

**A**

- AAA (authentication, authorization, and accounting), 315
- Abramson, Norman, 11
- ABRs (area border routers), 149
- accessing policies, 348
- acknowledgments
  - LSAs, 136
  - LSPs, 148
- Acknowledgment packet, 182
- acquiring RIDs, 82
- addresses
  - BGP summarization, 262
  - IPv6
    - formats*, 394-395
    - representations*, 396-397
  - IS-IS summarization, 261
  - NSAP, 88
  - OSPF summarization, 240-241
  - stateless autoconfiguration, 398-399
- adjacencies, 41, 101
  - IS-IS, 103
    - broadcast networks*, 104-107
    - point-to-point networks*, 107-109
  - neighbors, 103
  - OSPF, 101-102
  - point-to-point over Ethernet, 117
  - routers, 77
- administration (RIDs), 81-86
- Advanced Research Projects Agency (ARPA), 3-8
- Advertising Routers, 140
- AFI (Authority and Format Identifier), 88
- age of the LSA in seconds, 140
- aging, 45
- AID (area ID), 86
  - multiple, 269
  - IS-IS, 88-90
- algorithms
  - Bellman-Ford, 15, 28
  - Dijkstra, 17, 51
  - DUAL, 35
  - Ford-Fulkerson, 28
  - metric calculation, 18
  - SPF, 17, 273
    - delay*, 291-292
    - equal-cost multipath*, 274-286
    - iSPF calculations*, 287-288
    - partial route calculations*, 290
- announcement headers, 49
- ANSI (American National Standards Institute), 20
- Anycast addresses, 394
- Application-Specific Integrated Circuits (ASICs), 373
- applications, virtual links, 241-248
- architecture, message types, 69
- archives, 355
- areas, 61-62, 149
  - backbones, 66
  - design
    - BGP, 271
    - IS-IS, 248-258
    - OSPF, 224-234
    - reliability*, 222-223
    - scalability*, 220-221
  - fragmentation, 304-308
  - Inter-Area Prefix LSAs, 414
  - Inter-Area Router LSAs, 414
  - Intra-Area Prefix LSAs, 410
  - IS-IS, 151-153

- nonbackbone, 66
- OSPF, 149
- overloading, 308-312
- partitioned, 179
- stubs, 234-236
  - not-so-stubby*, 238-239
  - totally stubby*, 237
- Area Address TLVs, 96, 169
- area border routers (ABRs), 149
- area ID (AID), 86
  - multiple, 269
  - IS-IS, 88-90
- ARPA (Advanced Research Projects Agency), 3-8
- ARPA Network (ARPANET), 4-8, 14-19
- AS-External LSAs, 165-168, 415
- ASBRs (autonomous system boundary routers), 66, 151
  - Summary LSAs, 164-165
- ASICs (Application-Specific Integrated Circuits), 373
- AS (autonomous system), 37, 66
- attacks
  - DoS, 67
  - routing protocols, 316-318
- authentication, 319-322
  - IS-IS, 326-328
  - OSPF, 323-325
- authentication, authorization, and accounting. *See* AAA
- Authority and Format Identifier (AFI), 88
- autoconfiguration, stateless addresses, 398-399
- autonomous system (AS), 37, 66
- autonomous system boundary routers (ASBRs), 66, 151
  - Summary LSAs, 164-165

## B

- Bachman, Charlie, 20
- backbones, 66
  - ABRs, 150
  - areas
    - IS-IS*, 248-250
    - OSPF*, 224-228
  - and regional networks, 23
- Backup Designated Router neighbors, 187
- bandwidth
  - OSPF scalability, 228-233
  - reference, 154
- banners, login, 349
- Baran, Paul, 5, 8
- batch processing, 2
- BBN (Bolt Baranek and Newman), 2
- behavior, default IS-IS area, 256-260
- Behavioral Sciences division (DoD), 3
- Bellman, Richard, 15
- Bellman-Ford algorithm, 28
- BFD (bidirectional forwarding detection), 340-343
- BGP (Border Gateway Protocol), 37
  - address summarization, 262
  - area design, 271
- bidirectional forwarding detection (BFD), 340-343
- binding labels, 377
- Blitzer, Wolf, 13
- Bolt Baranek and Newman (BBN), 2
- Border Gateway Protocol (BGP), 37
  - address summarization, 262
  - area design, 271
- Bradley, Bill, 13
- broadcast networks, 122
  - designated routers, 110
  - IS-IS adjacencies, 104-107
  - synchronization, 211
- Bush, Vannevar, 3-4

**C**

## calculations

- iSPF, 287-288
- partial routes, 290
- shortest-path routing trees, 51
- SPF, 51-60

Callon, Ross, 22

Canepa, Mike, 20

Carr, Steve, 9

Cerf, Vint, 11, 14, 19-20

change controllers, 356

change management, 354-355

characteristics of vector protocols, 28-29

checksums, 49, 140

- security, 329-331

## circuits

- ASICs, 373
- demand, 302-303
- VC, 374

Circuit Type values, 94

circular sequence number spaces, 48

Cisco Systems, 23, 68

- default IS-IS L1 area behavior, 256
- NSF, 336
- stub areas, 236
- virtual links, 245

Clark, Wesley, 7

class of service (CoS), 68

## commands

- ip ospf flood-reduction, 304
- ip ospf retransmit-interval, 295
- isis lsp-interval, 295
- isis retransmit-interval, 295
- isis retransmit-throttle-interval, 296
- lsp-gen-interval, 294
- lsp-interval, 295
- overload, 312
- overload-bit on-startup, 312
- overload timeout, 312
- retransmit-interval, 295
- set-overload-bit, 312
- timers pacing flood, 294
- timers pacing lsa-group, 294

Command and Control Research division (DoD), 3

committees, change management, 355

comparative terminology, message types, 65-66

compatibility of OSPFv3, 404-405

CompleteSNPInterval, 211

Complete Sequence Number PDU (CSNP), 148

components (flooding), 133-134

IS-IS, 142-148

OSPF, 134-142

## configuration

- AID, 86-90
- management, 352-358
- NET, 88-90
- RIDs, 85
- stateless address autoconfiguration, 398-399

connections, OSPF virtual links, 241-248

constrained SPF, 383-385

control packets, BFD, 342

conventions, 70, 354

convergence, vector protocols, 27-28

cost of paths, 58

CoS (class of service), 68

counting to infinity, 32

CRC (cyclical redundancy check), 329

Crowther, Will, 15

CSNP (Complete Sequence Number PDU), 148

## customization

- flooding, 292
  - demand circuits*, 302-303
  - mesh groups*, 296-301
  - retransmit pacing*, 295-296
  - transmit pacing*, 293-294
- neighbors, 187
- SPF, 273
  - delay*, 291-292
  - equal-cost multipath*, 274-286
  - iSPF calculations*, 287-288
  - partial route calculations*, 290

cyclical redundancy check (CRC), 329

**D****databases**

- exchanges, 180
  - management*, 188-189
  - OSPF packets used for*, 180-183
- interfaces, 124
  - IS-IS*, 129-131
  - OSPF*, 124-129
- IS-IS LS, 74
- link state synchronization, 179
  - IS-IS*, 205-216
  - OSPF*, 179-189, 190-200, 202-204
- LSPs, 74
- RIB, 25
- synchronization, 49-50
- TED, 383

Database Description packet, 182

Database Summary List, 187

datagrams, 12, 66

data structures, OSPF neighbors, 186-187

Davies, Donald, 5

deception, 316

Decode-Encode Language (DEL), 10

default IS-IS L1 area behavior, 256-260

default metrics, 156

defining login banners, 349

delay

- acknowledgments, 136
- metrics, 156
- SPF, 291-292

DEL (Decode-Encode Language), 10

demand circuits, 302-303

demultiplexing, links, 76

denial-of-service (DoS) attacks, 67

dependent functions, subnetworks, 76-78

design

- areas
  - BGP*, 271
  - IS-IS*, 248-258
  - OSPF*, 224-234
  - reliability*, 222-223
  - scalability*, 220-221

reliability, 344

*domain edge protection*, 347

*redundancy*, 344-346

*router protection*, 348-352

security, 344

*domain edge protection*, 347

*redundancy*, 344-346

*router protection*, 348-352

sequence counter, 46

designated intermediate system (DIS),  
115-116

designated routers, 77, 109-112

IS-IS, 115-116

neighbors, 187

OSPF, 112-115

detection (BFD), 340-343

development of the Internet, 11-14

diffusing update algorithm (DUAL), 35

Dijkstra, Edsger W., 17, 50

Dijkstra algorithm, 51

direct acknowledgments, 137

disclosure, 316

disruption, 316

distance vector protocols, 27

distribution, MPLS labels, 377-378

DIS (designated intermediate systems),  
115-116

documentation, 355

domains

lookups (names), 100

protecting edges, 347

routing, 66

DoS (denial-of-service) attacks, 67

DUAL (diffusing update algorithm), 35

duplicate RIDs, troubleshooting, 82-86

Dynamic Hostname Exchange Mechanism,  
IS-IS, 99-100

**E**

E1 (Type 1 External), 155

E2 (Type 2 External), 155

- ECMP (equal-cost multipath), 274-280
    - pseudonodes and, 282-286
  - edges, protecting domains, 347
  - EIGRP (Enhanced IGRP), 35
  - encapsulation, message types, 67-69
  - end system (ES), 65
  - Enhanced IGRP (EIGRP), 35
  - equal-cost multipath (ECMP), 274-280
    - pseudonodes and, 282-286
  - error metrics, 156
  - essential LSAs, 158
    - AS-External LSAs, 165-168
    - ASBR Summary LSAs, 164-165
    - Network LSAs, 161
    - Network Summary LSAs, 162-164
    - Router LSAs, 158-161
  - essential TLVs, 168, 169
    - Area Address TLVs, 169
    - Extended IS Reachability TLVs, 173-175
    - IP External Reachability TLVs, 173
    - IP Interface Addresses TLVs, 171
    - IP Internal Reachability TLVs, 172
    - IS Neighbor TLVs, 169, 170
    - Protocols Supported TLVs, 171
  - ES (end system), 65
  - Ethernet, point-to-point adjacencies over, 117
  - European Commission, 21
  - evaluation
    - post-change, 357
    - pre-change, 356
  - exchanges (databases), 180
    - management, 188-189
    - OSPF packets used for, 180-183
  - excluding links, 430
  - expense metrics, 156
  - Extended IP Reachability TLVs, 174-175
  - Extended IS Reachability TLVs, 173
  - extensibility, 361
    - IS-IS, 368-369
    - message architecture, 69
  - OSPF, 362-368
    - route tagging, 369-371
  - extensions
    - IPv6, 391-392
      - address formats, 394-395
      - address representations, 396-397
      - extension headers, 402-403
      - features and functions of, 393
      - header formats, 400-401
      - IS-IS, 420-422
      - Neighbor Discovery Protocol, 397-398
      - stateless address autoconfiguration, 398-399
    - MT-ISIS, 430-434
    - MT-OSPF, 426-428
    - OSPFv3, 419
    - TE
      - IS-IS, 388-389
      - OSPF, 385-388
  - external prefixes
    - IS-IS redistribution, 268-269
    - OSPF scaling, 231-233
    - route prefixes, 369-371
- F**
- feasibility conditions, 35
  - features of IPv6, 393
  - FEC (forwarding equivalence classes), 377
  - fields
    - Link State ID, 139
    - LSA header formats, 138
    - OSPF link state database synchronization, 184-185
  - filtering packets, 351
  - flags
    - SRM, 208
    - SSN, 208
  - Fletcher checksums, 330
  - flooding, 44-48
    - components, 133-134
      - IS-IS, 142-148
      - OSPF, 134-142

- optimizing, 292
  - demand circuits*, 302-303
  - mesh groups*, 296-301
  - retransmit pacing*, 295-296
  - transmit pacing*, 293-294
- Ford, Lester Randolph , 15
- Ford-Fulkerson algorithm, 28
- formatting
  - addresses (IPv6), 394-395
  - headers
    - IPv6*, 400-403
    - MPLS*, 379
  - LSA headers, 138
  - LSPs, 143
- forwarding, 77
  - BFD, 340-343
  - LSRs, 375
  - NSF, 336
- forwarding equivalence classes (FEC), 377
- fragmentation, 304-308
  - packets (IPv6), 404
- frames, 66
- functions
  - IPv6, 393
  - messages, 76-78
- future extensions of OSPFv3, 419

## G

- gateways, 65
- general topology networks, 122
- Gore, Al, 13
- Goyette, Paul, 26
- graceful restart, 331-332
  - IS-IS, 337-339
  - OSPF, 332-336
- groups, mesh, 296-301

## H

- Hafner, Katie, 19
- handshaking, 42, 101
- Hashed Message Authentication Code (HMAC-MD5), 320

- HDSA (Honeywell Distributed Systems Architecture), 20

### headers

- announcements, 49
- IPv6, 400-403
- LSAs
  - formatting*, 138
  - OSPFv3*, 407-417
- MPLS, 379

- Heart, Frank, 7

- Hello messages, 41

- Hello protocol, 90

- IS-IS, 93-99

- OSPF, 91-92

- history of link state protocols, 1-3

- ARPANET, 4-8

- development of the Internet, 11-14

- IETF, 19-21

- NWG, 9-10

- routing ARPANET, 14-19

- standards, 21-23

- HMAC-MD5 (Hashed Message Authentication Code), 320

- holddown timers, 34-35

- Honeywell Distributed Systems

- Architecture (HDSA), 20

- hops, vector protocols, 26

- hosts, 65

## I

- ICCC (International Conference on Computer Communication), 8

- IETF (Internet Engineering Task Force), 19-21

- implementation

- AID, 86

- IS-IS, 88-90

- RIDs, 82

- implicit acknowledgments, 136

- IMPs (Interface Message Processors), 7

- Inactivity Timer, 186

- incompatible routers, forwarding to, 77

- incremental SPF (iSPF) calculations, 287-288
- independent functions of subnetworks, 76-78
- information corruption, 49
- Information Processing Techniques Office (IPTO), 3
- inherent security, 318-319
- Inter-Area Prefix LSA, 414
- Inter-Area Router LSA, 414
- interactive computer processing, 2
- interfaces
  - databases, 124
    - IS-IS*, 129-131
    - OSPF*, 124-129
  - loopback, 85
  - passive, 230
  - redistributing connected, 230
- Interface Message Processors (IMPs), 7
- Intergalactic Computer Network, 1-3
- intermediate system (IS), 65
- Intermediate System Neighbors TLV, 97
- International Conference on Computer Communication (ICCC), 8
- International Network Working Group (INWG), 11
- International Organization for Standardization (ISO), 20
- Internet
  - backbone and regional networks, 23
  - development of, 11-14
- Internet Engineering Task Force (IETF), 19-21
- Intra-Area Prefix LSAs, 410
- Intradomain Routing Protocol Discriminator, 69
- INWG (International Network Working Group), 11
- IPTO (Information Processing Techniques Office), 3
- IPv4 (Internet Protocol version 4), OSPFv3 compatibility, 404-405
- IPv6 (Internet Protocol version 6)
  - extensions, 391-392
    - address formats*, 394-395
    - address representations*, 396-397
    - extension headers*, 402-403
    - features and functions of*, 393
    - header formats*, 400-401
    - Neighbor Discovery Protocol*, 397-398
    - stateless address autoconfiguration*, 398-399
  - IS-IS extensions for, 420-422
  - OSPFv3 compatibility, 404-405
- IP (Internet Protocol)
  - address neighbors, 187
  - External Reachability TLVs, 173
  - Interface Addresses TLVs, 171
  - Interface Address TLV, 97
  - Internal Reachability TLVs, 172
- ip ospf flood-reduction command, 304
- ip ospf retransmit-interval command, 295
- IS-IS (intermediate systems-intermediate system)
  - adjacencies, 103
    - broadcast networks*, 104-107
    - point-to-point networks*, 107-109
  - AIDs, 88-90
  - areas, 151-153, 248
    - address summarization*, 261
    - backbone/non-backbone*, 248-250
    - default L1 behavior*, 256-260
    - multiple AIDs*, 269
    - redistributing external prefixes*, 268-269
    - redundant L1/L2 routers*, 260
    - route leaking*, 263-267
    - scalability*, 252-255
    - virtual links*, 270
  - authentication, 326-328
  - Dynamic Hostname Exchange Mechanism, 99-100
  - extensibility, 368-369
  - flooding, 142-148
  - graceful restart, 337-339
  - Hello Protocol, 93-99

interfaces, 129-131  
 IPv6  
     *extensions*, 420-422  
     *Interface Address TLV*, 422  
     *Reachability TLV*, 421  
 link state database synchronization,  
     205-216  
 LS databases, 74  
 media types, 122-123  
 messages, 67  
 metrics, 156-157  
 MT-ISIS extensions, 430-434  
 PDU synchronization, 205-207  
 router types, 151-153  
 TE extensions, 388-389  
 Working Group, 22  
 isis *lsp-interval* command, 295  
 isis *retransmit-interval* command, 295  
 isis *retransmit-throttle-interval*  
     command, 296  
 ISO (International Organization for  
     Standardization), 20  
 iSPF (incremental SPF) calculations,  
     287-288  
 IS (intermediate system), 65  
 IS Neighbor TLVs, 169-170

## J-K

Juniper Networks, 68  
     default IS-IS L1 area behavior, 256  
     stub areas, 236  
     virtual links, 245  
 Kahn, Robert, 8, 11, 14, 19  
 Katz, Dave, 23, 70  
 key administrative support, 355  
 Khanna, Atul, 18  
 Kleinrock, Leonard, 5, 9, 19  
 Kline, Charley, 9

## L

L1 (level 1), 66  
     default IS-IS area behavior, 256-260  
     IS-IS route leaking, 263-267  
     redundant routers, 260  
 L2 (level 2), 66  
     redundant routers, 260  
 Label-Switched Paths (LSPs), 374  
 Label-Switching Routers (LSRs), 374-375  
 labels, 373  
     binding, 377  
     MPLS, 374-378  
 labs, networks, 358-359  
 LANs (local area networks), 77  
 Last Received Database Description  
     Packet, 186  
 leaking, routes (IS-IS), 263-267  
 level 1. *See* L1  
 level 2 . *See* L2  
 Licklider, J. C. R., 1-3, 19  
 limitations  
     LSAs, 142  
     rates, 352  
 links  
     demultiplexing, 76  
     exclusion, 430  
     TE parameters, 381-382  
     virtual  
         OSPF, 241-248  
         IS-IS, 270  
 Link LSAs, 409  
 link state advertisement. *See* LSA  
 link state database synchronization, 179  
     IS-IS, 205-216  
     OSPF, 179-189  
 Link State ID field, 139  
 link state PDUs. *See* LSP  
 link state protocols  
     ARPANET, 4-8  
         *concepts*, 38-39  
         *adjacencies*, 41

- announcement headers*, 49
  - areas*, 61-62
  - database synchronization*, 49-50
  - flooding*, 44-48
  - SPF calculations*, 50-60
  - development of the Internet, 11-14
  - EIGRP, 37
  - history of, 1-3
  - IETF, 19-21
  - NWG, 9-10
  - routing ARPANET, 14-19
  - standards, 21-23
  - Link State Request Lists**, 188
  - Link State Transmission Lists**, 187
  - lists**
    - LSA databases exchanges, 187
    - retransmit, 136
  - local area networks (LANs)**, 77
  - login banners**, 349
  - lookups, domain names**, 100
  - loopback interfaces, configuring**, 85
  - loops (routing)**, 29
    - counting to infinity, 32
    - holddown timers, 34-35
    - split horizons, 30
  - LSA (link state advertisement)**, 66, 72-74
    - acknowledgments, 136
    - database exchanges, 187
    - essential, 158
      - AS-External LSAs*, 165-168
      - ASBR Summary LSAs*, 164-165
      - Network LSAs*, 161
      - Network Summary LSAs*, 162-164
      - Router LSAs*, 158-161
    - header formats, 138
    - Link, 409
    - MT-OSPF, 427
    - multiple copies of, 141
    - Opaque, 363-366
    - OSPFv3, 407-417
    - RI Opaque, 366-368
  - lsp-gen-interval command**, 294
  - lsp-interval command**, 295
  - LSP (link state PDU)**, 66, 72-74
    - acknowledgements, 148
    - formatting, 143
  - LSPs (Label-Switched Paths)**, 374
  - LSRs (Label-Switching Routers)**, 374-375
  - LS Request packets**, 183
  - Lyon, Matthew**, 19
- M**
- maintenance requests**, 357
  - malicious threats, routing protocols**, 316-317
  - management**
    - change, 354-355
    - configuration, 352-358
    - database exchange, 188-189
  - masters/slaves**
    - database exchange management, 188-189
    - selection, 186
  - McQuillan, John**, 16
  - media types**, 118
    - IS-IS, 122-123
    - OSPF, 118-122
  - memex**, 3
  - mesh groups**, 296-301
  - messages**
    - Hello, 41
      - IS-IS*, 93-99
      - OSPF*, 91-92
    - IS-IS, 67
    - SRM, 208
    - types, 71-72
      - architecture*, 69
      - comparative terminology*, 65-66
      - encapsulation*, 67-69
      - functions*, 76-78
      - LSAs*, 72-74
      - LSPs*, 72-74
    - Update (OSPF), 134

Method of Procedure (MoP), 358

metrics

- calculation algorithms, 18
- types, 154
  - IS-IS*, 156-157
  - OSPF*, 154-156

MILNET, 14

minimumLSPTransmissionInterval, 210

modes, BFD, 341

MoP (Method of Procedure), 358

Moy, John, 22

MPLS (Multiprotocol Label Switching), 373

- FEC, 377
- headers, 379
- labels, 374-376
  - binding*, 377
  - distribution*, 377-378
- overview of, 374
- TE, 380
  - constrained SPF*, 383-385
  - IS-IS*, 388-389
  - link parameters*, 381-382
  - OSPF*, 385-388
- TTL options, 379

MT-ISIS (Multi-Topology IS-IS)

- extensions, 430-434
  - MT Intermediate Systems TLV, 433
  - MT Reachable IPv6 Prefixes TLV, 434

MT-OSPF (Multi-Topology OSPF)

- extensions, 426-428

multi-area OSPF networks, 225

Multi-Topology ISIS. *See* MT-ISIS

Multi-Topology OSPF. *See* MT-OSPF

Multicast addresses, 394

Multiprotocol Label Switching. *See* MPLS

multiple AIDs, 269

multiple copies of LSAs, 141

multiple IP addresses per interfaces, 76

multiprotocols, 374

## N

names, domain lookups, 100

narrow metrics, 157

National Physical Laboratory (NPL), 6

NBMA (nonbroadcast multi-access), 101

NCP (Network Control Protocol), 10

neighbors, 41

- adjacencies, 103
- graceful restarts, 340
- OSPF*, 186-194

Neighbor Discovery Protocol, 397-398

neighbor state machines, 179

NetWare Link Services Protocol (NLSP), 23

networks

- broadcast, 122
  - designated routers*, 110
  - IS-IS adjacencies*, 104-107
  - synchronization*, 211
- convergence, 28
- general topology, 122
- labs, 358-359
- multi-area OSPF, 225
- point-to-point
  - IS-IS adjacencies*, 107-109
  - synchronization*, 209-210
- VPNs, 374

Network Control Protocol (NCP), 10

Network Entity Title (NET), 88-90

Network Interchange Language (NIL), 10

Network Layer Protocol Identifiers (NLPIDs), 96

Network LSAs, 161, 413

Network Mask, 91

Network Measurement Center (NMC), 9

network service access point (NSAP), 88

Network Summary LSAs, 162-164

Network Working Group (NWG), 9-10

NET (Network Entity Title), 88-90

NIL (Network Interchange Language), 10

- NLPIDs (Network Layer Protocol Identifiers), 96
  - NLSP (NetWare Link Services Protocol), 23
  - NMC (Network Measurement Center), 9
  - no-summaries option, 237
  - nodes, pseudonodes, 77, 111
  - non-backbone areas
    - IS-IS, 248-250
    - OSPF, 224-228
  - non-malicious threats, routing protocols, 317-318
  - Non-Stop Forwarding (NSF), 336
  - nonbackbone areas, 66
  - nonbroadcast multi-access (NBMA), 101
  - not-so-stubby areas, 238-239
  - NPL (National Physical Laboratory), 6
  - NSAP (network service access point), 88
  - NSAP Selector (SEL), 88
  - NSFNET, 14
  - NSF (Non-Stop Forwarding), 336
  - nuclear attacks, ARPANET
    - withstanding, 8
  - numbers, 140
  - NWG (Network Working Group), 9, 10
- O**
- Opaque LSAs, 363-368
  - Open Shortest Path First. *See* OSPF
  - Open Systems Interconnection (OSI)
    - model, 20
  - optimization
    - flooding, 292
      - demand circuits*, 302-303
      - mesh groups*, 296-301
      - retransmit pacing*, 295-296
      - transmit pacing*, 293-294
    - SPF, 273
      - delay*, 291-292
      - equal-cost multipath*, 274-286
      - iSPF calculations*, 287-288
      - partial route calculations*, 290
  - options
    - MPLS TTL, 379
    - neighbors, 187
    - no-summaries, 237
  - Options field
    - LSA header formats, 138
    - OSPF link state database
      - synchronization, 184-185
    - OSPFv3, 417
  - Oran, Dave, 22
  - OSI (Open Systems Interconnection)
    - model, 20
  - OSPF (Open Shortest Path First)
    - areas, 149, 224
      - address summarization*, 240-241
      - backbone/non-backbone*, 224-228
      - not-so-stubby*, 238-239
      - scaling*, 228-233
      - stub*, 234-236
      - totally stubby*, 237
      - virtual links*, 241-248
    - authentication, 323-325
    - extensibility, 362-368
    - flooding, 134-142
    - graceful restart, 332-336
    - link state database synchronization, 179-189
    - metrics, 154-156
    - MT-OSPF extensions, 426-428
    - neighbors, 186-194
    - router types, 149
    - TE extensions, 385-388
  - OSPFv3, 404
    - comparing to PSPFv2, 405-407
    - future extensions of, 419
    - IPv4 and IPv6 compatibility, 404-405
    - LSAs, 407-417
    - packets, 417-418
  - OSPF Working Group, 22
  - overload-bit on-startup command, 312
  - overloading, 308-312
  - overload command, 312
  - overload timeout command, 312

**P**

- packets, 12, 66
  - control (BFD), 342
  - filtering, 351
  - IPv6 fragmentation, 404
  - OSPF link state database
    - synchronization, 180-183
  - OSPFv3, 417-418
  - swapping, 374
- Padding TLV, 98
- parameters, TE links, 381-382
- partial route calculations, 290
- Partial Sequence Number PDU (PSNP), 148
- partitioned areas, 179
- passive interfaces, 230
- path costs, 58
- path vector protocols, 38
- PDU (protocol data unit), 66
  - IS-IS synchronization, 205-207
- Perlman, Radia, 22
- physical loops, 31
- planned restarts (OSPF), 333
- point-to-point adjacencies over
  - Ethernet, 117
- point-to-point networks
  - IS-IS adjacencies, 107-109
  - synchronization, 209-210
- Point-to-Point Three-Way Adjacency
  - TLV, 108
- policies, accessing, 348
- post-change evaluation, 357
- Postel, Jon, 10, 13, 19
- pre-change evaluation, 356
- prefixes
  - external, 231-233
  - Inter-Area Prefix LSA, 414
  - Intra-Area Prefix LSAs, 410
  - IS-IS
    - address summarization*, 261
    - redistributing external into*, 268-269
  - OSPF address summarization, 240-241
  - route tags, 369-371
- presumption of reachability, 303
- priority, neighbors, 187
- procedures
  - MT-ISIS, 431
  - MT-OSPF, 426
- process enforcers, 356
- process owners, 356
- protection. *See also* security
  - domain edges, 347
  - routers, 348-352
- protocols
  - BGP
    - address summarization*, 262
    - area design*, 271
  - Hello, 90
    - IS-IS, 93-99
    - OSPF, 91-92
  - IPv6
    - address formats*, 394-395
    - address representations*, 396-397
    - extensions*, 391-403
    - features and functions of*, 393
    - header formats*, 400-401
    - Neighbor Discovery Protocol*, 397-398
    - stateless address autoconfiguration*, 398-399
- link state
  - adjacencies*, 41
  - announcement headers*, 49
  - areas*, 61-62
  - ARPANET, 4-8
  - comparing to EIGRP*, 37
  - concepts*, 38-39
  - database synchronization*, 49-50
  - development of the Internet*, 11-14
  - flooding*, 44-48
  - history of*, 1-3
  - IETF, 19-21
  - NWG, 9-10
  - routing ARPANET*, 14-19
  - SPF calculations*, 50-60
  - standards*, 21-23

- routing
  - malicious threats*, 316-317
  - non-malicious threats*, 317-318
  - security*, 315
- vector
  - BGP, 37
  - characteristics of*, 28-29
  - convergence*, 27-28
  - EIGRP, 35
  - overview of*, 25
  - routing loops*, 29-35
- Protocols Supported TLV, 96, 171, 369
- protocol data unit (PDU), 66
  - IS-IS synchronization, 205-207
- pseudonodes, 77, 111
  - and ECMP, 282-286
- Q-R**
- RAND Corporation, 5
- rates, limiting, 352
- reachability, presumption of, 303
- redistributing
  - connected interfaces, 230
  - external prefixes into IS-IS, 268-269
- reduction, flood, 302-303
- redundancy
  - L1/L2 routers, 260
  - reliability/security design, 344-346
- reference bandwidth, 154
- refreshing, 45
  - retransmit pacing, 295-296
  - transmit pacing, 293-294
- regression testing, 358
- relationships, LSRs and forwarding
  - actions, 375
- reliability
  - areas, 222-223
  - flooding, 49
  - security, 318
    - authentication*, 319-328
    - BFD*, 340-343
    - checksums*, 329-331
    - configuration management*, 352-358
    - design*, 344-352
    - graceful restart*, 331-339
    - inherent*, 318-319
    - network labs*, 358-359
- repositories, configuring, 354
- representations, IPv6 addresses, 396-397
- requests, maintenance, 357
- Requests For Comments (RFCs), 10
- Request packet, 183
- requirements (flooding), 133-134
  - IS-IS, 142-148
  - OSPF, 134-142
- restarting (graceful restart), 331-332
  - IS-IS, 337-339
  - OSPF, 332-336
- Restart TLV, 337
- retransmit-interval command, 295
- retransmit
  - lists, 136
  - pacing, 295-296
  - timers, 136
- RFC (Requests For Comments), 10
- RIB (routing information database), 25
- Richer, Ira, 16
- RID (router ID), 41, 65, 81-82
  - configuring, 85
  - neighbors, 187
  - troubleshooting, 82-86
- RI (Router Information) Opaque LSAs, 366-368
- Roberts, Larry, 5-11, 19
- Rosen, Eric, 16
- routers, 65
  - ABRs, 149
  - access policies, 348
  - adjacencies, 77
    - IS-IS*, 103-109
    - OSPF*, 101-102
  - ASBRs, 151
  - designated, 77, 109-112
    - IS-IS*, 115-116
    - neighbors*, 187
    - OSPF*, 112-115

- flooding, 133-134
  - IS-IS*, 142-148
  - OSPF*, 134-142
- Inter-Area Router LSA, 414
- LSRs, 374
- protecting, 348-352
- redundant L1/L2, 260
- types, 149
  - IS-IS*, 151-153
  - OSPF*, 149
- router ID. *See* RID
- Router Information (RI) Opaque LSAs, 366-368
- Router LSAs, 158-161, 412
- routes
  - IS-IS*, 263-267
  - partial route calculations, 290
  - tagging, 369-371
  - vector protocols
    - BGP*, 37
    - characteristics*, 28-29
    - convergence*, 27-28
    - EIGRP*, 35
    - overview of*, 25
    - routing loops*, 29-35
- routing
  - ARPANET, 14-19
  - domains, 66
  - loops, 29
    - counting to infinity*, 32
    - holddown timers*, 34-35
    - split horizons*, 30
  - routing protocol security, 315
    - malicious threats*, 316-317
    - non-malicious threats*, 317-318
- routing information database (RIB), 25
- rules
  - Dijkstra algorithms, 52
  - split horizon, 44
- Rulifson, Jeff, 9

## S

- SATNET (satellite network), 12
- scalability, 273
  - areas, 220-221
  - flooding, 292
    - demand circuits*, 302-303
    - mesh groups*, 296-301
    - retransmit pacing*, 295-296
    - transmit pacing*, 293-294
  - fragmentation, 304-308
  - IS-IS*, 252-255
  - OSPF* areas, 228-233
  - overloading, 308-312
  - SPF, 273
    - delay*, 291-292
    - equal-cost multipath*, 274-284, 286
    - iSPF calculations*, 287-288
    - partial route calculations*, 290
- SDC (System Development Corporation), 4
- security
  - reliability, 318
    - authentication*, 319-328
    - BFD*, 340-343
    - checksums*, 329-331
    - configuration management*, 352-358
    - design*, 344-352
    - graceful restart*, 331-339
    - inherent*, 318-319
    - network labs*, 358-359
  - routing protocols, 315
    - malicious threats*, 316-317
    - non-malicious threats*, 317-318
- SEL (NSAP Selector), 88
- Send Routing Message (SRM) flags, 208
- Send Sequence Number (SSN) flags, 208
- sequences
  - counter design, 46
  - numbers, 140
    - CSNPs*, 148
    - DD packets*, 186
    - PSNPs*, 148
    - SSN*, 208

sequential flooding, 45  
Serr, Frederick, 18  
set-overload-bit command, 312  
Shand, Mike, 22  
shortest-path-first. *See* SPF  
shortest-path routing trees, calculating, 51  
SIA (stuck in active), 37  
SID (system ID), 65  
slaves. *See* masters/slaves  
Smit, Henk, 68  
SNPA (subnetwork point of attachment), 66  
SPF (shortest-path-first), 17  
  calculations, 51-60  
  constrained, 383-385  
  scalability, 273  
    *delay*, 291-292  
    *equal-cost multipath*, 274-286  
    *iSPF calculations*, 287-288  
    *partial route calculations*, 290  
split horizons, 30, 44  
spoofing, 67  
SRI (Stanford Research Institute), 7  
SRM (Send Routing Message) flags, 208  
SSN (Send Sequence Number) flags, 208  
standards, 354  
  history of, 21-23  
  ISO, 20  
Stanford Research Institute (SRI), 7  
starting, 339. *See also* restarting  
stateless address autoconfiguration, 398-399  
states  
  machines, 189-194  
  neighbors, 186  
  OSPF interfaces, 126-129  
stub areas (OSPF), 234-236  
  not-so-stubby, 238-239  
  totally stubby, 237  
stuck in active (SIA), 37  
subdomains, 66

subnetworks  
  convergence, 28  
  functions, 76-78  
subnetwork point of attachment (SNPA), 66  
summarization (addresses)  
  BGP, 262  
  IS-IS, 261  
  OSPF, 240-241  
Sutherland, Ivan, 4  
swapping packets, 374  
switching MPLS labels, 374-376  
synchronization  
  broadcast networks, 211  
  databases, 49-50  
  IS-IS PDUs, 205-207  
  link state databases, 179  
    *IS-IS*, 205-216  
    *OSPF*, 179-189  
  point-to-point networks, 209-210  
Systems Network Architecture, 20  
System Development Corporation (SDC), 4  
system ID (SID), 65

## T

tables, neighbors, 186-187  
tags, 369-373  
Taylor, Bob, 4  
TCP (Transmission Control Protocol), 12  
TED (traffic engineering database), 383  
testing, 358  
TE (traffic engineering), 374, 380  
  constrained SPF, 383-385  
  IS-IS, 388-389  
  link parameters, 381-382  
  OSPF, 385-388  
threats  
  *malicious*, 316-317  
  *non-malicious*, 317-318  
three-way handshaking, 42, 101

**timers**

- graceful restart (IS-IS), 338
- holddown, 34-35
- Inactivity Timer, 186
- retransmit, 136, 295-296
- transmit pacing, 293-294

**timers pacing flood command, 294****timers pacing lsa-group command, 294****TLVs (type/length/values), 69**

- essential, 168-169
  - Area Address TLVs*, 169
  - Extended IP Reachability TLVs*, 174-175
  - Extended IS Reachability TLVs*, 173
  - IP External Reachability TLVs*, 173
  - IP Interface Addresses TLVs*, 171
  - IP Internal Reachability TLVs*, 172
  - IS Neighbor TLVs*, 169-170

**Hello Protocol (IS-IS), 95-99****IS-IS**

- IPv6 Interface Address*, 422
- IPv6 Reachability*, 421

**MT-ISIS, 432**

- MT Intermediate Systems*, 433
- MT Reachable IPv6 Prefixes*, 434

**Protocols Supported, 171, 369****Restart, 337****totally stubby areas, 237****traffic engineering. *See* TE****traffic engineering database (TED), 383****training, 358****Transmission Control Protocol. *See* TCP****transmit pacing, 293-294****triggering updates, 32****troubleshooting, 358**

- holddown timers, 34
- IS-IS, 212-216
- OSPF, 194-204
- RIDs, 82-86

**type/length/values. *See* TLVs****types**

- of authentication, 319
- of LSRs, 375
- of media, 118
  - IS-IS*, 122-123
  - OSPF*, 118-122
- of messages, 71-72
  - architecture*, 69
  - comparative terminology*, 65-66
  - encapsulation*, 67-69
  - functions*, 76-78
  - LSAs*, 72-74
  - LSPs*, 72-74
- of metrics, 154
  - IS-IS*, 156-157
  - OSPF*, 154-156
- of Opaque LSAs, 363-366
- of OSPFv2 LSAs, 139
- of packets, 417-418
- of RI Opaque LSAs, 366-368
- of routers, 149
  - IS-IS*, 151-153
  - OSPF*, 149

**Type 1 External (E1), 155****Type 2 External (E2), 155****U****UDP (User Datagram Protocol), 13****Unicast addresses, 394****University of California at Berkley, 4****University of California Santa Barbara, 7****University of Utah, 7****unplanned restarts (OSPF), 334****updates**

- flow of, 30
- triggering, 32

**Update messages (OSPF), 134****User Datagram Protocol. *See* UDP****usurpation, 316**

**V**

## values

- Circuit Type, 94

- TLVs. *See* TLVs

VC (virtual circuit), 68, 374

## vector protocols

- BGP, 37

- characteristics of, 28-29

- convergence, 27-28

- EIGRP, 35

- overview of, 25

- routing loops, 29-35

virtual circuit. *See* VC

## virtual links

- IS-IS, 270

- OSPF, 241-248

VPNs (virtual private networks), 374

**W-Z**

Washington University (St. Louis), 7

wide metrics, 157

windowing transmission rates, 136

Zinky, John, 18