



## Numerics

---

32-bit dotted decimal notation, 68

## A

---

ABRs (Area Border Routers), 177, 255

LSA summary link entries, 179

access lists, 692–693

configuring, 694

creating, 696

distribute lists, 494

extended, 701

configuring, 702–706

example, 709–710

in distribute lists, 736

placement, 711

process flow, 701

extensions, backwards compatibility, 693

route maps, 590, 646, 736–738

displaying, 599

implementing, 592–597

match commands, 737–738

sequence numbering, 590–591

set commands, 737–738

standard, 693

example, 699–700

numbering, 693

placement, 700

verifying configuration, 713–714

vt, 711

wildcard masks, 695

implicit, 698

access-class command, 712

ACKs (acknowledgements), suppressing, 378

active routes, EIGRP, 379

active state, EIGRP, 33

adding EIGRP to Novell RIP/SAP network, 725

addressing, redistribution example, 749–752

adjacencies, 107

EIGRP, 356

IS-IS, establishing, 272–275

administrative distance, 7–8

modifying, 581–582

routing protocols, 560

static routes, 421

advanced distance vector routing protocols

BGP

appropriate use of, 420

autonomous systems, 415–416

CIDR, 442–444

creating summary addresses, 448–449

default routes, 423

example configuration, 451

floating static routes, 421–422

inappropriate use of, 420

message types, 438–439

neighbors, 424–425

path of last resort, 421

path vectors, 424

policy-based routing, 426

resetting, 450

RFCs, 417

route selection, 440–441

static routes, 421–422

synchronization rule, 436–437

tables, 425

verifying operation, 452

EIGRP, 352

case study, 387–389

configuration exercises, 390–397, 409

configuring, 368

DUAL, 362–367

feasible successors, 354

going active on a route, 379

hello packets, 356

hold time, 356

load balancing, 372

neighbor tables, 354

operational characteristics, 353

packets, 355

query scoping, 379

reliability, 355

route discovery, 359–360

route summarization, 369–372

routing process, 353

scalability variables, 379–383

successors, 354

summarization, 353

tiered network model, 384–385

topology tables, 354, 358

verifying operation, 386

WAN links, 374–377

advertised distance, 32

advertisements, LSA sequence number, 111

- advertising
  - aggregate routes, 512
  - networks into BGP, 511–512
  - networks into IGPs, 513–514
- aggregate addressing, BGP, 442–444
- aggregate routes, advertising, 512
- aggregate-address command, 449, 512
- aggregation, black holes, 512
- aggregator attribute (BGP), 443
- aging timers, 115
- AllSPFRouter address, 103
- analyzing routing tables, 38–39
- announcements
  - periodic, 38
  - triggered updates, 38
- APNIC (Asia Pacific-NIC), 416
- AppleTalk commands (table), 775
- AppleTalk configuration commands (table), 775
- application layer (OSI model), 808
- applying
  - prefix lists to BGP, 494–499
  - route maps to updates, 740
- area default-cost command, 192
- area routers, 257
- area stub command, 191, 193
- areas, 101, 256
  - configuring, 719–724
  - design guidelines, 177
  - flooding LSUs, 184–186
  - IS-IS, restrictions, 265–266
  - link-state database, 178
  - NSSAs, 716–717
    - configuring, 717–718
  - stubby areas, 189–190
    - configuring, 191–194
    - requirements, 190
  - totally stubby areas, 189–190
    - configuring, 191–194
    - requirements, 190
- ARIN (American Registry for Internet Numbers), 416
- ARP (Address Resolution Protocol), 14
- ASBRs (autonomous system boundary routers), 178
  - external route cost, 181
  - LSAs, autonomous system external link entries, 179
- AS-path attribute (BGP), 429–430
- ASes (autonomous systems), 101, 415–416, 641–642
  - boundary routers, 558
  - IGPs, 99
  - multihoming, 502
  - configuration exercises, 523–527
  - customer and default routes from all providers, 504
  - default routes from all providers, 503
  - examples, 508–510
  - full routes from all providers, 506
  - local preference, configuring, 507
  - weight, configuring, 507
- redistribution, 557–558, 571, 648–649
  - access lists, 576, 578–581
  - administrative distance, 560
  - advertising networks into BGP, 511–512
  - advertising networks into IGP, 513–514
  - best path selection, 559
  - configuring, 562–564
  - defining default metric, 564–566
  - example configuration, 583–588, 752–753, 755–757
  - guidelines, 559
  - implementing, 649
  - passive interfaces, configuring, 566–567
  - seed metric, 561–562
  - static routes, configuring, 567–575
  - verifying operation, 589
- assigned TCP port numbers, 706–707
- assigned UDP port numbers, 708
- assigning access lists, 578
- atomic aggregate attribute (BGP), 443
- attributes, BGP, 427–428
  - AS-path, 429–430
  - community, 435, 741
  - local preference, 432
  - MED, 433–434
  - next-hop, 430–431
  - optional transitive, 740
  - origin, 434
  - type codes, 429
  - weight, 435
- auto-cost command, 129
- auto-cost reference -bandwidth command, 128
- automatic generation of prefix lists, 499
- automatic summarization
  - classful routing protocols, 16
  - classless routing protocols, 18
  - disabling, 370
- autonomous system external link entries (OSPF), 179
- autosummarization, 369
  - EIGRP, forcing, 371

**B**

- backbone, 250, 275
- backbone area (OSPF), 186
- backbone areas, 181
- backbone routers, 177
- backwards compatibility, IP access list
  - extensions, 693
- bandwidth command, 128
- BDRs (backup designated routers), 106–108
  - election, 107
  - exchange state, 111
  - extstart state, 110
- believability of routing protocols, 560
- best paths, 6, 559
  - BGP, selecting, 440–441
  - metrics, 6
  - OSPF, selecting, 111
- BGP (Border Gateway Protocol), 500
  - administrative distance, modifying, 582
  - aggregator attribute, 443
  - appropriate use of, 420
  - AS-path attribute, 429–430
  - atomic aggregate attribute, 443
  - attributes, 427–428
    - type codes, 429
  - autonomous systems, 415–416
  - characteristics, 642
  - CIDR, 442, 444
  - communities, 435, 739
  - community lists, creating, 742
  - configuration commands, syntax, 445
  - configuration exercises, 315, 457–464
  - default routes, 423
  - distribute lists, 494, 647, 734
    - extended access lists, 736
  - example configuration, 451, 731–734
  - floating static routes, 421–422
  - inappropriate use of, 420
  - incomplete origin attribute, 513
  - keepalive messages, 439
  - learned routes, 643–644
  - local-preference attribute, 432
  - MED attribute, 433–434
  - message types, 438
  - multihoming, 644
    - case study, 514–516
    - default routes from all providers, 503–504
    - examples, 508–510
    - full routes from all providers, 506
    - local preference, configuring, 507
    - weight, configuring, 507
  - neighbors, 424–425
    - loopback interfaces, 446
    - next-hop attribute, 430–431
      - modifying, 448
    - notification messages, 439
    - open message, 438–439
    - optional transitive attributes, 740
    - origin attribute, 434
    - path of last resort, 421
    - path vectors, 424, 643
    - peer groups
      - configuring, 444, 745–746
      - disabling, 446
      - example, 746–748
    - policy-based routing, 426
    - preferred routes, 644
    - prefix lists
      - announcing to Internet, 502
      - characteristics, 495
      - configuring, 496–499
      - exact matches, 497
      - sequence numbers, 499
      - verifying, 501
    - prefixes, applying, 494
    - redistribution, 511–514
    - resetting, 450
    - RFCs, 417
    - route maps, 736–738
    - route selection, 440–441
    - scalability, comparing to other routing protocols, 419
    - sessions, resetting, 508
    - split horizon, 485–486
    - static routes, 421
      - administrative distance, 421
      - example, 422
    - synchronization, disabling, 448
    - synchronization rule, 436–437
    - tables, 425
      - creating summary address, 448–449
    - TCP, 424
    - TTL, configuring, 446
    - update messages, 439
    - verifying operation, 452
    - weight attribute, 435
  - bgp always-compare-med command, 434, 644
  - bgp bestpath missing-as-worst command, 440
  - bgp cluster-id command, 492
  - bidirectional communication, 566
  - binary numbering, decimal-to-binary conversion chart, 682–683
  - black holes, 512
  - boundary routers, 558
    - RIP, configuring, 573–574

- broadcast mode
  - neighborship, 124
  - OSPF, configuring, 132
- broadcast multiaccess topologies, 102
  - OSPF, 103–106
    - DRs, 106–107
- broadcast physical links, 268
- broadcast storms, 86
- broadcasts, helper addresses, 86–87
  - configuring, 88–89
  - example, 89–91
  - forwarding to multiple servers, 90–91
  - server placement, 87
- building IP forwarding tables (Integrated IS-IS), 287–288

## C

- calculating
  - EIGRP metric
    - composite metric, 34
    - variables, 360–361
  - IGRP metric, 11–12
  - subnet masks, 687–689
  - VLSMs, 73
- capabilities (EIGRP), for IPX, 725
- cells, 809
- characteristics
  - BGP, 642
    - prefix lists, 495
  - OSI model, 800
- CIDR (Classless Interdomain Routing), 83–84, 638–640
  - BGP, 442–444
- Cisco IOS Release 10.3
  - IP access list extensions, backwards compatibility, 693
- Class D multicast addresses, 69
- classes (IP addresses), 686
  - First Octet Rule, 68
- classful addressing, 686
  - subnet masks, 687
- classful routing, 15–16, 635–637
  - route summarization, 80
  - subnets, 17
- classless routing
  - automatic summarization, 18
  - subnetting, 19
  - VLSMs, 638
- clear access-list counters command, 781
- clear ip bgp command, 450, 508
- clear ip bgp peer-group command, 746
- clear ip route command, 38, 138
- clear isis command, 297
- clear logging command, 781

- client route reflectors, 488
  - verifying, 494
- CLNS (Connectionless Network Service), 23, 251
  - static routes, 254
  - troubleshooting commands, 280
    - show clns route, 281, 284
    - show ip route, 282
    - show isis route, 281, 284–285
    - show isis topology, 280, 283
    - which route, 281, 285–286
- clns host command, 291
- clns router isis command, 289
- cluster IDs, 488
  - configuring, 492
- cluster lists, 488
- clusters, 488
  - designing, 491
- CMNS (Connection-Mode Network Service), 251
- commands
  - access-class, 712
  - aggregate-address, 449, 512
  - AppleTalk (table), 775
  - AppleTalk configuration (table), 775
  - area default-cost, 192
  - area stub, 191–93
  - auto-cost, 129
  - auto-cost reference-bandwidth, 128
  - bandwidth, 128
  - bgp always-compare-med, 434, 644
  - bgp bestpath missing-as-worst, 440
  - bgp cluster-id, 492
  - clear access-list counters, 781
  - clear ip bgp, 450, 508
  - clear ip bgp peer-group, 746
  - clear ip route, 38, 138
  - clear isis, 297
  - clear logging, 781
  - clns host, 291
  - clns router isis, 289
  - configure terminal, 781
  - copy running-config startup-config, 781
  - debug, 781
  - debug eigrp neighbors, 781
  - debug eigrp packets, 386, 781
  - debug igrp transactions, 30–32
  - debug ip bgp updates, example output, 455
  - debug ip policy, 599
  - debug ip routing, 30
  - default-information originate, 195
  - default-information originate always, 423
  - dialer map, 117
  - distance, example, 583–584, 586–588
  - distance bgp, 582

- distribute list-out, 579
- distribute-list in, 578
- erase startup config, 781
- interface configuration (table), 771, 785
- interface serial, 120
- IP (table), 772
- ip access group, 697
- ip classless, 573
- ip community list, 742
- ip default network, 571
- ip default-gateway, 571
- ip default-network, 570–571
- ip forward-protocol, 89–90
- ip helper address, 88
- ip helper-address, 90
- ip ospf cost, 127–128
- ip ospf network, 129
- ip ospf network non-broadcast, 131
- ip prefix-lists, 496
  - options, 497–499
- ip route, parameters, 422
- ip subnet zero, 67
- ip summary address eigrp, 370
- ip unnumbered, 84
- isis circuit type, 290
- isis metric, 291
- isis route, 296
- is-type, 290
- line vty, 712
- match community, 743
- match length, 593
- maximum paths, 9, 113
- maximum-paths, 441
- neighbor, 130
- neighbor distribute list, 736
- neighbor distribute-list, 734
- neighbor peer-group, 746
- neighbor prefix list, 497
- neighbor route-reflector-client, 493
- neighbor send-community, 741, 744
- neighbor weight, 507
- network, 447
- network area, 127
- no synchronization, 513
- passive interface, 566–567
- ping, 599, 782
- redistribute, 719
- reload, 782
- route map, 590–591
- router is-is, 289
- set community, 740
- set default interface, 595–596
- set ip default next-hop, 595
- set ip next-hop, 594
- set ip precedence, 596
- setup, 782
- show access lists, 782
- show CDP neighbors, 782
- show CDP neighbors detail, 782
- show clns, 301
- show clns interface, 299–300
- show clns is-neighbors, 301–302
- show clns neighbors, 294, 299
- show clns protocol, 298–299
- show clns route, 281, 284, 296
- show controller, 782
- show interfaces, 361, 782
- show ip bgp, example output, 453
- show ip bgp neighbors, 494
  - example output, 454–455
- show ip bgp summary, example output, 454
- show ip eigrp, 387
- show ip eigrp neighbors, 356–358, 386
- show ip eigrp topology, 358, 386
- show ip eigrp traffic, 386
- show ip ospf database, 721
- show ip ospf interface, 127, 134
- show ip ospf neighbor, 135–136
- show ip policy, 599
- show ip prefix-list, 501
- show ip prefix-list detail, 501
- show ip protocols, 133, 297, 300–301, 386
- show ip route, 9, 38–39, 133, 282, 297
- show ip route eigrp, 386
- show ip route ospf, 134
- show isis database, 296
- show isis route, 281, 284–285
- show isis spf-log, 302
- show isis topology, 280, 283
- show lines, 782
- show logging, 782
- show route-maps, 782
- show running-config, 782
- show startup-config, 782
- show version, 782
- summary address, 291
- telnet, 782
- traceroute, 589, 599, 782
- traffic-share, 373
- variance 2, 374
- variance 4, 374
- WAN configuration (table), 777–778
  - which route, 281, 285–286
- communication protocols, 801
- communities, 739
- community attribute (BGP), 435, 740
- community lists (BGP), creating, 742
- comparing

- configuration file commands, 769, 783
  - link-state routing protocols, 23
  - OSPF routing tables, 182
- composite metrics, 11
  - EIGRP, calculating, 34
- composite values (metrics), 9
- configuration commands
  - IP-related, 788–795
  - WAN-related, 795–796
- configuration file commands, comparing, 769, 783
- configuration register, 762–763
- configure terminal command, 781
- configuring
  - access lists, 694
    - verification, 713–714
  - BGP
    - command syntax, 445
    - communities, 739
    - examples, 731–734
    - loopback interfaces, 446
    - peer groups, 444, 745–746
    - prefix lists, 496–499
    - summary addresses, 448–449
    - TTL, 446
  - EIGRP, 368
    - examples, 727–730
    - exercises, 390–397, 409
    - link utilization, 374–377
    - multipoint interfaces, 374
    - summarization, 370–372
  - extended IP access lists, 702–706
  - helper addresses, 88–89
  - Integrated IS-IS
    - dialup, 304
    - in NBMA WANs, 305–312
  - Integrated IS-IS routers, 288–294
  - IP access lists, standard, 696–697
  - IS-IS
    - multiarea networks, 314–349
    - point-to-point WANs, 303
    - switched WANs, 304
  - multihoming
    - connections, 502
    - examples, 509–510
    - exercises, 523–527
    - local preference, 507
    - weight, 507
  - OSPF
    - areas, 719–721
    - broadcast mode, 132
    - in single area, 125–129
    - link cost, 127
    - multiarea components, 188–189
    - multiple areas, 721–724
    - NBMA mode, 129–131
    - NSSAs, 717–718
    - point-to-multipoint mode, 131–132
    - point-to-point mode, 132–133
    - router ID, 126
    - stub areas, 191–194
    - summarization, 199–202
    - virtual links, 202–203
  - policy routing, fast-switched, 597
  - prefix list commands, 496
  - redistribution, 561–563
    - access lists, 576–581
    - examples, 752–757
    - into EIGRP, 564
    - into OSPF, 563
    - passive interfaces, 566–567
  - RIP, boundary routers, 573–574
  - route reflectors, 492
    - exercises, 517–523
    - restrictions, 493
  - static routing, 567–575
    - guidelines, 569–570
    - ip default-network command, 571
    - subnet zero, 67
- confreg utility, 760
- connectionless services, 249
- connection-oriented services, 249
- connections, multihoming, 502, 644
  - configuration exercises, 523–527
  - customer and default routes from all providers, 504
  - default routes from all providers, 503
  - examples, 508–510
  - full routes from all providers, 506
  - local preference, configuring, 507
  - weight, configuring, 507
- conserving IP addresses, 637–638
  - CIDR, 640
  - summarization, 639
  - VLSMs, 638
- control information, OSI model, 803
- controlling
  - EIGRP queries, 380
  - routing updates, 645
  - vty access, 711
- convergence, 24
  - EIGRP, 32–35
    - testing, 33–35
  - IGRP, 29–32
    - testing, 30

- OSPF, 35–36, 99
  - testing, 36
- RIP, 25–26, 28
  - testing, 26
- converting decimal-to-binary numbering, 682–683
- copy running-config startup-config command, 781
- cost metric, 101
  - IS-IS, 271
  - OSPF external routes, 181
  - OSPF summary routes, 181
- CRC (cyclical redundancy check), 14
- creating
  - access lists, 696
  - BGP community lists, 742
  - subinterfaces, 120
  - summary addresses (BGP), 448–449
  - summary routes, 370
- criteria
  - for prefix list permission/denial, 495
  - for stub areas, 190
- CSNPs, link-state database synchronization (IS-IS), 276

## D

- data link layer (OSI model), 805–806
  - frames, 809
- data units, 809–810
- databases, OSPF link-state, 178
- datagrams, 809
- DBDs (database description packets), 111
- dead interval, 35
  - OSPF, 118
- debug command, 781
- debug eigrp neighbors command, 781
- debug eigrp packets command, 386, 781
- debug igmp transactions command, 30–32
- debug ip bgp updates command, example output, 455
- debug ip eigrp command, 387
- debug ip policy command, 599
- debug ip routing command, 30
- decimal-to-binary conversion chart, 682–683
- default metric
  - defining for redistribution, 564–566
  - redistribution, configuration example, 754–755
- default routes, 423
  - OSPF, generating, 194–195
- default-information originate always command, 423
- default-information originate command, 195

- defining
  - BGP prefix lists, 494–495
  - route maps, 590–591
- delay metric (IS-IS), 271
- denying
  - prefix lists, criteria, 495
  - vtv access, 711
- depleting IP addresses, solutions for, 637–638
- designing
  - OSPF, 177
  - route reflectors, 488
    - example, 489–490
    - faulty, 490
- dialer map command, 117
- dialup, Integrated IS-IS configuration, 304
- diameter limit, EIGRP for IPX, 725
- Diffusing Update Algorithm. *See* DUAL
- Dijkstra algorithm, 23, 113, 261
- disabling
  - automatic summarization, 370
  - BGP peer groups, 446
  - BGP synchronization, 448
  - prefix lists, automatic generation, 499
- discontiguous networks, route summarization, 80
- discontinuity, backbone routers, 187
- discovery process (OSPF), 110–111
- displaying
  - route maps, 599
  - summary routes, 9
- distance bgp command, 582
- distance command, example, 583–588
- distance vector routing protocols, 20–22. *See also*
  - advanced distance vector routing protocols
  - BGP
    - characteristics, 642
    - learned routes, 643–644
  - IGRP, convergence, 29–32
  - RIP
    - convergence, 25–26, 28
    - holddown time, 26
- distribute lists, 494, 645–647, 734
  - extended access lists, 736
- distribute-list in command, 578
- distribute-list out command, 579
- domains, 249
  - IS-IS, 279–280
- don't care bits, 695
- dotted decimal notation, 68
- Drothers, 107



DRs (designated routers), 35, 106  
 elections, 107  
 exchange state, 111  
 exstart state, 110  
 DUAL (Diffusing Update Algorithm), 21, 351,  
 362–367  
 dual mode IS-IS, 254  
 dynamic IGP routes, redistributing into BGP, 512

## E

EBGP (external BGP), 426  
 EGPs (Exterior Gateway Protocols), 415–417,  
 641–642  
 BGP  
 aggregator attribute, 443  
 appropriate use of, 420  
 AS-path attribute, 429–430  
 ASes, 415–416  
 atomic aggregate attribute, 443  
 attribute type codes, 429  
 attributes, 427–428  
 CIDR, 442–444  
 community attribute, 435  
 configuration exercises, 315, 457–464  
 creating summary addresses, 448–449  
 default routes, 423  
 example configuration, 451  
 floating static routes, 421–422  
 inappropriate use of, 420  
 local preference attribute, 432  
 MED attribute, 433–434  
 message types, 438–439  
 neighbors, 424–425  
 next-hop attribute, 430–431  
 origin attribute, 434  
 path of last resort, 421  
 path vectors, 424  
 peer group configuration, 444  
 policy-based routing, 426  
 resetting, 450  
 RFCs, 417  
 route selection, 440–441  
 static routes, 421–422  
 synchronization rule, 436–437  
 tables, 425  
 verifying operation, 452  
 weight attribute, 435

EIGRP (Enhanced IGRP)  
 ACKs, suppressing, 378  
 autosummarization, forcing, 371  
 case study, 387–389  
 composite metric, calculating, 34  
 configuration exercises, 390–397, 409  
 configuring, 368  
 examples, 727–730  
 convergence, 32–35  
 testing, 33–35  
 default metric, defining, 565  
 feasible routes, 372  
 feasible successors, 354  
 for AppleTalk, 726  
 metrics, 726  
 redistribution, 726  
 route selection, 726  
 for IPX, 725  
 diameter limit, 725  
 metrics, 725  
 redistribution, 725  
 route selection, 725  
 going active on a route, 379  
 hold time, 356, 358  
 K-values, 357  
 link utilization, configuring, 374–375, 377  
 load balancing, 372  
 example, 373–374  
 metric, 352  
 K-values, 361  
 variables, 360–361  
 multipoint interfaces, configuring, 374  
 neighbor relationships  
 FD, 362  
 route discovery, 359–360  
 route selection, 360–361  
 Seq number, 358  
 split horizon, 360  
 uptime, 358  
 neighbor table, 354, 357  
 H (handle), 358  
 RTO, 358  
 SRTT, 358  
 operational characteristics, 353  
 packets, 355  
 hello, 356  
 Init bit, 360  
 query scoping, 379  
 reachability, 33  
 redistribution, 558, 562  
 configuration exercises, 607–611, 622

- configuring, 564
    - route summarization, 353, 369
      - configuring, 370–372
    - routing process, 353
    - routing table, DUAL, 362–367
    - scalability, variables, 379–383
    - successors, 354
    - tiered network model, 384–385
    - topology table, 354, 358
    - verifying operation, 386
      - WAN links, configuring, 374–377
  - eigrp log-neighbor-changes command, 379
  - elections, DRs/BDRs, 107
  - enabling route summarization, 79–80
  - encapsulation, 6, 804
  - Enhanced Interior Gateway Routing Protocol.
    - See* EIGRP
  - equipment requirements for configuration exercises, 847–850
  - erase startup config command, 781
  - error checking, 807
  - error metric (IS-IS), 271
  - error recovery, 807
  - ES (end system), 250
  - ES-IS protocol, 252
  - establishing BGP sessions, 508
  - exact matches (prefix lists), 497
  - examples
    - BGP
      - configuring, 731–734
      - peer groups, 746–748
    - CIDR, 83
    - EIGRP
      - configuring, 727–730
      - load balancing, 373–374
    - extended access lists, 709–710
    - IP helper addresses, 89–91
    - multihoming, 508–510
    - of NSAPs, 264–265
    - OSPF
      - multiple-area configuration, 721–724
      - single-area configuration, 719–721
    - PBR, 598–599
    - prefix lists, 500–501
    - redistribution, 749–752
      - configuring, 752–757
      - distance command, 583–588
    - route reflector design, 489–490
    - route reflectors, 493
    - standard IP access lists, 699–700
    - static route filtering, 580–581
    - wildcard masks, 695–696
  - exchange process (OSPF), 109
  - exchange state, 111
  - EXEC commands
    - IP-related, 785–788
    - WAN interface-related, 795
  - expense metric (IS-IS), 271
  - exstart state (DRs/BDRs), 110
  - extended access lists, 593, 701
    - configuring, 702–706
    - example, 709–710
    - in distribute lists, 736
    - placement, 711
    - process flow, 701
  - extended IP access lists, wildcard masks, 695
  - extending IP addresses
    - CIDR, 83–84
    - classful addresses, 687
    - job aids, 681–684
    - route summarization, 75–76
      - discontiguous networks, 80–82
      - octets, 77
      - subnetting, 67
  - external routes
    - EIGRP, 360
    - OSPF, cost, 181
    - summarization, 197
- 
- ## F
- 
- fast-switched policy routing, 597
  - faulty design, route reflectors, 490
  - FD (feasible distance), 362
  - feasible routes, EIGRP, 372
  - feasible successors
    - EIGRP, 32, 354
    - requirements, 362
  - fields of LSPs, 269
  - filtering
    - access lists, route maps, 646
    - BGP, distribute lists, 734
    - packets, access lists, 692–693
    - routes
      - access lists, 576, 578–581
      - route maps, 590–597
      - static routes, example, 580–581
      - with prefix lists, 495
      - matches, 497
  - First Octet Rule, 68
  - flapping links, 76
    - troubleshooting, 113
  - flapping routes, 25
  - flash updates, 25
  - floating static routes, 421–422

- flooding, 22–23
  - LSAs, 38, 114–115
  - LSUs in multiarea environment, 184–186
- flow control, 806–807
- forcing EIGRP autosummization, 371
- forwarding database, 101
- Frame Relay
  - EIGRP configuration, 374–377
  - full-mesh topology, 118
  - star topologies, 118
- frames, 809
- full-mesh topologies, calculating PVC requirements, 118

## G

- general configuration commands, 770–771
- general interface configuration commands, 771
- generating OSPF default routes, 194–195
- going active on a route, 379
- group addresses (multicast), 69
- guidelines
  - for redistribution, 559, 649
  - for static routing configuration, 569–570

## H

- H (Handle), EIGRP, 358
- headers, 803, 809
  - IP, TTL field, 15
  - OSPF packet fields, 105–106
- hello intervals
  - EIGRP, 356
  - OSPF, 118
- hello messages (IS-IS), 271
  - adjacency establishment, 272–275
- hello packets, 35, 104
  - EIGRP, 355–356
- Hello protocol, 101–103
- helper addresses, 86–87
  - configuring, 88–89
  - example, 89–91
  - server placement, 87
- hierarchical addressing, 637
  - benefits of, 70–71
  - planning, 69
  - summary numbers, 70
- hierarchical routing, 253–254
  - IS-IS, 258–260
  - link-state protocols, 22–23
  - OSPF, 176
    - comparing routing tables, 182
    - default route generation, 194–195
    - design guidelines, 177

- link-state database, 178
  - LSAs, 178–180
  - multiarea operation, 184–188
  - multiarea operation, configuring, 188–189
  - router types, 177–178
  - summarization, 195, 198–202
  - summary routes, cost, 181
  - unnumbered interfaces, 187–188
  - virtual links, 186
- history of IS-IS, 248
- hold time, EIGRP, 356–358
- holddown timers, 24
  - RIP, 26
- hop count, 10
  - TTL, 15
- hop-by-hop routing paradigm, 426
- hosts per class (IP addresses), 686
- hub-and-spoke topologies, 118
- hybrid routing protocols, EIGRP, 351–352
  - case study, 387–389
  - configuration exercises, 390–397, 409
  - configuring, 368
  - DUAL, 362–367
  - feasible successors, 354
  - going active on a route, 379
  - hello packets, 356
  - hold time, 356
  - load balancing, 372
  - neighbor tables, 354
  - operational characteristics, 353
  - packets, 355
  - query scoping, 379
  - reliability, 355
  - route discovery, 359–360
  - route summarization, 369–372
  - routing process, 353
  - scalability variables, 379–383
  - successors, 354
  - summarization, 353
  - tiered network models, 384–385
  - topology tables, 354, 358
  - verifying operation, 386
  - WAN links, 374–377

## I

- IANA (Internet Assigned Numbers Authority), 416
- IBGP (internal BGP), 426
- ICMP (Internet Control Message Protocol) messages, 694
- IGPs (Interior Gateway Protocols), 99, 415, 641–642
  - redistribution, 511, 513–514
  - dynamic routes, 512

- static routes, 512
- IGRP (Interior Gateway Routing Protocol)
  - convergence, 29–32
  - default metric, defining, 565
  - load balancing, 11
  - metric, 11–12
  - poison reverse, 29
  - redistribution, 558
    - configuration example, 752–753
- illegal addresses, 637
- implementing
  - IS-IS, 249
  - redistribution, guidelines, 559, 649
  - route summarization, 78
- implicit denies, prefix lists, 496
- implicit deny any entries (access lists), 694
- implicit wildcard masks, 698
- incomplete origins, show ip bgp command
  - output, 513
- information exchange process, OSI model, 803, 805
- information formats, 809
- Init bit (EIGRP packets), 360
- injecting default routes into areas (OSPF), 195
- Integrated IS-IS
  - building IP forwarding table, 287–288
  - CLNS troubleshooting commands, 280–286, 294–302
  - dialup, configuring, 304
  - IP routing, 277
    - IS-IS domains, 279–280
    - OSI routing process, 278–279
  - NBMA WAN configuration, 305–308
    - detecting mismatched interfaces, 311–312
    - multipoint interfaces, 308–311
    - point-to-point subinterfaces, 306–308
  - NSAPs, 260
    - address structure, 261–263
    - examples of, 264–265
    - NETs, 263–264
  - point-to-point WANs, configuring, 303
  - router configuration, 288–294
  - switched WANs, configuring, 304
  - two-area configuration, 293–294
  - versus OSPF, 255–256
- interarea routing, 176
  - summarization, 197
  - virtual links, configuring, 202–203
- interface configuration commands (table), 771, 785
- interface serial command, 120
- interfaces, 101
  - loopback, 85
  - unnumbered, 84–85
- internal routes, 177
  - EIGRP, 360
  - RIP, configuring, 573
- internetworks, nonscalable, 383
- ip access group command, 697
- IP access lists, 692–693
  - backwards compatibility, 693
  - configuring, 713–714
  - creating, 696
  - extended
    - example, 709–710
    - in distribute lists, 736
  - route maps, 736–738
  - standard, 693
    - configuring, 694, 696–697
    - example, 699–700
    - numbering, 693
    - processing, 694
  - wildcard masks, 695
    - implicit, 698
- IP addressing
  - CIDR, 83–84
    - BGP, 442, 444
  - classes, 686
  - classful, subnet masks, 687
  - conserving, 637–638
    - CIDR, 640
    - summarization, 639
    - VLSMs, 638
  - dotted decimal notation, 68
  - EXEC commands (table), 772
  - exhaustion of, reasons for, 65
  - extending, job aids, 681–684
  - First Octet Rule, 68
  - helper addresses, 86–87
    - configuring, 88–89
    - example, 89–91
    - server placement, 87
  - hierarchical
    - benefits, 70–71
    - planning, 69
    - summary numbers, 70
  - job aids, 681
  - multicast, OSPF, 104
  - redistribution, 749–752
  - route summarization, 75–76
    - classful routing protocols, 80
    - discontiguous networks, 80
    - implementing, 78
    - octets, 77
    - VLSM-designed networks, 78

- shortage of, 65–66
- subnet masking, 66
- subnet masks, 16
  - calculating, 687–689
  - prefixes, 690
- subnetting, 67–69
- unnumbered interfaces, 84–85
- VLSMs, 71–72
  - calculating, 73
  - example, 74
- ip classless command, 573
- ip community list command, 742
- IP configuration commands (table), 772–773
- ip default network command, 571
- ip default-gateway command, 571
- ip default-network command, 570–571
- ip eigrp hello-interval command, 357
- IP forwarding table (Integrated IS-IS), building, 287–288
- ip forward-protocol command, 89–90
- ip helper-address command, 88, 90
- ip ospf cost command, 127–128
- ip ospf network command, 129
- ip ospf network non-broadcast command, 131
- ip prefix-list command, 496
  - options, 497–499
- ip route command, parameters, 422
- IP routing, classful, 635–637
- ip subnet zero command, 67
- ip summary address eigrp command, 370
- ip summary-address command, 381
- ip unnumbered command, 84
- IP-related EXEC commands (table), 785–788
- IPv6, 65
- IPX configuration commands, 774–775
- IS (intermediate system), 250
- IS-IS (Intermediate System-to-Intermediate System), 23, 247
  - areas, 256
    - restrictions, 265–266
  - hierarchical routing, 258–260
  - history of, 248
  - implementations, 249
  - link-state database synchronization, 275–276
  - metrics, 271
  - multiarea networks, configuring, 314–349
  - NSAPs, NETs, 266
  - PDU, 267
    - hellos, 271–275
    - LSPs, 268–270
  - SNPA, 266
    - system IDs, restrictions, 265–266
- isis circuit-type command, 290
- isis metric command, 291

- ISO (International Organization for Standardization), 247–248
  - NSAP addressing, 262
- ISPs (Internet service providers), 417
  - multihoming, 502, 644
    - configuration exercises, 523–527
    - customer and default routes from all providers, 503–504
    - default routes from all providers, 503
    - examples, 508–510
    - full routes from all providers, 506
    - local preference, configuring, 507
    - weight configuration, 507
  - redistribution into IGP, 513–514
- is-type command, 290

## J-K

- JKL Corporation case study, 40
- job aids
  - decimal-to-binary conversion chart, 682–683
  - IP addresses, 681
  - subnetting, 681
- keepalive messages, BGP, 439
- K-values, 357
  - EIGRP, 361

## L

- LAN protocols, 801
- layers of OSI reference model, 249
  - network layer, 251
    - CMNS versus CONP, 252
    - ES-IS, 252
    - hierarchical routing, 253–254
- learned routes, BGP, 643–644
- Level 1 areas (IS-IS), 256
- Level 1 routers (IS-IS), 257
- Level 1-2 routers (IS-IS), 257
- Level 2 areas (IS-IS), 256
- Level 2 routers (IS-IS), 257
- limitations of route reflectors, 493
- limiting vty access, 711
- line vty command, 712
- links
  - cost, 101
  - EIGRP utilization, configuring, 374–377
  - flapping, 113
  - multiaccess, flooding, 114
  - OSPF cost, configuring, 127
- link-state protocols, 22–23
  - Integrated IS-IS

- IP routing, 277–286
  - NSAPs, 260–265
  - OSI routing process, 278–279
  - router configuration, 288–294
  - IS-IS
    - area restrictions, 265–266
    - hello messages, 271–275
    - link-state database synchronization, 275–276
    - LSPs, 268–270
    - metrics, 271
    - NETs, 266
    - PDU, 267
    - system ID restrictions, 265–266
  - OSPF
    - comparing routing tables, 182
    - convergence, 35–36, 99
    - default route generation, 194–195
    - design guidelines, 177
    - LSAs, 178–180
    - multiarea operation, 184–189
    - NSSAs, 716–718
    - redistribution, 563
    - router types, 177–178
    - summarization, 195, 198–202
    - summary routes, cost, 181
    - unnumbered interfaces, 187–188
    - versus Integrated IS-IS, 255–256
    - virtual links, 186
    - topology database, 101
  - LLC (Logical Link Control), 806
  - load balancing, 6, 9
    - EIGRP, 372–374
    - IGRP, 11
    - OSPF, 113
  - loading state, 111
  - local loopback address, 68
  - local preference (multihomed routes), configuring, 507
  - local preference attribute (BGP), 432
  - loopback interfaces, 85
    - BGP, 446
    - OSPF, configuring, 127
  - lost passwords, recovering, 760–763
  - lower layers of OSI model, 800
  - LSAs (link-state advertisements), 22–23, 178–180
    - aging timers, 115
    - flooding, 38, 114–115
    - router link, 116
    - sequence number, 111
    - type 7, 716–717
  - LSPs (link state packets), 268
    - fields, 269
    - LAN representations, 269–270
    - variables, 270
  - LSUs (OSPF), flooding in multiarea environment, 184–186
- ## M
- 
- MAC (Media Access Control), 806
  - manual summarization, 372
  - match commands, route maps, 737–738
  - match community command, 743
  - match length command, 593
  - matches (prefix lists), 497
  - maximum-paths command, 9, 113, 441
  - measuring convergence time, 24
  - MED attribute (BGP), 433–434
  - messages, 809
    - BGP, 438–439
    - ICMP, 694
  - metrics, 6, 9
    - EIGRP, 352
      - composite metric, calculating, 34
      - feasible distance, 32
      - for AppleTalk, 726
      - for IPX, 725
      - K-values, 361
      - maximum, 33
      - variables, 360–361
    - hop count, TTL, 15
    - IGRP, 11–12
    - IS-IS, 271
    - RIP, 10
  - migrating to route reflectors, 490
  - modifying
    - administrative distance, 581–582
    - BGP next-hop attribute, 448
    - weights in multihomed routes, 510
  - multiaccess networks
    - EIGRP hold time, 356
    - links, flooding, 114
  - multiarea operation, OSPF
    - case study, 204, 206–207
    - configuring, 188–189
    - NBMA, 195
    - verifying, 204
  - multicast addresses, 69
    - OSPF, 104

- multihoming, 484, 502
  - BGP, 644
  - case study, 514, 516
  - configuring, 523–527
  - customer and default routes from all providers, 503–504
  - default routes from all providers, 503
  - full routes from all providers, 506
  - local preference, configuring, 507
  - weight, configuring, 507
- multiple OSPF areas, 175
  - configuring, 721–724
- multiplexing, 807
- multipoint EIGRP interfaces, configuring, 374

## N

- NAT (network address translation), 637
- NBMA (non-broadcast multiaccess) networks
  - OSPF, 117–119
    - configuring, 129–131
    - neighbor relationship, 121–123
    - multiarea operation, 195
  - topologies, 102, 117–119
  - WANS, Integrated IS-IS configuration, 305–308
    - detecting mismatched interfaces, 311–312
    - multipoint interfaces, 308–311
    - point-to-point subinterfaces, 306–308
- neighbor command, 130
- neighbor distribute-list command, 734, 736
- neighbor peer-group command, 746
- neighbor prefix list command, 497
- neighbor relationships, 13
  - EIGRP, 356
    - DUAL, 362–367
    - FD, 362
    - route discovery, 359–360
    - route selection, 360–361
    - Seq number, 358
    - split horizon, 360
    - uptime, 358
- neighbor route-reflector-client command, 493
- neighbor send-community command, 741, 744
- neighbor table (EIGRP), 354, 357
  - H (handle), 358
  - RTO, 358
  - SRTT, 358
- neighbor weight command, 507
- neighbors, 101
  - BGP, 424–425
    - loopback interfaces, 446
    - peer group configuration, 444

- peer groups, configuring, 745–746
  - EIGRP feasible successors, 354
  - OSPF, NBMA mode, 121–123
  - peer groups, 746–748
  - two-way state, 109
- NETs (network entity titles), 249, 263–264
  - examples of, 266
- network area command, 127
- network command, 447
- network layer (OSI reference model), 251, 806
  - CMNS versus CONP, 252
  - ES-IS, 252
  - hierarchical routing, 253–254
  - packets, 809
- network link entries (OSPF), 179
- network protocols, 801
- network services, connection-oriented versus
  - connectionless, 249
- networks per class (IP addresses), 686
- next-generation IP, 65
- next-hop attribute (BGP), 430–431
  - modifying, 448
- no synchronization command, 513
- nonbroadcast physical links, 268
- nonclients (route reflectors), 488
- nonscalable internetworks, 383
- notification messages (BGP), 439
- NSAP (network service access point) addresses, 249, 260
  - address structure, 261–265
  - NETs, 263–266
- NSEL (N-selector), 262
- NSSA autonomous system external link entry, 179
- NSSAs (not-so-stubby areas), 182, 189–190, 716–718
- numbering standard IP access lists, 693

## O

- obtaining VLSM calculators, 74
- octets, route summarization, 77
- operational characteristics of EIGRP, 353
- optional attributes (BGP), 428
  - nontransitive, MED, 433–434
  - transitive
    - aggregator, 443
    - community, 435, 740
- options
  - ip prefix-list, 497–499
  - neighbor prefix list commands, 497
- origin attribute (BGP), 434

- OSI (Open System Interconnection) reference model, 6, 247–248
  - application layer, 808
  - backbone, 250
  - characteristics, 800
  - communication between layers, 802
  - control information, 803
  - data link layer, 805–806
  - distance vector routing, 21
  - domains, 249
  - ES (end system), 250
  - information exchange process, 803–805
  - IS (intermediate system), 250
  - layer services, 802–803
  - lower layers, 800
  - mapping protocols to layers of OSI reference model, 250
  - network layer, 251, 806
    - CMNS versus CONP, 252
    - ES-IS, 252
    - hierarchical routing, 253–254
  - physical layer, 805
  - presentation layer, 807
  - protocols, 801
  - session layer, 807
  - transport layer, 807
  - upper layers, 800
- OSI protocol suite, versus OSI reference model, 250
- OSI routing, CLNS troubleshooting commands, 280–286
- OSPF (Open Shortest Path First), 116–119
  - ABRs, 255
  - adjacencies, 107
  - areas, 101, 175, 256
    - configuring, 191–194
    - stub, 189–190
    - totally stubby, 189–190
    - types of, 181
  - backbone, 275
  - BDRs, 106–108
  - broadcast mode, configuring, 132
  - broadcast multiaccess topology, 103–106
    - DRs, 106–107
  - configuration exercises, 142, 144–146, 148–151
  - configuring in single area, 125–129
  - convergence, 35–36, 99
  - dead intervals, defaults, 118
  - default route generation, 194–195
  - default static routes, 423
  - design guidelines, 177
  - Dijkstra algorithm, 23
  - DRs, 106
    - elections, 107
    - flapping links, troubleshooting, 113
    - hello intervals, defaults, 118
    - hello packets, 104
    - Hello protocol, 101–103
    - hierarchical topology, 176
    - interfaces, 101
    - link cost, configuring, 101, 127
    - link state, 101
    - link-state database, 178
    - load balancing, 113
    - LSAs, 178–180
      - flooding, 114–115
      - router link, 116
    - multiarea operation
      - case study, 204–207
      - configuration exercise, 207–244
      - flooding LSUs, 184–186
      - NBMA, 195
      - verifying, 204
    - multicast addressing, 104
    - multiple-area configuration, example, 721–724
    - NBMA mode
      - configuring, 129–131
      - neighbors relationships, 121–123
      - subinterfaces, 120
    - neighbors, two-way state, 109
    - NSSAs, 716–718
    - packets, header fields, 105–106
    - path selection, 100
    - point-to-multipoint mode, configuring, 131–132
    - point-to-point mode, configuring, 132–133
    - reachability, 100
    - redistribution, configuring, 563
      - example, 753
      - exercises, 607–611, 622
    - route selection, 111–113
    - router IDs, configuring, 126
    - router types, 177–178
    - routing tables, comparing, 182
    - single-area configuration, example, 719–721
    - startup, 109–110
      - exchange process, 109
      - route discovery, 110–111
    - summarization, 195
      - configuring, 199–202



- VLSM, 198
- summary routes, cost, 181
- topologies, 102
- unnumbered interfaces, 188
- verifying operation, 133–138
- versus Integrated IS-IS, 255–256
- virtual links, 186
  - configuring, 202–203
- VLSMs, 99

## P

- 
- packet filtering, access lists, 692–693
    - configuring, 694
    - extensions, backwards compatibility, 693
    - standard, 693, 696–697
  - packets, 6, 809
    - EIGRP, 355
      - ACKs, suppressing, 378
      - hello, 356
      - Init bit, 360
      - queries, 380
      - reliability, 355
    - encapsulation, 6
    - hello, 35, 104
    - OSPF header fields, 105–106
    - TTL field, 15
  - parameters for ip route command, 422
  - partial updates, EIGRP, 351
  - passive interface command, 566–567
  - password recovery, 760, 762–763
  - path of last resort, 421
  - path selection, OSPF, 100
  - path vectors, 419, 424, 643
  - PBR
    - examples, 598–599
    - fast-switched, 597
    - route maps, 590
      - implementing, 592–597
    - sequence numbering, 590–591
    - standard access lists, placement, 700
    - verifying, 599
  - PDUs (protocol data units), 267
    - hello messages, 271
      - adjacency establishment, 272–275
    - IS-IS
      - CSNPs, 275–276
      - PSNPs, 275–276
    - LSPs, 268
      - fields, 269
      - LAN representation, 269–270
      - variables, 270
  - peer groups
    - BGP
      - configuring, 444
      - disabling, 446
      - compatibility with route reflectors, 493
      - configuring, 745–746
      - example, 746, 748
    - periodic announcements, 38
    - permitting prefix lists, criteria, 495
    - physical layer (OSI model), 805
    - physical topology, route reflector design, 490
    - ping commands, 599, 782
    - placement
      - extended access lists, 711
      - standard access lists, 700
    - planning hierarchical addressing schemes, 69
    - point-to-multipoint mode, OSPF
      - configuring, 131–132
      - neighbor relationship, 122–123
    - point-to-multipoint nonbroadcast mode (OPSF), neighbor relationship, 123
    - point-to-point interfaces, static routing, 568
    - point-to-point mode
      - IS-IS, link-state database synchronization, 276
      - neighborship, 124
      - OSPF, configuring, 116–117, 132–133
      - subinterfaces, 120
      - topologies, 102, 116–117
    - point-to-point WANs (IS-IS), configuring, 303
    - poison reverse, 26, 29
    - poisoned routes, 25
    - policy-based routing, 647
      - BGP, 426
    - port names
      - TCP, 706–707
      - UDP, 708
    - port numbers, 706
    - predefined well-known community numbers, 742
    - preferred routes, BGP, 644
    - prefix lists
      - announcing to Internet, 502
      - applying to BGP, 494
      - characteristics, 495
      - configuring, 496–499
        - commands, 496
      - exact matches, 497
      - example, 500
      - sequence numbers, 499
      - verifying, 501
    - prefixes (subnet masks), 690
    - presentation layer (OSI model), 807
    - private addresses, 66

- processing flow
  - extended IP access lists, 701
  - standard IP access lists, 694
- protocol suites, 6
- protocols, 801
  - transparency, 248
- PSNPs, link-state database synchronization (IS-IS), 275
- PVCs (permanent virtual circuits), calculating requirements for, 118

## Q-R

---

- queries, EIGRP, 355
  - controlling, 380
  - scoping, 379
- reachability
  - EIGRP routes, 33
  - OSFP, 100
  - path vectors, 643
- recovering passwords, 760–763
- redistribute command, 719
- redistribution, 181, 557–558, 648–649
  - access lists, configuring, 576–581
  - addressing, example, 749–752
  - administrative distance, 560
  - best path selection, 559
  - case study, 600–602
  - configuring, 561–563
    - examples, 752–757
    - exercises, 607–611, 622
    - into EIGRP, 564
    - into OSPF, 563
  - default metric, defining, 564–566
  - EIGRP
    - for AppleTalk, 726
    - for IPX, 725
  - example, 583–588
  - guidelines, 559
  - IGRP, 558
  - implementing, 649
  - in one direction, 571
  - into BGP, 511–512
  - into IGP, 513–514
  - passive interfaces, configuring, 566–567
  - seed metric, 561–562
  - static routes, configuring, 567–575
  - verifying, 589
- reliability, EIGRP, 355
- Reliable Transport Protocol. *See* RTP
- reload command, 782
- Remaining Lifetime field (LSPs), 269
- replies, EIGRP, 355
- requirements
  - classful routing subnets, 17
  - configuration exercises, equipment, 847–849
  - feasible successors, 362
  - routing, 6
  - stub areas, 190
- reserved TCP port numbers, 706–707
- reserved UPD port numbers, 708
- resetting BGP sessions, 450, 508
- restricting vty access, 711
- restrictions
  - route reflectors, 493
  - unnumbered interfaces, 84
- retransmission list, RTP, 356
- RFCs (Requests for Comments), 813–816
  - RFC 1700, Assigned Numbers, 706
  - RFC 1812, TTL, 15
- RIP (Routing Information Protocol)
  - boundary routers, configuring, 573–574
  - convergence, 25–28
  - holddown time, 26
  - internal routers, configuring, 573
  - metric, 10
  - poison reverse, 26
  - redistribution, 753
- RIPE-NIC (Reseaux IP Europeennes-Network Information Center), 416
- route filters, access lists
  - configuring, 576–581
  - route maps, 590–597
- route map command, 590–591
- route maps, 646, 736–738
  - displaying, 599
  - match commands, 737–738
  - PBR, 590–597
    - verifying, 599
  - sequence numbering, 590–591
  - set commands, 737–738
  - statements, 590
- route redistribution, 648–649
- route reflectors, 487
  - benefits of, 487
  - clients, 488
  - cluster IDs, 488
    - configuring, 492
  - clusters, 488
  - compatibility with peer groups, 493
  - configuring, 492
    - exercises, 517–523
  - design, 488
  - example, 489–490

- faulty, 490
    - example, 493
    - migrating to, 490
    - nonclients, 488
    - restrictions, 493
    - routing loops, 487
    - verifying, 494
  - route selection, EIGRP, 360–361
  - route summarization, 75–76, 638–640
    - CIDR, 83–84
    - classful routing protocols, 80
    - discontiguous networks, 80
    - EIGRP, 353, 369
    - implementing, 78
    - octets, 77
    - OSPF, 195
      - configuring, 199–202
      - VLSM, 198
    - VLSMs, 72, 78
  - router IDs, OSPF, 126
  - router is-is command, 289
  - router link entries (OSPF), 179
  - router link LSAs, 116
  - routers
    - adjacencies, 107
    - BDRs, 106–108
    - Drothers, 107
    - DRs, 106
    - Integrated IS-IS, configuring, 288–294
    - link state, 101
    - neighbors, 101
  - routes
    - flapping, 25
    - poisoned, 25
    - successors, 32, 354
  - routing, 5
    - administrative distance, 8
    - classful, 635–637
    - defined, 635
    - hierarchical, 176
    - IGRP, metrics, 11–12
    - interarea, 176
    - metrics, 9
    - neighbor relationships, 13
    - packets, 6
    - policy-based, 647
    - protocol suites, 6
    - requirements, 6
    - RIP, metrics, 10
  - routing by rumor, 20
  - routing loops, 487
  - routing masks. *See* subnet masks
  - routing policies, prefix lists
    - applying to BGP, 494
    - automatic generation, 499
    - characteristics, 495
    - configuring, 496–499
    - exact matches, 497
    - example, 500
    - sequence numbers, 499
    - verifying, 501
  - routing protocols, 801
    - administrative distance, 560
      - modifying, 581–582
    - advanced distance vector, EIGRP, 352
    - believability, 560
    - classful, 15–16
      - route summarization, 80
      - subnetting, 17
    - classless, 18
      - automatic summarization, 18
      - subnetting, 19
      - VLSMs, 638
    - convergence, 24
    - default metric, defining, 564–566
    - distance vector, 20–22
    - EIGRP, convergence, 32–35
    - IGRP, convergence, 29–32
    - link-state, 22–23
    - metrics, 6
    - OSPF, convergence, 35–36
    - RIP
      - convergence, 25–26, 28
      - holddown time, 26
      - poison reverse, 26
    - scalability, comparing, 419
  - routing tables, 101
    - analyzing, 38–39
    - best paths, 6
    - EIGRP, DUAL, 362–367
    - entries, 7
    - OSPF, comparing, 182
  - routing updates, controlling, 645
  - RTO (retransmit timeout), 358
  - RTP (Reliable Transport Protocol), 355
- 
- ## S
- 
- scalability, comparing among routing protocols, 419
  - seed metric, 561–562
  - segments, 809
  - selecting routes
    - BGP best paths, 440–441, 559

- modifying administrative distance, 581–582
      - EIGRP for AppleTalk, 726
      - EIGRP for IPX, 725
      - OSPF, 111–113
  - sending communities attribute to neighbors (BGP), 741
  - Seq number (EIGRP), 358
  - sequence numbering
    - BGP prefix lists, 499
    - route maps, 590–591
  - serial interfaces
    - EIGRP, configuring, 374
    - unnumbered, 84–85
  - server placement, helper addresses, 87
  - sessions
    - BGP, resetting, 508
    - TCP, 706
  - session layer (OSI model), 807
  - set commands, route maps, 737–738
  - set community command, 740
  - set default interface command, 595–596
  - set ip default next-hop command, 595
  - set ip next-hop command, 594
  - set ip precedence command, 596
  - setup command, 782
  - setup diagram, configuration exercises, 849
  - shortage of IP addresses, causes of, 65–66
  - show access-lists command, 782
  - show CDP neighbors command, 782
  - show CDP neighbors detail command, 782
  - show clns command, 301
  - show clns interface command, 299–300
  - show clns is-neighbors command, 301–302
  - show clns neighbors command, 294, 299
    - detail keyword, 295
  - show clns protocol command, 298–299
  - show clns route command, 281, 284, 296
  - show controllers command, 782
  - show interfaces command, 361, 782
  - show ip bgp command, example output, 453
  - show ip bgp neighbors command, 494
    - example output, 454–455
  - show ip bgp summary command, example output, 454
  - show ip eigrp neighbors command, 356, 358, 386
  - show ip eigrp topology command, 358, 386
  - show ip eigrp traffic command, 386
  - show ip ospf database command, 721
  - show ip ospf interface command, 127, 134
  - show ip ospf neighbor command, 135
  - show ip ospf neighbor detail command, 136
  - show ip policy command, 599
  - show ip prefix-list command, 501
  - show ip prefix-list detail command, 501
  - show ip protocols command, 133, 297, 300–301, 386
  - show ip route command, 9, 38–39, 133, 282, 297, 372
  - show ip route eigrp command, 386
  - show ip route ospf command, 134
  - show isis database command, 296
  - show isis route command, 281, 284–285, 296
  - show isis spf-log command, 302
  - show isis topology command, 280, 283
  - show lines command, 782
  - show logging command, 782
  - show route-maps command, 782
  - show running-config command, 782
  - show startup-config command, 782
  - show version command, 782
  - SIA (stuck-in-active) routes, 379–380
  - single-area OSPF configuration, 125–129, 719–721
  - SNPA (subnetwork point of attachment), 266
  - solutions to depleting IP addresses, 637–638
  - specifying prefix lists, sequence numbers, 499
  - split horizon
    - BGP, 485–486
    - EIGRP, 360
    - route reflectors
      - clients, 488
      - cluster IDs, 488
      - cluster lists, 488
      - compatibility with peer groups, 493
      - configuration exercises, 517–523
      - configuring, 492
      - design, 488–490
      - example, 493
      - faulty design, 490
      - migrating to, 490
      - restrictions, 493
      - verifying, 494
  - SRTT (smooth round trip timer), 358
  - standard access lists, placement, 700
  - standard areas, 181
  - standard IP access lists, 593, 693
    - configuring, 696–697
    - example, 699–700
    - numbering, 693
    - processing, 694
    - wildcard masks, 695
  - standards, ISO, 247–248
  - star topologies, 118

- startup (OSPF)
  - discovery process, 110–111
  - exchange process, 109
- statements (route maps), 590
- static routes, 421
  - administrative distance, 421
  - CLNS, 254
  - configuring, 567–575
  - example, 422
  - filtering, example, 580–581
  - redistributing into BGP, 512
- station routers, 257
- stub areas, 182
  - configuring, 191–194
  - NSSAs, 716–718
  - requirements, 190
- stubby areas, 189–190
- subinterfaces, 120
- subnet masking, 66, 637
- subnet masks, 16, 687
  - calculating, 687–689
  - prefixes, 690
- subnet zero, 67
  - configuring, 67
- subnetting, 67
  - classful routing, 17
  - classless routing protocols, 19
  - discontiguous, route summarization, 81–82
  - extending IP addresses
    - subnetting, 68–69
  - job aids, 681
  - VLSMs, 71–72
    - calculating, 73
    - example, 74
- subnetwork point of attachment (SNPA), 266
- successors, 32
  - EIGRP, 354
- summarization, 75–76, 638–639
  - CIDR, 83–84
  - classful routing protocols, 16, 80
  - discontiguous networks, 80
  - EIGRP, 353, 369
    - configuring, 370–372
  - implementing, 78
  - octets, 77
  - OSPF, 195
    - configuring, 199–202
    - VLSM, 198
  - VLSM-designed networks, 72, 78
- summary addresses, creating, 448–449
- summary link entries (OSPF), 179
- summary numbers, 70

- summary routes
  - advertising, 512
  - EIGRP, 360
  - OSPF, cost, 181
  - viewing, 9
- summary-address command, 291, 372
- Super Lab, part I
  - answers to, 662–668
  - configuration exercises, 655–658
- Super Lab, part II
  - answers to, 669–676
  - configuration exercises, 658–661
- supernetting, 639. *See also* summarization
- suppressing ACKs, 378
- switched WANs (IS-IS), configuring, 304
- switching, 5, 13
  - defined, 635
- synchronization (BGP), 436–437
  - disabling, 448
- syntax, BGP configuration commands, 445
- system IDs (IS-IS), restrictions, 265–266

---

## T

- tables
  - BGP, 425
  - EXEC commands
    - IP-related, 785–788
    - WAN interface-related, 795
  - IP-related configuration commands, 788–795
  - WAN configuration commands (table), 795–796
- TCP (Transmission Control Protocol), 424
  - port names, 706–707
  - sessions, 706
- TCP/IP applications, 808
- telnet command, 782
- testing convergence
  - EIGRP, 33–35
  - IGRP, 30
  - OSPF, 36
  - RIP convergence, 26
- third-party next hops, 431
- tiered network model, 384–385
- timers, IS-IS, 256
- topological database, 22–23, 101
  - convergence, 24
    - EIGRP, 32–35
    - IGRP, 29–32
    - RIP, 25–26, 28
  - periodic announcements, 38
  - triggered updates, 38
- topologies
  - OSPF, 102

- broadcast multiaccess, 103–107
  - NBMA, 117–119
  - point-to-point, 116–117
  - route reflector design, 490
- topology table, EIGRP, 354, 358
- totally stubby areas, 182, 189–190
  - configuring, 191–194
  - requirements, 190
- traceroute command, 589, 599, 782
- traffic
  - BGP, controlling, 647
  - EIGRP, load balancing, 372
  - routing updates, filtering, 576, 578–581
- traffic-share command, 373
- trailers, 803, 809
- transparent protocols, 248
- transport layer (OSI model), 807
  - routing protocols, 21
- triggered updates, 38
- troubleshooting
  - flapping links, 113
  - Integrated IS-IS, 294–302
- trustworthiness, 7–8
- TTL (time-to-live), BGP configuration, 446
- TTL field, 15
- two-area Integrated IS-IS configuration, 293–294
- two-way redistribution, 575
- two-way state, 109
- type 7 LSAs, 716–717
- type codes for BGP attributes, 429

## U

- UDP port names, 708
- unicasts, helper addresses, 86–87
  - configuring, 88–89
  - example, 89–91
  - server placement, 87
- unnumbered interfaces, 84–85
  - OSPF, 188
- unreachable routes, EIGRP, 33
- update messages (BGP), 439
- update policies, peer group configuration, 745–746
- updates
  - BGP, controlling, 645–647
  - EIGRP, 355
  - LSAs, 178–180
- upper layers of OSI model, 800
- uptime, EIGRP, 358
- utilities, confreg, 760

## V

- variables of EIGRP metric calculation, 360–361
- variance 2 command, 374
- variance 4 command, 374
- variance command, 372
- verifying
  - access list configuration, 713–714
  - BGP operation, 452
  - EIGRP operation, 386
  - OSPF operation, 133–138
    - multiarea operation, 204
  - policy based routing, 599
  - prefix lists, 501
  - redistribution operation, 589
  - route reflectors, 494
- viewing
  - route maps, 599
  - summary routes, 9
- virtual circuit management, 807
- virtual links, 186
  - OSPF, configuring, 202–203
- VLSM (variable-length subnet masking), 19, 71–72, 198, 638
  - calculating, 73
  - calculators, obtaining, 74
  - example, 74
  - OSPF, 198
    - configuring, 199–202
  - route summarization, 78
- vtv access, denying, 711

## W-Z

- WAN commands, 776–778
- WAN interface-related EXEC commands, 795
- WANs, 801
  - EIGRP links, configuring, 374–375, 377
  - IS-IS, 305–312
    - point-to-point configuration, 303
    - switched configuration, 304
- weight (multihomed routes)
  - configuring, 507
  - modifying, 510
- weight attribute (BGP), 435
- well-known attributes (BGP), 428
  - discretionary
    - atomic aggregate, 443
    - local preference, 432
  - mandatory
    - AS-path, 429–430
    - next-hop, 430–431

- origin, 434
- well-known UDP port numbers, 21
- which route command, 281, 285–286
- wildcard masks, 695
  - examples, 695–696
  - implicit, 698
- wire, 67