



Index

- ACC (accept) frame, 77
- Access, 371
- Access control, 346, 351–53
 - SNIA definition, 371
- Access control lists (ACLs), 169, 371–72
- Access control mechanism, 372
- Access fairness, 372
- Access fairness window, 80
- Access method, 25, 372
- Access path, 349–50, 372
- Access security, 169–70
- ACS, 372
- Active, SNIA definition, 372
- Active-active configuration, 204, 373
- Active component, 373
- Active copper, 373
- Active-passive configuration, 204, 373
- Adapters
 - Ethernet, 25, 417
 - FDDI, 424
 - Fibre Channel, 46
 - Gigabit Ethernet, 156
 - host, 434
 - hot swap, 436
 - I/O, 443
 - iSCSI, 186–89, 536, 541–42
 - device drivers, 188
 - functional diagram, 187
 - TOEs in, 187–88, 189
 - iSCSI host, 536
 - network, 462
 - SCSI, 490
 - SNIA definition, 373
 - target channel (TCA), 299
 - troubleshooting, 213–14
- Adaptive array, 373
- Address, 373–74
- Address identifier, 374
- Addressing, 374
 - in arbitrated loops, 59, 68–70
 - block, 386
 - cylinder-head-sector, 391, 402
 - DNS, 270
 - explicit, 418
 - in fabric environments, 58–59, 89–90
 - in Fibre Channel, 57–59
 - implicit, 438
 - IP, 151–52
 - network, 25–26
 - NL_Port, 68
 - SCSI, 77, 491
 - 24-bit, 58
- Address resolution, 374
- Address Resolution Protocol (ARP), 111, 152, 374
- Administration host, 374
- Administrator, 374
 - division of labor between
 - server/storage and traditional network, 298
- Advanced encryption standard, 375
- Advanced Intelligent Tape, 375
- AES, 375
- Agents, 375
 - CIM, 236
 - service (SAs), 164, 165
 - user (UAs), 164, 165
- Aggregated storage, 346–47
- Aggregation, 3, 348, 375
- AH, 375

- AIT, 375
- Algorithmic mapping, 375
- Alias address identifier, 376
- Aliases, 26, 376
- AL_PA. *See* Arbitrated loop physical address (AL_PA)
- AL_PS, 71–72
- Alternate client restore, 376
- Alternate path restore, 376
- Alternative BB_credit, 57
- Always on, 376
- American National Standards Institute (ANSI), 376–77
- ANSI T10 committee, 16, 285, 314, 377, 508, 524, 530
- ANSI T11. 2 Methodologies for Jitter Specification (MJS), 43
- ANSI T11 committee, 16, 285, 377, 508, 524, 530
- APIs, 377, 378
 - HBA (HBA API), 111–12, 322
 - proprietary, 235
 - standardized, 236
- Appliance, 377
- Application I/O request, 377
- Application read request, 377
- Application response measurement, 378
- Applications, infrastructures and, 538–39
- Application specific integrated circuit (ASIC), 127, 378, 380
- Application studies, 15, 257–81
 - campus storage networks, 272–74
 - disaster recovery, 276–78
 - Internet service providers, 270–72
 - LAN-free and server-free tape backup, 261–65
 - post-production video editing, 257–59
 - prepress operations, 259–61
 - remote tape vaulting, 275–76
 - server clustering, 265–67
 - storage consolidation, 267–69
- Application write request, 378
- ARB(F0) primitive, 74, 80
- Arbitrated loop(s), 13, 25, 42, 51, 63, 65–87, 378
 - addressing, 59, 68–70
 - arbitration, 78–80
 - Class 1 service in, 54
 - Class 2 service in, 54
 - Class 3 service in, 54–55
 - daisy chain configuration, 66
 - design considerations, 82–87
 - bandwidth requirements, 65, 85–86
 - distance requirements, 86
 - high availability requirements, 87
 - managed or unmanaged environments, 86–87
 - private and public loop support, 84–85
 - total number of loop devices per segment, 85
 - types of devices per loop segment, 83–84
 - fabric-supported, 94, 102
 - initialization, 70–76
 - LIPs, 71–73
 - positional mapping, 75–76
 - temporary loop master, 73–75
 - triggers of, 70
 - loop port state machine, 77–78
 - media access, 65, 73
 - node loop ports (NL_Ports), 59
 - nonbroadcast nature of, 80–82
 - physical topology, 65–68
 - port login (PLOGI), 76–77
 - tenancies of, 116–17
 - virtual, 94–95
- Arbitrated loop hubs, 66–67, 118–24
 - analyzer functionality in, 82
 - architecture, 119–22
 - cascaded, 67–68
 - managed, 123–25
 - redundant configurations, 87
 - star topology for, 118–19
 - unmanaged, 122–23
- Arbitrated loop physical address (AL_PA), 68–70, 378
 - assignment of, 74–75
 - association between SCSI addressing and, 77
 - fabric-assigned, 92
 - positional mapping of, 75–76
 - SNIA definition, 376
- Arbitrating state, 77
- Arbitration, 379
- Arbitration protocol, 65

- Arbitration won state, 77
- ARB(x) primitive, 79, 80
- Archive, 379
- Archiving, 379
- Area byte, 89
- ARM, 379
- ARP. *See* Address Resolution Protocol (ARP)
- Array, 379
- Array-based virtualization, 248–49
- Array configuration, 379
- ASIC technology, 127, 378, 380
- Association_Header, 380
- Asymmetric block service, 364–65
- Asymmetric cryptosystem, 380
- Asymmetric file service, 368
- Asymmetric virtualization (out-of-band virtualization), 469
- Asynchronous I/O operation, 380
- Asynchronous I/O request, 380
- Asynchronous Transfer Mode (ATM), 20, 23, 380
- ATA/IDE protocols, 294
- Atomic operation, 381
- Attenuation, 381
- Audit trail, 381
- Authentication, 170, 352, 381
- Authentication header, 381–82
- Authorization, 352, 382
- Automated cartridge system, 382
- Automatic backup, 382
- Automatic failover (switchover), 382
- Automatic swap, 382
- Auto-negotiation circuitry, 44
- Autonomous areas, 135–36, 153
- Auto swap, 382
- Availability, 382–83
- Backing store, 383
- Backup, 383. *See also* Tape backup
 - automatic, 382
 - block change, 11–12
 - cold, 395
 - disk image, 410–11
 - full, 430
 - hot, 435
 - incremental, 439
 - cumulative, 402
 - differential, 408
 - LAN-free, 37, 447
 - offline, 466
 - online, 466
 - raw partition, 481
 - remote, 11–12
 - security via, 201
 - serverless, 37, 494
- Backup client, 383
- Backup image, 383
- Backup manager, 383
- Backup policy, 383–84
- Backup window, 384
- Bandwidth
 - allocation of, 172–74
 - in arbitrated loop, 65
 - of arbitrated loops, 65, 85–86
 - management of, 22–23
 - for prepress operations, 259–60
 - SNIA definition, 384
 - for video editing, 258
- Basic input/output system (BIOS), 384, 386
- Baud, 384
- Bayonet Neil Councilman (BNC), 385, 387
- BB_buffer, 385
- BB_credit, 57, 385
- Beginning running disparity, 385
- Berkeley RAID levels, 385
- Best effort (class of service), 385
- Big endian, 386
- Bit error rate (BER), 43, 385, 386
- Bit synchronization, 386
- Black, 386
- Blades, 184
- Blind mating, 386
- Block addressing, 386
- Block aggregation, 3
- Block change backup, 11–12
- Block layer (SNIA Shared Storage Model), 345–47, 348–49
- Blocks, 3, 386
 - in NAS, 34
 - striping, 4
- Block storage
 - aggregation in SAN appliance, 363–67
 - data movement over long distances, 533–34
 - direct-attached, 361–62

- Block storage (*cont.*)
 - multi-site, 365–66
 - storage network-attached
 - with metadata server (“asymmetric block service”), 364–65
 - over traditional IP networks, 528
- Block subsystem, 3
- Block virtualization, 387
- Bluefin (Common Information Model (CIM)), 232, 234–37
- BNC, 385, 387
- Boot/booting/bootstrapping, 387
- Bridge controller, 387
- Bridge port (B_Port), 59, 383
- Broadcast, 387
- Broadcast storms, 150
- Broadcast transports, 80
- Browser-based management, 123, 230.
 - See also* Hypertext Transfer Protocol (HTTP)
- Buffer(s)/buffering, 388
 - double, 412–13
 - end-node, 56
 - infinite, 439
 - port, 176
- Buffer-to-buffer credit (BB_Credit), 57, 385
- Buffer-to-buffer flow control, 388
- Build fabric link service, 101
- Bursty data transmission, 86
- Bus, 28
- Bypass circuit, 66, 388
- Bypass mode, 119–20, 213
- Byte, 388

- CA, 388
- Cable plant, 388
- Cache, 388–89
 - coherency, 207
 - controller, 400
 - disk, 410
 - host, 435
 - NVRAM, 465–66
 - write back, 523
 - write through, 523–24
- Caching, 346, 350–51
- Camp on, 54
- Campus storage network, 272–74
- Canister, 389

- Capacity management, 269
- Capacity planning utilities, 233
- Carlson Companies, 8–12, 542
- Carousel, 389
- Carrier sense multiple access with collision detection, 25, 389
- Cascading, 67–68, 389
- Catalog, 389–90
- CD lasers, 106–7
- Certification, 298
- Certification authority, 390
- Changed block, 390
- Changed block point in time copy, 390
- Channel, 390
- Character, 390–91
- Character cell interface, 391
- Check data, 391
- Checkpoint, 391
- Childs, Sheila, 320
- Chunk, 391
- Chunk size, 391
- CIM/WBEM, 288
- CIOs, 298
- Cipher, 392
- Ciphertext, 392
- Circuit, 392
- Cisco SN 5420, 191, 541
- Cisco SN 5428, 191
- CKD architecture, 392, 401
- Clark, Tom, 320, 527
- Class 1 service, 53–54, 57, 392
- Class 2 service, 54, 57, 392
- Class 3 service, 54–55, 57, 392
- Class 4 service, 55, 56, 392–93
- Class 6 service, 55–56, 393
- Class F protocol, 56, 59, 93
- Classified information, 393
- Classless Inter-Domain Routing (CIDR), 151
- Class of service, 393
- Clartext, 393
- Clients, 393
 - backup, 383
 - management, 236
- Client service request, 394
- Clock, reference, 42–43
- Clock and data recovery (CDR) circuit, 43, 390, 394
- Clocking functionality, 25

- Close primitive (CLS), 51, 81
- Clustering software, 199–200, 265–67
- Clusters/clustering, 341, 354–55, 394
- CMU NASD, 369–70
- Coaxial cable, 394
- Code balance, 394
- Code bit, 394
- Code byte, 394
- Code violation, 395
- Cold backup, 395
- Cold swap, 395
- Collision recovery, 142
- Comdex, 317
- Comma character, 395
- Command descriptor block (CDB), 30–31, 160
- Command line interface (CLI), 393, 395
- Comma sequence, 49
- Commoditization, 294–95
- Common data access, 199
- Common HBA API, 111–12
- Common Information Model (CIM) (Bluefin), 15, 232, 234–37, 285, 391, 395
- Common Information Model Object Model (CIM OM), 236, 322
- Common Internet File System (CIFS), 6, 251, 391, 395–96
- Common Management Information Protocol (CMIP), 394, 396
- Communication circuit, 396
- Communications security, 396
- Compaq Computer Corporation, 320
- Complex array, 396
- Compliance testing, 314–15
- Compression, 396
 - data, 275
 - file, 260
- Computer security, 397
- Computerworld*, 321
- Concatenation, 397
- Concord Communications, 219
- Concurrency, 397
- Concurrent/concurrent copy, 397
- Concurrent operations, 397
- Conditioning, 397
- Conference Committee (SNIA), 321
- Confidentiality, 398
- Configuration, 398
- Connection, 398
- Connection allegiance, 162
- Connection ID (CID), 163
- Connection initiator, 398
- Connectionless buffer, 398
- Connectionless frame, 398
- Connectionless integrity service, 399
- Connectionless service, 399
- Connection-oriented transport protocol, 154
- Connection recipient, 398
- Connectors, small form factor (SFF)
 - fiber-optic, 45–46, 47
- Console, 399
- Consolidation, 267–69, 399
- Content sharing, 356
- Context switching, 29–30
- Continuously increasing relative offset, 399
- Contributing technologies, 299–300
- Controller(s), 400
 - bridge, 387
 - domain, 412
 - embedded, 414
 - external storage, 419
 - file server, 366–67
 - intelligent, 441, 540
 - RAID, 28, 112, 113–14, 239–40
- Controller based array/controller based disk array, 400
- Controller cache, 400
- Control software, 399
- Convergence, 154, 289–90, 293
- Copper media, Fibre Channel on, 44–45, 46
- Copper ports, 121
- Copyback, 400
- Copy on write, 400
- Count-key-data (CKD) architecture, 392, 401
- Covert channel, 401
- Credit, 401
- Credit-based flow control, 56–57
- Cross-talk, 121–22
- Cryptanalysis, 401
- Cryptosystem, 380, 401
- CSMA/CD, 401
- Cumulative incremental backup, 402
- Current fill word (CFW), 79

- Current running disparity, 402
- Current utilization (load), 99
- Customer Advisory Council (SNIA), 320–21
- Customer Executive Council (SNIA), 320
- Customer replaceable unit (CRU), 401, 402
- Customers, SAN, 527–28
- Cut-through switches, 185
- Cut-through switching, 88, 402
- Cyclic redundancy check (CRC), 52, 401, 402
- Cylinder, 402
- Cylinder-head-sector (C-H-S) addressing, 391, 402

- Daemon, 403
- DAFS (direct access file system) Forum, 323
- Dark fiber, 133, 534
- Data access, common, 199
- Data availability, 403
- Database management systems, 343, 405
- Databases, host-based, 344
- Database server, 344–45
- Data blocks, striping, 112, 346, 505
- Data byte, 403
- Data character, 403
- Data compression, 275
- Data duplication, 532
- Data encoding
 - in Fibre Channel, 48–50
 - in Gigabit Ethernet, 50, 143
- Data encryption, 170, 296
- Data Encryption Standard (DES), 170, 403, 406, 537
- Data frame, 403
- Data generators, 217
- Datagram, 405
- Data manager, 404
- Data mirroring, 203, 204
- Data model, 404
- Data packets. *See* Frame(s) (data packets)
- Data paths, dual, 200
- Data reliability, 404
- Data replication, 203–5
- Data Replication Manager, 203
- Data restoration, 487, 540
- Data sharing, 205–7, 356

- Data storage utility, 252
- Data stripe depth, 404
- Data striping, 112, 346, 404, 505
- Data transfer capacity, 404
- Data transfer-intensive application, 404
- Data transfer rate, 405
- Data vs. storage issue, 355
- Decoding, 405
- Decryption, 405
- Dedicated connection, 406
- Dedicated connection service, 406
- Degaussing, 406
- Degraded mode (reduced mode), 406, 483
- Delimiter, 406
- Denial of service (DoS), 406, 412
- Dense Wave Division Multiplexing (DWDM), 132–34, 272, 534, 539, 540
- Departmental fabric switches, 128–29
- Desktop Management Interface (DMI), 406, 411
- Destination (DA) address, 143–44
- Destination identifier, 407
- Destination N_Port, 407
- Device. *See* Storage devices
- Device bus/device I/O bus, 407
- Device channel, 407
- Device drivers
 - IP over Fibre Channel, 111
 - iSCSI, 188
 - NIC, 151
 - SCSI-3, 111
 - troubleshooting, 213
- Device fanout, 407
- Device management applications, 224–25
- Device Memory Export Protocol (DMEP), 207
- Device status information, 228
- D_ID, 403
- Differential cable propagation delay, 32
- Differential incremental backup, 408
- Differential mirror resynchronization (DMR), 408, 411
- Differential signaling, 408
- Differentiated Services (DiffServ), 169, 408
- Digest, 408

- Digital Linear Tape, 408, 411
- Digital signature, 409
- Direct-attach architecture, 348, 349
- Direct-attached block storage, 361–62
- Direct-attached storage (DAS), 3–4, 361–62
- Director fabric switches, 128, 129–30
- Directory, 409
- Directory agent (DA), 164, 165
- Directory Enabled Network (DEN), 406, 409
- Directory tree, 409
- Disaster recovery (DR), 97, 276–78, 539–41
- Discard policy, 409
- Disclosure, unauthorized, 514
- Disconnection, 409
- Discovery domains (DDs), 166–67, 195
- Discovery in IP SANs, 164–68
 - Internet Storage Name Server (iSNS), 166–68
 - Service Locator Protocol (SLP), 164–65
- Disk array, 410
- Disk array subsystem, 410
- Disk block, 410
- Disk cache, 410
- Disk drives, 410
 - Fibre Channel, 76
- Disk image backup, 410–11
- Disk information retrieval, automated, 233
- Disk mirroring. *See* Mirroring
- Disk scrubbing, 411
- Disk shadowing. *See* Mirroring
- Disk striping. *See* Data striping
- Disk subsystem, 411
- Disparity, 411
- Distance requirements for open systems storage, 277
- Distance-vector protocol, 153
- Distributed File Access System (DAFS), 35
- Distributed file systems and file sharing, 205–7
- Distributed Management Task Force (DMTF), 235, 285, 411, 412
- Document type definition (DTD), 412, 413
- Domain, 412
 - Domain byte, 89
 - Domain controller, 412
 - Domain Name System (DNS), 412
 - Domain Name System (DNS) addressing, 270
 - Domain Name System (DNS) servers, 164
 - Domain sets, 166
 - Double buffering, 412–13
 - Drive letter, 413
 - Driver, 413. *See also* Device drivers
 - I/O, 444
 - DSA, 413
 - Dual active components, 413
 - Dual data paths, 200
 - Duplicate, 413
 - Duplication of data, 532
 - Dynamic host control protocol (DHCP), 407, 413
 - Dynamic mapping, 414
- Education Committee (SNIA), 321
- EE_buffer, 414
- eHealth-SAN, 219
- 8b/10b encoding, 48–50, 143, 371
- 8b/10b running disparity, 69
- Electromagnetic interference (EMI), 43, 46
- Electronic storage element, 414
- Embedded controller, 414
- Embedded HTTP, 230
- Embedded-loop switch technology, 36
- EMC SRDF, 248
- Encapsulating Security Payload (ESP), 415, 416
- Encoding, 415
- Encoding algorithm, 8b/10b, 48–50, 143, 371
- Encryption, 415
 - data, 170, 296
 - end-to-end, 415
 - third-party devices, 537–38
- End of frame (EOF) ordered set, 51, 52, 69, 415, 416
- End-to-end encryption, 415
- End-to-end flow control (EE_Credit), 57, 414, 415
- Enterprise management applications, 234
- Enterprise Network Storage Architecture (ENSA), 296

- Enterprise Resource Management (ERM), 415, 416
- Enterprise storage management, 233–34, 342
- Enterprise Systems Connection (ESCON), 416
- Entry/exit port, 416
- E_Port, 59, 127, 414
 - iFCP and, 159
 - standardization, 99–100
 - stretched, 134, 159
- E_Port connections (interswitch links), 98
 - to DWDM infrastructure, 133–34
 - to fabrics, 192
 - troubleshooting, 214
- Error correcting code (ECC), 414, 416
- Error recovery, Fibre Channel, 53
- ESRM (Enterprise Storage Resource Management), 416
- Ethernet, 1, 19, 21–23, 141–49. *See also* Gigabit Ethernet
 - access method in, 25
 - broadcast storms, 150
 - as broadcast transport, 80
 - collision recovery mechanism, 142
 - cut-through switching, 88
 - evolution of, 293–94
 - fabrics management over, 128
 - Fast, 1, 21
 - frame format, 143–44
 - IP protocol over, 144
 - iSCSI storage development and, 299
 - SNIA definition, 417
 - transmission rates, 21–22
 - virtual LANs in, 147–48
- Ethernet adapter, 25, 417
- European Broadcast Union (EBU), 414, 417
- Event logs, 123–24
- Exchange, 52–53, 417
- Exchange_Identifier (X_ID), 417, 524
- Exchange status block, 418
- Exclusive connection, 418
- Exit port, 418
- Expansion card/module, 418
- Expansion module, 418
- Expansion ports. *See* E_Port
- Expansion slot, 418
- Explicit addressing, 418
- Export (verb), 418
- Extended copy (third-party copy), 83, 194, 202, 203, 264, 510, 511
- Extended link services, 76, 77
- EXtensible Markup Language (XML), 236, 419, 524
- Extent, 419
- External storage controller, 419
- External volume serial number (EVSN), 417, 419
- Eye, 419
- Eye diagram, 43–44, 419
- Eye opening, 420
- Fabric login (FLOGI), 76, 91–92, 126, 420, 429
 - compliance to, 315
- Fabric loop ports (FL_Port), 59, 429
 - access fairness in, 79
 - arbitrated loop devices via, 94
- Fabric Name, 420
- Fabric/node loop port (F/NL_Port), 59
- Fabrics, 13, 42, 63, 88–102, 420
 - addressing, 58–59, 89–90
 - ASIC-based, 127
 - cascading, 127
 - distributed, 159
 - E_Port connectivity to, 192
 - extended, 97–102
 - E_Port standardization, 99–100
 - principal switch selection, 100–102
 - identifier, 74
 - iFCP gateway to, 157
 - loops and, 94, 102
 - management, 128
 - mesh topology, 90–91
 - performance issues, 127
 - per-port cost, 91
 - private and public loop support, 84, 94–96
 - reconvergence issues, 101–2
 - Simple Name Server (SNS), 91, 92–93, 100
 - State Change Notification (SCN), 91, 93–94
 - switching hubs and, 125
 - troubleshooting, 214–15
 - zoning, 96–97, 100

- Fabric Shortest Path First (FSPF), 27, 98, 99–100, 154
- Fabric stability timeout value (F_S_TOV), 101
- Fabric switches, 88–89, 126–30
 - departmental, 128–29
 - director, 128, 129–30
 - performance over distance, 133
- Failback (switch-back), 420, 506
- Failover (switch-over), 421, 506
 - automatic, 382
 - for clustered servers, 199, 200
 - transparent, 512
- Failure tolerance, 421
- Fair access, 79–80
- Fanout, 421
- Fast Ethernet, 1, 21
- Fast mirror resynchronization (FMR), 421, 430
- Fast SCSI, 421
- Fault tolerance, 422
- FC-0 layer, 42, 422
- FC-1 layer, 42, 422
- FC-2 layer, 41, 42, 78, 422
- FC-3 layer, 41, 42, 422
- FC-4 layer, 41, 42, 77, 422
- FC-AL-2, 75
- FCIA, 315, 317, 324
- FCIP, 134–35, 156, 272–73, 285
 - data replication and, 205
- FC-PH, 422
- FDDI adapter, 424
- Federal Information Processing Standard (FIPS), 424, 429
- Federated Management Architecture Specification, 424
- Fermilab, 207
- Fiber, multimode and single-mode, 45
- Fiber Channel Protocol for SCSI-3, 77
- Fiber Distributed Data Interface (FDDI), 423, 424
- Fibre, 424
- Fibre Alliance, 314
- Fibre Channel, 1, 13, 25, 37, 41–139, 285, 424–25
 - access method in, 25
 - address space assumptions, 42
 - analyzers, 81–82
 - arbitrated-loop disk drives, 36
 - arbitrated-loop hubs, 66–67, 118–24
 - architecture, 119–22
 - cascaded, 67–68
 - managed, 123–25
 - redundant configurations, 87
 - star topology for, 118–19
 - unmanaged, 122–23
 - architecture, 63
 - autonomous regions, 135–36
 - bit error rate, 43
 - campus SANs based on, 272–73
 - compliance testing, 315
 - convergence issue and, 289
 - data encryption, 296
 - discovery process, 164
 - disk drives, 76, 85
 - distances supported, 272
 - error recovery, 53
 - extension products, 132–36, 273
 - dense wave division multiplexing (DWDM), 132–34
 - Fibre Channel WAN bridging, 135–36
 - IP tunneling (Fibre Channel over IP (FCIP)), 134–35, 156, 205, 272–73, 285
- fabric switches, 88–89, 126–30
 - departmental, 128–29
 - director, 128, 129–30
 - performance over distance, 133
- host bus adapters, 85, 108–12
- infrastructure using, 37
- internals, 41–62
 - classes of service, 53–56
 - data encoding, 48–50
 - flow control, 56–57
 - framing protocol, 51–53
 - layers, 41–42
 - name and addressing conventions, 57–59
 - 1Gbps and 2Gbps transport, 42–44
 - ordered sets, 50–51
 - physical layer options, 44–48
- IP over, 111
- JBODs, 115–18
- jitter, 43–44
- long distance data storage and, 534
- management information bases (MIBs), 228, 232

- Fibre Channel (*cont.*)
 - management protocol, 226
 - multicast service, 55–56
 - network assumptions, 42
 - packet recovery in, 26
 - port standards, 127
 - product interoperability, 105
 - RAID, 112–15
 - routing in, 27
 - SAN topologies. *See* Arbitrated loop(s); Fabrics; Point-to-point topology
 - security weakness of, 169
 - standards, 286, 303
 - switching hubs, 124–26
 - switch routing protocols, 285
 - technical and marketing resources, 304
 - 10Gbps, 299
 - transceivers, 46–47, 106–8
 - transport topologies, 42
 - unique identifiers in, 26
 - upper-layer protocol in, 27
 - vendors, 308–9
 - virtual circuits, 55
- Fibre Channel analyzers, 215–17
- Fibre Channel Arbitrated Loop (FC-AL), 423, 425
- Fibre Channel Association (FCA), 423, 425
- Fibre Channel Audio Video (FC-AV), 423, 425
- Fibre Channel Avionics Environment (FC-AE), 422, 425
- Fibre Channel Generic Services (FC-GS2), 423, 426
- Fibre Channel Industry Association (FCIA), 105, 286, 317, 324, 426
- Fibre Channel Loop Community, 425
- Fibre Channel Management Integration MIB, 530
- Fibre Channel Name, 426
- Fibre Channel Protocol (FCP), 27, 205, 423, 426
 - bus/target/LUN mapping in, 28
 - information units (IUs), 31
- Fibre Channel server, 76–77
- Fibre Channel Service Protocol (FSP), 426, 430
- Fibre Channel Single Byte (FC-SB), 423, 426
- Fibre Channel Switched (FC-SW), 423, 426
- Fibre Channel switches
 - OEM microcode in, 111
 - standards, 530
 - troubleshooting, 214
- Fibre Channel Switch Fabric (FC-SW), 89
- Fibre Channel Systems Initiative (FCSI), 423, 427
- Fibre Channel-to-SCSI bridges, 131–32
- Fibre Channel Virtual Interface (FC-VI), 423, 427
- Fibre Channel WAN bridging, 135–36
- Fibre Connect (FICON), 427
- Field replaceable unit (FRU), 129, 427, 430
- File, 427
- File-based data, 1
- File compression, 260
- Filer, 428
- File/record layer (SNIA Shared Storage Model), 343–45, 348–49
- File/record subsystem, 2
- File server, 344–45, 428
- File server controllers, 366–67
- File service, asymmetric, 368
- File systems, 343, 344, 428
 - distributed, 205–7
 - host-based, 344
 - network, 344–45
- File systems virtualization, 250–51, 428
- File virtualization, 428
- Fill byte/word, 428–29
- Fill word, 429
- Finance Committee (SNIA), 321
- Firmware, 428
- Fixed block architecture (FBA), 422, 429
- Flash ROMs, 110–11
- FLOGI. *See* Fabric login (FLOGI)
- Flow control, 25, 146–47
 - buffer-to-buffer, 388
 - credit-based, 56–57
 - end-to-end (EE_Credit), 57, 414, 415
 - Fibre Channel, 56–57
 - TCP, 155

- Formatting, 429
- F_Port, 59, 127, 420
 - connection to DWDM infrastructure, 133–34
 - local, 450
- F_Port name, 420
- Frame activity, capturing for diagnosis, 215–16
- Frame check sequence (FCS), 144
- Frame content, 430
- Frame(s) (data packets), 26, 51–52, 429–30, 469
 - corruption of, 26
 - Ethernet format, 143–44
 - jumbo, 275
 - out-of-order delivery of, 90, 91
 - queuing of, 89
 - routing of, 26–27
- Frame error, 172
- Frame header, 52
- Frame parsing (frame cracking), 191
- Frame prioritization, 149
- Frame Relay, 20, 23
- Frame routing, 24-bit port addressing, 58
- Framing, variable-length, 52
- Framing format, Gigabit Ethernet, 143–44
- Framing protocol, 51–53
- Frozen image method (FIM), 424, 430, 431
- Full backup, 430
- Full duplex, 25, 430
- Full volume transfer rate (spiral data transfer rate), 430, 500
- Future of SAN, 15–16, 293–301
 - contributing technologies, 299–300
 - human factors, 298–99
 - integration into mainstream networking, 293–95
 - ubiquity of shared storage, 296–97
 - virtualization, 297
- GBE. *See* Gigabit Ethernet
- GBIC. *See* Gigabit interface converters (GBICs)
- GByte (GB), 431, 432
- Generic port (G-Port), 59
- Geometry, 431–32
- Gigabaud link module (GLM), 46, 432
- Gigabit Ethernet, 1, 21–22, 25, 142–49, 163, 285, 431
 - access method in, 25
 - adapter cards, 156
 - for campus storage networks, 272–74
 - data encoding in, 50, 143
 - flow control, 146–47
 - frame prioritization, 149
 - framing format, 143–44
 - GBIC support of, 108
 - iFCP protocol and, 158
 - physical and data-link layers, 143
 - quality of service mechanisms, 168–69
 - SAN infrastructure using, 37
 - SNIA definition, 432
 - standards, 303–4
 - traffic prioritization, 168
 - transport, 142–49
 - vendors, 311
 - VLAN tagging, 147–48
- Gigabit Ethernet switches, 142, 183–86, 299
 - architecture, 184–85
 - capabilities, 183–84
 - link aggregation, 144–45
 - 10Gbps interswitch link modules, 185
- Gigabit (Gb, Gbit), 431, 432
- Gigabit interface converters (GBICs), 46–47, 106–8, 121–22, 431, 432
- Gigabit media-independent interface (GMII), 142
- Gigabit serial transport. *See* Fibre Channel
- Gigabit transport, 3
- Gigabyte System Network, 432, 433
- GL_Port, 59
- G_Port, 127, 431
- Graphical images, 259
- Graphical user interface, 433
- Group, 433
- Hacker, 433
- Handshake, OFC, 47–48
- Hard zone, 433
- HBA. *See* Host bus adapters (HBAs)
- HDS TrueCopy, 248

- Headers, 26
 - Fibre Channel, 52
- Heartbeat protocol, 200, 247
- Heartbeat status, 266–67
- Hierarchical storage management (HSM), 433, 436
- High availability, 433–34
- Highground Systems, 532
- High Performance Parallel Interface (HiPPI), 41, 434
- High-speed serial direct connect (HSSDC), 47, 434, 436
- Hop, 21
- Hop count limitations, 127, 130
- Hop count method of IP routing, 153
- Host, 434
 - access control in, 352
- Host adapter, 434
- Host based disk array, 434
- Host-based file systems and databases, 344
- Host-based storage virtualization, 245–46
- Host based virtualization, 434
- Host Bus Adapter API (HBA API), 322
 - Common, 111–12
- Host bus adapters (HBAs), 28, 85, 108–12, 435
 - CIM agent support, 236
 - device drivers, 111
 - dual-provisioning, 87
 - FC layers in, 109–10
 - Flash ROMs, 110–11
 - functional diagram, 109
 - loop initialization, 71–72
 - multiported, 109
 - 64-bit PCI, 110
- Host cache, 435
- Host computer, 341, 435
- Host environment, 435
- Host I/O bus, 434, 435
- Hot backup, 435
- Hot file, 436
- Hot spare (disk), 435, 436
- Hot standby (component, controller), 436
- Hot swap, 436
- Hot swap adapter, 436
- HP DRM, 248
- Hub cascading, 67–68
- Hub port, 59, 437
- Hubs, 437
 - arbitrated loop. *See* Arbitrated loop hubs
 - switching, 124–26
- Human factors, 298–99
- Hunt group, 437
- HyperText Markup Language (HTML), 436, 437
- Hypertext Transfer Protocol (HTTP), 227, 229–30, 231, 436, 437
- IBM 200i TotalStorage array, 189, 541
- Idempotency, 437–38
- IDE protocol, 294
- IDLE primitive, 51, 69, 79
- Idle word, 438
- IEEE, 285
- IEEE 802.1p/Q frame prioritization, 149
- IEEE 802.1Q VLAN tagging, 147–48
- IEEE 802.3ad link aggregation, 144–45
- IEEE 802.3 committee, 530
- IEEE 802.3x flow control, 146–47
- IEEE 802.3z standard, 142
- IETF, 16, 285, 303, 313, 314, 438, 442, 529, 530
- iFCP, 272–73, 285
 - data replication and, 205
 - for Fibre Channel-to-Fibre Channel extension, 192–93
- iFCP gateways, 273
- iFCP protocol, 134
- Ignored (field), 438
- Images, graphical, 259
- Implicit addressing, 438
- In-band storage network management, 225–27
- In-band storage virtualization, 243–45
- In-band transmission, 438
- Incremental backup, 439
 - cumulative, 402
 - differential, 408
- Incremental mirror resynchronization (IMR), 438, 439
- Independent access array, 439
- Industry associations, 317. *See also* SNIA
- Industry forums, SNIA, 323–24

- InfiniBand, 285, 299, 324
 - standards, 304
- InfiniBand Trade Association (IBTA), 285, 314, 324
- Infinite buffer, 439
- Information category, 439
- Information model, 439
- Information system, 440
- Information technology (IT), 440, 445
- Information units (IUs), 31, 440
- Infrastructure, 5–6
 - applications and, 538–39
 - using Fibre Channel, 37
- Infrastructure-based virtualization, 440
- Inherent cost, 440
- Initialization, 440
 - of arbitrated loop, 70–76
 - LIPs, 71–73
 - positional mapping, 75–76
 - temporary loop master, 73–75
 - triggers of, 70
- Initial relative offset, 440
- Initiators, 19, 25, 63, 65, 70, 75, 441
 - in iSCSI environment, 163
 - multiple, 83–84
 - performance and, 85
 - SCSI, 28, 29–30
 - target discovery, 76, 92
 - transaction launching, 83
- Inode, 441
- Instantiation, 441
- Intelligence, network, 160
- Intelligent controllers, 441, 540
- Intelligent device, 441
- Intelligent Peripheral Interface (IPI), 441, 445
- Intercabinet, 441
- Interconnect, 441
- Interconnect-based storage virtualization, 246–48, 249
- Interconnection network, 340–41
- Interface connector, 441
- Interfaces to modular systems, 358–59
- Interference, electromagnetic (EMI), 43, 46
- Intermix, 55, 442
- International Standards Organization (ISO), 442, 445
- International Telecommunications Union (ITU) X.509 standard, 170
- Internet, 150, 293
- Internet Control Message Protocol (ICMP), 437, 442
- Internet Engineering Task Force (IETF), 16, 285, 303, 313, 314, 438, 442, 529, 530
- Internet Fibre Channel Protocol (iFCP), 27, 156, 157–60, 534
- Internet Key Exchange (IKE), 438, 442
- Internet Protocol. *See* IP
- Internet SCSI. *See* iSCSI
- Internet service providers (ISPs), 270–72
- Internet Storage Name Server (iSNS), 166–68
- Interoperability, 15, 105, 286–88, 539.
 - See also* Standardization
 - standards compliance vs., 530–31
 - zone merging and, 128
- Interoperability Committee (SNIA), 321–22
- Interoperability Compliance Test Program (ICTP), 315
- Interrupt, 442
- Interrupt switch, 443
- Interswitch links (ISLs), 98
 - to DWDM infrastructure, 133–34
 - to fabrics, 192
 - troubleshooting, 214
- Intracabinet, 443
- Intracabinet copper, 45
- Inventory information, 107
- I/O, 443
 - multi-path, 460
- I/O adapter, 443
- I/O bottleneck, 443
- I/O bus, 443
- I/O driver, 444
- I/O intensity, 444
- I/O load, 444
- I/O load balancing, 444
- I/O load optimization, 444
- I/O operation, 444
- I/O request, 444
- I/O subsystem, 444
- IP, 25, 442
 - addressing, 151–52
 - over Ethernet, 144
 - Fibre Channel over, 111, 134–35
 - voice over, 293

- IP Authentication Header, 170
- IP network analyzers, 217–18
- IP networks, standards organizations governing, 530
- IP routers, 186
- IP routing, 27, 152–54, 278
- IP SAN, 141–81, 183–98, 536, 539
 - discovery in, 164–68
 - Internet Storage Name Server (iSNS), 166–68
 - Service Locator Protocol (SLP), 164–65
- Ethernet, 141–49
 - collision recovery mechanism, 142
 - Gigabit Ethernet transport, 142–49
- Gigabit Ethernet switches, 183–86
 - architecture, 184–85
 - capabilities, 183–84
 - 10Gbps interswitch link modules, 185
- IP routers, 186
- IP storage gateways, 191–93
- iSCSI adapter cards, 186–89
 - device drivers, 188
 - functional diagram, 187
 - TOEs in, 187–88, 189
- iSCSI storage devices, 189–90
- iSCSI-to-SCSI bridges, 193–94
- iSNS servers, 195
- management issues and, 288
- management protocol, 226
- native IP storage protocols, 156–63
 - Internet Fibre Channel Protocol (iFCP), 156, 157–60
 - Internet SCSI (iSCSI), 156, 160–63
- quality of service for, 168–69
- security issues, 169–71, 537–38
 - access, 169–70
 - authentication, 170
 - data encryption, 170
- TCP/IP, 141, 149–56
 - address resolution protocol (ARP), 152
 - IP addressing, 151–52
 - IP routing, 152–54
 - TCP session control, 154–56
- vendors, 309–10
- wide area storage networking, 171–76
 - bandwidth allocation, 172–74
 - data throughput, 174–75
 - latency issues, 172, 175–76
- IP Security (IPSec), 170, 186, 445
- IP storage, 232, 304, 322, 323
- IP storage gateways, 191–93
- IP storage protocols, 156–63
 - native, 156–63
 - Internet Fibre Channel Protocol (iFCP), 27, 156, 157–60, 534
 - Internet SCSI (iSCSI), 156, 160–63
- IP storage switches, 192–93, 536
- IP tunneling (Fibre Channel over IP (FCIP)), 111, 134–35
- IP tunneling gateways, 534
- iSCSI, 27, 28, 134, 285, 289
 - campus SANs based on, 273–74
 - discovery in, 164–65
 - enabling migration to, 541–42
 - for Fibre Channel-to-Fibre Channel extension, 192–93
 - hardware, 188–89
 - identity assignment, 161–62
 - IP-based features, 163
 - in IP SANs, 156, 160–63
 - ISP configuration using, 272
 - logout command, 163
 - network intelligence issue and, 160
 - protocol data unit (PDU), 31
 - protocol proposal, 286
 - protocol stack, 161
 - security issues, 163
 - IPSec and, 170–71
 - standard, 296
 - software, 188
 - unique identifiers in, 26
 - write operation, 162
- iSCSI adapters, 186–89, 536, 541–42
 - device drivers, 188
 - functional diagram, 187
 - TOEs in, 187–88, 189
- iSCSI network analyzers, 217–18
- iSCSI standards initiative, 531
- iSCSI storage devices, 189–90, 299, 542
- iSCSI-to-Fibre Channel storage switch, 191–92
- iSCSI-to-SCSI bridges, 193–94, 536

- iSNS protocol, 296
- iSNS servers, 195
- Issues, 283–91
 - convergence, 289–90
 - interoperability, 286–88
 - management, 288–89
 - standardization, 283–86
 - storage network, 231–32
- ITA, 324
- Java, 445
- JBODs (just a bunch of disks), 65, 67, 85, 102, 115–18, 233, 445
 - enclosures, 117
 - iSCSI, 190
 - software RAID with, 116–17
- Jini, 445
- Jiro, 445–46
- Jitter, 43–44, 446
- Jitter budget, 43
- Jones, Arnold, 319
- K28.5 command character, 49–50, 446
- Key, 446
 - encryption, 170
- Key exchange, 446
- Keying material, 447
- Key management, 446
- Key pair, 447
- Kilobyte (KB; KByte), 446, 447
- Label, 447
- LAN-free backup, 37, 447
- Large I/O request (large read request; large write request), 447–48
- Laser(s)
 - CD, 106–7
 - long wavelength (LWL), 451, 452
 - non-OFC, 464
 - troubleshooting, 212–13
 - vertical cavity surface emitting (VCSELs), 107, 516, 517
- Latency, 448
 - link, 172
 - speed-of-light, 172, 175, 277, 534
 - video editing and, 259
 - wide area storage networking and, 172, 175–76
- Latent fault, 448
- Layer 2 networks, 149–50
- Legacy devices, 131–32
 - SCSI disk arrays, 193
- Library, 448
- Light-emitting diodes (LEDs), 120–21, 448
- Lightweight Directory Access Protocol (LDAP), 448, 449
- Link, 449
- Link aggregation (trunking), 144–45
- Link control frame, 449
- Link latency, 172
- Link layer LANs, 534
- Link-state protocol, 99, 153
- Lit fiber, 133
- Load balancing, 449
- Load (current utilization), 99
- Load optimization, 449
- Load sharing, 199, 450
- Load sharing trunking, 127
- Local area network emulation (LANE), 447, 450
- Local area networks (LANs), 6, 21, 447, 450
 - link layer, 534
 - management information base (MIB) for, 228
 - protocol analyzers, 217
- Local F_Port, 450
- Logical block, 450
- Logical block address (LBA), 448, 450
- Logical disk, 451
- Logical Disk Manager (LDM), 448, 451
- Logical sharing, 356
- Logical storage resource, 342
- Logical Unit Numbers (LUNs), 28, 205–6, 346, 451, 452
 - troubleshooting, 214–15
- Logical units (LUs), 345, 356, 451
- Logical volume, 451
- Logical volume management (LVM), 4, 245
- Login
 - fabric (FLOGI), 76, 91–92, 126, 420, 429
 - compliance to, 315
 - iSCSI, 161–62

- Login (*cont.*)
 - N_Port (PLOGI), 63, 76–77, 92–93, 473, 475
- Login server, 451
- Long Wavelength Laser (LWL), 451, 452
- Loopback, 452
- Loop identifier, 68, 95
- Loop initialization, 452
 - in switching hubs, 125
- Loop initialization fabric address (LIFA), 74
- Loop initialization hard address (LIHA), 75
- Loop initialization loop position (LILP), 75–76
- Loop initialization previous address (LIPA), 74
- Loop initialization primitives (LIPs), 51, 71–73, 449, 452
- Loop initialization report position (LIRP), 75
- Loop initialization select master (LISM), 74, 449, 452
- Loop initialization soft address (LISA), 75
- Loop master, 73–74
- Loop port state machine (LPSM) circuit, 77–78, 110, 452
- Loops
 - redundant, 122
 - virtual, 125
- L_Port, 447
- LUN masking, 214, 269
- LUNs. *See* Logical Unit Numbers (LUNs)

- MAC addresses, link aggregation and, 145
- Magnetic remanance, 453
- Maintenance of gigabaud link module (GLMs), 46
- Managed Object Format (MOF), 453, 458
- Management, 223–38, 342
 - Common Information Model (CIM) (Bluefin), 15, 232, 234–37, 285, 395
 - of distributed file systems, 206–7
 - of fabrics, 128
 - hierarchy of, 224
 - integration of storage, systems, and enterprise management, 234
 - issues in, 288–89
 - of SANs, 15
 - standardization of, 288–89
 - of storage, 233–34
 - of storage network, 123, 223–32
 - HTTP, 227, 229–30, 231
 - in-band, 225–27
 - issues in, 231–32
 - out-of-band, 225, 227
 - SNMP, 35, 224, 227, 228–29, 313, 314
 - Telnet, 227, 230–31
 - of storage resources, 232–33, 532–33
 - vendors, 310–11
- Management Information Bases (MIBs), 228, 232, 313, 453, 457
- Management services, 3
- Management workstations, 225, 226–27
- Mandatory (provision), 453
- Mapping, 453
- Mapping boundary, 453
- Marketing, undue influence on systems engineering, 98–99
- Marketing Committee (SNIA), 322
- Maximum Transfer Unit (MTU), 453, 459
- MD5, 454
- Meaningful (control field), 455
- Mean time between failures (MTBF), 87, 454, 458
- Mean Time to Data Loss (MTDL), 454, 458
- Mean time to (loss of) data availability, 454
- Mean Time to Repair (MTTR), 454–55, 458
- Mean Time Until (Loss of) Data Availability (MTDA), 458
- Media, 455
- Media Access Control (MAC), 25, 452, 455
- Media defect, 455
- Media ID, 455, 482
- Media interface adapters (MIAs), 47, 121
- Media manager, 455
- Media stacker, 456

- Megabaud, 456
- Megabit (Mb; Mbit), 454, 456
- Megabits per second (Mbps), 454
- Megabyte (MB; MByte), 454, 456
- Megabytes per second (MBps), 454
- Megatransfer, 456
- Member disk, 456
- Member (member disk), 456
- Membership Committee (SNIA), 322
- Meshed network, 27
- Mesh topology, 90–91
- Message-digest algorithm, 456
- Metadata, 34, 243–45, 265, 456–57
- Metadata server, 364–65
- Metropolitan area network (MAN), 141, 453, 457
- Mirrored array, 458
- Mirrored disks (mirrors), 457
- Mirroring, 112–13, 203, 277, 457, 508, 540
 - data, 203, 204
 - long distance, 540–41
 - to virtual storage, 247
- Mirror resynchronization (resilvering), 457, 487
- Modeling language, 458
- Mode of fiber-optic cabling, 45
- Modular systems, 357–59
- Monitoring state, 77
- Monitor (program), 458
- Mount, 458
- Multicast, 459
- Multicast group, 459
- Multicast service, 55–56
- Multi-level disk array, 459
- Multilevel security (MLS), 458, 459
- Multimode fiber, 45, 459
- Multi-path I/O, 460
- Multi-Protocol Label Switching (MPLS), 169
- Multipurpose Internet Mail Extensions (MIME), 457, 460
- Multiservice ports, 192, 193
- Multi-site block storage, 365–66
- Multi-threaded, 459

- Name_Identifier, 460
- Name server, 92, 460
- Namespace, 461

- Naming, 460–61
- NAS appliances, 194
- NAS devices, 6–7
- NAS/file server metadata manager (“asymmetric file service”), 368
- NAS head, 345, 349, 366–67
- NAS (Network Attached Storage), 1, 6–7, 289, 359–60, 368, 461
 - ISP using, 270–71
 - Shared Storage Model mapped to, 6–7, 359–60, 368
- NAS server, 349
- NAS virtualization, 250–51
- National Committee Information Technology Standards (NCITS), 461
- National Institute of Standards and Technology (NIST), 461, 463
- Native IP protocol, 156–63
 - Internet Fibre Channel Protocol (iFCP), 27, 156, 157–60, 534
 - Internet SCSI (iSCSI), 156, 160–63
- “Native” storage devices, 345–46
- NCITS/ANSI FC-GS-2 standard, 100
- NCITS/ANSI FC-SW-2 standard, 99, 100
- NCITS/ANSI T10 committee, 16, 285, 314, 377, 508, 524, 530
- NCITS/ANSI T11 committee, 16, 285, 317, 377, 508, 524, 530
- NCITS/ANSI T11X3 committee, 41
- Negative disparity, 48
- NeoScale, 169
- NetApp filers, 320
- Network(s). *See also* Storage network
 - bandwidth management in, 26–27
 - campus storage, 272–74
 - interconnection, 340–41
 - meshed, 27
 - peer-to-peer, 1, 202
 - routers, 23
 - SNIA definition, 461–62
 - wide area (WANs), 23, 520, 521
- Network adapter, 462
- Network Address Authority (NAA), 460, 462
- Network Appliance, 36, 320
- Network Associates, 81

- Network-attached storage, 34–36, 462
 - architecture, 34
 - file transport, 34–35
 - separation of storage from processor or head, 35–36
- Network Attached Storage. *See* NAS (Network Attached Storage)
- Network Data Management Protocol (NDMP), 461, 462
- Network File System (NFS), 6, 251, 344–45, 463
- Networking, 19
 - bandwidth management, 22–23
 - behind the server, 36–38
 - Ethernet. *See* Ethernet
 - in front of the server, 19–27
 - access method, 25
 - addressing, 25–26
 - packetizing of data, 26
 - routing of packets, 26–27
 - serial transport, 24–25
 - upper-layer protocol support, 27
 - OSI model, 20
 - segmentation of, 24
- Networking technology, 333
- Network intelligence, 160
- Network interface card (NIC), 463
 - device drivers, 151
- Network management. *See* Management
- Network operating center (NOC), 227
- Network protocols, 21
- Networld+Interop, 317
- Neutral disparity, 48
- Nishan Systems, 176, 192
- NL_Port, 59, 127, 463
 - addressing, 68
 - arbitration, 78–79
 - fabric login services for, 91–92
 - fabric-supported, 102
 - identifier, 74
 - loop initialization and, 73
- Node, 57, 464
- Node name, 57–58, 464
- Node port. *See* N_Ports
- Nonbroad-cast transport, 81–82
- Non-linear mapping, 464
- Non-OFC laser, 464
- Non-OFC transceivers, 48
- Non-repeating ordered set, 464
- Nonrepudiation, 464–65
- Non-transparent failover, 465
- Non-Uniform Memory Architecture (NUMA), 465
- Non-volatile random access memory (NVRAM), 465
- Non-volatility, 465
- Normal mode (normal operation), 464
- Not operational (receiver or transmitter), 465
- N_Port login (PLOGI), 63, 76–77, 92–93, 473, 475
- N_Port Name, 460
- N_Ports, 57, 127, 460
 - destination, 407
 - fabric-attached, 89
 - fabric login services for, 91–92
 - fabric-supported, 102
 - iFCP and, 159
 - source, 499
 - State Change Notification (SCN) and, 93–94
- NT servers, 71
- NVRAM cache, 465–66
- NVRAM card, 466
- Object, 466
- Object-based Storage Devices (OSD), 369–70
- Object oriented (OO) methodology, 466
- OC-n, 466
- Offline backup, 466
- Online backup, 466
- Online transaction processing (OLTP), 53
- Open, 467
- Open fiber control (OFC), 47–48, 466, 467
- Open Group, the, 467
- Open-Init state, 73
- Open interconnect (standard interconnect), 467
- Open Shortest Path First (OSPF), 27, 99, 153
- Open state, 78
- Open System Inter-connection (OSI) Reference Model, 20
- Open systems, 231, 283–84, 313, 529
 - storage virtualization and, 249

- OpenView, 229
- Operating environment, 467
- Operating system environments, heterogeneous, 269
- Operation, 467
- Operational (state), 467–68
- Operation_Associator, 467
- Optical fall time, 468
- Optional (characteristic), 468
- Ordered sets, 50–51, 468
 - capturing for diagnosis, 215–16
 - non-repeating, 464
- Original equipment manufacturer (OEM), 105
- Originator, 468
- Originator Exchange_Identifier (OX_ID), 468, 469
- Out-of-band storage network management, 225, 227
- Out-of-band storage virtualization, 243–45, 469
- Out-of-band transmission, 469
- Overwrite procedure, 468

- Packet loss recovery, 154, 156
- Packet over SONET (POS), 23
- Packet recovery, 26
- Packets. *See* Frame(s) (data packets)
- Panic, 469
- Parallel access array, 469
- Parallel topologies, 42–43
- Parallel transport, 24, 469
- Parity data, 112
- Parity disk, 469
- Parity RAID, 470
- Partition, 470
- Partitioning, 470
- Passive copper, 470
- Passphrase, 470
- Password protection, 230, 471
- Path, 471
- Path length, 471
- Path name, 471
- PAUSE frame, 146–47
- Payload, 471
- pcnfsd, 472
- PDUs, 217
- Peer-to-peer network, 1, 202
- Penetration, 472
- Performance statistics, 217, 218–19
- Peripheral Component Interconnect (PCI), 471, 472
- Peripheral component interface (PCI) bus interfaces, 109
- Permanent Virtual Circuit (PVC), 472, 478
- Persistence, 472
- Petabyte (PB; PByte), 471
- Phantom mode, 94
- Phillips, Gary, 320
- Physical block, 472
- Physical block address, 472
- Physical configuration, 472
- Physical disk, 473
- Physical extent, 473
- Physical extent block number, 473
- Physical-layer problems, diagnosis of, 212
- Physical storage resource, 342
- Plaintext, 473
- Pointer copy, 474
- Pointer remapping, 474
- Point in time copy, 473–74
- Point-to-Point Protocol (PPP), 23
- Point-to-point topology, 42, 63–65
 - link utilization in, 63–64
- Policy processor, 474
- Port, 474
 - multiservice, 192, 193
 - types of, 121
- Port address (N_Port ID), 58
- Port buffering, 176
- Port Bypass Circuit (PBC), 119–20, 471, 474–75
- Port byte, 89
- Port density, 121
- Port_ID, 474
- Port login (PLOGI), 63, 76–77, 92–93, 473, 475
- Port name, 58, 475
- Port numbers, 155
- Port utilization data, 217, 219
- Port zoning, 97
- Positional map, 75–76
- Positive disparity, 48
- Post-production video editing, 252–53, 257–59
- Power conditioning, 475

- Power On Self Test (POST), 475
- Preamble delimiter, 143
- Prepress operations, 259–61
- Present (verb), 475
- Primary Domain Controller (PDC), 472, 475
- Primitive sequences, 51, 475
 - loop initialization (LIPs), 51, 71–73, 449, 452
- Primitive signals, 51, 475
- Principal switch selection, 100–102
- Printer sharing, 294–95
- Privacy, 352
- Private key, 476
- Private key cryptography, 476
- Private Loop Direct Attach (PLDA), 473, 476
- Private loops, 68, 74, 84–85, 476
 - fabric-supported, 94–96, 127
- Problem isolation, 211–21
 - Fibre Channel analyzers, 215–17
 - iSCSI network analyzers, 217–18
 - performance tools, 218–19
 - simple techniques, 212–15
- Process_Associator, 476
- Process policy, 476
- Profile, 476
- Promontory Project, 176, 277
- Propagation delay, 86
- Proprietary I/O bus (proprietary interconnect), 477
- Protected space, 477
- Protocol(s), 477
 - network, 21
- Protocol capture, 215–16, 217
- Protocol data unit (PDU), 31
- Public key, 477
- Public key cryptography, 477
- Public Key Infrastructure (PKI), 170, 473, 477
- Public loops, 68, 74, 84–85, 477, 478
 - fabric support for, 94–96
- Pull technology, 478
- Push technology, 478

- Quality of service (QoS), 478
 - for Gigabit Ethernet, 168–69
 - for IP SANs, 168–69
- Queued requests in Fibre Channel, 54
- Queuing of frames, 89
- Quiescent state, 478
- Quiesce (verb), 478
- Qwest, 176, 541

- RAID Advisory Board, 480
- RAID controllers, 28, 112, 113–14, 239–40
- RAIDs, 4, 15, 233, 289, 295, 479, 484
 - Fibre Channel, 112–15
 - controller, 112, 113–14
 - data integrity issues, 112–13
 - software RAID, 113, 116–17
 - Levels, 479–80
 - parity, 470
- RAMdisk, 480
- Random I/O, 480–81
- Random relative offset, 481
- Rank, 481
- Raw partition, 481
- Raw partition backup, 481
- Read/write head, 481–82
- Read/write time, 259–60
- Real time copy. *See* Mirroring
- Rebuilding, 482
- Received close state, 78
- Receive lead, 25
- Receiver, 482
- Receiver-ready (R_RDY) ordered set, 57
- Receptacle, 482
- Reconfigure fabric link service, 101
- Reconstruction (rebuilding), 482
- Recorded volume serial number (RVSN), 489
- Recovery, 482–83
- Red, 483
- Red/black concept, 483
- REDI-SANlinks, 204
- Reduced mode (degraded mode), 406, 483
- Reduction, 483
- Redundancy, 265, 341, 483
 - through block aggregation, 346
- Redundancy group, 483–84
- Redundancy group stripe, 484
- Redundancy group stripe depth, 484
- Redundant Array of Independent Disks. *See* RAIDs
- Redundant components, 484

- Redundant configuration/system, 87, 484
- Redundant loops, 122
- Redundant Web servers, 270
- Reference clock, 42–43
- Regeneration, 485
- Registered State Change Notification (RSCN), 93–94, 485, 489
- Rekeying, 485
- Relative offset, 485
- Relative offset space, 485
- Reliability, Availability, and Serviceability (RAS), 481
- Reliability, data, 404
- Remote Access Server (RAS), 481
- Remote backup, 11–12
- Remote direct memory access (RDMA), 35
- Remote storage access, 10–11
- Remote tape vaulting, 275–76
- Removable media, 485
- Removable media storage device, 485
- Repeater, 485
- Repeating ordered set, 486
- Replacement disk, 486
- Replacement unit (RU), 486, 489
- Replay attack, 486
- Replica, 486
- Replicate, 486
- Replication, data, 203–5
- Request for Comment (RFC), 487, 488
- Request for Quotation (RFQ), 284
- Request intensive application, 487
- Requests for Proposals (RFPs), 539
- Reserved (field), 487
- Resilvering (mirror resynchronization), 457, 487
- Resource Reservation Protocol (RSVP), 169
- Resources, 303–5
 - Fibre Channel technical and marketing, 304
 - IP storage technical and marketing, 304
 - sharing, 356
 - standards and proposals, 303–4
 - on the Web, 305
- Responder, 487
- Responder Exchange Identifier, 487
- Restoration, 487, 540
- Retention period, 488
- Retimer, 488
- Return loss, 488
- Robotic media handler (media robot), 455, 488
- ROMs, flash, 110–11
- Rotational latency, 488
- Routers, 23, 26
 - IP, 186
- Routing Information Protocol (RIP), 99, 152–53, 154
- Row, 488–89
- R_RDY primitive, 81
- RS-232, 25
- RSA, 489
- Run length, 489
- Running disparity, 49–50, 489
- SAN attached storage (SAS), 490
- SAN bridges, 295
- SAN extensions vendors, 310
- SANmark Conformance Documents (SCDS), 105
- SANmark framework, 105
- SANmark program, 315, 317, 324
- Saturated disk, 490
- Scale (verb), 490
- Schema, 235–36, 490
- Scope entry, 165
- Script, 490
- SCSI, 1, 285, 490, 496. *See also* iSCSI
 - architecture, 27–32
 - command descriptor block (CDB), 30–31, 160
 - high-availability configurations, 87
 - initiators, 28, 29–30
 - parallel SCSI bus, 32–34
 - retries and timeouts, 30
 - fast, 421
 - Fibre Channel interface, 41
 - Fibre Channel-to-SCSI bridges, 131–32
 - serial, 494
 - Serial Attached (SAS), 34
 - standards, 303
 - write operation, 31
 - write request handling in, 27–28
- SCSI-3, 27–28, 41, 257
- SCSI-3 device driver, 111
- SCSI adapter, 490

- SCSI address, 491
- SCSI addressing, 77
- SCSI architectural model (SAM-2), 28–29
- SCSI block access, 289
- SCSI bus, 491
- SCSI disk arrays, 193
- SCSI Enclosure Services (SES), 111, 224, 491, 495
- SCSI Industry Association (SIA), 495
- SCSI Parallel Interface (SPI), 491, 500
- SCSI targets, operating system identification of, 28
- SCSI Trade Association (STA), 491, 501
- Sector, 491
- Secure hash, 492
- Secure Sockets Layer (SSL), 492, 505
- Security, 536–38
 - access control, 346, 351–53, 371
 - via backup, 201
 - computer, 397
 - of HTTP, 230
 - for IP SANs, 169–71, 537–38
 - access, 169–70
 - authentication, 170
 - data encryption, 170
 - IPSec, 170, 186, 445
 - iSCSI protocol and, 163, 170–71, 296
 - iSNS, 166
 - ubiquity of shared storage and, 296
 - by zoning, 537
- “Security Architecture for the Internet Protocol,” 170
- Security Identifier (SID), 492, 495
- Segmentation, 94
 - by IP routers, 150
 - network, 24
- Selective reset LIP, 73
- Semiconductor Industries Association (SIA), 495
- Sequence, 52–53, 492
- Sequence Identifier (SEQ_ID), 492
- Sequence initiative, 492
- Sequence Initiator, 493
- Sequence Recipient (SR), 493, 500
- Sequence Status Block, 493
- Sequential I/O, 493
- Serial adapter, 493
- Serial ATA (Advanced Technology Attachment), 194
- Serial attached SCSI (SAS), 34
- Serial console, 493
- Serial ID, 107
- Serializer Deserializer (SERDES), 493, 494
- Serial links, 25
- Serial SCSI, 494
- Serial transport, 24–25, 493
- Server(s), 494
 - database, 344–45
 - DNS, 164
 - Fibre Channel, 76–77
 - file, 344–45, 428
 - iSNS, 195
 - login, 451
 - metadata, 364–65
 - multicast, 56
 - NAS, 349
- Server based virtualization, 494
- Server clustering, 37, 199–200, 265–67
- Serverless backup, 37, 494
- Server Message Block (SMB), 494, 497
- Server/storage administrators, division of labor between traditional network administrators and, 298
- Service agents (SAs), 164, 165
- Service Incident Standard (SIS), 494, 496, 499
- Service Level Agreements (SLAs), 219, 495, 496
- Service Locator Protocol (SLP), 164–65
- Services subsystem, 2, 3, 353–54
- Service URLs, 164–65
- Session control protocol, 144
- Share, 495
- Shared nothing environment, 205
- Shared Storage Model. *See* SNIA Shared Storage Model (SSM)
- Shielded enclosure, 495
- Simple Name Server (SNS), 59, 91, 92–93, 100, 164, 495, 498
 - troubleshooting, 214–15
- Simple Network Management Protocol (SNMP), 167, 224, 227, 228–29, 496, 497
 - IETF standard for, 313

- requirements definition for, 35, 314
- SAN management via, 123, 124
- Single (component) configuration, 496
- Single ended (signaling), 496
- Single-mode fiber, 45, 496
- Single Point of Failure (SPOF), 496, 500
- Sistina Global File System (GFS), 207
- Skew, 32
- Sliding window, 155
- Slow start algorithm, 155–56
- Small Computer System Interface. *See* SCSI
- Small form factor, 108
- Small form factor pluggable (SFP), 108
- Small form factor (SFF) fiber-optic connectors, 45–46, 47
- Small I/O request, 497
- SNA, 19
- Snapshot, 497
- SNIA, 105, 111, 235, 236, 249, 285, 286, 317–25, 497, 503
 - Board of Directors, 318–19
 - committees, 321–22
 - Interoperability Committee, 265, 286, 315, 324, 531
 - Technical Center Committee, 324
 - customer councils, 320–21, 528
 - executive director and staff, 319–20
 - industry forums, 323–24
 - other industry associations and, 324
 - SNIA Technology Center, 320
 - technical work groups, 322
- “SNIA Dictionary of Storage Networking Terminology,” 371–525
- SNIA FC SAN certification program, 298
- SNIA Shared Storage Model (SSM), 1–12, 319, 327–70
 - access control, 351–53
 - access paths, 349–50
 - benefits of, 337
 - caching, 350–51
 - in Carlson Companies, 8–12
 - clustering, 354–55
 - common storage architectures mapped to, 361–70
 - block storage aggregation in SAN appliance, 363–64
 - direct-attached block storage, 3–4, 361–62
 - file server controllers, 366–67
 - multi-site block storage, 365–66
 - NAS, 6–7, 359–60, 368
 - NAS/file server metadata manager (“asymmetric file service”), 368
 - Object-based Storage Devices (OSD), CMU NASD, 369–70
 - SAN, 359–60, 362–64
 - storage network-attached block storage with metadata server (“asymmetric block service”), 364–65
 - data sharing, 356
 - data vs. storage issue, 355
 - executive summary, 331
 - graphical conventions used in, 338–39
 - layering scheme, 342–44
 - block layer, 345–47, 348–49
 - file/record layer, 343–45, 348–49
 - modular systems, 357–59
 - overview of, 2
 - potential of, 335–36
 - rationale for, 334–35
 - resource sharing, 356
 - revision history, 328
 - sample architectures, 347–48
 - services subsystem, 2, 3, 353–54
 - standardization challenge, 360–61
 - status of, 370
 - storage domain, 2–3
 - storage networks, 359
 - storage system components, 340–42
 - usage terms, 328–30
 - vision of, 332–33
- SNIA Technical Council, 285
- SNIA technical workgroups, 314
- SNIA Technology Center and Storage Networking World conferences, 286
- Sniffer, 81, 497
- SNIFFER iSCSI protocol trace, 218
- SNW Interoperability Lab, 322
- Society of Motion Picture and Television Engineers (SMPTE), 497, 498
- Sockets, 155

- Software, 199–209
 - clustering, 199–200, 265–67
 - control, 399
 - data replication, 203–5
 - distributed file systems and file sharing, 205–7
 - iSCSI, 188
 - server clustering, 199–200
 - tape backup, 201–3
- Software RAID, 113, 116–17
- Soft zone, 498
- Solicited control, 498
- Solicited data, 498
- Solid state disk, 498–99
- Solution Exchange Standard (SES), 495, 499
- Source Identifier (S_ID), 489, 499
- Source N_Port, 499
- Source (SA) address, 144
- Space management, 346
- Spanning tree, 91, 144–45
- Spare (disk, extent), 499
- Special character, 499
- Special code, 499
- Speed-of-light latency, 172, 175, 277, 534
- Spiral data transfer rate (full volume transfer), 430, 500
- Split I/O request, 500
- Split mirror point in time copy, 500
- Spoofing, 500
- S_Port, 489
- Stability, 539
- Stacked connect, 54
- Stand alone drive, 501
- Standard interconnect (open interconnect), 467, 501
- Standardization, 15, 16, 283–86, 360–61, 529–30, 539
 - of management, 288–89
 - process of, 313–16
 - compliance testing, 314–15
 - participants in, 314
 - proposal or standards discussion, 314
 - vendors and, 529–30
- Standard (SC) fiber-optic connectors, 45–46
- Standards compliance, interoperability vs., 530–31
- Standards organizations, 529
- Star, 501
- Start-of-frame (SFD) delimiter, 143–44
- Start of frame (SOF), 51, 52, 498, 501
- Star topology, 118–19
- State Change Notification (SCN), 91, 93–94
 - iSNS-issued, 167
- Status information, 107
- Stealth mode, 94
- Stever, Dona, 320
- Storage, 19. *See also* Storage devices
 - IP, 232, 304, 322, 323
 - network-attached, 34–36, 462
 - architecture, 34
 - file transport, 34–35
 - separation of storage from processor or head, 35–36
 - parallel SCSI and, 33–34
- Storage area networks (SANs), 1, 489–90, 501–2
 - designing, 1
 - infrastructure, 5–6
 - NAS vs., 34
 - server-storage target relationship and, 4–5
- Storage array, 502. *See also* RAIDs
- Storage-based virtualization, 248–49
- Storage consolidation, 267–69
- Storage controller, 502
- Storage devices, 342, 345, 502
 - access control in, 353
 - intelligent, 441
 - iSCSI, 189–90
 - native, 345–46
- Storage device virtualization, 502
- Storage domain, 2–3, 502
- Storage element, 502
- Storage extent, 502
- Storage management (enterprise storage management), 233–34, 342
- Storage Management Initiative (SMI) Steering Committee, 321
- Storage network
 - access control in, 352–53
 - block storage aggregation in (“SAN appliance”), 363–67

- management of, 223–32
 - HTTP, 227, 229–30, 231
 - in-band, 225–27
 - issues in, 231–32
 - out-of-band, 225, 227
 - SNMP, 35, 224, 227, 228–29, 313, 314
 - Telnet, 227, 230–31
- Storage-network aggregation, 348
- Storage-network attach architecture, 348, 349
- Storage network-attached block storage (SAN), 362–67
- Storage network-attached block storage with metadata server (“asymmetric block service”), 364–65
- Storage networking, 502
- Storage Networking Industry Association. *See* SNIA
- Storage Networking World (SNW), 319, 321
- Storage network management, 223–32
 - HTTP, 227, 229–30, 231, 436, 437
 - in-band, 225–27
 - issues in, 231–32
 - out-of-band, 225, 227
 - SNMP, 167, 224, 227, 228–29, 496, 497
 - IETF standard for, 313
 - requirements definition for, 35, 314
 - SAN management via, 123, 124
 - Telnet, 227, 230–31
- Storage network (SN), 333, 336, 359, 360
- Storage pool, 206, 240, 241, 242, 355–56
- Storage resource management (SRM), 232–33, 501, 503, 532–33
- Storage subsystem, 503
- Storage subsystem virtualization, 503
- Storage systems, 335–36
- Storage virtualization, 15, 239–56, 269, 297, 331, 503, 519, 528
 - array-based, 248–49
 - block, 387
 - data storage utility and, 252–53
 - defined, 239–43
 - extension of, 242–43
 - file system and NAS virtualization, 250–51
 - host-based, 245–46, 434
 - in-band and out-of-band, 243–45
 - multivendor, 249–50
 - open systems approach to, 249
 - out-of-band, 469
 - proprietary nature of, 249–50
 - RAID controllers, 239–40
 - SAN interconnect-based, 246–48, 249
 - server based, 494
 - storage-based, 248–49
 - storage device, 502
 - storage resource management and, 532–33
 - symmetric, 507
 - tape library, 509
 - tape virtualization, 251–52
 - vendors, 310–11
- Storage volume, 503
- Storage vs. data issue, 355
- Store-and-forward algorithm, 88
- Store-and-forward switch, 185, 504
- Streamed sequence, 504
- Stretched E_Port, 134, 159
- Strip, 504
- Stripe, 504
- Striped array (stripeset), 505
- Striped disk array, 505
- Stripe depth (strip size), 504
- Stripe element (strip), 504
- Stripe size, 505
- Striping, 112, 346, 404, 505
- Strobe line, 42–43
- Structure of Management Information (SMI), 228, 229, 497, 505
- Subdirectory, 505
- Subject, 506
- Subnet mask, 151
- Substitution, 506
- Sun Microsystems, 64
- Sun Solaris servers, 71
- Swap/swapping, 506
- Switch(es), 26, 506
 - cut-through, 185
 - director, 128
 - fabric. *See* Fabric switches

- Switch(es) (*cont.*)
 - Fibre Channel
 - OEM microcode in, 111
 - standards, 530
 - troubleshooting, 214
 - Gigabit Ethernet, 142, 183–86, 299
 - architecture, 184–85
 - capabilities, 183–84
 - link aggregation, 144–45
 - 10Gbps interswitch link modules, 185
 - interrupt, 443
 - IP storage, 192–93, 536
 - multiprotocol, 289
 - multivendor interoperability, 98
 - principal, 100–102
 - store-and-forward, 185
- Switched Virtual Circuit (SVC), 506
- Switching
 - context, 29–30
 - cut-through, 88, 402
 - embedded-loop, 36
 - selective, 96
 - store-and-forward, 88
- Switching hubs, 124–26
- Switchover. *See* Failover (switch-over)
- Switch-to-switch protocol, 98
- Symmetric cryptosystem, 507
- Symmetric virtualization, 507
- Symmetrix Remote Data Facility (SRDF), 192–93, 203, 204
- Synchronization, 507
- Synchronous Digital Hierarchy (SDH), 491, 507
- Synchronous operations, 507
- Synchronous Optical Network (SONET), 499, 507
- System board, 507
- System disk, 508
- Systems management applications, 234
- Systems Network Architecture (SNA), 142
- System under test, 508

- T1 links, 175
- T3 links, 174–75
- Table space, 343–44
- Tabular mapping, 508
- Tachyon chip set, 75, 76

- Tape array, 509
- Tape backup, 37, 201–3
 - behind Fibre Channel-to-SCSI bridge, 131–32
 - data streaming for, 53
 - with direct-attached storage, 262
 - high-performance, 265
 - LAN-based, 201, 202
 - LAN-free, 261–65
 - legacy subsystems, 131
 - multi-initiator loops and, 83
 - remote vaulting, 275–76
 - SAN-attached, 201–2
 - server-free, 202, 261–65
 - zoning for, 96
- Tape library virtualization, 509
- Tape transport (drive), 508
- Tape virtualization, 251–52
- Target, 28, 509
- Target channel adapter (TCA), 299
- Target ID, 509
- Targets, 19
- TCP/IP, 41, 509
 - in IP SANs, 141, 149–56
 - address resolution protocol (ARP), 152
 - IP addressing, 151–52
 - IP routing, 152–54
 - TCP session control, 154–56
 - packet recovery in, 26
- TCP off-load engines (TOEs), 156, 163, 187–88, 189
- Telnet, 227, 230–31
- Temporary loop master, 73–75
- Tenancies of arbitrated loops, 116–17
- Tenancy, 509
- 10Gbps Ethernet links, 22
- 10Gbps Fibre Channel, 299
- Terabyte (TByte), 509–10
- Test equipment and verification labs, 312
- Test system, 510
- Third party copy (extended copy), 83, 194, 202, 203, 264, 510, 511
- Throughput, 510
- Throughput-intensive (application), 510
- Time server, 510
- TNC, 510
- Token, 25

- Token Ring, 19, 66, 142, 510–11
 - access method in, 25
 - broadcast storms, 150
 - as broadcast transports, 80–81
- Topology, 511
- Total Cost of Ownership (TCO), 509, 511
- Trace field headers, 216
- Traffic management, 168–69
- Training certification, 298
- Transceivers, 511
 - Fibre Channel, 46–47, 106–8
 - GBICs, 106–8
 - non-OFC, 48
 - small form factor, 108
- Translational strategy, 95–96
- Transmission character, 511
- Transmission code, 511
- Transmission Control Protocol (TCP), 172, 509, 511
- Transmission word, 512
- Transmit lead, 25
- Transmitted close state, 78
- Transmitter, 512
- Transparent failover, 512
- Trap (unsolicited status information), 228–29, 512
- Triaxial cable, 512
- Triple DES, 170, 538
- Trojan horse, 512
- Troubleshooting. *See* Problem isolation
- True Copy, 203
- Trunking (link aggregation), 144–45
- Tunneling, 512–13

- Ultra2 SCSI, 513
- Ultra3 SCSI, 513
- Ultra SCSI, 513
- Unauthorized disclosure, 514
- Unclassified information, 514
- Unicast, 514
- Unicode, 514
- Unified Modeling Language (UML), 513, 514
- Uninterruptible power source (UPS), 514, 515
- University of New Hampshire (UNH), 286, 314, 324
- iSCSI Consortium, 324

- Unsolicited control, 514
- Unsolicited data, 515
- Upper Layer Protocol (ULP), 513, 515
- Usable capacity, 515
- User agents (UAs), 164, 165
- User data, 515
- User data extent, 515
- User data extent stripe depth, 515
- User Datagram Protocol/Internet Protocol (UDP/IP), 54
- User Datagram Protocol (UDP), 513, 516
- User identification number (UID), 516
- User priority bits, 149

- Valid data byte, 516
- Valid frame, 516
- Validity control bit, 516
- Value-added reseller (VAR), 105
- Vendor affinity groups (alliances), 287, 288
- Vendor monopolies, 283
- Vendors, 307–12, 527–28
 - Fibre Channel products, 308–9
 - Gigabit Ethernet, 311
 - interoperability issues and, 287
 - IP SAN products, 309–10
 - SAN extensions, 310
 - SAN management and virtualization, 310–11
 - SAN storage and tape, 307–8
 - SAN systems, 307
 - standardization and, 283–85, 529–30
 - test equipment and verification labs, 312
- Vendor unique, 517
- Verification, 517
- Verification labs, 312
- Versioning, 517
- Vertical Cavity Surface Emitting Laser (VCSEL), 107, 516, 517
- Video editing, post-production, 252–53, 257–59
- Virtual arbitrated loop, 94–95
- Virtual block, 517
- Virtual Block Address (VBA), 516, 517
- Virtual Channel Identifier (VCI), 516, 518
- Virtual circuit, 55, 518
- Virtual device, 518

- Virtual disk (volume set), 518, 520
- Virtual Interface Architecture (VIA), 517, 518
- Virtual Interface (VI), 35, 111, 517
- Virtualization, storage. *See* Storage virtualization
- Virtual LAN (VLAN), 37, 147–48
- Virtual loops, 125
- Virtual Path Identifier (VPI), 518, 520
- Virtual tape, 519
- Virus, 519
- Vixel Corporation, 36
- VLAN tagging, 144, 147–48
- Voice over IP, 293
- Volatility, 519
- Volume, 519
- Volume administration tools, 116
- Volume group, 519
- Volume manager, 519
- Volume pool, 520
- Vulnerability, 520

- WAN bridging, 135–36
- WAN protocol analyzers, 217
- Warm spare (disk), 520
- Warm swap, 520
- Wave Division Multiplexing (WDM), 520, 521
- Web Based Enterprise Management (WBEM), 230, 235, 521
- Web browser, 230
- Web Committee (SNIA), 322
- Web resources, 305
- Well-known address, 521
- Wide area networks (WANs), 23, 520, 521
 - management information base (MIB) for, 228
- Wide area services, data replication in, 205

- Wide area storage networking, 171–76
 - bandwidth allocation, 172–74
 - data throughput, 174–75
 - IP routers for, 186
 - latency issues, 172, 175–76
- Wide SCSI, 521
- Windows Driver Model (WDM), 521
- Windows Hardware Engineering Conference (WinHEC), 533
- Windows Internet Naming Service (WINS), 522
- Windows Management Instrumentation (WMI), 522
- Windows NT, 84, 96–97
- Word, 522
- Workgroup, 522
- World-Wide Name (WWN), 26, 58, 522–23, 524
 - priority value of, 74
 - zoning on, 97, 128
- Worm, 523
- Write back cache, 523
- Write hole, 523
- Write penalty, 523
- Write through cache, 523–24

- XF0, 80
- XF7 character, 71, 72
- XF8 character, 72
- XIOtech REDI-SANlinks, 248

- Zero filling, 524
- Zeroization, 524
- Zone merging, 97, 128
- Zones, 352–53, 524–25
- Zoning, 96–97, 100, 525, 537
 - fabric switch support of, 127–28
 - troubleshooting, 214