

# Index

**Note to the reader:** Throughout this index **boldfaced** page numbers indicate primary discussions of a topic. *Italicized* page numbers indicate illustrations.

---

## Numbers

/31 subnet, **286–288**  
10Base2/Thinnet, 38  
10Base5/Thicknet, 38  
10BaseFL, 39  
10BaseT, 586  
10BaseT/UTP, 39  
20/80 rule, **80–82**, 81  
80/20 rule, **79–80**, 80  
100BaseFX, 103  
100BaseT, 566  
100BaseT Fast Ethernet, **103–106**  
    advantages, 104  
    specifications, **104–106**  
    repeaters, 105  
100BaseT4, 103  
100BaseTX, 103, 566  
100BaseX, 103  
100VG AnyLan, 104  
802.1D standard (IEEE), 84, 389, 550  
802.1q standard (IEEE), 98  
802.2 standard (IEEE), 232  
802.3 standard (IEEE), 30, **38–40**, 550  
802.3u standard (IEEE), 103  
802.5 standard (IEEE), 43, 390, 550  
802.10 standard (IEEE), 99

---

## A

A&B bit signaling, 518  
AAL (ATM Adaptation Layer), 518  
AAL1 (ATM Adaptation Layer 1), 518

AAL2 (ATM Adaptation Layer 2), 518  
AAL3/4 (ATM Adaptation Layer 3/4), 518  
AAL5 (ATM Adaptation Layer 5), 518  
AARP (AppleTalk Address Resolution Protocol), 518  
AARP probe packets, 519  
ABM (Asynchronous Balanced Mode), 232, 519  
ABR (area border router), 519  
    in OSPF, 362, 374  
Abstract Syntax Notation (AS.1), 18  
access control, 486  
access layer, 519  
    in hierarchical network, 196–197  
access links, 96, 97  
access lists, 481, 519  
    in Cisco IOS, **406–410**  
access method, 519  
access server, 519  
acknowledgments of data receipt, 25, 519  
ACR (allowed cell rate), 519  
active monitor on Token Ring network, 45, 519  
active router in HSRP, 202  
activity management, 20  
address mapping, 520  
Address Mapping group in RMON, 440  
address mask, 520  
address resolution, **131–135**, 520  
    ARP cache, 133  
    local, **131–132**, 132  
    remote, **133–135**, 134  
Address Resolution Protocol (ARP), **128–129**, 131, 522  
Address Translation Gateway (ATG), 523

- addresses, physical vs. logical, 130–131
- addressing scheme, 256. *See also* IP addresses
- adjacency, 335, 520
- adjacency database
  - for NLSP, 377
  - in OSPF, 357
- adjacency table, 229
- administrative data, for network
  - evaluation, 157–158
- administrative distance, 520
- administrative weight, 520
- ADSL (asymmetric DSL), 243–244
- ADSU (ATM Data Service Unit), 520
- advertised distances, 337–338
- advertising, 520
- AEP (AppleTalk Echo Protocol), 520
- AFI (authority and format identifier), 520
- AFP (AppleTalk Filing Protocol), 520
- AIP (ATM interface processor), 521
- Alarm group in RMON, 439
- algorithm, 521
- alignment error, 521
- all-hosts multicast, IP v6 and, 296
- all-rings explorer packet, 391
- all-routes explorer packet, 391, 521
- allowed cell rate (ACR), 519
- alternate mark inversion (AMI), 521
- AM (amplitude modulation), 521
- American Standard Code for Information Interchange (ASCII), 523
- American Standards Institute (ANSI), 40
- AMI (alternate mark inversion), 521
- amplitude, 521
- amplitude modulation (AM), 521
- analog transmission, 491, 521
- ANSI (American National Standards Institute), 40, 521
- anycast, 521
- appendixes, in design document, 461–462
- AppleTalk, 522
  - EIGRP configuration for, 344
  - AppleTalk Control Protocol (ATCP), 523
  - AppleTalk Echo Protocol (AEP), 520
  - AppleTalk Filing Protocol (AFP), 520
  - AppleTalk Remote Access (ARA), 522
  - AppleTalk Session Protocol (ASP), 21, 523
  - AppleTalk Transaction Protocol (ATP), 524
  - AppleTalk Update-based Routing Protocol (AURP), 525
- Application layer (OSI), 17–18, 522
- Application Layer Host group in RMON, 440
- Application Layer Matrix group in RMON, 440
- application-specific integrated circuit, 523
- applications
  - evaluating network needs and expectations, 169
  - and network evaluation, 162–163
  - traffic type as WAN design criteria, 224
- ARA (AppleTalk Remote Access), 522
- area border router (ABR), 519
  - in OSPF, 362, 374
- area command, 374
- areas, 522
  - identification for OSPF, 359
  - for NLSP, 377
- ARM (asynchronous response mode), 232, 522
- ARP (Address Resolution Protocol), 128–129, 131, 522
- ARP cache, 131, 133
- AS (autonomous system), 314
- ASBR (autonomous system boundary router), 522
  - in OSPF, 362, 374
- ASCII (American Standard Code for Information Interchange), 523
- ASN.1 (Abstract Syntax Notation 1), 18, 523
- ASP (AppleTalk Session Protocol), 21, 523
- AST (Automatic Spanning Tree), 523
- asymmetric DSL (ADSL), 243–244

- Asynchronous Balanced Mode (ABM), 232, 519
  - asynchronous response mode (ARM), 232, 522
  - Asynchronous Time-Division Multiplexing (ATDM), 523
  - asynchronous transfer mode (ATM), 524
    - switches, 10
  - asynchronous transmission, 523
  - ATCP (AppleTalk Control Protocol), 523
  - ATDM (Asynchronous Time-Division Multiplexing), 523
  - ATG (Address Translation Gateway), 523
  - ATM (asynchronous transfer mode), 524
  - ATM ARP server, 524
  - ATM Data Service Unit (ADSU), 520
  - ATM endpoint, 524
  - ATM Forum, 524
  - ATM protocol, 45–48
    - ATM Adaptation layer (AAL), 47, 518
    - ATM layer, 46–47, 524
    - ATM Physical layer, 45–46
  - ATM switches, 10
    - for WANs, 11
  - ATM user-user connection, 524
  - ATMM (ATM Management), 524
  - ATP (AppleTalk Transaction Protocol), 524
  - attenuation, 6–7, 524
  - AURP (AppleTalk Update-based Routing Protocol), 525
  - AURP tunnel, 525
  - AuthNoPriv message (SNMP), 437
  - authority and format identifier (AFI), 520
  - authority zone, 525
  - AuthPriv message (SNMP), 437
  - automatic call reconnect, 525
  - Automatic Spanning Tree (AST), 523
  - automatic tunneling, 297
  - autonomous confederation, 525
  - autonomous switching, 525
    - for WANs, 226–227
  - autonomous system (AS), 314, 525
  - autonomous system boundary router (ASBR), 522
    - in OSPF, 362, 374
  - autonomous system entry LSA, 361
  - autoreconfiguration, 525
  - availability, as WAN design criteria, 223
- 
- B**
- B channel, 234, 526
  - B8ZS (Binary 8-Zero Substitution), 525
  - back end, 526
  - backbone, 526
  - backbone area, for OSPF, 361
  - backbone routers
    - in IS-IS, 380
    - in OSPF, 362
  - backup designated router (BDR), 526
    - in OSPF, 357, 359, 362–363
  - backward explicit congestion notification (BECN), 243, 419, 526
  - balanced hybrid routing, 324–325
  - bandwidth, 526
    - and congestion, 69
    - consumption, 91
    - for link-state router, 323
    - as OSPF metric, 368
    - for routing updates in distance-vector protocols, 315
    - as WAN design criteria, 223
  - bandwidth command, 341
  - baseband, 526
  - Basic Rate Interface (BRI), 234, 527
  - baud, 526
  - Bc (Committed Burst), 243, 526
  - BDR (backup designated router), 526
    - in OSPF, 357
  - beacon, 526

- BECN (backward explicit congestion notification), 243, 419, 526
  - BGP version 4 (BGP4), 526
  - binary, 527
  - Binary 8-Zero Substitution (B8ZS), 525–526
  - binding, 13, 527
  - BIP (bit interleaved parity), 527
  - BISDN (broadband ISDN), 527
  - bit-oriented protocol, 527
  - blocked port, for Spanning-Tree Protocol, 85
  - border gateway, 527
  - bottleneck, 23–24
    - information gathering about, 163
  - Bpdu (Bridge Protocol Data Unit), 84, 527
  - BRI (Basic Rate Interface), 234, 527
    - uses, 235
  - bridge-group virtual interface (BVI), 390
  - bridge ID, for Spanning-Tree Protocol, 84
  - Bridge Protocol Data Unit (Bpdu), 84, 527
  - bridges, 7, 7–8, 527
    - and collisions, 70
    - design considerations, 74
    - segmentation with, 70–71, 71
    - vs. switches, 74
  - bridging protocols, 382–392, 383
    - exam essentials, 393–394
    - integrated routing and bridging, 390
    - source-route bridging, 390–391
    - source-route translational bridging, 392
    - source-route transparent bridging, 391–392
    - transparent bridging, 384, 384–390
      - filtering packets, 387–388
      - forwarding packets, 385–386
      - learning MAC addresses, 384–385
      - loop avoidance, 388–390
  - broadband, 527–528
  - broadband ISDN (BISDN), 527
  - broadcast addresses, IP v6 and, 296
  - Broadcast-and-Unknown Server (BUS), 48, 528
  - broadcast domains, 73, 528
  - broadcast storms, 7–8, 78, 78, 388–389, 528
    - blocking, 92
    - Spanning-Tree PortFast and, 386–387
  - broadcasts, 39–40, 528
    - control, 90–91
    - preventing forwarding, 27
  - buffer, 528
  - buffering, 24
  - Building Access-sub-module, 198
  - Building Distribution sub-module, 198
  - bulletin boards, Application layer for, 18
  - BUS (Broadcast-and-Unknown Server), 48, 528
  - bus, 528
  - bus topology, 528
  - business constraints, 157
    - evaluating network needs and expectations, 167
    - information gathering about, 164
  - BVI (bridge-group virtual interface), 390
  - BX.25, 528
  - bypass mode, 528
  - bypass relay, 528
  - byte-oriented protocol, 529
- 
- C**
- cable, for 100BaseT repeaters, 105
  - cable range, 529
  - CAC (connection admission control), 529
  - call admission control, 529
  - call center, 492, 529
  - call priority, 529
  - call set-up time, 529
  - Campus Backbone sub-module, 198
  - Campus functional area, security risks, 489

- Campus Infrastructure module, 198
- carrier detect (CD), 530
- Carrier Sense, Multiple Access with Collision Detect (CSMA/CD), 38, 39
- CAS (Channel Associated Signaling), 529
- case study introductions
  - Have-A-Seat, 172–174
  - MPS Construction, 174–175
  - Willow Creek School District, 175–177
- CBR (constant bit rate), 529
- CBWFQ (class based weighted fair queuing), 530
- CCS, 530
- CD (carrier detect), 530
- CDDI (Copper Distributed Data Interface), 40
- CDP (Cisco Discovery Protocol), 441, 530
  - real world scenarios, 441–442
- CDVT (cell delay variation tolerance), 530
- CEF (Cisco Express Forwarding), 532
  - for WANs, 229–230
- cell, 530
- cell delay variation tolerance (CDVT), 530
- cell error ratio (CER), 531
- cell loss priority (CLP), 533
- cell loss ratio (CLR), 533
- cell payload scrambling, 530
- cell relay, 530
- cell switching, 530
- Cell Transfer Delay (CTD), 536
- central office (CO), 533
- centralized computing environment, 3
- Centrex, 492, 531
- CER (cell error ratio), 531
- CGMP (Cisco Group Management Protocol), 82
- Challenge Handshake Authentication Protocol (CHAP), 531
- Channel Associated Signaling (CAS), 529
- Channel Interface Processor (CIP), 531
- channel service units (CSUs), 11, 536
- channelized E1, 531
- channelized T1, 531
- CHAP (Challenge Handshake Authentication Protocol), 531
- checksum, 531
- choke packet, 531
- CIDR (Classless Interdomain Routing), 266, 280–283, 531
  - Cisco and, 281–282
  - subnet mask display formats, 282–283
- CIP (Channel Interface Processor), 531
- CIR (committed information rate), 243, 532, 533–534
- circuit-switched networks, 220–221
- Cisco
  - document on router security, 483
  - intrusion-detection devices, 480
- Cisco CNS Network Registrar, 294–295, 532
- Cisco Discovery Protocol (CDP), 441, 530
  - real world scenarios, 441–442
- Cisco Express Forwarding (CEF), 532
  - for WANs, 229–230
- Cisco FRAD (Frame-Relay Access Device), 532
- Cisco Group Management Protocol (CGMP), 82
- Cisco Internetwork Operating System (IOS), 406, 532
  - access lists, 406–410
  - compression, 412–413
  - exam essentials, 421–422
  - proxy services, 410–412
    - IP helper addresses, 412
    - for IPX, 411
    - proxy ARP, 412
  - queuing methods, 413–419
    - custom queuing, 417–418, 418, 536
    - FIFO (First In First Out), 414, 544

- priority queuing, 416–417, 417, 571
- traffic shaping, 419, 588
- weighted fair queuing, 415, 415–416, 416
- RSVP (Resource Reservation Protocol), 420–421
- Cisco PIX firewall, 480
- Cisco routers, applying supernets to, 280
- Cisco SAFE (Security Blueprint for Enterprise Networks), 487–490, 576
  - module concept, 488, 488–490
- Cisco Small- to Medium-sized Business Solutions Framework, 153–155, 154
  - exam essentials, 170
  - media problems, 154
  - protocol problems, 154–155
  - transport problems, 155
- CiscoFusion, 153, 532
- CiscoView, 532
- CiscoWorks2000, 532
- class based weighted fair queuing (CBWFQ), 530
- classfull, 533
- classfull routing, 325
- classical IP over ATM, 533
- classless, 533
- Classless Interdomain Routing (CIDR), 266, 280–283, 531
  - Cisco and, 281–282
  - subnet mask display formats, 282–283
- classless IP address structure, converting to classes, 261
- classless routing, 325
- client/server applications, 123
- client/server communication, in Novell IPX, 138–139
- CLP (cell loss priority), 533
- CLR (cell loss ratio), 533
- CO (central office), 533
- collapsed backbone, 533
- collision, 533
- collision domain, 70, 533
- collision-free, full-duplex Ethernet as, 101
- collision window, 88
- Committed Burst (Bc), 526
- committed information rate (CIR), 243, 532, 533–534
- communication servers, 11
- community string, 534
- compatibility, reference model for, 14
- competition, and pilot project design, 463
- compression, 412–413, 533
- computing environment, centralized, 3
- concentrator, 41
- confidentiality of data, 482
- configuration register, 534
- congestion, 23–24, 534
  - Frame Relay control, 242–243
  - relieving, 69–73
- congestion avoidance, 534
- congestion collapse, 534
- connection admission control (CAC), 529
- connection-oriented, 534
- connection-oriented session, 20, 125, 127
  - establishing, 23
- connectionless, 534
- connectionless protocol, 126, 127
- connectionless session, 20
- connectors, for 100BaseT repeaters, 105
- constant bit rate (CBR), 529
- contention, MAC sublayer and, 32–33
- control direct VCC, 534
- control distribute VCC, 534
- convergence, 535
  - link-state router handling of, 322–323
  - time requirements, 315, 317–318
- convergence sublayer, in ATM Adaptation layer, 47
- Copper Distributed Data Interface (CDDI), 40
- core layer, 194–195, 535

- Corporate Internet module, security risks, 489
  - cost, 535
    - dedicated leased lines vs. circuit-switched, 220
    - of hierarchical network, 193
    - link cost, 368
    - as WAN design criteria, 223–224
  - count to infinity, 320, 535
  - CPCS (common part convergence sublayer), 535
  - CPE (customer premises equipment), 535
  - crankback, 535
  - CRC (cyclic redundancy checksum), 31, 535
    - in store-and-forward switching, 87
  - CSMA/CD (Carrier Sense, Multiple Access with Collision Detect), 38, 39, 129, 535–536
  - CSU (Channel Service Unit), 536
  - CSUs/DSUs, for WANs, 11
  - CTD (Cell Transfer Delay), 536
  - custom queuing, 417–418, 418, 536
  - customer premises equipment (CPE), 11, 535
  - customer requirements, and prototype development, 464
  - cut-through (real-time), 86
  - cut-through packet switching, 536
  - cyclic redundancy checksum (CRC), 31, 535
    - in store-and-forward switching, 87
- 
- D**
- D channel, 234, 537
  - data communication equipment (DCE), 537
    - Frame Relay and, 238
  - Data Country Code (DCC), 537
  - data direct VCC, 536
  - data encapsulation, 36–37, 37, 542
    - at Data Link layer, 33–34
  - Data Exchange Interface (DXI), 540
  - data frames, 7
    - 802.3 Ethernet, 30
    - elements of, 30–31
    - Ethernet II, 30
  - data-link connection identifier (DLCI), 238, 239, 539
  - data link control layer, 537
  - Data Link layer (OSI), 29–34, 537
    - Logical Link Control sublayer, 31–32, 32
    - MAC sublayer, 32–33
    - WAN protocols, 33–34
  - data service units (DSUs), 11, 540
  - data set ready (DSR), 540
  - data terminal equipment (DTE), 540
    - Frame Relay and, 238
  - data terminal ready (DTR), 540
  - databases
    - MAC, forward/filter table, 75, 75–77
    - for NLSP, 377
    - in OSPF, 357
    - route, in EIGRP, 334
    - synchronization, 363
    - topology, 322
      - in EIGRP, 334
  - Datagram Delivery Protocol (DDP), 537
  - datagrams, 23, 536
  - DCC (Data Country Code), 537
  - DCE (data communication equipment), 537
    - Frame Relay and, 238
  - DDP (Datagram Delivery Protocol), 537
  - DDR (Dial-On-Demand Routing), 205, 236, 537
    - in case study, 509
  - DE (Discard Eligible) bit for Frame Relay, 242
  - de-encapsulation of data, 37, 37
  - dedicated leased lines, 220, 220
  - default route, 537
  - delay, 538
    - in voice transmission, 494–495
  - demarc, 538

- demilitarized zone (DMZ), 480–481, 539
- demodulation, 538
- demultiplexing, 538
- denial of service, 538
- denial of service (DoS) attacks, 484
  - real world scenarios, 484–485
- design
  - methodology, 160–162
  - in PDIOO methodology, 156
  - pilot or prototype project, 462–465
- design document
  - exam essentials, 466, 466–467
  - preparation, 458–462
    - appendixes, 461–462
    - design requirements, 460
    - design solution, 460–461
    - executive summary, 459–460
    - summary, 461
- designated bridge, 538
- designated port, for Spanning-Tree Protocol, 85
- designated router, 538
  - in link-state routing, 323
  - in OSPF, 357, 359, 362–363
- destination address in data frame, 30, 538
- destination service access points (DSAPs), 31, 539
- DHCP (Dynamic Host Configuration Protocol), 412, 538
- Dial-On-Demand Routing (DDR), 236, 537
  - in case study, 509
- dialer-group command, 237
- dialer-list command, 237
- Diffusing Update Algorithm (DUAL), 540
- Digital Network Architecture Session Control Protocol (DNA SCP), 21
- digital subscriber line (DSL), 243–244, 538
- Dijkstra’s algorithm, 323, 367
- discontiguous addressing, 278, 539
- discovery mode, 539
- distance ospf command, 368
- Distance Vector Multicast Routing Protocol (DVMRP), 540
- distance-vector protocols, 539
  - routing algorithm vs. link-state routing, 324, 367
  - scalability limitations, 315–316
  - update intervals for, 318
- distribute-list command, 342
- distributed denial of service, 484–485, 539
- distributed switching, for WANs, 227
- Distribution layer, 539
- distribution layer, in hierarchical network, 195–196
- DLCI (data-link connection identifier), 238, 239, 539
- DMZ (demilitarized zone), 480–481, 539
- DNA SCP (Digital Network Architecture Session Control Protocol), 21
- DNS (Domain Name System), 539
- DOD (Department of Defense) model, 120–121
  - exam essentials, 142–143
  - Host-to-Host layer protocols, 124–127
  - Internet layer protocols, 127–129
  - Network Access layer protocols, 129–131
  - vs. OSI model, 121
  - Process/Application layer protocols, 122–124
- Domain Name System (DNS), 539
- DoS (denial of service) attacks, 484
  - real world scenarios, 484–485
- downtime, 539
  - information gathering about, 164
- DSAP (Destination Service Access Point), 539
- DSCP, 539
- DSL (digital subscriber line), 243–244, 538
- DSR (data set ready), 540
- DSU (data service unit), 540
- DTE (data terminal equipment), 540
  - Frame Relay and, 238

DTR (data terminal ready), 540  
 DUAL (Diffusing Update Algorithm), 540  
 dual attachment stations in FDDI, 41  
 dual homing, 41  
 dual-stack migration strategy, 296  
 dumb terminals, 3  
 DVMRP (Distance Vector Multicast Routing Protocol), 540  
 DXI (Data Exchange Interface), 540  
 dynamic addressing, 540  
 Dynamic Host Configuration Protocol (DHCP), 412, 538  
 dynamic routing, 540  
 dynamic VLANs, 96

---

## E

E channel, 541  
 E-Commerce module, 199  
   security risks, 489  
 e-mail gateways, Application layer for, 18  
 E.164, 541  
 E1, 541  
 ECNM (Enterprise Composite Network Modules), 488, 541  
 edge device, 541  
 Edge Distribution module, 199  
 EDI (electronic data interchange), Application layer for, 18  
 EFCI (explicit forward congestion indication), 541  
 EIA/TIA-232-C, 236  
 EIGRP (Enhanced Interior Gateway Routing Protocol), 313, 317, 325, 333–344  
   in case study, 515  
   configuration, 341–344  
     for AppleTalk, 344  
     for IP, 341–342  
     for IPX, 342–343  
   features and operation, 333–339  
     neighbor relationships, 334–335  
     route calculation and updates, 335–339, 336, 340  
     route tagging, 334  
     turning off auto-summarization for, 279  
 EIP (Ethernet interface processor), 541  
 ELAN (emulated LAN), 542  
 ELAP (EtherTalk Link Access Protocol), 542  
 elastic traffic, 420  
 electronic data interchange (EDI), Application layer for, 18  
 emulated LAN (ELAN), 542  
 encapsulation of data, 36–37, 37, 542  
   at Data Link layer, 33–34  
 encryption, 542  
 end nodes  
   cable type, connector type and maximum distance, 105  
   with repeaters, maximum distance for, 106  
 Enhanced Interior Gateway Routing Protocol (EIGRP), 313, 317, 325, 333–344, 542  
   turning off auto-summarization for, 279  
 Enterprise Composite Network Model (ECNM), 197–200, 541  
   Enterprise Campus modules, 198–199, 542  
   Enterprise Edge modules, 199, 542  
   Service Provider Edge modules, 200  
 enterprise network, 542  
 EPROM (Erasable Programmable Read-Only Memory), 542  
 ESF (Extended Superframe), 543  
 Ethernet, 38–40, 543  
   100BaseT Fast, 103–106  
     advantages, 104  
     specifications, 104–106  
   bridge vs. repeater for, 7  
   bridging between Token Ring and, 392

- full-duplex mode, 69, 101–103
  - design, 102–103, 103
  - half-duplex mode for, 102, 102
- Ethernet switches, 382
- EtherTalk, 543
- EtherTalk Link Access Protocol (ELAP), 542
- Events group in RMON, 440
- exceeding TTL, 320
- excess rate, 543
- Exchange Protocol, 363
- executive summary, in design document, 459–460
- expansion, 543
- expedited delivery, 543
- explicit forward congestion indication (EFCI), 541
- explorer packets, 391, 543
- Extended Superframe (ESF), 543
- exterior routes, in IGRP, 329

---

## F

- failure domain, 543
- fallback, 543
- Fast Ethernet, 69, 544
- Fast Ethernet Interface Processor (FEIP), 544
- Fast Serial Interface Processor (FSIP), 546
- fast switching, 544
  - for WANs, 226
- FastHub 300, 105
- fault-tolerance, 544
  - redundant LAN configurations, 200–203
  - redundant WAN connections, 203–205
- FCS field in data frame, 31
- FDDI (Fiber Distributed Data Interface), 40–43, 41, 544
- FDM (Frequency-Division Multiplexing), 544
- feasible distances, 338
- FECN (Forward Explicit Congestion Notification) bit for Frame Relay, 242–243, 544
- FEIP (Fast Ethernet Interface Processor), 544
- FIB (Forwarding Information Base), 229
- Fiber Distributed Data Interface (FDDI), 40–43, 41, 544
- FIFO (First In First Out), 414, 544
- File Transfer Protocol (FTP), 123–124, 546
- filtering, 545
  - in OSPF, 376
  - in transparent bridging, 387–388
- Filters group in RMON, 440
- firewall, 479, 479–482, 481, 545
  - in case study, 509
- First In First Out (FIFO), 414, 544
- flash memory, 545
- flat network, 89, 89, 383, 545
- flexibility
  - in business, real world scenarios, 13
  - VLANs and, 92–95
- flooding, 385, 545
- flow control, 19–20, 545
  - segment transmission with, 24
  - in Transport layer, 21
- flush timers, in IGRP, 328
- forward/filter table, 75, 75–77
- forwarded ports, 289–290
- forwarding, 545
- Forwarding Information Base (FIB), 229
- forwarding packets, in transparent bridging, 385–386
- forwarding port, for Spanning-Tree Protocol, 85
- FRAD (Frame Relay Access Device), 545
- fragment, 545
- fragmentation, 545
- FragmentFree, 86–87, 545
- frame, 129, 546
- frame filtering, 77, 546
- Frame Relay, 221, 237–243, 546
  - CIR (committed information rate), 243
  - with Cisco routers, 238–239
  - congestion control, 242–243

DLCI (data-link connection identifier)  
     for, 239  
 LMI (Local Management Interface),  
     239–240  
 partial mesh networks, 241, 241–242  
 subinterfaces, 240–241  
     defining, 242  
 Frame-Relay Access Device (Cisco FRAD),  
     532, 545  
 Frame Relay Access Support (FRAS), 546  
 Frame Relay/ATM module, 200  
 Frame Relay bridging, 546  
 Frame Relay protocol, 34  
 Frame Relay switches, for WANs, 11  
 Frame Relay Traffic Shaping (FRTS), 546  
 frame status field in Token Ring, 44, 44–45  
 frame tagging, 98  
 frames, 7  
 FRAS (Frame Relay Access Support), 546  
 frequency, 546  
 Frequency-Division Multiplexing (FDM), 544  
 FRTS (Frame Relay Traffic Shaping), 546  
 FSIP (Fast Serial Interface Processor), 546  
 FTP (File Transfer Protocol), 123–124, 546  
 full-duplex mode, 8, 19, 546  
     for Ethernet, 69, 101–103  
     design, 102–103, 103  
 full mesh network, 203, 204, 546

---

## G

gateway of last resort, 329  
 gateways, 9, 547  
 Generic Routing Encapsulation (GRE), 547  
 GetBulkRequest message (SNMP), 437  
 GetNextRequest message (SNMP), 436  
 GetRequest message (SNMP), 436  
 GetResponse message (SNMP), 436  
 GNS (Get Nearest Server) request, 138,  
     411, 547

graphical user interface, X Window for  
     defining, 124  
 GRE (Generic Routing Encapsulation), 547  
 groups in RMON, 439–440  
 guard band, 547

---

## H

H channel, 548  
 H.323 protocol, 493, 547  
 hackers, 479, 547–548  
     targets of, 482–485  
 half-duplex mode, 19, 548  
     for Ethernet, 102, 102  
 handshake, 548  
 hardware address, 548  
 hardware for LANs, 6–10  
     ATM switches, 10, 11  
     bridges, 7, 7–8, 527  
         and collisions, 70  
         design considerations, 74  
         segmentation with, 70–71, 71  
         vs. switches, 74  
     gateways, 9, 547  
     hubs, 8, 8, 549  
         and collisions, 70  
     repeaters, 6, 6–7, 574  
         and collisions, 70  
         maximum distance for end nodes  
             with, 106  
     routers, 9, 9. *See also* routers  
     switches, 8, 89, 585. *See also* Layer 2  
         switching  
         vs. bridges, 74  
         and collisions, 70  
         for LANs, 86–87  
         real world scenario on configuration, 88  
         redundant links between, 77–78  
         security, 482–483  
 hardware for WANs, 10, 10–11

HDLC (High-Level Data Link Control)  
  protocol, 33, 231–232, 237, 548  
HDSL (high bit-rate DSL), 244  
header compression, 413  
header translation, 297  
Hello packets, 321–322, 335  
helper address, 548  
hierarchical addressing, 278, 548  
hierarchical network topology, 190–197. *See also*  
  Enterprise Composite Network Model  
  benefits, 191–193  
  in case study, 509, 510  
  three-layer, 193–197  
    access layer, 196–197  
    core layer, 194–195  
    distribution layer, 195–196  
high bit-rate DSL (HDSL), 244  
High-Level Data Link Control (HDLC)  
  protocol, 33, 231–232, 548  
High-Speed Communication Interface  
  (HSCI), 549  
High-Speed Serial Interface (HSSI), 549  
HIP (HSSI Interface Processor), 548  
History group in RMON, 439  
hold-down timers, in IGRP, 328  
holddown, 321, 332, 548–549  
hop count, 319, 549  
  OSPF and, 357  
hops, 318, 549  
host-based IDS (HIDS) systems, 486, 549  
Host group in RMON, 439  
Host-to-Host layer (DOD), 121  
  protocols, 124–127  
hosts, security for, 485  
HostTopN group in RMON, 439  
Hot Standby Router Protocol (HSRP), 202,  
  202, 203, 549  
HSCI (High-Speed Communication  
  Interface), 549  
HSRP (Hot Standby Router Protocol), 202,  
  202, 203, 549

HSSI (High-Speed Serial Interface), 549  
HSSI Interface Processor (HIP), 548  
hubs, 8, 8, 549  
  and collisions, 70  
hybrid network, 549  
hybrid routing, balanced, 324–325

---

**I**

IANA (Internet Assigned Numbers Authority),  
  IP addresses for private networks, 283  
IBM, Systems Network Architecture (SNA), 3  
ICD (International Code Designator), 549–550  
ICMP (Internet Control Message Protocol),  
  135, 550  
IDS (Intrusion Detection System), 552  
IDSL (ISDN DSL), 244  
IEEE (Institute of Electrical and Electronics  
  Engineers), 550  
IEEE 802.10, 99  
IEEE 802.1D, 84, 389, 550  
IEEE 802.1q, 98  
IEEE 802.2, 232  
IEEE 802.3, 30, 38–40, 550  
IEEE 802.3u, 103  
IEEE 802.5, 43, 390, 550  
IGMP (Internet Group Management Protocol),  
  82, 550  
IGP (Interior Gateway Protocol), 550  
IGRP (Interior Gateway Routing Protocol),  
  313, 317, 327–332, 550  
  features, 327–328  
  route update process, 330, 330–331  
  routes, 328–331, 329  
  routing loop prevention, 331–332  
  timers, 328  
ILMI (Integrated Local Management  
  Interface), 550  
implementation, in PDIOO methodology, 156  
in-band environment, 486–487

- in-band management, 551
- inbound packets, 409
- incremental update command, 343–344
- industry standard management technologies,
  - benefits, 433
- inelastic traffic, 420
- infinite, 321
- InformRequest message (SNMP), 437
- Institute of Electrical and Electronics Engineers (IEEE), 550
- insured burst, 551
- Integrated Local Management Interface (ILMI), 550
- Integrated Services Digital Network (ISDN), 34, 232–236, 554
- integrity of data, 482
- Inter-Switch Link (ISL) protocol, 99–100
- interactive voice response (IVR), 492, 551
- interarea routing, 551
- interface loopback command, 369
- interface processor, 551
- Interior Gateway Protocol (IGP), 550
- Interior Gateway Routing Protocol (IGRP), 313, 317, 327–332, 550
- interior routes, in IGRP, 328
- Intermediate System-to-System (IS-IS), 313, 317, 325, 378–382, 379, 554
  - configuration on Cisco routers, 379–382
  - enabling and assigning areas, 380–382
- internal routers, in OSPF, 362, 369–371
- International Code Designator (ICD), 549–550
- International Standards Organization (ISO), 11.
  - See also* OSI reference model
  - network management model, 442–443
- Internet, 221, 551
- internet, 551
- Internet Assigned Numbers Authority (IANA),
  - IP addresses for private networks, 283
- Internet Connectivity module, 199
- Internet Control Message Protocol (ICMP), 135, 550
- Internet Group Management Protocol (IGMP), 82, 550
- Internet layer (DOD), 121–122
  - protocols, 127–129
- Internet navigation, Application layer for, 18
- Internet Protocol (IP), 128, 551
  - EIGRP configuration for, 341–342
- Internet Service Provider module, 200
- Internetwork Packet Exchange (IPX).
  - See* Novell IPX (Internetwork Packet Exchange)
- internetworking, 551
  - evolution, 3–4
- internetworks, 4–5, 551. *See also* networks communicating through, 28
- intra-area routing, 552
  - link-state databases for, 378
- intrusion-detection devices, 480, 486
- Intrusion Detection System (IDS), 552
- invalid timers, in IGRP, 328
- Inverse ARP (Inverse Address Resolution Protocol), 552
- IOS. *See* Cisco Internetwork Operating System (IOS)
- IOS Network Management Model, 552
- IP (Internet Protocol), 128, 551, 552
  - EIGRP configuration for, 341–342
- IP addresses, 127
  - design considerations, 292–299
    - Cisco CNS Network Registrar, 294–295
    - IPX considerations, 298–299
    - router addresses, 292–293
    - server addresses, 294
  - exam essentials, 301
  - extending, 256–274
    - variable-length subnet mask (VLSM), 258, 258–262
  - hierarchical structure, 259
  - IP v4 addresses, 258, 552–553
  - migration to IPv6, 297

- IP v6 addresses, 295–296, 553
  - design considerations, 295–296
  - migration, 296–297
  - obtaining and testing, real world scenarios, 298
- private, 283–290
- real world scenarios, 135–136
- router filtering of, 9
- in VLSM implementation, 264
- IP Control Protocol (IPCP), 553
- ip forward protocol, 553
- ip helper address, 553
- ip helper-address command, 288, 288–290
  - forwarded ports, 289–290
  - multiple server example, 289
  - single server example, 288
- ip-helper command, 289–290
- IP multicast, 553
- ip ospf command, 368
- ip ospf priority command, 368
- ip sap-incremental eigrp command, 344
- IP Security (IPSec), 553–554
- IP telephony, 493–494
- ip unnumbered command, 284–286, 552
- IPCP (IP Control Protocol), 553
- IPSec (IP Security), 553–554
- IPX (Internetwork Packet Exchange).
  - See Novell IPX (Internetwork Packet Exchange)
- IPX addressing, 298–299, 554
- IPX Control Protocol (IPXCP), 554
- IPX network 7C80, 141
- ipx router command, 342
- IPXCP (IPX Control Protocol), 554
- IPXWAN protocol, 554
- IS-IS (Intermediate System-to-System), 313, 317, 325, 378–382, 379, 554
  - configuration on Cisco routers, 379–382
  - enabling and assigning areas, 380–382
  - exam essentials, 393–394
- is-type command, 380

- ISDN (Integrated Services Digital Network), 34, 232–236, 554
  - BRI (Basic Rate Interface), 234, 527
    - uses, 235
  - DDR (Dial-On-Demand Routing), 205, 236, 537
    - in case study, 509
  - PRI (Primary Rate Interface), 235, 571
- protocols, 233
- reference points, 233
- switch types, 234
- terminals, 233
- ISDN dial-on-demand, for ISP
  - connection, 326
- ISDN DSL (IDSL), 244
- isis password command, 381
- ISL (Inter-Switch Link) protocol, 99–100
- ISO (International Standards Organization), 11.
  - See also OSI reference model
- isochronous transmission, 554
- isolation LAN, 480–481, 554
- ISP (Internet service provider), ISDN dial-on-demand for connection, 326
- ITU-T (International Telecommunication Union Telecommunication Standardization Sector), 554
- IVR (interactive voice response), 492, 551

---

## J

- jitter, 495, 555
- Joint Photographic Experts Group (JPEG), 19
- JPEG (Joint Photographic Experts Group), 19

---

## K

- keepalives, LMI messages on, 240

**L**

- 
- LAN (local area network), 555. *See also* local area networks (LANs)
  - LAN Emulation Address Resolution Protocol (LE ARP), 556
  - LAN Emulation Client (LEC), 48, 556
  - LAN Emulation Configuration Server (LECS), 48, 556
  - LAN Emulation Server (LES), 48, 556
  - LAN switch, 555
  - LANE (LAN Emulation), 98, 555
    - components, 48
  - LAPB (Link Access Procedure, Balanced) protocol, 33, 232, 555
  - LAPD (Link Access Procedure on D channel), 555
  - latency, 7, 86, 165, 555–556
    - for frames processing, 71
  - Layer 2 switching, 68, 73–74
    - 20/80 rule, 80–82, 81
    - 80/20 rule, 79–80, 80
    - functions, 75–79
      - address learning, 75–77
      - forward/filter decisions, 77
      - loop avoidance, 77–79
    - vs. Layer 3 switching, 100
    - limitations, 74
    - multicasting, 82
    - quality of service, 83
  - Layer 3 switching, 68, 100–101
  - layered reference model, 12–15
    - advantages, 14
  - LCP (Link Control Protocol), 237, 556
  - LE ARP (LAN Emulation Address Resolution Protocol), 556
  - leaky bucket, 556
  - learning bridge, 385, 556. *See also* transparent bridging
  - leased networks
    - circuit-switched, 220–221
    - dedicated lines, 220, 220
    - packet-switched, 221
    - for WANs, 219–221
  - LEC (LAN Emulation Client), 48, 556
  - LECS (LAN Emulation Configuration Server), 48, 556
  - Length field in data frame, 31
  - LES (LAN Emulation Server), 48, 556
  - Level 1 routing, 378, 557
  - Level 2 routing, 378, 557
  - limited-route explorer packet, 391
  - Line Printer Daemon (LPD), 124, 558
  - Link Access Procedure, Balanced (LAPB) protocol, 33, 232
  - link compression, 413
  - Link Control Protocol (LCP), 556
  - link cost, 368
  - link-state advertisement (LSA), 558
    - in OSPF, 357, 361–362
  - link-state database, for NLSP, 377
  - link-state packets (LSPs), 321–322
  - link-state protocols, scalability
    - limitations, 316
  - link-state routing, 321–324, 356–357, 557.
    - See also* OSPF (Open Shortest Path First)
    - vs. distance vector routing algorithm, 324, 367
  - link-state update (LSU), 363, 558
    - packets, 364–365
      - acknowledgments, 365–367
  - listening, 557
  - listening router, 359
  - LLAP (LocalTalk Link Access Protocol), 557
  - LLC (Logical Link Control), 557
  - LLQ, 557
  - LMI (Local Management Interface), 239–240, 558

LNNI, 558  
load balancing, 205–206, 558  
    with CEF, 229  
local area networks (LANs), 4. *See also*  
    virtual LANs  
    exam essentials, 49–50  
    hardware, 6–10. *See also* hardware  
    for LANs  
    redundant configurations, 200–203  
    segmentation, exam essentials, 107–108  
    technologies, 38–48  
        ATM protocol, 45–48  
        Ethernet and IEEE 802.3, 38–40  
        FDDI (Fiber Distributed Data Interface),  
            40–43, 41  
        Token Ring, 43–45  
local explorer packet, 391, 558  
Local Management Interface (LMI),  
    239–240  
LocalTalk, 558  
LocalTalk Link Access Protocol  
    (LLAP), 557  
logging, for access lists, 409–410  
logical addresses, 558  
    vs. physical, 130–131  
logical data movement, in reference  
    model, 15, 15  
Logical Link Control (LLC) sublayer in  
    Data Link layer, 31–32, 32, 557  
loop avoidance, 77–79  
    in transparent bridging, 388–390  
loopback interface, 369  
loose coupling, 13  
LPD (Line Printer Daemon), 124, 558  
LSA (link-state advertisement), 558  
    in OSPF, 357, 361–362  
LSU (link state update), 363, 558  
    packets, 364–365  
    acknowledgments, 365–367  
LUNI, 558

---

## M

MAC (media access control), 559  
MAC (media access control) address, 7, 129,  
    130, 559  
    real world scenarios, 135–136  
MAC database, forward/filter table, 75, 75–77  
MAC sublayer in Data Link layer, 32–33  
MacIP, 559  
mainframe, 3  
MAN (Metropolitan-Area Network), 559  
manageability, 559  
    evaluating network needs and  
    expectations, 169  
    of hierarchical network, 192–193  
    as WAN design criteria, 224  
Management Information Base (MIB),  
    434, 438, 561  
Manchester encoding, 559  
mapping private IP v4 addresses. *See* Network  
    Address Translation (NAT)  
master-slave relationships, 363  
Matrix group in RMON, 439  
MAU (Multi-station Access Unit), 559  
maximum burst, 559–560  
Maximum Burst Size (MBS), 560  
Maximum Cell Delay Variation (MCDV), 560  
Maximum Cell Loss Ratio (MCLR), 560  
Maximum Cell Transfer Delay (MCTD), 560  
maximum hop count, 320  
maximum rate, 560  
maximum transmission unit (MTU), 327, 562  
MBONE (Multicast Backbone), 560  
MBS (Maximum Burst Size), 560  
MCDV (Maximum Cell Delay Variation), 560  
MCLR (Maximum Cell Loss Ratio), 560  
MCR (Minimum Cell Rate), 560  
MCTD (Maximum Cell Transfer Delay), 560  
mean time between failure (MTBF), 164, 562

media, 561  
 media access control (MAC), 559  
 Media Access Control (MAC) address, 7  
 media access control field in Token Ring, 44, 44  
 memory, for link-state algorithm, 323  
 metrics, for path determination, 225  
 Metropolitan-Area Network (MAN), 559  
 MIB (Management Information Base), 434, 438, 561  
 microsegmentation, 69, 561  
 MIDI (Musical Instrument Digital Interface), 19  
 minicomputers, 4  
 Minimum Cell Rate (MCR), 560  
 MIP (Multichannel Interface Processor), 561  
 mips, 561  
 MLP (multilink PPP), 561  
 MMP (Multichassis Multilink PPP), 561  
 modem eliminator, 561  
 modems, 561  
     for WANs, 11  
 modulation, 561  
 MOSPF (multicast OSPF), 562  
 MPEG (Motion Picture Experts Group), 19  
 MPOA (Multiprotocol over ATM), 562  
 MSAU (multistation access unit), 43  
 MTBF (mean time between failure), 164, 562  
 MTU (maximum transmission unit), 327, 562  
 multi-point subinterface, 242  
 Multi-station Access Unit (MAU), 559  
 multicast, 562  
 multicast addressing, 562  
     LMI messages on, 240  
 Multicast Backbone (MBONE), 560  
 multicast OSPF (MOSPF), 562  
 multicast send VCC, 562  
 multicasting, 82  
     LMI messages on, 240  
 Multichannel Interface Processor (MIP), 561

Multichassis Multilink PPP (MMP), 561  
 multilayer switch, 562  
 multilink PPP (MLP), 237, 561  
 multiplexing, 562  
 multiplexors, 11  
 Multiprotocol over ATM (MPOA), 562  
 multistation access unit (MSAU), 43  
 Musical Instrument Digital Interface (MIDI), 19  
 mux, 11

---

## N

NAK (negative acknowledgment), 562  
 Name Binding Protocol (NBP), 563  
 names, synchronizing with dynamically assigned IP addresses, 294–295  
 naming standards, 299–300  
 NAT (Network Address Translation), 290–292, 291, 563  
     in case study, 513  
     deciding to use, 291–292  
 National Security Agency (NSA), 480, 483  
 native VLAN, 96, 563  
 NBP (Name Binding Protocol), 563  
 NCP (NetWare Core Protocol), 137, 563  
 NCP (Network Control Protocol), 237  
 negative acknowledgment (NAK), 562  
 neighbor table, in EIGRP, 334, 335  
 neighboring routers, 316, 563  
     in OSPF, 357, 358  
     in RIP, 326  
 NET (network entity titles), 380  
 NetBEUI, 563  
 NetBIOS, 563  
 NetFlow switching, 563  
     for WANs, 228  
 NetView, 564  
 NetWare, 564

- NetWare Core Protocol (NCP), 137, 563
- NetWare Link Services Protocol (NLSP), 137, 313, 376–378, 565
- NetWare servers, client tracking, 411
- Network Access layer (DOD), 122
  - protocols, 129–131
- Network Address Translation (NAT), 290–292, 291, 563
  - in case study, 513
  - deciding to use, 291–292
- Network Campus module, 564
- Network Control Protocol (NCP), 237
- Network Edge module, 564
- network entity titles (NET), 380
- network entry LSA, 361
- Network File System (NFS), 20, 565
- Network IDS, 486, 564
- Network Information Center (NIC), 256
- network interface cards (NICs), 565
  - physical addresses, 130
- Network layer (OSI), 27–28, 29, 564
- Network Layer Host group in RMON, 440
- Network Layer Matrix group in RMON, 440
- network management, 564
- Network Management module, 198
  - security risks, 490
- Network Management Processor (NMP), 565
- network map, 27
- network *network-number* command, 327
- network operations center, 564
- network switching technology, 69
- Network Time Protocol (NTP), 487, 564
- networks. *See also* security
  - calculating number, 257
  - corporate requirements, 5
  - data integrated with voice, 493–495
    - delay in voice, 494–495
  - evaluating existing, 157–166
    - administrative data, 157–158
    - design methodology, 160–162
    - inventory, 162–166
    - technical data, 159
  - evaluating needs and expectations, 166–169
  - evolution, 3–4
  - exam essentials, 170
  - guidelines, 465
  - ISO management model, 442–443
  - life cycle, 155–156
  - management, 432
    - benefits of industry standard technologies, 433
    - exam essentials, 446
    - proactive, 444–445
  - naming standards, 299–300
  - relieving congestion, 69–73
  - segmentation, 40, 69
  - topology, 163, 164, 190, 564. *See also* Enterprise Composite Network Model
  - exam essentials, 207–208
  - fault-tolerance, 200–206
  - full mesh, 203, 204
  - hierarchical, 190–197
  - load balancing, 205–206
  - partial mesh, 204, 204–205
- Next Hop Resolution Protocol (NHRP), 565
- next-hop router, 331
- Next Hop Server (NHS), 565
- NFS (Network File System), 20, 565
- NHRP (Next Hop Resolution Protocol), 565
- NHS (Next Hop Server), 565
- NIC (network interface card), 565
- NLSP (NetWare Link Services Protocol), 137, 313, 376–378, 565
- NMP (Network Management Processor), 565
- NoAuthNoPriv message (SNMP), 437
- node, 565
- non-designated port, for Spanning-Tree Protocol, 85
- non-hierarchical addressing, 278
- non-root bridge, for Spanning-Tree Protocol, 85

non-stub area, 565  
 non-volatile RAM (NVRAM), 566  
 nonreturn to Zero (NRZ), 565  
 normal response mode (NRM), 232  
 Novell IPX (Internetwork Packet Exchange),  
 136–141  
   client/server communication, 138–139  
   EIGRP configuration for, 342–343  
   IPX addressing, 140–141  
   protocol suite, 136–138  
     and OSI model, 136  
   server/server communication, 139–140  
   watchdog spoofing, 411  
 NRM (normal response mode), 232  
 NRZ (nonreturn to Zero), 565  
 NRZI (nonreturn to zero inverted), 566  
 NSA (National Security Agency), 480, 483  
 NTP (Network Time Protocol), 487, 564  
 NVRAM (non-volatile RAM), 566

---

## O

object identifier (OID) in MIB, 438  
 OC (optical carrier), 566  
 octets, 258  
 offline operation, 438, 566  
 OID (object identifier) in MIB, 438  
 ones density, 566  
 Open Shortest Path First (OSPF). *See* OSPF  
   (Open Shortest Path First)  
 Open Systems Interconnection, 567. *See also*  
   OSI reference model  
 operation, in PDIOO methodology, 156  
 optical carrier (OC), 566  
 optimization, in PDIOO methodology, 156  
 optimum switching, 566  
   for WANs, 227  
 Organizational Unique Identifier (OUI), 130  
 OSI reference model, 11–37, 16, 567  
 Application layer, 17–18  
 bridge routing, 383  
 Data Link layer, 29–34  
   Logical Link Control sublayer, 31–32, 32  
   MAC sublayer, 32–33  
   WAN protocols, 33–34  
 vs. DOD model, 121  
 exam essentials, 49–50  
 IPX protocol suite and, 136  
 layer functions, 17  
 Network layer, 27–28, 29  
 Physical layer, 34–35  
 Presentation layer, 18–19  
 real-world use, 35–36  
 Session layer, 19–21  
 Transport layer, 21–25, 26  
 OSPF (Open Shortest Path First), 313, 317,  
 356–376, 567  
   configuration, 369–374  
     area configuration and wildcard masks,  
     371–375  
     internal routers, 369–371  
     multi-area router example, 373–374  
   configuring summary route advertised by, 280  
   exam essentials, 393–394  
   features and operation, 358–367  
     designated routers, 362–363  
     initialization, 358–362, 360  
     initializing and maintaining route  
     information, 363–367  
   filtering, 376  
   metrics, 368–369  
   redistribution, 375–376  
   route summarization, 374  
   stub areas, 374–375  
 OUI (Organizational Unique Identifier), 130  
 out-of-band environment, 486  
 out-of-band management, 567  
 out-of-band signaling, 567  
 outbound packets, 409

---

**P**

- Packet Capture group in RMON, 440
- packet filters, access lists as, 407
- Packet Level Protocol (PLP), 570
- packet loss, in voice transmission, 495
- packet switch, 568
- Packet Switch Exchange (PSE), 572
- packet-switched network (PSN), 221, 573
- packet switching, 27, 568
- packetizing, 567
- packets, 6, 36, 567
- PAP (Password Authentication Protocol), 568
- parity checking, 568
- partial mesh topology, 204, 204–205, 568
  - with Frame Relay, 241, 241–242
- passive-interface command, 342
- Password Authentication Protocol (PAP), 568
- passwords
  - for IS-IS routers, 381
  - for OSPF, 359
- path determination, 568
  - in WAN, 224–225
- payload compression, 413
- PBXs (private branch exchanges), 491–492, 571
- PCM (pulse code modulation), 491
- PCR (Peak Cell Rate), 568
- PDIOO methodology, 155–156, 160–161
  - for WANs, 222–223
- PDN (Public Data Network), 568
- PDU (protocol data unit), 436, 572
- Peak Cell Rate (PCR), 568
- peer machines, 138
- peer-to-peer communication, 15, 15
- peers, 569
- per-destination load balancing, 229–230, 569
- per-packet load balancing, 229–230, 569
- performance
  - evaluating network needs and expectations, 169
  - existing, 165
    - of hierarchical network, 193
- permanent virtual circuit (PVC), 573
- permanent virtual path (PVP), 573
- PGP (Pretty Good Privacy), 569
- phantom, 569
- phantom router, 202
- physical addresses, vs. logical, 130–131
- physical data movement, in reference model, 14–15, 15
- Physical layer (OSI), 34–35, 569
- Physical layer in ATM protocol, 45–46
- Physical medium dependent (PMD) sublayer, in ATM Physical layer, 45–46
- physical security, 485–486
- physical segmentation, 69
- PICT standard, 19
- pilot project, 462–465
  - exam essentials, 466
  - implementation steps, 463–464
- PIM (Protocol Independent Multicast), 82
- ping, 569
- pinhole congestion, 206, 206, 569
- planning, in PDIOO methodology, 155–156
- pleisochronous, 569
- PLP (Packet Level Protocol), 570
- PNNI (Private Network-Network Interface), 570
- Point of Presence (POP), 570
- point-to-multipoint connection, 570
- point-to-point connection, 570
- Point-to-Point Protocol (PPP), 34, 236–237, 571
  - protocol stack, 236
- point-to-point subinterface, 242
- point-to-point subnet mask, 286
- poison reverse updates, 326, 332, 570

- poisoned route, 321
- polling, 570
  - MAC sublayer and, 33
- POP (Point of Presence), 570
- POP (Post Office Protocol), 570
- port number, 570–571
- PortFast BPDU filter, 387
- ports
  - 137 and 138, 290
  - cost for Spanning-Tree Protocol, 85
  - forwarded, 289–290
  - security for, 483
- positive acknowledgment with
  - retransmission, 25
- Post Office Protocol (POP), 570
- PPP (Point-to-Point Protocol), 34, 236–237, 571
  - protocol stack, 236
- preamble of data frame, 30
- prefix routing protocols, 325
- Presentation layer (OSI), 18–19, 571
- Pretty Good Privacy (PGP), 569
- PRI (Primary Rate Interface), 235, 571
- Primary Rate Interface (PRI), 235, 571
- primary ring in FDDI, 41
- primary stations for SDLC, 231
- printer queuing, 4
- printers, sharing, 3–4, 124
- priority queueing, 416–417, 417, 571
- private branch exchanges (PBXs), 491–492, 571
- private IP addresses, 283–290, 571
  - in case study, 511–512
  - IP v4, 571
- Private Network-Network Interface (PNNI), 570
- private networks, for WANs, 219
- proactive network management, 444–445
- Probe Configuration group in RMON, 440
- Process/Application layer (DOD), 121
  - protocols, 122–124
- process identification number, for OSPF
  - routers, 369
- process switching, 571
  - for WANs, 226
- processing power, for link-state
  - algorithm, 323
- PROM (programmable read-only memory), 572
- propagation delay, 494, 572
- protocol analyzer, 165, 572
- protocol data unit (PDU), 436, 572
- Protocol Directory group in RMON, 440
- Protocol Distribution group in RMON, 440
- Protocol Independent Multicast (PIM), 82
- protocol stack, 15, 572
- protocols, 12, 572
  - information gathering about, 163
  - non-routable, 383
- prototype, 462–465
  - exam essentials, 466
  - implementation steps, 464–465
- proxy ARP, 203, 572
- proxy services, 410–412, 572
  - IP helper addresses, 412
  - for IPX, 411
  - proxy ARP, 412
- PSE (Packet Switch Exchange), 572
- PSN (packet-switched network), 573
- PSTN (Public Switched Telephone Network), 220, 491–492, 573
- PSTN module, 200
- Public Data Network (PDN), 568
- public networks, for WANs, 221–222
- Public Switched Telephone Network (PSTN), 220, 491–492, 573
- pulse code modulation (PCM), 491
- PVC (permanent virtual circuit), 573
- PVP (permanent virtual path), 573
- PVP tunneling, 573

---

## Q

Quality of Service (QoS), 573  
  real world scenarios, 419–420  
  for voice transmission, 495  
queue, 573  
queuing methods, 413–419  
  custom queuing, 417–418, 418, 536  
  FIFO (First In First Out), 414, 544  
  priority queuing, 416–417, 417, 571  
  traffic shaping, 419, 588  
  weighted fair queuing, 415, 415–416, 416  
QuickTime, 19

---

## R

RARP (Reverse Address Resolution Protocol),  
  129, 131, 573  
rate queue, 573  
RCP (Remote Copy Protocol), 574  
Real-time Transport Protocol (RTP), 576  
real world scenarios  
  BRI (Basic Rate Interface), 235  
  business flexibility, 13  
  CDP (Cisco Discovery Protocol), 441–442  
  denial of service (DoS) attacks, 484–485  
  MAC (media access control) address,  
    135–136  
  MAC and IP address changes, 135–136  
  network security, 168  
  OSI reference model use, 35–36  
  Quality of Service (QoS), 419–420  
  route summarization, 278–279  
  Routing Information Protocol (RIP),  
    326–327  
  security, 168, 480  
  Spanning-Tree PortFast, 386–387  
  switching modes configuration, 88  
reconnaissance attacks, 483

Red Hat 7.2, IP v6 use in, 298  
redistribution, 574  
  in OSPF, 375–376  
redundancy, 574  
  in LAN configurations, 200–203  
  in switch links, 77–78  
  WAN connections, 203–205  
reference models. *See also* OSI reference model  
  advantages, 13–14  
  layered approach, 12–15  
  physical and logical data movement,  
    14–15, 15  
reliability of network, 165  
reload, 574  
Remote Access and VPN module, 199  
  security risks, 489  
remote address resolution, 133–135, 134  
Remote Copy Protocol (RCP), 574  
Remote Monitoring (RMON), 438–440  
  groups, 439–440  
Remote Procedure Call (RPC), 21  
repeaters, 6, 6–7, 574  
  and collisions, 70  
  maximum distance for end nodes with, 106  
Request to Send (RTS), 576  
Resource Reservation Protocol (RSVP),  
  420–421, 576  
retirement, of network, 156  
Reverse Address Resolution Protocol (RARP),  
  129, 131, 573  
RFCs (Request for Comments)  
  760 for IP version 4, 261  
  791 for class definitions, 261  
  1058 on RIP, 325  
  1155 on SNMP, 434  
  1157 on SNMP, 434  
  1212 on MIB, 434  
  1213 on MIB, 434  
  1247 on OSPF, 357  
  1723 on RIP, 325

- 1757 on RMON, 438
- 1902 on SNMPv2, 434
- 1903 on SNMPv2, 434
- 1904 on SNMPv2, 434
- 1905 on SNMPv2, 435
- 1906 on SNMPv2, 435
- 1907 on SNMPv2, 435
- 1908, 435
- 1909 on SNMPv2, 434
- 1918 on filtering guidelines, 484
- 2574 on SNMPv3, 435
- 2575 on SNMPv3, 435
- 2827 on filtering guidelines, 484–485
- RFP (request for proposal), 458–459, 574
- RIF (Routing Information Field), 574
- ring, 574
- ring topology, 574
- RIP (Routing Information Protocol), 313, 317, 325–326, 574
  - configuration to advertise network, 327
  - in Novell IPX protocol suite, 137, 140
  - real world scenarios, 326–327
  - turning off auto-summarization for, 279
- RMON (Remote Monitoring), 438–440, 575
  - groups, 439–440
- root bridge, 390
  - for Spanning-Tree Protocol, 84
- root port, for Spanning-Tree Protocol, 85
- route aggregation. *See* route summarization
- route database, in EIGRP, 334
- route poisoning, 321
- Route Processor (RP), 576
- route summarization, 274, 274–280, 575
  - 10.1.0.0 through 10.7.0.0, 275–276
  - 172.16.16.0 through 172.16.31.0, 276–277
  - 192.168.32.0 through 192.168.63.0, 277
  - applying to Cisco routers, 280
  - design considerations, 277–280
  - discontiguous addressing, 278
    - in OSPF, 374
  - real world scenarios, 278–279
  - turning off on routers, 279
- route/switch processor (RSP), 576
- route tables
  - in OSPF, 357
  - for RIP, 325–326
- route update process, in IGRP, 330, 330–331
- routed protocol, 313, 575
- router eigrp command, 341
- router ID, for OSPF, 358
- router link entry LSA, 361
- router ospf command, 369
- router priority, for OSPF, 359
- routers, 9, 9, 575
  - addresses, 292–293
  - and collisions, 70
  - with distance-vector algorithms, awareness
    - of topology change, 315
  - evaluating, 165
  - in hierarchical network, 196
  - in OSPF
    - areas to group, 372
    - changing priority, 368
    - types, 362
  - security, 482–483
  - segmentation with, 71–73
  - turning route summarization off, 279
  - for WANs, 11
- routing, 575
  - hierarchical decisions, 260
  - implementation issues in WAN, 224–225
- routing domain, 575
- Routing Information Field (RIF), 574
- Routing Information Protocol (RIP), 313, 317, 325–326, 574
  - configuration to advertise network, 327
  - in Novell IPX protocol suite, 137, 140
  - real world scenarios, 326–327
  - turning off auto-summarization for, 279

routing loops, 319–320, 575  
  preventing in IGRP, 331–332  
routing metric, 575  
routing protocols, 312, 313–325, 575. *See also*  
  EIGRP (Enhanced Interior Gateway  
  Routing Protocol); IGRP (Interior  
  Gateway Routing Protocol); Routing  
  Information Protocol (RIP)  
  exam essentials, 345–346  
  interior, 317–325  
    distance-vector protocols, 317–321  
    link-state routing, 321–324  
  scalability features, 314–315  
Routing Table Maintenance Protocol  
  (RTMP), 317  
routing tables, 72, 322, 576  
RP (Route Processor), 576  
RPC (Remote Procedure Call), 21  
RSP (route/switch processor), 576  
RSVP (Resource Reservation Protocol),  
  420–421, 576  
RTMP (Routing Table Maintenance  
  Protocol), 317  
RTP (Real-time Transport Protocol), 576  
RTS (Request to Send), 576

---

## S

SAA (Service Assurance Agents), 576  
SAFE (Security Blueprint for Enterprise  
  Networks), 487–490, 576  
sampling rate, 576  
SAP (Service Advertising Protocol), 137, 140  
SAP (service access point), 576  
SAP (Service Advertising Protocol), 576  
scalability, 577  
  of hierarchical network, 191–192  
  link-state protocols limitations, 316  
  of routing protocols, 314–315  
  VLANs and, 92–95  
SCR (sustainable cell rate), 577  
script, for pilot demonstration, 463  
SDLC (Synchronous Data Link Control)  
  protocol, 33, 231, 577  
SDSL (symmetric DSL), 244  
secondary ring in FDDI, 41  
secondary stations for SDLC, 231  
Secure Shell Protocol (SSH), 577  
Secure Sockets Layer (SSL), 577  
security, 478–490  
  access lists, 481, 519  
  evaluating network needs and  
  expectations, 167  
  exam essentials, 496  
  firewall, 479, 479–482, 481  
  for hosts, 485  
  policy components, 485–487  
    access control, 486  
    intrusion-detection devices, 486  
    physical security, 485–486  
    secure device management, 486–487  
  real world scenarios, 168, 480  
  reports, 487  
  for routers and switches, 482–483  
  targets of hackers, 482–485  
  VLANs and, 90, 91–92  
Security Blueprint for Enterprise Networks  
  (Cisco SAFE), 487–490  
  module concept, 488, 488–490  
seed router, 577  
segmentation, 577  
  with bridge, 70–71, 71  
  with router, 71–73  
segmentation and reassembly sublayer, in  
  ATM Adaptation layer, 47  
Sequence Packet Exchange (SPX), 137,  
  581–582  
Serial Line Address Resolution Protocol  
  (SLARP), 131  
Serial Line Internet Protocol (SLIP), 579  
Serial Line IP (SLIP), 34

- Serial Tunnel (STUN), 584
- serialization, 577
- server, 577
  - addresses, 294
- Server Farm module, 199
  - security risks, 490
- Server Provider Edge functional area, 489
- server/server communication, in Novell IPX, 139–140
- service access point (SAP), 576
- Service Advertising Protocol (SAP), 137, 140, 576
- Service Assurance Agents (SAA), 576
- service level agreement (SLA), 578
- service-level contract (SLC), 578–579
- service level manager (SLM), 443–444, 579
- service profile identifiers (SPIDs), 234, 581
- service provider, 578
- Session layer (OSI), 19–21, 578
- set spantree portfast command, 387
- SetRequest message (SNMP), 436
- SF (super frame), 578
- Shielded-Twisted Pair (STP), 583
- ships-in-the-night routing, 314
- Shortest Path First algorithm (SPF), 581
- show interface command, 286
- show-running command, 293
- signaling, 492
- signaling packet, 578
- Signaling System 7, 578
- significant bits, 578
- silicon switching, 578
  - for WANs, 227
- Silicon Switching Engine (SSE), 582
- Simple Mail Transfer Protocol (SMTP), 124, 579
- Simple Network Management Protocol (SNMP), 18, 434–437, 579
  - exam essentials, 446
- simplex mode, 19
- single attachment stations in FDDI, 41
- single-route explorer packet, 391
- SLA (service level agreement), 578
- SLARP (Serial Line Address Resolution Protocol), 131
- SLC (service-level contract), 578
- sliding window, 579
- SLIP (Serial Line Internet Protocol), 34, 579
- SLM (service level manager), 443–444, 579
- SMDS (switched multimegabit data service), 579
- smooth round trip timer (SRTT), 335
- SMTP (Simple Mail Transfer Protocol), 124, 579
- SNA (Systems Network Architecture), 3, 579
- SNAP (Subnetwork Access Protocol), 579
- SNMP (Simple Network Management Protocol), 18, 434–437, 579
  - communications, 436–437
  - exam essentials, 446
  - functionality, 435–436
  - RFCs for, 434–435
- sockets, 580
  - for IPX, 137
- software image, 123
- SONET (Synchronous Optical Network), 580
- source address in data frame, 30
- source-route bridging (SRB), 390–391, 582
- source-route translational bridging, 392, 582
- source-route transparent bridging (SRT), 391–392, 582
- source service access points (SSAPs), 31, 582
- SP (switch processor), 580
- span, 580
- SPAN (Switched Port Analyzer), 580
- spanning explorer packet, 391, 580
- spanning tree, 580
- spanning-tree algorithm (STA), 84, 580
- Spanning-Tree PortFast, real world scenarios, 386–387

## 618 Spanning-Tree Protocol (STP) – switches

- Spanning-Tree Protocol (STP), 68, 77–78, 84–85, 581
- SPF (Shortest Path First algorithm), 581
- SPIDs (service profile identifiers), 234, 581
- split-horizon, 320, 331, 332
  - updates, 581
- spoofing, 581
- spooler, 581
- SPX (Sequence Packet Exchange), 137, 581–582
- SQE (signal quality error), 582
- SQL (Structured Query Language), 21
- SR/TLB (Source-Route Translational Bridging), 392, 582
- SRB (Source-Route Bridging), 390–391, 582
- SRT (Source-Route Transparent) bridging, 391–392, 582
- SRTT (smooth round trip timer), 335
- SSAPs (source service access points), 31, 582
- SSE (Silicon Switching Engine), 582
- SSH (Secure Shell Protocol), 577
- SSL (Secure Sockets Layer), 577
- STA (Spanning Tree Algorithm), 84, 580
- standard area, for OSPF, 361
- standby monitors on Token Ring network, 45, 582
- standby router in HSRP, 202
- star topology, 582–583
- start indicator of data frame, 30
- startup range, 583
- state transitions, 34
- static addressing, 583
- static route, 583
- static VLANs, 95–96, 583
- statistical multiplexing, 583
- Statistics group in RMON, 439
- STM-1 (Synchronous Transport Module Level 1), 583
- store-and-forward switching, 87, 583
- STP (Spanning-Tree Protocol), 68, 77–78, 84–85, 581
- STP (Shielded-Twisted Pair), 583
- Structured Query Language (SQL), 21
- stub area flag, for OSPF, 359
- stub areas, 583–584
  - in OSPF, 361, 374–375
- stub network, 326, 584
- STUN (Serial Tunnel), 584
- subarea, 584
- subarea node, 584
- subchannel, 584
- subinterfaces, 240–241, 584
  - defining, 242
- subnet
  - /31, 286–288
  - calculating number of hosts available, 257
- subnet address, 584
- subnet mask, 256–257, 584
  - display format configuration, 282–283
  - point-to-point, 286
- subnetting, 256, 584
- subnetwork, 584
- Subnetwork Access Protocol (SNAP), 579
- summary-address command, 374
- summary entry LSA, 361
- summary, in design document, 461
- super frame (SF), 578
- supernetting. *See* route summarization
- sustainable cell rate (SCR), 577
- SVC (switched virtual circuit), 585
- switch fabric, 92, 585
- switch processor (SP), 580
- switched LAN, 585
- switched multimegabit data service (SMDS), 579
- Switched Port Analyzer (SPAN), 580
- switched virtual circuit (SVC), 585
- switches, 8, 89, 585. *See also* Layer 2 switching
  - vs. bridges, 74
  - and collisions, 70
  - for LANs, 86–87

real world scenario on configuration, 88  
 redundant links between, 77–78  
 security, 482–483  
 switching  
   autonomous, 226–227  
   distributed, 227  
   Fast, 226  
   NetFlow, 228  
   optimum, 227  
   process, 226  
   silicon, 227  
 switching path, 225  
 symmetric DSL (SDSL), 244  
 Synchronous Data Link Control (SDLC)  
   protocol, 33, 231, 577  
 Synchronous Optical Network (SONET), 580  
 synchronous transmission, 585  
 Synchronous Transport Module Level 1  
   (STM-1), 583  
 Syslog data, 487  
 system routes, in IGRP, 329  
 Systems Network Architecture (SNA), 3, 579

---

## T

T1, 585  
 T3, 585  
 TACACS+ (Terminal Access Controller Access  
   Control System Plus), 585  
 tag switching, 585  
 tagged traffic, 586  
 TCP (Transmission Control Protocol),  
   125, 586  
   access lists to permit or deny ports, 408–409  
   vs. UDP, 126  
 TCP/IP (Transmission Control Protocol/  
   Internet Protocol), 120–131, 586  
   and DOD model, 122  
   exam essentials, 142–143  
   window sizes, 26  
 TDM (time-division multiplexing), 586  
 TE (terminal equipment), 586  
 TE1, 586  
 technical data, for network evaluation, 159  
 telco, 586  
 Telnet, 123, 586  
 Terminal Access Controller Access Control  
   System Plus (TACAC+), 585  
 terminal adapter, 586  
 terminal emulation, 586  
 terminal equipment (TE), 586  
 terminal ip netmask-format command,  
   282–283  
 testing, 463  
   in prototype development, 465  
 TFTP, 587  
 Thicknet, 38  
 thin protocol, 126  
 Thinnet, 38  
 thrashing, 79, 587  
 three-part firewall, 587  
   in case study, 509  
 tie-lines, 493, 587  
 TIFF (Tagged Image File Format), 19  
 time-division multiplexing (TDM), 586  
 time intervals, for OSPF, 358  
 time slots, 104  
 Time to live (TTL), 588  
   exceeding, 320  
 timers, in IGRP, 328  
 token, 587  
 token bus, 587  
 token passing, 587  
   MAC sublayer and, 33  
 Token Ring, 43–45, 587  
   bridging between Ethernet and, 392  
 Token Ring group in RMON, 440  
 Token Ring Interface Processor (TRIP), 588  
 topology database, 322  
   in EIGRP, 334  
   in OSPF, 357

topology of networks, 163, 164, 190, 564. *See also* Enterprise Composite Network Model exam essentials, 207–208  
fault-tolerance, 200–206  
    redundant LAN configurations, 200–203  
    redundant WAN connections, 203–205  
full mesh, 203, 204  
hierarchical, 190–197  
    benefits, 191–193  
    three-layer, 193–197, 194  
load balancing, 205–206  
partial mesh, 204, 204–205  
topology table, 338  
ToS (Type of Service), 587  
totally stubby area, 588  
    for OSPF, 361, 374–375  
traffic attacks, 484  
traffic shaping, 419, 588  
traffic stream, data segment sharing of, 22  
transfer modes, HDLC support for, 232  
translational bridging, source-route, 392  
Transmission Control Protocol (TCP), 125, 586  
    vs. UDP, 126  
Transmission Control Protocol/Internet Protocol (TCP/IP), 120–131, 586  
    and DOD model, 122  
    exam essentials, 142–143  
    window sizes, 26  
Transmission convergence (TC) sublayer, in ATM Physical layer, 45–46  
transmit buffers, 419  
transparent bridging, 384, 384–390, 588  
    filtering packets, 387–388  
    forwarding packets, 385–386  
    learning MAC addresses, 384–385  
    loop avoidance, 388–390  
    source-route, 391–392  
Transport layer (OSI), 21–25, 26, 588  
Trap message, 436, 437

Trap Message, 588  
triggered updates, 321  
TRIP (Token Ring Interface Processor), 588  
trunk, 588  
trunk links, 96–97, 97  
Trunk Up-Down (TUD), 588–589  
TTL (Time to live), 588  
    exceeding, 320  
TUD (Trunk Up-Down), 588–589  
tunneling, 589  
Type field in data frame, 30  
Type of Service (ToS), 587

---

## U

UDP (User Datagram Protocol), 126, 436, 589  
    preventing forwarding of broadcasts, 290  
unnumbered frames, 589  
up time, 165  
update interval, 589  
    for distance-vector protocols, 318  
update timers, in IGRP, 328  
uptime, 589  
User History Collection group in RMON, 440

---

## V

Van Jacobson algorithm, 413  
variable bit rate (VBR), 589  
variable-length subnet mask (VLSM), 258, 258–262, 268, 590  
    design considerations, 262–266  
    example, 265  
    for OSPF, 371  
    structure, 266–274  
    subnet adjustment, 263  
VBR (variable bit rate), 589  
VCC (Virtual Channel Connection), 589

VCI (Virtual Circuit Identifier), 47  
 vendor code, 130  
 VIP (Versatile Interface Processor) cards, 227, 589–590  
 virtual addressing, 130–131. *See also* logical addresses  
 virtual channel, 47  
 Virtual Channel Connection (VCC), 589  
 virtual circuit, 125, 590  
   LMI messages on, 240  
 Virtual Circuit Identifier (VCI), 47  
 virtual LANs (VLANs), 88–95, 590  
   broadcast control, 90–91  
   flexibility and scalability, 92–95  
   identifying, 96–100  
     frame tagging, 98  
     Inter-Switch Link (ISL) protocol, 99–100  
     methods, 98–99  
   memberships, 95–96  
   security, 91–92  
 Virtual Path Identifier (VPI), 47  
 virtual ring, 590  
 VLAN ID, 98  
 VLAN Management Policy Server, 96  
 VLSM (variable-length subnet mask), 258, 258–262, 268, 590  
   design considerations, 262–266  
   example, 265  
   for OSPF, 371  
   structure, 266–274  
   subnet adjustment, 263  
 VoATM (Voice over ATM), 493, 590  
 VoFR (Voice over Frame Relay), 493, 590  
 voice, 490–495  
   data network integration with, 493–495  
   exam essentials, 496  
   traditional technologies, 491–492  
 voice mail, 492  
 Voice over ATM (VoATM), 493, 590  
 Voice over Frame Relay (VoFR), 493, 590

Voice over IP (VoIP), 493, 590  
   packet loss, 419  
   quality of service for, 83  
 VPI (Virtual Path Identifier), 47

---

## W

WAN module, 199  
   security risks, 490  
 WANs. *See* wide area networks (WANs)  
 web resources, to request IP v6 addresses, 298  
 weighted fair queuing, 415, 415–416, 416  
 wide area networks (WANs), 4, 590  
   connection to Internet, 260, 260–261  
   exam essentials, 245  
   hardware, 10, 10–11  
   options, 218–222  
     leased networks, 219–221  
     private networks, 219  
     public networks, 221–222  
 planning and design, 222–230  
   autonomous switching, 226–227  
   Cisco Express Forwarding (CEF), 229–230  
   criteria, 223–224  
   distributed switching, 227  
   Fast switching, 226  
   implementation issues, 224–225  
   NetFlow switching, 228  
   optimum switching, 227  
   PDIOO methodology, 222–223  
   process switching, 226  
   silicon switching, 227  
 protocols, 230–244  
   Data Link protocols, 33–34  
   DSL (digital subscriber line), 243–244, 538  
   Frame Relay, 237–243. *See also* Frame Relay

HDLC (High-Level Data Link Control)  
protocol, 33, 231–232, 237, 548  
ISDN, 232–236. *See also* ISDN  
(Integrated Services Digital Network)  
PPP (Point-to-Point Protocol), 34,  
236–237, 571  
SDLC (Synchronous Data Link Control)  
protocol, 33, 231, 577  
redundant configurations, 203–205  
wildcard mask, 590  
window (data transmission), 25  
sizes for TCP/IP, 26  
Windows 2000 workstations, IP v6 use in, 298  
WinSock, 591  
workgroup switching, 591  
World Wide Web, Application layer for, 17

---

## **X**

X Window, 21, 124, 591  
X.25 protocol, 34, 591  
X.25 switches, for WANs, 11

---

## **Z**

ZIP (Zone Information Protocol), 591  
ZIP storm, 591  
zone, 591  
Zone Information Protocol (ZIP), 591