Numerics

50-ms resiliency, 15–16

A

access control lists (ACLs), 206, 337
access layer, 143, 292–298
accounting, management of, 334–335
accumulated outage time (AOT), 356
achieving high-availability, 16–25
ACLs (access control lists), 206, 337
Address Resolution Protocol (ARP), 49, 312
addresses
  Internet module, 194–199
  multihoming, 202
  net-hop address tracking (BGP), 214
  vMAC, 296
adjacency tables, 50–51
adjusted availability, 18
Adv Rtr (advertising router), 87
aggregation
  layer design, 298–300
  switches, 298
aggressive mode, UDLD configuration, 155
alerts, PSIRT, 350
Automatic Protection Switching (APS), 249
architecture
  DPT, 252–258
  flow-based, 187
  MPLS-VPN, 269
  networks (Data Center module), 291–301
  next-generation IOS, 362
  scaling, 301–302
  servers, 288–289, 301
  switch forwarding, 314
  three-tier, 142
  two-tier, 142
ARP (Address Resolution Protocol), 49, 312
ASIC (application-specific integrated circuit), 3
assigning addresses, 194
attacks
  DoS, 195, 204
  failures, 21
authoritative name server (ANS), 321
auto route injection, 231
Automatic Protection Switching (APS), 249
autonegotiation, turning off, 178
availability
  calculating, 10
  defects-per-million method, 367
  devices, 369
  high-availability networks, 9
  50-ms resiliency, 15–16
  achieving, 16–25
  five-nines, 9–12
  Telcordia GR-512-Core document, 12–15
  HSA, 39
  measuring, 17
  of parallel devices, 369
  percentage method, 367
  simple network topologies, 370
  simple systems, 370
  theoretical availability of devices, 368–369
avoidance, congestion, 75
B

BackboneFast, 152–154
backbones, Gigabit Ethernets, 3
backups
   dial backups (WAN), 258–261
   simple hardware, 38
baselines, establishing, 337–345
BCPs (Best Current Practices), 194
best practices
   Layer 2, 173–178
   Layer 3, 187, 189–190
BFD (Bidirectional Forwarding Detection), 103, EIGRP, 124–126
BGP (Border Gateway Protocol), 7, 193
   convergence, 213
   fast peering session deactivation, 214
   Internet modules, 222
   next-hop address tracking, 214
   route dampening, 215
   updates, 221
BID (bridge ID), 147
Bidirectional Forwarding Detection. See BFD
bidirectional line switch ring (BLSR), 249
binding, delayed, 319
blade server connectivity, 288
blocks
   private addresses, 195
   states, 148
BLSR (bidirectional line switch ring), 249
boot codes, 334
Border Gateway Protocol. See BGP
BPDU (Bridge Protocol Data Unit), 153
BPDUGuard, 157–158
bridge ID (BID), 147
Bridge Protocol Data Unit. See BPDU
bridges, 146
   root, 148
   selecting, 176
building blocks (access module), 144

caches, 326
calculations
   availability, 10
      defects-per-million method, 367
      percentage method, 367
   simple network topologies, 370
   simple systems, 370
   theoretical availability of devices, 368–369
downtime, 12
   MTBF using COOL, 357
capacity failures, 21
Catalyst switch support, PVLANs, 310
causes of network failures, 20
CE (customer edge) routers, 270, 276–278
CEF (Cisco Express Forwarding), 46, 129
   central mode, 53
   configuring, 53
   dCEF, 54
   switching, 50
channeling, 171–173
CIDR (classless interdomain routing), 194
circuits
   half, 239
   WAN leased lines, 237–244
Cisco Component Outage Online (COOL), 355
Cisco Express Forwarding, See CEF
Cisco IOS deployment, 345–351
Cisco Networking Services (CNS) events, 360
CISCO-OUTAGE-MONITOR MIB, 355
CISCO-PROCESS-MIB, OIDs within, 341
Class-Based QoS MIB, 82
classes of service, DPT/SPR, 254
classification
   applications, 78
   DiffServ model, 75
   IP Precedence, 66
classless interdomain routing (CIDR), 194
client name server (CNS), 321
clustering, 297
CNS (Cisco Networking Services) events, 360
CNS (client name server), 321
cold restart feature, 37
coloring, 75
commands
   backboneFast, 154
      debug dampening interface, 128
debug ip ospf database-timer rate-limit, 99
debug ip ospf flood, 99
debug ip ospf spl, 95, 99
debag isis adj, 121
debag isis adj-packets, 115
debag isis nsf, 121
debag isis snp, 121
execute-on <lot>, 125
flood packet pacing timer, 104
glb priority, 184
ip accounting, 335
ip cef load-sharing algorithm original, 132
ip ospf network point-to-point, 87
ip tcp path-mtu-discovery, 213
ip-ospf flood-reduction, 101
mpls traffic-eng backup path tunnel, 135
peer, 229
pim query-interval, 138
ping, 353
portfast, 150
primary, 229
redistribute connected, 276
redistribute ospf 10, 278
router ospf 10 vrf RED, 278
show, 337
show bfd neigh detail, 125
show ip bgp neighbors, 211
show ip cef, 131
show ip cef exact-route, 132
show ip ospf, 96, 98
show ip ospf neighbor detail, 110
show ip pim neighbor, 138
show ip route, 129
show ip rpf events, 139
show isis nsf, 120
show running-config, 36
spf-interval, 112
timer lsa arrival, 100
times spf spf-holdtime, 97
tunnel mode gre, 264
tunnel mode ipip, 264
tunnel mpls traffic-eng fast-reroute, 135
tunnel path-mtu-discovery, 264
uplinkfast, 152

Common Spanning Tree (CST), 161
community ports, 305
community VLANs, 306

Complete Sequence Number Packet (CSNP), 117
-components
availability, 10
COOL, 355
network management, 331–337
PBX systems, 12
-conditioning, traffic, 76
configuration
BackboneFast, 154
BGP
- NSF/SSO, 217–218
  route dampening, 215
  soft reconfiguration, 210
BPDUGuard, 158
CE routers, 276–278
CEF, 53
DHCP, 315
DPR/SPR rings, 256
dynamic ARP inspection, 313
EEM, 362
EtherChannel, 177
file management, 333
GLBP, 186
HSA, 38
HSRP, 181
IEEE 802.1s, 170
IP
- event dampening, 127
tunnels, 263
IS-IS
- Fast Hello, 115
- incremental SPF, 117
- LSA Flooding Reduction, 114
- LSP generation interval timers, 113
- partial route computation timers, 113
- SPF throttling, 112
- update packet-pacing timers, 116
ISL trunking, 159
L2TP, 266
LoopGuard, 157
management, 333
MPLS-VPN, 273
MPPP, 243
NAT
- HSRP, 225
- maximum number of entries, 230
- multihoming, 223
- stateful NAT on HSRP, 227
networks, 86
NSF, 46
OSPF
  BFD, 125
  Fast Hello, 102
  incremental SPF, 106
  LSA flood-reduction, 101
  LSA throttling, 98
  NSF/SSO, 109
  update packet-pacing timers, 104
P routers, 273
PE routers, 274
per-packet load balancing, 130
PortFast, 150
port security, 311
PVLANs, 307
RACL, 68
Rapid-PVST+, 168
reverse proxy caching, 327
RootGuard, 156
RPR, 40
RPR+, 42
single line card reload, 36
SONET/SDH, 250
SPF throttling, 96
SSO, 44
static routes, 259
UDLD, 155
WCCP, 326
congestion
  avoidance, 75
  management, 76
  QoS (uncongested links), 73
  transient, 73
connections
  blade servers, 288
  cabling, 283. See also cabling
  Layer 2, 175
  leased circuit encapsulation, 239
  NIC teaming, 296
  three-way handshakes (TCP), 31
conserving peering resources, 189
content switching. See SLB
Content Switching Module (CSM), 328
continuous fault detection, 23
customization. See also configuration
EIGRP, 123
  BFD, 124–126
  graceful shutdown, 123
  stub router, 123
IS-IS, 111
  Fast Hellos, 114–115
  graceful restart, 117–122
  incremental SPF, 116
  LSA flooding reduction, 114
  LSP generation, 113
  SPF throttling, 112–113
  update packet-pacing timer, 115–116
OSPF, 86–95
  Fast Hello, 102–103
  graceful restart, 106–111
  incremental SPF, 105
  LSA flooding reduction, 100–101
  LSA throttling, 98–100
  SPF, 97
  update packet-pacing timer, 104–105
cycles, STP, 148

control planes
  MIB, 342
  policing, 314
  protecting, 55–56
  QoS, 63–69
  traffic, 76–77
controller cards, 13
core layer, 144
convergence
  BGP, 213
  IP event dampening, 126
  MPLS-TE, 132
  multicast subsecond, 137–139
  network in the core, 85–86
  networks, 90
  OSPF, 86–95
COOL (Cisco Component Outage Online), 355
customer edge (CE) routers, 270, 276–278

See also configuration
congestion avoidance, 75
management, 76
QoS (uncongested links), 73
transient, 73
connections
blade servers, 288
cabling, 283. See also cabling
Layer 2, 175
leased circuit encapsulation, 239
NIC teaming, 296
three-way handshakes (TCP), 31
conserving peering resources, 189
content switching. See SLB
Content Switching Module (CSM), 328
continuous fault detection, 23
customization. See also configuration
EIGRP, 123
  BFD, 124–126
  graceful shutdown, 123
  stub router, 123
IS-IS, 111
  Fast Hellos, 114–115
  graceful restart, 117–122
  incremental SPF, 116
  LSA flooding reduction, 114
  LSP generation, 113
  SPF throttling, 112–113
  update packet-pacing timer, 115–116
OSPF, 86–95
  Fast Hello, 102–103
  graceful restart, 106–111
  incremental SPF, 105
  LSA flooding reduction, 100–101
  LSA throttling, 98–100
  SPF, 97
  update packet-pacing timer, 104–105
cycles, STP, 148
Dampening (routes), 215
DARPA (Defense Advanced Research Projects Agency), 4
Data Center module, 281
  environmental considerations, 282
    cabling, 282–283
    power supply, 287
    rack space, 283
    server architecture, 288–289
    server size, 284–287
  networks, 289–291
    architecture, 291–301
    security, 289, 302–315
    server performance, 290
  service optimization, 315–328
data planes
  MIBs, 342
  protecting, 55–56
datagrams, 27. See also UDP
dCEF (Distributed CEF), 54
design
  access layer, 292–298
  aggregation layer, 298–300
  ASIC, 3
Data Center module, 281
  cabling, 282–283
    environmental considerations, 282
    network architecture, 291–301
    network security, 289, 302–315
    network server performance, 290
    networks, 289–291
    power supply, 287
    rack space, 283
    servers, 284–289
    service optimization, 315–328
  high availability, 21
Internet module, 193
  BGP, 222
    filtering, 206
    NAT, 235
    redundancy, 199–204
    security, 204–209
Internet modules, 194–199
  life cycle management (IOS), 349
  multilayer campus, 141–143
    access layer, 143
    building blocks, 144
    core layer, 144
    distribution layer, 143
    Layer 2 domains, 145–178
    Layer 3 domains, 178–190
  resiliency, 59–61
  security, 60
designated IS (DIS), 114
designated ports, 146
detection, 332
  continuous fault, 23
  EEM, 361
device-level redundancy, 201
device-level resiliency, 34, 57
  HSA, 39
  NSF, 45–48
  OIR, 34–36
  RPR, 40–41
  RPR+, 41–43
  single line card reload, 36–37
  SSO, 43–45
devices
configuration file management, 333
parallel, 369
theoretical availability of, 368–369
DHCP (Dynamic Host Control Protocol)
servers, 314
snooping, 315
diagrams, cabling, 283
dial backup (WAN), 258–261
diameter keyword, 176
DiffServ model (QoS), 74–76
direct connections (Layer 2), 175
directed mode (SLB), 318
DIS (designated IS), 114
disabled ports, 146
disabled states, 148
disasters (failures), 21
discipline, cabling, 283
dispatch mode (SLB), 318
Distributed CEF (dCEF), 54
distribution layer, 143
DLC (domestic leased circuit), 238
DMZ (demilitarized zone) servers, 196
DNS (Domain Name System), 321
DNSR (DNS resolver), 321
documentation, cabling, 283
Domain Name System (DNS), 321
domains
Layer 2, 145–178
Layer 3, 178–190
domestic leased circuit (DLC), 238
DoNotAge link-state advertisements, 114
DoS (denial-of-service) attacks, 195, 204
downtime
calculating, 12
fault management, 332
scheduling, 23
DPT (Dynamic Packet Transport), 7, 251
architecture, 252–258
classes of service, 254
duplicate acknowledgment (DUPACK), 130
dynamic ARP inspection, 312
Dynamic Host Control Protocol. See DHCP
Dynamic Packet Transport. See DPT
dynamic soft reset, 211

E
Early Deployment (ED) release, 346
echo (ICMP), 353
ECMP (equal-cost multipath), 129, 188
ED (Early Deployment) release, 346
EEM (Embedded Event Manager), 359–362
effect of Internet growth, 4
EIGRP (Enhanced Interior Gateway Routing Protocol), 123
BFD, 124–126
graceful shutdown, 123
stub routers, 123
Embedded Event Manager (EEM), 359–362
enabling
BGP fast peering session deactivation, 214
COOL, 357
encapsulation
ISL, 159
leased circuit, 239
end nodes (L2TP), 268
End of Engineering (EOE), 346
End of Life (EOL), 346
End of Sales (EOS), 346
End-of-Table (EOT) signal, 123
Enhanced Interior Gateway Routing Protocol. See EIGRP
entries
in adjacency tables, 51
MIB, 340
entry limitation (NAT), 230
environmental considerations (Data Center module), 282
cabling, 282–283
power supply, 287
rack space, 283
servers
architecture, 288–289
size, 284–287
EOE (End of Engineering), 346
EOL (End of Life), 346
EOS (End of Sales), 346
EOT (End-of-Table) signal, 123
equal-cost load balancing, 241
equal-cost multipath (ECMP), 129, 188
errors, software protection, 38
establishing baselines, 337–345
EtherChannel, 172
  configuring, 177
  deploying, 177
  Later 2, 177
  load balancing, 177
event dampening (IP), 126
Event Publisher, 360
Event Subscriber, 360
events
  CNS, 360
  EEM, 359–362
  internal trouble-ticket, 24
execute-on, 125
exponential back-off behavior, SPF, 97
extensions, graceful restart, 46
external users, routing, 198
extranet servers, reachability, 196

F
failure, 3. See also troubleshooting
  causes of, 20
  MTBF, 10, 368
fairness algorithms (SRP), 255
farms (servers), 292, 301
Fast EtherChannel (FEC), 171
Fast Hellos
  IS-IS, 114–115
  OSPF, 102
fast peering session deactivation, 214
Fast Reroute (FRR), 6
fast reroute link protection, 133
fast reroute node protection, 136
fault detection, 23
fault management, 332
fault-tolerant servers, 290
FCIP (Fibre Channel over IP), 5
  FEC (FastEtherChannel), 171
  FEC (forwarding equivalence class), 6, 270
  Fibre Channel over IP (FCIP), 5
  Field Programmable Gate Array (FPGA) codes, 334
  files, configuration management, 333
  filtering (Internet module), 206
Firewall Service Module (FWSM), 328
five-nines availability, 9–12
flags, pak_priority, 66
flaps (routing), 45
flash crowds, 316
floating static routes, 258
flood packet pacing timer command, 104
flooding
  IS-IS, 114
  LSAs, 100–101
flow-based architecture, 187
formatting UDP, 33. See also configuration
forward delay timers, 149
forwarding
  architecture (switches), 314
  CEF, 46, 129
    central mode, 53
    configuring, 53
  dCEF, 54
  switching, 50
NSF, 45–48
  packets, 134
  states, 148
forwarding equivalence class (FEC), 6, 270
FPGA (Field Programmable Gate Array) codes, 334
framing (SONET/SDH), 245
FRR (Fast Reroute), 6
functional entities, 57
FWSM (Firewall Service Module), 328

G
gateways, application-specific, 233
GD (General Deployment) release, 346
GEC (Gigabit EtherChannel), 171
General Deployment (GD) release, 346
generation
  LSP, 113
  of updates, 211
Gigabit EtherChannel (GEC), 171
Gigabit Ethernet backbones, 3
Gigabit Switch Router (GSR), 106
GLBP (Global Load Balancing Protocol), 183–186
glbp priority command, 184
Global Load Balancing Protocol (GLBP), 183–186
global server load balancing (GSLB), 320
Global Site Selector (GSS), 320–323
global synchronization, 75
graceful restart
  extensions, 46
  IS-IS, 117–122
  OSPF, 106–111
graceful shutdown (EIGRP), 123
graphs, MRTG, 343
groups, availability of, 369
growth of Internet, effect of, 4
GSLB (global server load balancing), 320
GSR (Gigabit Switch Router), 106
GSS (Global Site Selector), 320–323

H

half circuits, 239
hardware
  baselines. See baselines
  failures, 21
  simple backups, 38
headers, ISL, 158
heartbeat mechanisms, 297
Hello packets, 86
Hello protocol, 102, 114–115
hello timers, 149
hierarchical IP addressing schemes, 190
high system availability (HSA), 39
high-availability networks, 9
  50-ms resiliency, 15–16
  achieving, 16–25
  five-nines, 9–12
  Telcordia GR-512-Core document, 12–15
high-density server farms, scaling, 301
high-priority services, 254
hops, next-hop address tracking (BGP), 214
Hot Standby Routing Protocol (HSRP), 179, 181
  stateful NAT, 227
  static mapping, 224
hot swap capability, 35
HSA (high system availability), 39
HSRP (Hot Standby Routing Protocol), 179, 181
  stateful NAT, 227
  static mapping, 224
human error (failures), 21
Internet Engineering Task Force (IETF), 6, 118
Internet module, 193
  addressing/routing, 194–199
  BGP, 222
  filtering, 206
  NAT, 235
  redundancy, 199–204
  security, 204–209
Internet Protocol. See IP
Internet Small Computer System Interface
  (iSCSI), 5
Inter-Switch Link (ISL), 158
intervals, 86
inventory
  management, 334
  snapshots, 340
  tracking, 333
IOS deployment, 345–351
IP (Internet Protocol), 27–29
  event dampening, 126
  next-generation transport systems, 6
  next-generation applications, 5
    IP Storage, 5
    VoIP, 5
  Precedence, 65
  SLA, 354
  VPNs, 261
ip accounting command, 335
ip cef load-sharing algorithm original command,
  132
ip ospf flood-reduction command, 101
ip ospf network point-to-point command, 87
IP SLA (IP Service Level Agreement), 82, 352
IP SLA (IP Service Level Agreement), 82, 352
IPLC (international private leased circuit), 238
iSCSI (Internet Small Computer System
  Interface), 5
ISDN (Integrated Service Digital Network)
  as dial backups, 258
IS-IS (Intermediate System-to-Intermediate
  System), 7, 111
  Fast Hellos, 114–115
  graceful restart, 117–122
  incremental SPF, 116
  LSA flooding reduction, 114
  LSP generation, 113
  SPF throttling, 112–113
  update packet-pacing timer, 115–116
ISL (Inter-Switch Link), 158
isolated ports, 305
isolated VLANs, 306
ISP-level redundancy (multihoming), 202
ISSU (in-service software upgrade), 364
ITU-T (International Telecommunication Union-
  Telecommunication Standardization Sector),
  15

J–K

  jitter, 71
  keywords, diameter, 176

L

  L2TP (Layer 2 Tunnel Protocol), 265
  Label Distribution Protocol (LDP), 270
  label edge router (LER), 269
  label switch router (LSR), 269
  label switched path (LSP), 113, 269
  labels
    MPLS, 6
    stacking, 134
  LAN Management Solution (LMS), 334
  LATA (Local Access and Transport Area)
    switching systems, 12
  latency, 70
  Layer 2
    best practices, 173–178
    control packets, 65
    domains, 145–178
    EtherChannel, 177
    security, 303–313
  Layer 2 Tunnel Protocol (L2TP), 265
  Layer 3
    best practices, 187, 189–190
    domains, 178–190
    security, 313–315
  layers
    access design, 292–298
    aggregation design, 298–300
    multilayer campus design, 141–143
    access, 143
building blocks, 144
core, 144
distribution, 143
Layer 2 domains, 145–178
Layer 3 domains, 178–190
LD (limited deployment) release, 346
LDP (Label Distribution Protocol), 270
leaf nodes, 150
learning states, 148
leased lines (WAN), 237–244
LER (label edge router), 269
levels of security breaches, 205
life cycle management (IOS), 348
limitation of entries (NAT), 230
Limited Deployment (LD) release, 346
limiting spans of VLANs, 174
lines cards, 13
link local signaling (LLS), 108
link-level redundancy, 58, 200
Link-Local Opaque link-state advertisements, 107
links
  fast reroute link protection, 133
  sham, 278
  uncongested, 72
link-state advertisements. See LSAs
link-state ID (LSID), 87
link-state type (LS-Type), 87
listening states, 148
LLS (link local signaling), 108
LMS (LAN Management Solution), 334
load balancing
  equal-cost, 241
  EtherChannel, 177
  GLBP, 183–184, 186
  multipath routing, 128
  per-destination, 130
  per-packet, 129
Local Access and Transport Area (LATA)
switching systems, 12
local protection, 133
logging, 332
logical redundancy, 57
LoopGuard, 157
loops, 146–154
  BPDUGuard, 157–158
  channeling, 171–173
IEEE 802.1s, 168–171
IEEE 802.1w, 165–168
LoopGuard, 157
PortFast, 150
RootGuard, 155–157
UDLD, 154–155
UplinkFast, 151
VLANs, 158–165
loss, 72
lower-bound thresholds, 344
low-priority services, 254
LSAs (link-state advertisements)
  DoNotAge, 114
  flooding reduction, 100–101, 114
  Link-Local Opaque, 107
  neighbor propagation, 88
  OSPF, 87
  throttling, 98–100
LSID (link-state ID), 87
LSP (label switched path), 113, 269
LSR (label switch router), 269
LS-Type (link-state type), 87
Management Information Base. See MIB
maps
  routes (NAT with), 223
  static mapping with HSRP, 224
marking (DiffServ model), 75
maximum age timers, 149
maximum segment size (MSS), 213
maximum transmission unit (MTU), 29
MBGP (Multiprotocol BGP), 271
mean time before failure (MTBF), 368
mean time between failure (MTBF), 10, 355
mean time to repair (MTTR), 368
mean time to restore (MTTR), 355
measurements. See also calculations
  availability, 17
  COOL, 356
  high availability, 23
merge point (MP), 134
messages
  fault management, 332
  SRM, 118
metrics
  COOL measurements, 356
  defining, 19
MHSRP (Multigroup HSRP), 181
MIB (Management Information Base), 82
  CISCO-OUTAGE-MONITOR, 355
  entries, 340
microcodes, 334
models, network management, 331–337
modularity of network design, 59
modules
  Data Center, 281
    architecture, 291–301
    cabling, 282–283
    environmental considerations, 282
    networks, 289–291
    power supply, 287
    rack space, 283
    security, 289, 302–315
    server architecture, 288–289
    server size, 284–287
    service optimization, 315–328
  IGESM, 288
  integrated service, 328–329
  Internet, 193
    addressing/routing, 194–199
    BGP, 222
filtering, 206
  NAT, 235
redundancy, 199–204
security, 204–209
  pass-through, 288
  Traffic Anomaly Detector service, 335
monitoring
  QoS, 82
  RMON, 332
MP (merge point), 134
MPLS (Multiprotocol Label Switching), 6
  mpls traffic-eng backup path tunnel command, 135
MPLS-TE (MPLS Traffic Engineering), 6, 132
MPLS-VPN, 269
MPPP (Multilink Point-to-Point Protocol), 243
MRTG (Multi-Router Traffic Grapher), 340, 343
MSS (maximum segment size), 213
MTBF (mean time between failure), 10, 355, 368
MTTR (mean time to repair), 355, 368
MTU (maximum transmission unit), 29
multicast subsecond convergence, 137–139
multifaceted servers, 291
Multigroup HSRP (MHSRP), 181
multihoming, 202, 223, 230
multilayer campus design, 141–143
  access layer, 143
  building blocks, 144
  core layer, 144
  distribution layer, 143
  Layer 2 domains, 145–178
  Layer 3 domains, 178–190
Multilink Point-to-Point Protocol (MPPP), 243
multipath routing, 128
multiplexing SONET, 247
Multiprotocol BGP (MBGP), 271
Multiprotocol Label Switching (MPLS), 6
Multi-Router Traffic Grapher (MRTG), 340, 343

N

NAF (number of accumulated failures), 356
NAM (Network Analysis Module), 328, 332
naming conventions (IOS), 346
NAT (Network Address Translation), 49, 194
  effect on applications, 232
  entry limitation, 230
  ICMP, 232
  Internet modules, 235
  multihoming, 223, 230
  performance, 235
  security, 235
  stateful, 226
  TCP, 232
  VoIP, 234
NEBS (Network Equipment Building System), 57
  need for application QoS, 69–72
neighbors
  BFD, 125
  LSA neighbors, propagating, 88
NetFlow, 335
Network Address Translation. See NAT
Network Analysis Module (NAM), 328, 332
Network Equipment Building System (NEBS), 57
  network interface card (NIC), 288, 295
network layer reachability information (NLRI), 213
networks
  configuring, 86
  convergence, 90
  core, 85–86
  Data Center module, 289–291
    architecture, 291–301
    security, 289, 302–315
    server performance, 290
  high-availability, 9
    50-ms resiliency, 15–16
    achieving, 16–25
    five-nines, 9–12
    Telcordia GR-512-Core document, 12–15
Layer 2 best practices, 173–178
management
  Cisco IOS deployment, 345–351
  components, 331–337
  establishing baselines, 337–345
  proactive, 351–364
multilayer campus design, 141–143
  access layer, 143
  building blocks, 144
  core layer, 144
  distribution layer, 143
  Layer 2 domains, 145–178
  Layer 3 domains, 178–190
WAN
  dial backup, 258–261
  leased lines, 237–244
  RPR, 251–258
  SONET/SDH, 244–251
  VPN, 261–279
next-generation IOS architecture, 362
next-generation IP applications, 5
  IP Storage, 5
  VoIP, 5
next-hop address tracking (BGP), 214
next-hop routers, 134
NIC (network interface card), 288, 295
NLRI (network layer reachability information), 213
nodes
  fast reroute node protection, 136
  leaf, 150
Non Stop Forwarding with Stateful Switchover (NSF/SSO), 106, 216
  non-responder-based IP SLA operations, 354
  nonstop forwarding (NSF), 45–48
  normal mode, UDLD configuration, 155
  notification, 332
  NSF (nonstop forwarding), 45–48
  NSF/SSO (Non Stop Forwarding with Stateful Switchover), 106, 216
  number of accumulated failures (NAF), 356
object identifier (OID), 340
objects, COOL measurements of, 356
OID (object identifier), 340
OIR (online insertion and removal), 34–36
Open Shortest Path First. See OSPF
Open Systems Interconnection (OSI), 27
operations
  IP SLAs, 354
  life cycle management (IOS), 350
  non-responder-base IP SLA, 354
  responder-based IP SLA, 353
optimization. See also customization
  BGP convergence, 213
EIGRP, 123
  BFD, 124–126
  graceful shutdown, 123
  stub routers, 123
  enhanced NAT resiliency, 222
IS-IS, 111
  Fast Hellos, 114–115
  graceful restart, 117–122
  incremental SPF, 116
  LSA flooding reduction, 114
  LSP generation, 113
  SPF throttling, 112–113
  update packet-pacing timer, 115–116
OSPF, 86–95
  Fast Hello, 102–103
  graceful restart, 106–111
  incremental SPF, 105
  LSA flooding reduction, 100–101
  LSA throttling, 98–100
  SPF throttling, 97
  update packet-pacing timer, 104–105
protocols, 7
security, 7
services, 315–328
options
cabling, 286
EIGRP, 123
  BFD, 124–126
  graceful shutdown, 123
  stub router, 123
IS-IS, 111
  Fast Hellos, 114–115
  graceful restart, 117–122
  incremental SPF, 116
  LSA flooding reduction, 114
  LSP generation, 113
  SPF throttling, 112–113
  update packet-pacing timer, 115–116
OSPF, 86–95
  Fast Hello, 102–103
  graceful restart, 106–111
  incremental SPF, 105
  LSA flooding reduction, 100–101
  LSA throttling, 98–100
  SPF throttling, 97
  update packet-pacing timer, 104–105
OSI (Open Systems Interconnection), 27
OSPF (Open Shortest Path First), 7
  enhancements, 86–95
  Fast Hello, 102–103
  graceful restart, 106–111
  incremental SPF, 105
  LSA
    flooding reduction, 100–101
    throttling, 98–100
  network convergence in the core, 85
  NSF, 46
  SPF throttling, 97
  update packet-pacing timer, 104–105
outbound soft reset, 211

P

P (provider) routers, 270, 273
Packet over SONET (POS) interface, 28
packets
  CSNP, 117
  DPT, 251–258
  forwarding, 134
  Hello intervals, 86
  loss, 72
  PSNP, 118
  RPR, 251–258
  tagging, 65
pak_priority flags, 66
parallel components, 10
parallel devices, availability of, 369
Partial Sequence Number Packet (PSNP), 118
partial SPF, 106
pass-through modules, 288
passwords, 337
PAT (Protocol Address Translation), 222
paths
  default costs for STP, 147
  LSP, 269
  multipath routing, 128
  network convergence in the core, 85–86
  protection, 133
  switching, 48–55
PBX (private branch exchange) systems, 12
PE (provider edge) routers, 270, 274
peer command, 229
peering resources, conserving, 189
penultimate hop popping, 134
percentage method, calculating availability, 367
per-destination load balancing, 130
performance
baselines. See baselines
management, 335–336
NAT, 235
per-packet load balancing, 129
Per-VLAN Spanning Tree (PVST), 162
Per-VLAN Spanning Tree Plus (PVST+), 164
physical redundancy, 57
pim query-interval command, 138
ping command, 353
planning life cycle management (IOS), 349
PLR (point of local repair), 134
point of local repair (PLR), 134
policies
defining, 81
security, 204–205
SLB, 317
testing, 81
polling data (baselines), 340–343
PortFast, 150
portfast command, 150
ports
alternate, 146
designated, 146
disabled, 146
EtherChannel, 177
IEEE 802.1w, 166
PVLANs, 305
root, 146
routed (aggregation switches), 299
security, 311
trunks (aggregation switches), 298
POS (Packet over SONET) interface, 28
power supplies, 13
Data Center module, 287
UPS, 287
PPP over SONET/SDH, 247
primary command, 229
primary power equipment, 287
primary VLANs, 306
primary/secondary method (static NAT), 228
principles of security policies, 205
prioritization
syslog messages, 360
thresholds, 345
private addresses, 194
blocks, 195
DoS attacks, 195
filtering, 206
private branch exchange (PBX) systems, 12
private VLANs (PVLANs), 304
Catalyst switch support, 310
configuring, 307
ports, 305
proactive network management, 351–364
process switching, 49
processors
RPR, 40–41
RPR+, 41–43
Product Security Incident Response Team (PSIRT), 23, 350
promiscuous ports, 305
properties, applications, 78
protection
applications with QoS, 69–74
control planes, 55–56, 63–69
data planes, 55–56
switching (SONET/SDH), 248
Protocol Address Translation (PAT), 222
protocols
ARP, 49, 312
BGP, 193–222
corversion, 213
fast peering session deactivation, 214
next-hop address tracking, 214
route dampening, 215
updates, 221
EIGRP, 123
BFD, 124–126
graceful shutdown, 123
GLBP, 183–186
Hello, 102, 114–115
HSRP, 179, 181
stateful NAT, 227
static mapping, 224
ICMP, 232
IP, 27–29
IS-IS, 111

Fast Hellos, 114–115
graceful restart, 117–122
incremental SPF, 116
LSA flooding reduction, 114
LSP generation, 113
SPF throttling, 112–113
update packet-pacing timer, 115–116

L2TP, 265
LDP, 270
MPPP, 243
NAT, 235
optimizing, 7
OSPF

enhancements, 86–95
Fast Hello, 102–103
graceful restart, 106–111
incremental SPF, 105
LSA flooding reduction, 100–101
LSA throttling, 98–100
update packet-pacing timer, 104–105

routing, 65
RSTP, 165
SNMP, 332
Spatial Reuse Protocol, 251
STP, 146–150

BackboneFast, 152–154
BPDUGuard, 157–158
channeling, 171–173
cycles, 148
IEEE 802.1s, 168–171
IEEE 802.1w, 165–168
Layer 2 domains, 145
LoopGuard, 157
PortFast, 150
RootGuard, 155–157
UDLD, 154–155
UplinkFast, 151
VLANs, 158–165

TCP, 29–33
delayed binding, 320
MSS, 213
NAT, 232
three-way handshakes, 31
UDP, 33–34
VRRP, 183
WCCP, 324–328

provider (P) routers, 270, 273
provider edge (PE) routers, 270, 274
PSIRT (Product Security Incident Response Team), 23, 350
PSNP (Partial Sequence Number Packet), 118
public addresses, 194–195, 202
punting, 49
PVLANs (private VLANs), 304

Catalyst switch support, 310
configuring, 307
ports, 305
PVST (Per-Vlan Spanning Tree), 162
PVST+ (Per-Vlan Spanning Tree Plus), 164

Q

QoS (quality of service), 29, 63
applications, 69–74
ccontrol plane traffic, 76–77
ccontrol planes, 63–69
deploying, 77–82
diffServ model, 74–76
implementing, 82
monitoring, 82
queues (SRP), 254

R

rack space, Data Center module, 283
RACL (receive access control list), 67
RANCID (Really Awesome New Cisco Config Differ), 333
random early detect (RED), 75
Rapid Spanning Tree Protocol (RSTP), 165
Rapid-PVST+, 168
raw availability, 18
reachability, 196
Really Awesome New Cisco Config Differ (RANCID), 333
receive access control list (RACL), 67
RED (random early detect), 75
redistribute connected command, 276
redistribute ospf 10 command, 278
redundancy, 13
  device-level, 201
  Internet modules, 199–204
  ISP-level, 202
  link-level, 58, 200
  logical, 57
  NIC teaming, 297
  physical, 57
  router status, 217
  RPR, 40–41, 107
  RPR+, 41–43, 216
  site-level, 203
  strategies, 56
  VRRP, 183

release, Cisco IOS, 346
reliability, 9, 34
  HSA, 39
  IP networks, 3
  NSF, 45–48
  OIR, 34–36
  RPR, 40–41
  RPR+, 41–43
  single line card reload, 36–37
  SSO, 43–45
remote monitoring (RMON), 332, 336
Request For Proposals (RFPs), 12
rerouting 85–86
resiliency
  50-ms, 15–16
  design, 59–61
  device-level, 34, 57
    HSA, 39
    NSF, 45–48
    OIR, 34–36
    RPR, 40–41
    RPR+, 41–43
    single line card reload, 36–37
    SSO, 43–45
  IP, 28
  strategies, 59
Resilient Packet Ring (RPR), 7, 85, 251–258
resolution, DNS, 321
resources, peering, 189
responder-based IP SLA operations, 353
restarting (graceful restart)
  IS-IS, 117–122
  OSPF, 106–111
reverse proxy caching, 326
RFC 3623, 107
RFPs (Request For Proposals), 12
rings, configuring DPR/SPR, 256
RMON (remote monitoring), 332, 336
RNS (root name server), 321
root bridges, 148, 176
root name server (RNS), 321
root ports, 146
RootGuard, 155–157
route processor redundancy (RPR), 40–41, 107
route processor redundancy plus (RPR+), 41–43, 216
routed ports, aggregation switches, 299
router ospf 10 vrf RED command, 278
routers
  Adv Rtr, 87
  CE, 276–278
  CRS-1, 3
  DPT, 252
  equal-cost load balancing, 241
  GSR, 106
  ISDN, 258
  leased line connections, 241
  LER, 269
  LSR, 269
  MPPP, 243
  NAT performance, 235
  next hop, 134
  P, 270, 273
  PE, 270, 274
  redundancy status, 217
  stub (EIGRP), 123
routes
  CE, 270
dampening, 215
  floating static, 258
  maps (NAT), 223
routing
  CIDR, 194
e external users, 198
  flaps, 45
  internal users, 197
  Internet module, 194–199
  multipath, 128
tagging, 65
RPR (Resilient Packet Ring), 7, 85, 251–258
RPR (route processor redundancy), 40–41, 107
RPR+ (route processor redundancy plus), 41–43, 216
RSTP (Rapid Spanning Tree Protocol), 165

S

SAA (Service Assurance Agent), 82
SAFE (Security Blueprint for Enterprise Networks), 289
scaling
architecture, 301–302
strategies, 58
scheduling downtime, 23
scripting (TCL), 360
SDH (Synchronous Digital Hierarchy), 15
security
Data Center networks, 289
design, 60
DHCP servers, 314
Internet modules, 204–209
Layer 2, 303–313
Layer 3, 313–315
management, 336–337
NAT, 235
networks (Data Center module), 302–315
optimizing, 7
policies, 204–205
ports, 311
Security Blueprint for Enterprise Networks (SAFE), 289
selecting root bridges, 176
send routing message (SRM), 118
serial devices, availability of, 369
series components, 10
server load balancing (SLB), 316–320
servers
blade connectivity, 288
clustering, 297
Data Center module, 284–289
Data Center network performance, 290
DHCP, 314
DMZ, 196
extranet reachability, 196
failures, 21
farms, 292, 301
fault-tolerant, 290
Service Assurance Agent (SAA), 82
service level agreement. See SLA
services
classes of, 254
integrated service modules, 328–329
optimization, 315–328
QoS. See QoS
sessions, fast peering deactivation, 214
sham links, 278
shortest path first. See SPF
shortest-path tree. See SPT
show bfd neigh detail command, 125
show commands, 337
show ip bgp neighbors, 211
show ip cef, 131
show ip cef exact-route, 132
show ip ospf, 96, 98
show ip ospf neighbor detail, 110
show ip pim neighbor, 138
show ip route, 129
show ip rpf events, 139
show isis nsf, 120
show running-config, 36
SIA (stuck-in-active) state, 123
signals, EOT, 123
simple hardware backups, 38
Simple Network Management Protocol (SNMP), 332
simple network topology availability, 370
simple system availability, 370
simplicity
Layer 2, 173
of network design, 59
single line card reload, 36–37
site-level redundancy, 203
sizing windows, 32
SLA (service level agreement), 16, 335
ICMP, 353
IP SLAs, 352
SLB (server load balancing), 316–320
sliding windows (TCP), 32
snapshots, taking of inventory, 340
SNMP (Simple Network Management Protocol), 332
snooping (DHCP), 315
soft reconfiguration (BGP), 210
soft reset refresh, 211
software error protection, 38
software management, 334
SONET (Synchronous Optical Network)/SDH (Synchronous Digital Hierarchy), 244–251
Spanning Tree Protocol. See STP
spans of VLANs, limiting, 174
Spatial Reuse Protocol, 251
special-use address measures, 206
speeds, SONET/SDH, 244
SPF (shortest path first)
  incremental, 105, 116
  partial, 106
  throttling (IS-IS), 112–113
spf-interval command, 112
spoofing, anti-spoofing measures, 206
SPT (shortest-path tree), 105
SRM (send routing message), 118
SSO (stateful switchover), 43–45
stacking labels, 134
standards, RPR, 255
standby power equipment, 287
stateful NAT, 226
stateful switchover (SSO), 43–45
states
  blocking, 148
  disabled, 148
  forwarding, 148
  learning, 148
  listening, 148
  steady (STP), 149
static mapping with HSRP, 224
static routes, configuring, 259
status
  router switching, 53
  RPR, 40
  RPR+, 42
  SSO, 44
steady state (STP), 149
STM (Synchronous Transport Module), 244
storage, IP, 5
stored routing update information, 211
STP (Spanning Tree Protocol), 7, 146–150
  BackboneFast, 152–154
  BPDUGuard, 157–158
  channeling, 171–173
cycles, 148
IEEE 802.1s, 168–171
IEEE 802.1w, 165–168
Layer 2 domains, 145
LoopGuard, 157
PortFast, 150
RootGuard, 155–157
UDLD, 154–155
UplinkFast, 151
VLANs, 158–165
strategies
  high availability, 21
  QoS deployment, 77–82
  redundancy, 56
  resiliency, 59
  scaling, 58
stream data transfers, 30
STS (Synchronous Transport Signal), 244
stub routers, 123
stuck-in-active (SIA) state, 123
switches, 146
  aggregation, 298
  forwarding architecture, 314
  L2TPv3, 268
  PVLANs, 310
switching
  CEF, 50
  LATA, 12
  MPLS, 6
  paths, 48–55
  process, 49
  protection (SONET/SDH), 248
  topology-based, 186
synchronization, global, 75
Synchronous Optical Network (SONET)/ Synchronous Digital Hierarchy (SDH). See SONET/SDH
Synchronous Transport Module (STM), 244
Synchronous Transport Signal (STS), 244
syslog messages
  fault management, 332
  prioritizing, 360
<table>
<thead>
<tr>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>tables</td>
</tr>
<tr>
<td>adjacency, 50</td>
</tr>
<tr>
<td>entries in, 51</td>
</tr>
<tr>
<td>TACACS, 337</td>
</tr>
<tr>
<td>tagging</td>
</tr>
<tr>
<td>cables, 282</td>
</tr>
<tr>
<td>routing protocols, 65</td>
</tr>
<tr>
<td>TCL (Tool Command Language), 360</td>
</tr>
<tr>
<td>TCP (Transmission Control Protocol), 29–33</td>
</tr>
<tr>
<td>delayed binding, 320</td>
</tr>
<tr>
<td>MSS, 213</td>
</tr>
<tr>
<td>NAT, 232</td>
</tr>
<tr>
<td>sliding windows, 32</td>
</tr>
<tr>
<td>three-way handshakes, 31</td>
</tr>
<tr>
<td>TDM (time-division multiplexing), 13</td>
</tr>
<tr>
<td>teaming (NIC), 295</td>
</tr>
<tr>
<td>Telcordia GR-512-Core document, 12–15</td>
</tr>
<tr>
<td>testing</td>
</tr>
<tr>
<td>life cycle management (IOS), 350</td>
</tr>
<tr>
<td>policies, 81</td>
</tr>
<tr>
<td>theoretical availability of devices, 368–369</td>
</tr>
<tr>
<td>three-tier architecture, 142</td>
</tr>
<tr>
<td>three-way handshakes (TCP), 31</td>
</tr>
<tr>
<td>thresholds</td>
</tr>
<tr>
<td>analyzing, 344</td>
</tr>
<tr>
<td>baselines. See baselines</td>
</tr>
<tr>
<td>prioritizing, 345</td>
</tr>
<tr>
<td>troubleshooting, 345</td>
</tr>
<tr>
<td>throttling</td>
</tr>
<tr>
<td>LSAs, 98–100</td>
</tr>
<tr>
<td>SPF (IS-IS), 112–113</td>
</tr>
<tr>
<td>time-division multiplexing (TDM), 13</td>
</tr>
<tr>
<td>timers</td>
</tr>
<tr>
<td>forward delay, 149</td>
</tr>
<tr>
<td>hello, 149</td>
</tr>
<tr>
<td>maximum age, 149</td>
</tr>
<tr>
<td>timers lsa arrival command, 100</td>
</tr>
<tr>
<td>timers spf spf-holdtime command, 97</td>
</tr>
<tr>
<td>Tool Command Language (TCL), 360</td>
</tr>
<tr>
<td>tools</td>
</tr>
<tr>
<td>COOL, 355</td>
</tr>
<tr>
<td>MRTG, 343</td>
</tr>
<tr>
<td>topologies 171–174</td>
</tr>
<tr>
<td>topology-based switching, 186</td>
</tr>
<tr>
<td>ToS (type-of-service), 29</td>
</tr>
</tbody>
</table>

| tracking          |
| inventory, 333    |
| next-hop address tracking (BGP), 214 |
| traffic           |
| conditioning, 76  |
| control planes, 76–77 |
| network convergence in the core, 85–86 |
| types that affect control planes, 64 |
| VoIP, 234         |
| Traffic Anomaly Detector service module, 335 |
| transferring stream data, 30 |
| transient congestion, 73 |
| Transmission Control Protocol. See TCP |
| traps, SNMP, 332   |
| trees, SPT, 105    |
| triangle topologies, 174 |
| troubleshooting    |
| congestion, 73     |
| DoS attacks, 195   |
| failures, 3, 20    |
| fault management, 332 |
| MTTR, 368         |
| thresholds, 345    |
| trunking          |
| cards, 13         |
| ports, 298        |
| STP, 158–165      |
| tunnel mode gre command, 264 |
| tunnel mode ipip command, 264 |
| tunnel mpls traffic-eng fast-reroute command, 135 |
| tunnel path-mtu-discovery command, 264 |
| tunneling         |
| IP, 261           |
| L2TP, 265         |
| turning off autonegotiation, 178 |
| two-tier architecture, 142 |
| type-of-service (TOS), 29 |
| types             |
| of ISDN, 258       |
| of traffic that affect control planes, 64 |
| of VLANs, 306      |
UDLD (Unidirectional Link Detection), 154–155
UDP (User Datagram Protocol), 33–34
uncongested links, 72
Unicast Reverse Path Forwarding (uRPF), 335
Unidirectional Link Detection (UDLD), 154–155
unidirectional self-healing ring (USHR), 248
uninterruptible power supply (UPS), 287
universal load-sharing algorithm, 131
update packet-pacing timer, 104–105, 115–116
updates
BGP, 221
generating, 211
upgrading ISSU, 364
UplinkFast, 151
uplinkfast command, 152
upper-bound thresholds, 344
UPS (uninterruptible power supply), 287
upstream failures, 21
uRPF (Unicast Reverse Path Forwarding), 335
User Datagram Protocol. See UDP
User IDs, 337
USHR (unidirectional self-healing ring), 248

W–Z

WAN (wide area network)
dial backup, 258–261
leased lines, 237–244
RPR, 251–258
SONET/SDH, 244–251
VPN, 261–279
warm standby mode, 40
WCCP (Web Cache Communication Protocol), 324–328
weighed random early detection (WRED), 30
what-if analysis, 344
windows, sliding (TCP), 32
worms, 204, 304
WRED (weighted random early detection), 30

VACL (VLAN access control list), 310
verification
OSPF in NSF mode, 47
router switching status, 53
RPR+ status, 42
SSO status, 44
virtual LANs. See VLANs
virtual MAC (vMAC) addresses, 4, 296
Virtual Private Network. See VPN
virtual router identifier (VRID), 183
Virtual Router Redundancy Protocol (VRRP), 183
viruses, 204
VLAN access control list. See VACL
VLANs (virtual LANs)
spans, 174
types of, 306
STP, 158–165

vMAC (virtual MAC) addresses, 4, 296
VoIP (Voice over IP), 5, 234
VPN (Virtual Private Network), 6, 261–279
VRID (virtual router identifier), 183
VRRP (Virtual Router Redundancy Protocol), 183