET (EoS), 216
 European digital hierarchies, 41
 event hierarchy, IPS, 367
 extended super frame (ESF), 38–40

F

F1 user defined bytes (SOH), 74
 F2 user channel (POH), 78
 failures, DPT

- single-fiber failures, 371–374
- signal degradation, 375–378
- two-fiber failures, 375

 FDM (frequency-division multiplexing), 34
 fiber-loss variables, metro optical networks, 414
 fiber-optic cable, 31
 Fibre Channel, 17
 filter connectors, cleaning, 277
 filters, 264
 fixed wireless services, 6
 flapping, PoS (Packet over SONET), 303–304
 four-fiber BLSR rings, 122–124, 192

- creating, 197–198

 frame formats, 38

- D4 frame format, 39
- ESF (extended super frame), 38–40

 Frame Relay services, 6
 framing

- PoS interfaces, 317
- SONET, 68–73
 - LOH (line overhead), 75–77
 - POH (path overhead), 77–79
 - SOH (section overhead), 72–74

 frequencies

- computing, 258
- DWDM systems, 257

 frequency-division multiplexing (FDM), 34

G-H

G1 path status byte (POH), 78
 Gigabit Ethernet, 17
 H1 and H2 pointers (SOH), 75
 H3 pointer action byte (SOH), 76
 H4 multiframe indicator (POH), 79

- handling packets, 350–354
 - SRP-fa (SRP fairness algorithm), 360–363
- hard failures, 368
- HDLC (High-Level Data Link Control) protocol, 286
 - PoS interfaces, 317
- headers, SRP packets, 341
- High-Level Data Link Control (HDLC) protocol.
See HDLC
- high-order containment, PoS (Packet over SONET), 290–293
- HSRP (Hot Standby Router Protocol), 300

I

- IEEE 802.1D Spanning Tree Protocol (STP), 222–223
- IEEE 802.1p Priority Queuing support
 - Ethernet, 223
- IEEE 802.1Q VLANs, 223
- injection loss, fiber-optic cable, 31
- interfaces, PoS (Packet over SONET)
 - accessing, 316
 - ais-shut interface configuration command, 319
 - alarm thresholds, 319–320
 - clocking, 318
 - configuring, 315–323
 - CRC (cyclic redundancy check), 318
 - encapsulation, 317
 - framing, 317
 - IP addresses, 316
 - loopbacks, 327
 - payload scrambling, 317
 - with APS protection, 321–323
 - without protection, 321
- international digital hierarchies, 41
- Internet Small Computer System Interface (iSCSI), 14
- IP addresses, PoS interfaces, 316
- IP encapsulation, DPT (Dynamic Packet Transport), 339
- IP Quality of Service, 288

- IP services (Layer 3), 12
- IP+Optical networks, 333
- IPS (intelligent protection switching), 366–368
 - control messages, 367
 - DPT (Dynamic Packet Transport), 366–368
 - event hierarchy, 367
 - failure and recovery, 366
 - signaling, 368
 - SRP, 345
- iSCSI (Internet Small Computer System Interface), 17

J-L

- J0/Z0/C1 bytes (SOH), 74
- J1 circuits, 37
- J1 trace byte (POH), 77
- K1 and K2 bytes (SOH), 76
- layers, SONET, 61–62
 - line layer, 64–66
 - path layer, 65–68
 - photonic layer, 62
 - section layer, 62–64
- line layer, SONET, 64–66
- line overhead (LOH), 75–77
- line termination equipment (LTE), 266
- linear limitations, DWDM, 267–268
- linear networks, timing in, 177–178
- load balancing, PoS (Packet over SONET), 304–305
- LOF (loss of frame), 305
- LOH (line overhead), SONET frames, 75–77
- long-haul backbones, MANs, 5
- long-haul transports, POP interconnects, 213–215
- loopbacks, PoS, 327
- LOP (loss of pointer), 305
- LOS (loss of signal), 305
- LTE (line termination equipment), DWDM, 266

M

- M0/M1/Z2 bytes (SOH), 76
- M12 multiplexing, 45
- M23 multiplexing, 45
- MANs (metropolitan-area networks), 3, 255
 - architecture, 4–9, 12, 16–23
 - challenges, 255–257, 261–263, 267–268, 273–274, 277–280
 - choosing, 143–146, 152, 156, 160
 - cores, 5, 7
 - DPT, 333–335
 - metro optical space, 4
 - services
 - access services, 6
 - metro optical services, 6
 - service POPs, 5-7
 - service traffic patterns, 9-10
- MAONs (metropolitan area optical networks), 3
 - corporate network transmission requirements, 12–13
 - data networking, 11
 - physical topologies, 9
 - private line aggregation, 10
 - Ring topologies, 8
 - transparent lambda, 10
- mesh topology, SONET, 87–88
- metro Ethernet services, 3, 21
- Metro IP access rings, DPT, 386–391
- metro mirroring, Ethernet, 18
- metro optical networks, designing
 - component manufacturers, 412
 - customer requirements, 412
 - fiber manufacturers, 413
 - fiber-loss variables, 414
 - ONS 15216 product specifications, 415–416
 - ONS 15454 line cards, 416–417
 - physical technical specifications, 413–414
 - service providers, 413
 - system manufacturers, 412
- metro optical space, MANs, 4
- metro rings, timing in, 179–180
- metropolitan area optical networks (MAONs). *See* MAONs
- metropolitan Ethernet, 203–206
 - architectures, 206–215
 - CPE (customer premises equipment), 209–212
 - POP Interconnect, 213–215
 - circuits
 - configuring, 144-146, 152, 156, 160, 235–241
 - creating, 242–249
 - troubleshooting, 251
 - verification, 249–250
 - transporting, 215–216
 - EoDWDM, 217
 - EoS (Ethernet over SONET), 216
 - P2P circuits, 218–219
 - QoS, 220–222
 - shared packet rings, 218–220
 - shared point-to-multipoint circuits, 218–220
- metropolitan-area networks (MANs). *See* MANs
- mid-span amplifiers, DWDM mid-span amplifiers, 265
- mirroring, Ethernet, 18
- mixed timing, 185
- modeling SRP-fa (SRP fairness algorithm), 362
- modems (modulator/demodulators), 36
- Modular QoS CLI (MQC), 206
- MQC (Modulator QoS CLI), 206
- Multiaccess Protocol, PoS (Packet over SONET), 290
- multicast packets (SRP), 347
- multiple virtual-output queues, Cisco PoS line cards, 313
- multiplexing, 81
 - channel spacing, 262–263
 - optical signals, DWDM, 257–261
 - single-step multiplexing, SONET, 57

N

- negative timing adjustments, 76
- network elements, SONET, 79–80
 - ADMs (add/drop multiplexers), 81
 - DCSs, 83–84
 - DLCs (digital loop carriers), 85
 - drop and continue nodes, 85
 - regenerators, 82–83
 - TM (terminal multiplexer), 80–81
- Network view (CTC), 158
- node information, ONS optical platforms, entering, 168–176
- node states, DPT, 369–378
- Node view (CTC), 158
- nonlinear limitations, DWDM, 268–269
- nonrevertive protection (APS), 95–96
- North American digital hierarchies, 40
- numeric aperture, fiber-optic cable, 31
- Nyquist rule, 32

O

- OADM (optical add/drop multiplexers)
 - DWDM, 266
 - optical power levels, 419
- OAM&P (operations, administration, maintenance, and provisioning) functionality, 203, 331
- OC-48 ELR ITU optics, 270–272
- OC-48 ELR ITU optics cards, 270–272
 - arming keys, 279
 - provisioning, 279–280
- OCX (optical cross-connect), DWDM, 266
- O-E-O (optical-electrical-optical), DWDM, 266
- ONS (Optical Networking Systems) devices, 206, 225
 - specifications, 415–416
- ONS 15216 filters
 - DWDM, 273–274

- ONS 15327 optical platform, 155–156
 - configuring, 165
 - entering node information, 168–176
 - initial configuration, 165–184, 189–195
 - rings, 190–198
 - SONET timing, 177–189
- control cards, 156
- electrical cards, 156
- Ethernet cards, 157
- optical cards, 157
- ONS 15454 E-series cards, 224
- ONS 15454 G-Series cards, 226–228, 416–417
- ONS 15454 optical platform, 145–148
 - configuring, 165
 - entering node information, 168–176
 - initial configuration, 165–173, 176–184, 189–195
 - rings, 190–198
 - SONET timing, 177–189
- control cards, 148–149
 - AIC cards, 150
 - TCC+ cards, 148
 - XC cards, 149–150
 - XC-10G cards, 150
 - XC-VT cards, 149
- electrical cards, 150–152
- Ethernet cards, 154
- optical cards, 153
- ONS 15454/15327 optical platforms, 143
 - MANs, choosing, 143–146, 152, 156, 160
- ONS SONET rings, DPT (Dynamic Packet Transport), 386–391, 404–407
- operations, administration, maintenance, and provisioning (OAM&P), 203, 331
- operator-initiated events, 368
- optical amplifiers, DWDM optical amplifiers, 264
- optical cards
 - ONS 15327 optical platform, 157
 - ONS 15454 optical platform, 153

Optical Networking Systems (ONS) devices. *See* ONS devices

optical networks, 333

Optical Services Router (OSR), 206

optical signals, multiplexing, DWDM, 257–261

Optical Signal-to-Noise Ratio (OSNR), 420

optical systems, span-loss calculations, 275–276

oscillation signals, 258

OSNR (Optical Signal-to-Noise Ratio), 420

OSR (Optical Services Router), 206

overhead, user traffic, 38

overhead efficiency, PoS (Packet over SONET), 294–295

overhead layers, 333

P

P2P circuits, metropolitan Ethernet, 218–219

Packet over SONET (PoS). *See* PoS

packet rings, shared packet rings, metro Ethernet, 218–220

packets

- handling, 350–354
 - SRP-fa (SRP fairness algorithm), 360–363
- processing, 348–350
- SRP packets, 340–350
- transmit processing, 353

Pass-through mode, DPT, 369

path layer, SONET, 65–68

path overhead (POH), 77–79

path-protected mesh networks (PPMN), 124–126

payload scrambling, PoS (Packet over SONET), 290, 293–294, 317

PCM (pulse code modulation), 34

PDH (plesiochronous digital hierarchy), 45

per-channel power, DWDM networks, 420

performance event collection, SONET, 129–130

PGP (Protect Group Protocol), 300

photonic layer, SONET, 62

physical fiber configuration, PoS (Packet over SONET), 314–315

physical interface loopbacks, PoS (Packet over SONET), 327

physical topologies, MAONs, 9

ping command, PoS configuration verification, 327

plesiochronous digital hierarchy (PDH), 45

POH (path overhead), SONET frames, 77–79

point of demarcation, 209

point-to-multipoint shared circuits, metro Ethernet, 218–220

point-to-multipoint/linear topology, SONET, 86

Point-to-Point Protocol (PPP), 286

point-to-point topology, SONET, 86

POP interconnects, 212–215

port options, metro Ethernet, configuring, 237–239

PoS (Packet over SONET), 3, 22, 285

- applications, 287
 - ATM technology, 288
 - Multiaccess Protocol, 290
 - transport, 289
- APS commands, 323
- Cisco 1200 Series routers, 312
- Cisco 12000 Series line cards, 312–315
- configuring
 - interfaces, 315–323
 - physical fiber configuration, 314–315
 - verification, 327
- CRC (cyclic redundancy check), 318
- high-order containment, 290–293
- interfaces
 - accessing, 316
 - ais-shut interface configuration command, 319
 - alarm thresholds, 319–320
 - clocking, 318
 - encapsulation, 317
 - framing, 317
 - IP addresses, 316
 - loopbacks, 327
 - with APS protection, 321–323
 - without protection, 321

- network designs, 295–296
 - alarms, 305–306
 - convergence time, 302–303
 - flapping, 303–304
 - load balancing, 304–305
 - one router, 296
 - protection schemes, 298–301
 - two routers, 296–298
- octet alignment, 290
- overhead efficiency, 294–295
- payload scrambling, 290, 293–294, 317
- protection mechanism, 299
- Reflector mode, 304
 - show commands, 324–326
- positive timing adjustments, 76
- post amplifiers, DWDM post amplifiers, 265
- power budge calculation, 421
- power conversion, DWDM networks, 418–420
- PPMN (path-protected mesh networks), SONET, 124–126
- PPP (Point-to-Point Protocol), 286
- PRC (primary reference clock), 178
- pre-amplifiers, DWDM pre-amplifiers, 265
- primary reference clock (PRC), 178
- primary reference source (PRS), 178
- Priority Queuing support, Ethernet, 223
- private line aggregation, 10
- Protect Group Protocol (PGP), 300
- PRS (primary reference source), 178
- pulse code modulation (PCM), 34

Q-R

- QoS (Quality of Service)
 - DPT (Dynamic Packet Transport), 359
 - SRP-fa (SRP fairness algorithm), 360–365
 - metropolitan Ethernet, 220–222
- quantizing digital voice signals, 34
- queues, DPT (Dynamic Packet Transport), 352
- Rapid Spanning Tree Protocol (RSTP), 223

- receivers
 - decibel meters, 275
 - DWDM receivers, 264
- Reeves, Alec, 33
- Reflector mode, PoS (Packet over SONET), 304
- regenerators
 - analog signals, 31
 - SONET, 82–83
- remote mirroring, Ethernet, 18
- repeaters, 31
- Resource Reservation Protocol (RSVP), 288
- revertive protection (APS), 96
- RFC 2615, *Payload Scrambler*, 294
- Ring Creation dialog box, 197
- Ring topologies, 8, 88–89
- rings
 - BLSRs (bidirectional layer switched rings), 331
 - configuring, ONS optical platforms, 190–198
 - DPT (Dynamic Packet Transport), 354
 - automatic configurations, 357–358
 - creating, 390–391
 - Ethernet, 355–357
 - operations, 369–378
 - SRP ring selection, 354
 - four-fiber BLSR rings, creating, 197–198
 - metro rings, timing in, 179–180
 - SONET, 299
 - synchronization, 181–189
 - transporting, DPT, 334
 - two-fiber BLSR rings, creating, 195
 - UPSRs (unidirectional path switched rings), 331
 - configuration verification, 194–195
 - creating, 193
- Route Review and Edit dialog box, 248
- routers, DPT (Dynamic Packet Transport), 335
- RPR (Resilient Packet Ring). *See* DPT (Dynamic Packet Transport)
- RSTP (Rapid Spanning Tree Protocol), 223
- RSVP (Resource Reservation Protocol), 288

S

- S1/Z1 bytes (SOH), 76
- samples, digital signals, 32
- SANs (storage-area networks), Ethernet, 15–16
- scalable IP network routing protocols, 302
- scrambling, payload, PoS (Packet over SONET), 290, 293–294, 317
- SDH (Synchronous Digital Hierarchy), 3, 51
 - SONET/SDH, 51–56
- SDLC (Synchronous Data Link Control) protocol, 286
- section layer, SONET, 62–64
- section overhead (SOH), 72–74
- section terminating equipment (STE), 62
- Service Level Agreements (SLAs), 295
- service POPs, 5–7
- service providers (SPs). *See* SPs
- service traffic patterns, MANs, 9–10
- Shannon, Claude, 34
- shared packet rings, metropolitan Ethernet, 218–220
- shared point-to-multipoint circuits, metropolitan Ethernet, 218–220
- show aps command, 326
- show commands
 - DPT (Dynamic Packet Transport), 394–400
 - PoS, 324–326
- show controllers pos command, 324–325
- show controllers srp command (DPT), 398–399
- show diag command (DPT), 398
- show interface pos slot/interface command, 317
- show interfaces pos command, 325–326
- show interfaces srp command (DPT), 395
- show protocols pos command, 325
- show srp command (DPT), 396–397
- show srp topology command (DPT), 400
- show version command (DPT), 397
- signal loss, calculating, formula, 421
- signaling, IPS, 368
- signals
 - DPT, degradation, 375–378
 - oscillation, 258
- single-fiber failures, DPT, 371–374
- single-step multiplexing, SONET, 57
- SLAs (Service Level Agreements), 295
- SMDS (Switched Multimegabit Data Service), 205
- soft failure, 368
- SOH (section overhead), SONET frames, 72–74
- SONET (Synchronous Optical Networking), 3, 20–21, 47, 331
 - advantages of, 56
 - alarms, 126
 - error-causing events, 126–127
 - error-event propagation, 127–129
 - performance event collection, 129–130
 - APS 1+1 protection scheme, 298–299
 - bit stuffing, eliminating, 59–60
 - Cisco enhancements, 131–134
 - digital hierarchy, 54–56
 - DPT (Dynamic Packet Transport), 389
 - internetworking, 335–338
 - EoS (Ethernet over SONET), 216
 - framing, 68–73
 - LOH (line overhead), 75–77
 - POH (path overhead), 77–79
 - SOH (section overhead), 72–74
 - high-speed data transmissions, 61
 - layers, 61–62
 - line layer, 64–66
 - path layer, 65–68
 - photonic layer, 62
 - section layer, 62–64
 - low-level signal access, 57
 - management devices, 131
 - network elements, 79–80
 - ADMs (add/drop multiplexers), 81
 - DLCs (digital loop carriers), 85
 - drop and continue nodes, 85
 - regenerators, 82–83
 - TM (terminal multiplexer), 80–81

- PoS, 285
 - applications, 287–290
 - Cisco 12000 Series line cards, 312–315
 - Cisco Series 1200 Series routers, 312
 - high-order containment, 290–293
 - interface configuration, 315–323
 - network designs, 295–296
 - alarms, 305–306
 - convergence time, 302–303
 - flapping, 303–304
 - load balancing, 304–305
 - one router, 296
 - protection schemes, 298–301
 - two routers, 296–298
 - octet alignment, 290
 - overhead efficiency, 294–295
 - payload scrambling, 290, 293–294
 - physical fiber configuration, 314–315
 - protection mechanism, 299
- RFC 2615, *Payload Scrambler*, 294
- rings, 299
 - synchronization, 181–189
- single-step multiplexing, 57
- SONET DCS, 83–84
- SONET/SDH, 51–56
- TOH (transport overhead), 75
- topologies, 85
 - APS (automatic protection switching), 89–124
 - BLSR rings, 125
 - mesh topology, 87–88
 - point-to-multipoint/linear topology, 86
 - point-to-point topology, 86
 - PPMN (path-protected mesh networks), 124–126
 - ring topology, 88–89
- UPSR rings, creating, 193
- virtual tributaries, 57–58
- VTGs, 70–71
- SONET Ring hierarchy, CPE (customer premises equipment), 210
- SONET timing, configuring, 177–189
- SONET/SDH, 51–56
- span switches, 123
- span-loss calculations, optical systems, 275–276
- Spanning Tree Protocol (STP). *See* STP
- SPE (Synchronous Payload Envelope), 60
- SPS (synchronization protection switching), 182
- SPs (service providers), 3
 - categories, 413
 - MANs, challenges, 255–280
 - modern challenges, 3
 - SLAs (Service Level Agreements), 295
- squelching, two-fiber BLSRs, 118
- SRP, DPT (Dynamic Packet Transport), 338–339, 352–354
 - packets, 340–350
 - protection, 339–340
 - ring selection, 354
 - SRP-fa (SRP fairness algorithm), 360–365
- SRP-fa (SRP fairness algorithm), 360
 - congestion, 364–365
 - modeling, 362
 - monitoring, 365
 - packet handling, 360–363
- static routing, 172
- STE (section terminating equipment), 62
- storage service providers, Ethernet, 16–17
- storage-area networks (SANs), 15–16
- STP (Spanning Tree Protocol), 206
 - IEEE 802.1D support, 222–223
 - RSTP (Rapid Spanning Tree Protocol), 223
- switch oscillation, 303–304
- Switched Multimegabit Data Service (SMDS), 205
- switches, ATM, 288
- synchronization, rings, 181–189
- synchronization protection switching (SPS), 60
- Synchronous Data Link Control (SDLC) protocol, 286
- Synchronous Digital Hierarchy (SDH). *See* SDH
- Synchronous Optical Networking (SONET). *See* SONET

Synchronous Payload Envelope (SPE). *See* SPE
 (Synchronous Payload Envelope)
 synchronous timing, bit stuffing, eliminating, 59–60

T

T1 (T-carrier level 1) lines, 37
 transparent lambda, 10
 T-carrier level 1 (T1) lines. *See* T1 lines, 37
 TCC+ cards, 148
 TDM (time-division multiplexing), 3, 36–38, 331
 Telecommunications Technologies Reference, 45
 telephone, invention of, 29
 terminal multiplexer (TM). *See* TM (terminal multiplexer)
 time-division multiplexing (TDM). *See* TDM (time-division multiplexing)
 timing
 linear networks, 177–178
 metro rings, 179–180
 mixed timing, 185
 TLS (Transparent LAN Services), 3, 21
 TM (terminal multiplexer), SONET, 80–81
 TOH (transport overhead), SONET, 75
 topologies
 MAONs, 9
 SONET, 85
 APS (automatic protection switching), 89–124
 BLSR rings, 125
 mesh topology, SONET, 87–88
 point-to-multipoint/linear topology, SONET, 86
 point-to-point topology, SONET, 86
 PPMN (path-protected mesh networks), 124–126
 ring topology, SONET, 88–89
 topology discovery packets (SRP), 345
 traffic, overhead, 38
 traffic patterns, MANs, 9–10

transporting DPT (Dynamic Packet Transport), 333–338
 transmissions, digital voice, 33
 transmitters
 decibel meters, 275
 DWDM transmitters, 263
 Transparent LAN Services (TLS), 3, 21
 transponders, DWDM transponders, 263
 transport overhead (TOH), 75
 transport services (Layers 0 and 1), 12
 transporting metropolitan Ethernet, 215–216
 EoDWDM, 217
 EoS (Ethernet over SONET), 216
 P2P circuits, 218–219
 PoS (Packet over SONET), 289
 QoS, 220–222
 shared packet rings, 218–220
 shared point-to-multipoint circuits, 218–220
 transmit processing, packets, 353
 troubleshooting
 CTC (Cisco Transport Controller), 167–168
 DPT (Dynamic Packet Transport), 394–404
 metro Ethernet circuits, 251
 tuned lasers with narrow spectral width, 262
 two-fiber BLSR rings, 192, 104–110
 creating, 195
 protection, 110–122
 two-fiber failures, DPT, 375
 Tx and Rx syntax, 277

U

unicast packets (SRP), 346
 unidirectional path switched rings (UPSRs), 93–104
 Universal Transport Interface, 334
 UPSRs (unidirectional path switched rings), 93–104, 182, 235, 331
 configuration, verifying, 194–195
 rings, creating, 193
 usage control packets (SRP), 346
 UTI (Universal Transport Interface), 334

V

verification

- DPT (Dynamic Packet Transport), 394–404

- metro Ethernet circuits, 249–250

Very Short Reach (VSR) optics, 288

virtual tributaries, SONET, 57–58

VLANs

- configuring, 239–241

- IEE 802.1Q VLANs, 223

voice and data network architectures, early advances

- in, 20

voice and data networking, evolution of, 286

voice transmissions, E1 voice transmissions, 42

VSR (Very Short Reach) optics, 288

VTGs, SONET, 70–71

W-Z

wavelength division multiplexing (WDM), 7

wavelengths, frequencies, computing, 258

WDCS (wideband digital cross-connect system), 145

WDM (wavelength division multiplexing), 7

wideband digital cross-connect system, 145

wideband laser signals, 261

XC cards, 149–150

XC-10G cards, 150

XC-VT cards, 149

Z3/Z4/Z5 byte (POH), 79