

- Last-Modified: header line, 106, 115  
 layered architecture, 47–48, 51–53  
 layer-2 packet switch, 480  
 layer-4 switch, 492  
**LDNS (Local DNS Server)**, 136–137, 605–606  
 leaky bucket mechanism, 646–648  
 least-cost path, 365, 367–368
  - Bellman-Ford equation, 371–372**LEO (low-earth orbiting) satellites**, 21–22  
**Limelight**, 35, 114, 604, 609  
 limited-scope flooding, 405  
 link-cost changes and DV (distance-vector) algorithm, 376–377  
 link-layer acknowledgments, 532  
 link-layer addressing, 462–469  
 link-layer frames, 55, 434, 436, 438–445, 461–462  
 link-layer protocols, 52
  - cable Internet access, 460–461
  - error detection and correction, 437
  - services 436–437**link layer**, 52, 433–436
  - bit-level error detection and correction, 438–445
  - broadcast channels, 433
  - CRC (cyclic redundancy check) codes, 443–445
  - error-detection and-correction techniques, 438–445
  - IEEE protocols, 444
  - implementation, 437–438
  - link-layer frame, 434
  - multiple access protocols, 445–461
  - networks as, 486–490
  - point-to-point communication link, 434
  - services, 436–437
  - switches, 461
  - wireless links, 17–18, 519–522**link-layer switches**, 4, 22, 53–54, 310, 476–482  
 link rates, 515  
 links, 434
  - broadcast, 445
  - heterogeneous, 479
 MPLS header format, 488  
 point-to-point, 445  
 transmission rates, 4  
**link-scheduling disciplines**
  - FIFO (first-in-first-out), 641–642
  - priority queuing, 642–643
  - round robin queuing discipline, 643–644
  - WFQ (weighted fair queuing), 644–645
  - work-conserving round robin discipline, 644**link-state advertisements**. *See* LSAs  
**link-state broadcast**, 366–367  
**link-state messages**, 689  
**link-state protocols**, 388, 400  
**link-state routing algorithms**, 366–371  
**link virtualization**, 486–490  
**link weights**, 390  
**load balancer**, 491–492  
**load distribution**, 132–133  
**load-insensitive routing algorithm**, 366  
**local area networks**. *See* LANs  
**Local DNS Server**. *See* LDNS  
**local ISP**, 392  
**logical communication between processes**, 186  
**longest prefix matching rule**, 318–319  
**Long-Term Evolution**. *See* LTE  
**loss recovery schemes**, 618  
**loss-tolerant**, 91, 592–593  
**lost packets**, 262–263  
**low-earth orbiting satellites**. *See* LEO  
 satellites  
**LSAs (link-state advertisements)**, 405  
**LTE (Long-Term Evolution)**, 18, 553–554
- ## M
- MAC addresses**, 463–465, 497  
 adapters, 464–465, 465, 471  
 AP (access point), 528  
 BSS, 539  
 802.11 wireless LAN, 528  
 flat structure, 464  
 no two adapters have same, 464  
 permanent, 463–464  
 switches, 477, 480

- MAC-based VLANs (virtual local area networks), 486
- MAC (message authentication code), 691–693, 777
  - compared with digital signatures, 696–697
- MAC (multiple access protocols), 436, 464, 531
  - 802.11 wireless LANs, 531–537
- mail access protocols, 125–130
- mailbox, 120–121
- mail clients, 97, 125
- mail servers, 97, 119–121, 125–126
- main-in-the-middle attack and DNS (domain name system), 143
- malicious packet attacks, 355
- malware, 56–57
- managed device, 761
- managed objects, 761
- Management Information Base. *See* MIB
- managing entity, 761
- MANETs (mobile ad hoc networks), 518
- manifest file, 601, 610
- MAP message, 460
- Master Key. *See* MK
- Master Secret. *See* MS
- maximum segment size. *See* MSS
- maximum transmission unit. *See* MTU
- MBone multicast network, 411
- MCR (minimum cell transmission rate), 313
- MD5, 710
  - authentication, 389
- MDCs (modular data centers), 494
- MD5 hash algorithm, 690
- message authentication code. *See* MAC
- message digests, 707
- message integrity, 688–693, 706
  - cryptographic techniques, 675
  - digital signatures, 695
  - secure e-mail system, 707–708
- message queue, 121
- messages, 51
  - application-layer, 51
  - authenticating, 689
  - breaking into shorter segments, 51
- confidentiality, 672–673
- eavesdropping, 673
- encrypted, 672
- HTTP format, 103–108
- integrity, 673
- segmentation, 77
- semantics of fields, 97
- syntax, 96
- transmitting and receiving, 7–8
- Metcalf, Bob, 454, 470, 473
- metering function, 650
- method field, 104
- MIB (Management Information Base), 761–762, 765, 770
- MIB modules, 765, 770–772
- MIB objects, 765
- Microsoft, 64–66, 66, 114
- middleboxes, 303
- MIMO (multiple-input, multiple output) antennas, 553
- minimum cell transmission rate. *See* MCR
- minimum spanning tree, 403
- Minitel project, 63–64
- MK (Master Key), 730
- mobile ad hoc networks. *See* MANETs
- mobile devices, 81
  - Internet, 550–552
  - power management, 543–544
- mobile IP, 349, 563–569, 576, 568–569
- mobile IP standard, 562
- mobile nodes, 554–564
  - COA (care-of-address), 559
  - direct routing, 563–564
  - foreign address, 559
  - foreign network, 559
  - home network, 559
  - indirect routing, 559–562
  - location protocol, 563
  - permanent address, 559
  - permanent home, 557
  - registering with foreign agent, 566–567
  - routing to, 559–564
  - sending datagrams to correspondent, 561
  - mobile-node-to-foreign-agent protocol, 562

mobile phones and wireless LAN base stations, 548

mobile station roaming number. *See* MSRN

mobile switching center. *See* MSC

mobility, 513–514

- addressing, 556–559
- cellular network management, 570–577
- GSM (Global System for Mobile Communications), 576
- in IP subnet, 541–542
- management, 555–564
- mobile IP, 576
- network-layer functionality required, 561–562
- routing to mobile node, 559–564
- scalability, 558
- wireless networks, 575–577

mobility-related services, 513

modems, 15

modular arithmetic, 685

modular data centers. *See* MDCs

modulo arithmetic, 687–688

MPEG, 624

MPLS (Multiprotocol Label Switching), 487–490

MPLS paths, 303

MP3 (MPEG 1 layer 3), 590

MSC (mobile switching center), 550

MSDP (Multicast Source Discovery Protocol), 412

MS (Master Secret), 714, 716

MSRN (mobile station roaming number), 571–572

MSS (maximum segment size), 232–234

MTU (maximum transmission unit), 232–233

- Ethernet, 471
- IP datagrams, 335

multicast routing, 405–412

multicast addresses, 356

multicast group, 406

multicast packets, 405–412

multicast protocols, 362

multicast routing, 399, 407–412

Multicast Source Discovery Protocol. *See* MSDP

multicast trees and RTP packets, 624–625

multi-homed stub network, 397

multi-homing, 33

multi-hop wireless networks, 518

multihop paths, 263–265

multimedia

- network supported for, 632–655
- streaming stored video, 593–612
- system-level approach for delivering, 633
- VoIP (Voice-over-IP), 612–623

multimedia applications, 588

- audio properties, 590–591
- bandwidth sensitive, 92
- conversational voice, 587, 592–593
- improving quality, 635
- Internet telephony, 592–593
- streaming live audio and video, 587, 593
- streaming stored audio and video, 587, 591–592

TCP (Transmission Control Protocol), 200

- types, 591–593

UDP (User Datagram Protocol), 200–201, 282

- video over IP, 592–593
- video properties, 588–589

multipath propagation, 519

multi-player online games, 83

multiple access links, 445–461

multiple access problem, 445

multiple access protocols, 445–461

- ALOHA protocol, 63
- CDMA (code division multiple access), 449

channel partitioning protocols, 447–448

characteristics, 447–448

FDM (frequency-division multiplexing), 448

random access protocols, 447

taking-turns protocols, 447, 459–460

TDM (time-division multiplexing), 448