



## Symbols

---

^ (caret), translation rule syntax, 26

## A

---

AAL2 (ATM Abstraction Layer 2)  
 CPS, 77  
 managed voice and data services, 75–77  
 profiles, 79  
 SSCS, 77

access rules, 144–145

ACLs (access control lists), traffic classification, 90–91

aggregation routers, call agent architecture, 58

A-links, SS7 interconnection, 67

AMA (Automatic Message Accounting), 67

Amphenol connectors, 113

application servers, H.232 VoIP networks, 35–36

architecture, managed voice and data service, 73–74  
 AAL2, 75–77  
 DS1/T1 access, 74–75

archiving and reporting database, VoIP management architecture, 173

ASCII messages, harvesting VoIP management data, 179

ASR (Answer Seizure Ratio), 140  
 extracting from VoIP network data, 174

assigning  
 alternate DGKs, 154  
 alternate gatekeepers, 151–152

associated signaling, 67

authentication  
 CHAP, 158  
 H.323 RAS, 157–160

AVBO (Advanced Voice Busyout), 102

avoiding congestion, 100–101

## B

---

B channels, 121

bandwidth, overprovisioning, 86

bearer channels, 33

best effort, 87

billing systems, 67–68  
 reconciliation, 68–69

bit stuffing, C-bit parity method, 116

BML (Business Management Layer), TMN framework, 169

busy hour, estimating, 139

## C

---

CAC (call admission control), 101  
 local CAC, 102  
 network CAC, 103  
 RSVP CAC, 103

call agent architectures, 19  
 aggregation routers, 58  
 call agent signaling, 54–55  
 edge routers, 58  
 feature servers, 59  
 gateways, 57–58  
 interworking, 56  
 local access services, 52–53  
 MGCP, 52  
 solutions, 73  
 voice services, 49, 51  
 VoIP services, 49

call centers, screen pop applications, 61

call legs, 23

call settlement, 9

calling card services, 9–10

carrier IDs, 27

carrier sensitive routing, 65

carrier systems, 109–110

CAS (channel associated signaling), T1 trunks, 117–119

case studies, VoIP network direct IP interconnect, 111–113

categories of service providers, 62

C-bits, 116

cCallHistory MIB as SLA indicator source, 177

CDRs (call detail records), 68  
 example, 69–70  
 reconciling billing data, 69  
 related MIBs, 177

- central database, VoIP management architecture, 172–173
- CHAP (Challenge Handshake Authentication Protocol), 158
- characteristics
  - of call legs, 23
  - of DS3, 117
- CIC mapping, SS7, 130
- CID (channel ID) field (CPS packets), 79
- circuit types, 109–110
- Cisco access tokens, 158
- Cisco IOS Software
  - gateways, enhanced number translation, 27
  - rotary calling pattern feature, 150
- Class 4 switches, 63
- Class 5 switches, 75
- classification, 89
  - CB-marking, 95
  - QPPB, 96–97
- clear channel connections, 116
- clearinghouse peering arrangements, 63
- CLECs (competitive local exchange carriers), direct IP interconnect with DS3, 115–117
- clients, SIP, 39
- clipping, 85–86
- clustering SIP servers, 42
- coloring, 90
- congestion avoidance in VoIP networks, 100–101
- congestion management, LLQ, 98–100
- control plane architecture, IntServ, 87
- correlating harvested VoIP management data, 183–184
- CPS (common part sublayer), 77
- CSRs (Campus Switch Routers), 35
- CSUs (channel service units), 114–115

## D

---

- D channel, 121
  - NFAS, 124–125
- data plane architecture, DiffServ, 87
- databases, harvesting VoIP management data, 180
- delay variance, effect on voice quality, 85
  
- deploying

- QoS, DiffServe, 90–92
- VoIP networks, 13
- designing VoIP networks, 20
  - DGK sizing, 147
  - dial peers, 141–143
  - dial plan administration, 146
  - gateway and gatekeeper, 135–138
  - high availability, 148–154
  - normalization rules, 143–145
    - GKTMP, 146
  - requirements, 19
  - traffic engineering, grade of service requirements, 139
  - zones, 141
- devices
  - Class 5 switches, 75
  - security, 161–162
  - Tandem Switches, 75
- DGKs (directory gatekeepers)
  - call routing, 65
  - dial plan administration, 146
  - high availability, 153–154
  - peering, 63
  - sizing, 147
- dial peers, 22–23, 141–143
- dial plans, 22
  - administration, 146
  - normalization rules, 143–145
    - GKTMP, 146
  - translation rules, 26
- DiffServ, 87–88
  - DSCP, traffic classes, 88
  - EF PHB, 92
  - implementing, 90–95
  - services, 89
- direct IP interconnect
  - carrier systems, 109–110
  - signaling types
    - in-band, 110
    - out-of-band, 111
  - with DS3, 115–117
  - with E1, 115
  - with PRI trunks, 121
    - digit sending method, 125
    - incoming digit format, 126
    - NFAS, 124–125
    - Q.921 protocol, 121–122

- Q.931 protocol, 122–123
  - with SS7 trunks, 127
  - CIC mapping, 130
  - FAS, 128
  - link speeds, 129
  - point codes, 129–130
- with T1s, 113–114
  - line termination, 114–115
  - punchdown blocks, 113
- direct mode gatekeepers, H.323, 31
- direct peering, 63
- directory gatekeepers
  - H.232 VoIP networks, 32–33
  - peering, 33
- dropping packets, 91
- DS1 architecture, managed voice and data services, 74–75
- DS3 architecture
  - characteristics, 117
  - interconnecting to CLECs, 115–117
  - unframed connections, 116
- DSCP (Diffserv Codepoint), 87
  - PHBs, EF, 92–95
  - traffic classes, 88
- DSUs (data service units), 115
- DSX-3 interfaces, 117

## E

---

- E&M signaling on T1 lines, 118
- E1 lines
  - interconnecting to PTT, 115
  - multiframe, 115
- edge routers, call agent architecture, 58
- EML (element management layer), TMN
  - framework, 169
- end-to-end delay, effect on voice quality, 84
- enterprise services
  - H.323 VoIP networks, 20
  - managed voice and data service architecture, customers, 74
- ERD (entity relationship diagram), 179
- Erlangs, calculating VoIP trunking requirements, 140
- ESF (Extended Super Frame) format, 120
- estimating busy hour, 139

- executive level views, correlated SLA data, 185
- extracting SLA indicators from VoIP network data, 174

## F

---

- FAS (Facility Associated Signaling), 111
- FEAC (far end alarm and control), 116
- feature servers, call agent architecture, 59
- fields
  - of CDRs, 68
  - of CPS packets, 78–79
- FIFO (first in first out) queuing, 91
- filtering harvested VoIP data, 183–184
- firewalls, 161
- fixed delay, effect on voice quality, 84
- F-links, SS7 interconnection, 67
- fragmentation, 92
- framing mode, T1, 120
- FRR (Fast Re-Route), 106
- fully associated signaling, SS7, 128
- functionality of gatekeepers, 28

## G

---

- G.704 framing methods, 120
- gatekeepers, 13, 154
  - clustering, 29
  - dial peers, 141–143
  - dial plan administration, 146
  - H.232 VoIP networks, 28–29
  - high availability, 151–153
  - load balancing, 152–153
  - normalization rules, 143–145
    - GKTMP, 146
  - signaling, 29
  - sizing, 147
  - troubleshooting, 155
  - VoIP network design, 135–137
    - bandwidth requirements, 137–138
  - zones, 141
- gateways, 11
  - call agent architecture, 57–58
  - Cisco IOS Software supported features, 27–28
  - dial peers, 141–143

- dial plan administration, 146
- direct mode, 31
- H.232 VoIP networks, 22–25
  - Cisco IOS Software supported features, 27–28
  - interconnecting to PSTN, 33–34
  - translation rules, 26
- high availability, 148–151
- normalization rules, 143–145
  - GKTMP, 146
- OGW, call establishment, 24
- signaling, 29
- SIP network architecture, 40–41
- translation rules, 26
- troubleshooting, 155
- VoIP network design, 135–137
  - bandwidth requirements, 137–138
  - zones, 141
- GKTMP (Gatekeeper Transaction Message Protocol), 28, 146
  - call routing, 65
- grade of service, traffic engineering requirements, 139

## H

---

- H.225 protocol in H.232 VoIP networks, 30–31
- H.245 protocol in H.232 VoIP networks, 31
- H.323 VoIP network architecture, 17, 20
  - application servers, 35–36
  - directory gatekeepers, 32–33
  - enterprise services, 20
  - gatekeepers, 28–29
  - gateways, 22–25
    - Cisco IOS Software supported features, 27–28
    - translation rules, 26
  - H.225, 30–31
  - H.245, 31
  - RAS, 30
    - authentication, 157–160
  - retail services, 21
  - RTP, 31
  - signaling, 29
  - SIP interworking, 47–48

- SS7, 33–34
  - wholesale services, 20
- hairpin, 143
- harvesting VoIP management data, 174
- HEC (Header Error Control) field (CPS packets), 79
- hierarchical structure of international call routing, 32
- high availability, 148
  - DGKs, 153–154
  - gatekeepers, 151–153
  - gateways, 148–151
- hop-off zone, 142
- hunt groups, 150

---

- identifying SLA indicator data sources, 175
  - MIBs, 176–183
- idle channel suppression, 77
- ILECs (incumbent local exchange carriers), 11
  - call agent architecture, 19
  - direct IP interconnect with T1s, 113–115
  - migration to TDM-based architecture, 62–63
- impetus for IP/voice convergence, 4–5
- implementing
  - device security, 161–162
  - DiffServe, requirements, 90–92
  - EF behavior, 93–95
  - VoIP networks, 13
- IMTs (Inter-Machine Trunks), 33, 67
- in-band signaling, 110
- indication bit, 116
- integrated access architecture, AAL2, 75
- interface layer MIBs as SLA indicator source, 178
- interLATA toll calls, 113
- international call routing, hierarchical structure, 32
- interworking, call agent architecture, 56
- intraLATA calls, 75
- IntServ architecture, 87
- INVITE messages, 45
- IP packets, precedence bits (ToS field), 89
- IPSec (IP Security), 163

ISDN (Integrated Services Digital Network)  
 PRI signaling, 121  
   digit sending method, 125  
   incoming digit format, 126  
   NFAS, 124–125  
   Q.921 protocol, 121–122  
   Q.931 protocol, 122–123  
 variants, 124  
 ISPs (Internet service providers), 62  
 ITSPs (Internet telephony service providers), 62  
 ITU-T (International Telecommunications Union  
 Telecommunication Standardization Sector),  
   G.704 framing standards, 120  
 IVR (interactive voice response) applications, 12, 36  
 IZCT (Inter-Zone Clear Token), 157

## J

JIT (Jim's International Traffic), VoIP network case  
 study, 111–113  
 jitter  
   effect on voice quality, 85  
   latency swing, 174

## L

LATAs (interlocal access and transport areas), 113  
 latency, effect of end-to-end delay on voice  
 quality, 84  
 latency swing, 174  
 layers of TMN framework, 168–169  
 LBO (long-range build out), 117  
 LCR (Least Cost Routing), 8, 64–65  
 LI (Length Indicator) field (CPS packets), 79  
 limitations of IPsec security, 163  
 line coding, T1, 119  
 link speeds, SS7, 129  
 LLQ (Low Latency Queuing), congestion  
 management, 98–100  
 load balancing, gatekeepers, 152–153  
 local access services, call agent architecture, 52–53  
 local CAC, 102  
 loopback testing on T1 lines, 132

## M

managed voice and data service architecture, 73–74  
   AAL2 architecture, 75–77  
   CPS, 77  
   SSCS, 77  
   T1/DS1 access architecture, 74–75  
 management architecture (VoIP)  
   harvesting data, 174  
   SLAs, identifying data sources of, 175–183  
 marking, 90  
   CB-marking, 95  
   QPPB, 96–97  
 messages  
   RAI, 148–150  
   syslog, 172  
     harvesting VoIP management data, 179  
 MGCP (Media Gateway Control Protocol), call  
 agent architecture, 52  
 MIBs (management information bases) as SLA  
 indicator source, 176–177  
   cCallHistory MIB, 177  
   interface layer MIB, 178  
   physical layer MIB, 178  
   resource management layer MIB, 178  
 migrating from TDM to VoIP architecture, 61–63  
   billing systems, 67–68  
     reconciliation, 68–69  
   LCR, 64–65  
   SS7 support, 65–67  
 motivation for IP/voice convergence, 4–5  
 MPLS TE (Multi-Protocol Layer Switching Traffic  
 Engineering), 104–105  
   FRR, 106  
 MQC (modular QOS CLI), 95  
 MSN Messenger PC-to-Phone, 17  
 multiframe, 115

## N

NAM (Network Applications Manager), 35  
 NANP (North American Numbering Plan), 126  
 NetFlow, harvesting VoIP management data,  
 182–183

- network access security, 160–161
- network CAC, 103
- network management
  - H.323 VoIP networks, 36
  - SLAs, requirements for VoIP networks, 170–171
  - TMN framework, 168–169
  - VoIP management architecture
    - archiving and reporting database, 173
    - central database, 172–173
    - trouble ticket application, 173
- NFAS (Non-Facility Associated Signaling), 111, 124–125
- NML (network management level), TMN framework, 169
- Non-Facility Associated Signaling (NFAS), 111, 124–125
- normalization rules, 143–145
  - GKTMP, 146

## O

---

- OGW (originating gateway), call establishment, 24
- one-stage dialing, 24
- one-way hashing algorithms, 158
- OOS (out-of-service) conditions, local CAC, 102
- operational level views of correlated SLA data, 185
- OPT (Open Packet Telephony), 10
- OSP (Open Settlement Protocol), 9, 63, 157
  - access tokens, 160
  - server functions, 63
- out-of-band signaling, 111
- outpulsing (ISDN), 125
- overprovisioning, 86

## P

---

- packet loss
  - effect on voice quality, 85–86
  - extracting from VoIP network data, 174
- packets, marking, 90
- PDD (post dial delay), 84
  - extracting from VoIP network data, 174

- peering arrangements
  - directory gatekeepers, 33
  - wholesale VoIP, 63
- peering partner views of correlated SLA data, 186–187
- PGW 2200 servers, interconnecting H.323 gateways to PSTN, 34
- PHBs (per-hop behaviors), EF, 92
  - implementing, 93–95
- physical layer MIBs as SLA indicator source, 178
- point codes, SS7, 129–130
- policing, 90
- POPs (points of presence), 11, 63, 75
  - traffic engineering, grade of service requirements, 139
- POTS (plain-old telephone service) dial peers, 22
- precedence bits, 89
- prefixes, 141
  - hop-off zone, 142
- presenting correlated SLA data, 187–188
- proxy servers in SIP network architecture, 41
- PSTN (public switched telephone network),
  - connecting with SS7, 66–67
- PTT (Post, Telephone, and Telegraph), direct IP interconnect with E1s, 115
- punchdown blocks, 113

## Q

---

- Q.921 protocol, 121–122
- Q.931 protocol, 122–123
- QoS (quality of service)
  - best effort, 87
  - CAC, 101
    - local CAC, 102
    - network CAC, 103
    - RSVP CAC, 103
  - DiffServ, 87–88
    - EF PHB, 92–95
    - requirements for implementing, 90–92
    - services, 89
  - IntServ, 87
  - MQC, 95
  - QPPB, 96–97
  - selecting mechanism of, 86

- SLAs, 170
- traffic classes, 88
- QPPB (QoS Policy Propagation through BGP), 96–97
- quasi-associated signaling, SS7, 128
- queuing mechanisms, 91
  - LLQ congestion management, 98–100

## R

- RADIUS (Remote Authentication Dial-In User Service), 12
  - billing records, 35
- RAI (Resource Availability Indicator) messages, 28, 148–150
- RAS (registration, admission, and status)
  - authentication, 158
  - H.232 VoIP networks, 30
- RCFs (registration confirms), 29
- real-time data collectors, harvesting VoIP
  - management data with NetFlow, 182–183
- reconciling billing data, 68–69
- redirect servers, SIP network architecture, 42
- REGISTER messages, 45
- registrar servers, SIP network architecture, 42
- relational databases, harvesting VoIP management data, 180
- Remote Zone Priority, 65
- reporting correlated SLA data, 187–188
- requirements
  - for DiffServe deployment, 90–92
  - for SLA support on VoIP networks, 170–171
  - VoIP network design, 135–137
    - bandwidth, 137–138
    - high availability, 148–154
- resource management layer MIBs as SLA indicator source, 178
- retail VoIP services
  - H.323 networks, 21
  - OPT, 10
  - OSP, 9–10
- RJ-48C interface, 113
- rotary calling pattern feature (Cisco IOS Software), 150
- rotary dial peers, 25
- route servers, 35
- RRQs (registration requests), 29

- RSVP (Resource Reservation Protocol), CAC, 103
- RTD (round trip delay), extracting from VoIP
  - network data, 174
- RTP (Real-Time Transport Protocol), H.232 VoIP networks, 31
- RUDP (Reliable User Datagram Protocol), 67

## S

- SA Agents, harvesting VoIP management data, 180–182
- screen pop applications, 61
- security
  - devices, 161–162
  - firewalls, 161
  - H.323 RAS authentication, 157–160
  - IPSec, 163
  - network access, 160
- selecting QoS mechanisms, 86
  - best effort, 87
  - DiffServ, 87–88
  - IntServ, 87
- servers
  - OSP, functions of, 63
  - SIP network architecture, 41
    - proxy servers, 41
    - redirect servers, 42
    - registrar servers, 42
- service providers
  - categories of, 62
  - migration to VoIP architecture, 62–63
    - billing systems, 67–69
    - LCR, 64–65
    - SS7 support, 65–67
- services (QoS), 89
- SF (Super Frame) format, 120
- shaping traffic, 92
- signaling
  - call agent architecture, 54–55
  - E&M on T1 lines, 118
  - H.232 VoIP networks, 29
  - ISDN PRI, 121
    - digit sending method, 125
    - incoming digit format, 126
    - NFAS, 124–125
    - Q.921 protocol, 121–122



- Q.931 protocol, 122–123
  - variants, 124
- SIP
  - H.323 interworking, 47–48
  - messages, 45
  - services, 46–47
- SS7, 127
  - CIC mapping, 130
  - FAS, 128
  - link speeds, 129
  - point codes, 129–130
  - T1 CAS schemes, 117–119
- single-stage dialing, 13
- SIP (Session Initiation Protocol) network
  - architecture, 37
    - clients, 39
    - gateways, 40–41
    - H.323 interworking, 47–48
    - servers, 41
      - proxy servers, 41
      - redirect servers, 42
      - registrar servers, 42
    - services, 46–47
  - signaling messages
    - INVITE, 45
    - REGISTER, 45
  - third-party registration, 45
  - UAs, 38
  - wholesale services, 38
- sizing
  - gatekeepers, 147
  - trunks, 140
    - dial peers, 141–143
    - dial plan administration, 146
    - GKTMP, 146
    - normalization rules, 143–145
    - zones, 141
- SLAs (Service Level Agreements), 170
  - correlated data
    - executive-level views, 185
    - operational-level views, 185
    - peering partner views, 186–187
    - presenting, 187–188
    - reporting, 187–188
  - data sources of
    - correlating harvested data, 183–184
    - filtering harvested data, 183–184
    - identifying, 175–183
    - extracting from VoIP network data, 174
  - smart jacks, line termination, 114
- SMBs (server message blocks), managed voice and data services, 73–75
  - AAL2, 75–77
  - T1/DS1 architecture, 74–75
- SML (Service Management Layer), TMN framework, 169
- SNMP (Simple Network Management Protocol), MIBs as SLA indicator source, 176–178
- softswitches, call agent architecture
  - aggregation routers, 58
  - call agent signaling, 54–55
  - edge routers, 58
  - feature servers, 59
  - gateways, 57–58
  - interworking, 56
  - local access services, 52–53
  - MGCP, 52
  - voice services, 49, 51
  - VoIP services, 49
- sRTP (Secure Real-Time Transport Protocol), 163
- SS7 (Signaling System 7)
  - H.232 VoIP networks, interconnecting
    - gateways to PSTN, 33–34
    - wholesale VoIP implementations, 65–67
- SSCS (service-specific convergence sublayer), 77
- Start field (CPS packets), 78
- statistical gains, 5
- STPs (signal transfer points), 111
- syslog messages, 172
  - harvesting VoIP management data, 179

---

## T

- T1 architecture
  - CAS schemes, 117–119
  - direct IP interconnect, 113–114
    - line termination, 114–115
    - punchdown blocks, 113
  - E&M signaling, 118

- framing mode, 120
- line coding, 119
- loopback testing, 132
- managed voice and data services, 74–75
- Tandem Switches, 63, 75
- tandem voice services, 20
- TDM-based architecture, migration to VoIP, 61–63
  - billing systems, 67–69
  - LCR, 64–65
  - SS7 support, 65–67
- terminating T1 circuits, 113–114
- TMN (Telecommunication Management Network)
  - framework, layers of, 168–169
- toll calls, LATA, 113
- ToS field (IP packets), precedence bits, 89
- traffic
  - CAC, 101
    - local CAC, 102
    - network CAC, 103
    - RSVP CAC, 103
  - classification, 88–89
    - CB-marking, 95
  - congestion avoidance in VoIP networks, 100–101
  - congestion management, LLQ, 98–100
  - fragmentation, 92
  - marking, 90
  - policing, 90
  - queuing, 91
  - shaping, 92
  - SLAs, 170
- traffic engineering
  - grade of service requirements, 139
  - MPLS, 104–105
    - FRR, 106
- transit voice services, 20
- translation rules, 26, 144–145
- triggers (database), harvesting VoIP management data, 180
- trouble ticket applications, 173
- troubleshooting
  - gateways and gatekeepers, 155
  - trunks, 131–133
- trunk groups, 27
- trunks, 110
  - conditioning, local CAC, 102
  - DS3s, 115–117

- E1, 115
- in-band signaling, 110
- ISDN PRI
  - digit sending method, 125
  - incoming digit format, 126
  - NFAS, 124–125
  - Q.931, 122–123
- out-of-band signaling, 111
- sizing, 140
- SS7, direct IP interconnect, 127–130
- T1, 113–115
  - CAS, 117, 119
  - E&M signaling, 118
  - framing mode, 120
  - line coding, 119
  - line termination, 114–115
  - punchdown blocks, 113
- troubleshooting, 131–133
- tunnels, MPLS-TE, 105
- two-stage dialing, 12, 24

---

## U

- UAs (User-Agents), 38
- unframed connections, DS3, 116
- unified messaging, 10
- UUI (User-to-User Indication) field (CPS packets), 79

---

## V

- voice services, impetus for, 4–5
- VoIP (Voice over IP)
  - benefit to service providers, 5
  - gatekeepers, 13
  - gateways, 11
  - H.323, 20
    - application servers, 35–36
    - directory gatekeepers, 32–33
    - enterprise services, 20
    - gatekeepers, 28–29
    - gateways, 22, 24–28
    - H.225, 30–31
    - H.245, 31
    - interworking, 47–48

- RAS, 30
- retail services, 21
- RTP, 31
- signaling, 29
- SS7, 33–34
- wholesale services, 20
- management architecture
  - archiving and reporting database, 173
  - central database, 172–173
  - harvesting data, 174
  - SLA indicators, identifying data sources
    - of, 176–183
  - trouble ticket application, 173
- network deployment, 13
- peers, 22
- retail services
  - OPT, 10
  - OSP, 9–10
- services, 46–47
- signaling messages
  - INVITE, 45
  - REGISTER, 45
- SIP, 37
  - clients, 39
  - gateways, 40–41
  - servers, 41–42
  - UAs, 38
  - wholesale services, 38
- SLA support, 170–171
- wholesale services, 6, 61–63
  - billing systems, 67–69
  - call settlement, 9
  - LCR, 8, 64–65
  - OSP, 9
  - peering arrangements, 63
  - peering partner selection, 8
  - SS7 support, 65–67

- peering arrangements, 63
- peering partner selection, 8
- SS7 support, 65–67
- SIP network architecture, 38

## X-Y-Z

---

- XP operating system (Windows), MSN Messenger
  - PC-to-Phone, 17
- zones, 141
  - hop-off zone, 142

## W

---

- wholesale VoIP services, 6, 61–63
  - H.323 networks, 17, 20
    - billing systems, 67–69
    - call settlement, 9
    - LCR, 8, 64–65
    - OSP, 9