INDEX

Symbols

μ-law, 59

Numerics

10-high-day (10HD) busy period, 416
1750 series routers, 91
2600 series routers, 92–94
  configuring, 147–148
  digital T1/E1 packet voice trunk, 103–104
  PVDM, 103
  VICs, 102
  voice/fax network module, 101–102
3600 series routers, 95
  Cisco 3620 modular access routers, 95
  Cisco 3640 modular access routers, 95
  Cisco 3660 modular access routers, 95
  configuring, 148, 150–151
  digital T1/E1 packet voice trunk, 103–104
  hardware, verifying installation, 156
  PVDM, 103
  VICs, 102
    port addressing, 155
    selecting, 154–155
  VNMs
    assembly, 155
    selecting, 152
  voice/fax network module, 101–102
7200 series routers, 112–114
7500 series routers, 114, 117

A

A bit, 73
ABBH (average bounding busy hour), 416
ABCD bit pattern, 74
  robbed bit format, 76
  trunk configuration, 237–239
ABR (available bit rate), 308
access codes, 124
access gateways, 375
access layer, 9
  in new-world networks, 18
access numbers, pilot number, 374
access servers, AS5300, 107
    DSP module, 170
    DSP module, selecting, 172
    feature card module, 170
    feature cards, selecting, 171–172
    MICA (modem ISDN channel aggregation), 170
    setting up, 168
ACD, 421–422
adaptive differential pulse code modulation (ADPCM), 431
adding string description to voice ports, 185
address signaling, 36, 417
Ad-Hoc conferences, 391
adjunct control PBXs, 406
adjusting
  voice port timing parameters, 212–213
  voice quality, 203
admission control, 349
  CCM, 381–383
ADPCM (adaptive differential pulse code modulation), 431
advanced router systems (ARSs), Cisco 7500 series, 114, 117
A-law, 59
alert signaling, 418
alerting indicators, 38
allocation of bandwidth in voice networks, 381–383
analog signaling
  coding, 61
  delay-start, 35
  digitization
    compression, 61–64
    encoding process, 60–61
    quantization process, 58–60
    sampling, 56–57
  immediate-start, 36
  supervisory, 28
  wink-start, 34–35
analog technologies
  access gateways, 375
  E&M signaling

Type I lines, 42–43
Type II lines, 43
Type III lines, 44
Type IV lines, 44
Type V lines, 46
hybrid 2-to 4-wire conversion, balanced, 49
telephones
dialer, 27
glare, 30
handset, 26
hybrid 2- to 4-wire converter, 27
placing a call, 23–26
power supply, 40
ringer, 27
sidetone, 27
switch hook, 27
trunks, 46–47
CO trunks, 47
DID/DOD trunks, 48
FXO trunks, 47–48
FXS, 48
private trunk lines, 47
telco trunks, 48
voice-grade channels, bandwidth, 56
voice networks, 6
cable connections, configuring on MC3810, 166–167
echo, 49–50
voice ports, configuring, 182–183
applications
FXS, 129
gatekeepers, 133–134
IP Phone, 130
MCM (Multimedia Conference Manager), 133–134, 139
applying QoS policies to VoFR, 264–265
architecture
ATM, requirements of, 308
DVMs (digital voice modules), 160–161
ISDN, 81
PBXs, 408, 410–414
line interfaces, 412
main system controller, 410
trunk interfaces, 413
wiring, 413–414
Architecture for Voice, Video and Integrated Data. *See* AVVID
ARS (advanced router systems), Cisco 7500 series, 114, 117
AS5300s
DSP module, selecting, 172
feature cards, selecting, 170–172
MICA (modem ISDN channel aggregation), 170
setting up, 168
assembling VNM/VIC for 3600 routers, 155
assigning DLCIs to Frame Relay subinterfaces, 270–271
ATM (Asynchronous Transfer Mode)
architectural requirements, 308
bandwidth, calculating, 312
configuration commands
dial-peer voice voatm, 324
encapsulation, 320
inarp parameter, 325
interface atm, 319
mode, 316, 318–319
pvc name, 319
session target, 324
vbr-rt, 322
MC3810 fixed prioritization, 314–316
MFT (Multiflex Trunk), 311
PVCs, virtual template parameters, 321
SAR, 309
service classes, 308–309
minimizing delay, 310
non-real time, 314, 316
real time, 314–315
traffic shaping, 312
for data/video, 314
atm pvc command, 326
auditing network inventory, 428–429
global firms, 440
multinational firms, 463
pan-European firms, 449
auto-cut-through command, 191–192
automated attendant, 421
available bit rate (ABR), 308
availability on old-world telephony systems, 390
average bounding busy hour (ABBH), 416
average options for voice traffic, calculating, 323–324

AVVID (Architecture for Voice, Video and Integrated Data), 14–16
  access gateways, 375
  components of, 372
    access gateways, 375
    CallManager, 373
    Cisco IP Phones, 375
    uOne, 374
  hardware
    Cisco conference bridges, 391–392
    Cisco WebAttendant, 392
    gateways, 386–387, 389
    IP Phone, 384–385
    media convergence servers, 389–390
  IP protocols
    DHCP, 376
    H.323, 377
    MGCP, 378–379
    SCCP, 379
    TFTP, 376
  signaling, 380

B

B8ZS (Bipolar with Eight-Zero Substitution Return-to-Zero), 77
backplane (PBXs), 411
balanced hybrid 2- to 4-wire conversion, 49
bandwidth
  allocating, 309, 381–383
  ATM, calculating, 312
  calculating for voice calls, 359–360
  conservation techniques, digital speech interpolation, 65
  managing, 349
  reserving, 344
    on DLCIs, 275
  voice-grade analog channels, 56
baselining input/output power levels, 205
BC (Basic Call) sublayer, QSIG, 419
Bc (committed burst size), configuring, 281
Be (excess burst), configuring, 281
BECN (backward explicit congestion notification), 260
BHCA (busy hour call attempts), 416
Bipolar Alternate Mark Inversion Return-to-Zero, 77
bipolar violation (BPV), 77
Bipolar with Eight-Zero Substitution Return-to-zero (B8ZS), 77
BPV (bipolar violation), 77
break segment, 36
building blocks of IP voice installations
  backbone speed and scale, 349
  bandwidth management/admission control, 349
  congestion management, 350
  packet classification, 349
  queue management, 350
burst options for voice traffic, calculating, 323–324
business level telephone voice quality, 66
busy hour call attempts (BHCA), 416
busy hour call handling, PBXs, 415–416
busy signal, 38
BVM (BRI voice module)
  configuring on MC3810, 163–164
  specifying as clock source, 164

C

cabinet carriers, PBX systems, 411–412
cabinet/shelf controller, PBX systems, 409
cablelength long command, 216
cablelength short command, 216
cabling
  analog voice connections (MC3810), 166–167
  PBX systems, 413–414
calculating
  average options for voice traffic, 323–324
  bandwidth
    ATM, 312
    for voice calls, 359–360
  burst options for voice traffic, 323–324
  busy-hour call handling, 416
  centum call seconds, 416
  decibel levels, 205
  delay budget, 435, 437–438
  erlangs, 416
  fragmentation size, 268–269
  payback period of capital investments, 460–461
  peak options for voice traffic, 323–324
call detail recording (CDR), 421
call legs, 181

call progress indicators, 38
call progress tone, voice port configuration, 185
call setup (VoFR), displaying information, 301–302
CallManager, 373
    admission control, 381–383
callout, PBX systems, 416–417
calls
    analog, placing, 23–26
    VoIP, 345
capacitors, 27
capacity planning
    for voice traffic, 416–417
    integrated voice/data networks, 438–439
        global firms, 445
        multinational firms, 468–470
        pan-European firms, 453, 456–458
capital investments, calculating payback period, 460–461
carriers (PBX systems), 411–412
CAS (channel-associated signaling), 79, 317, 417
case studies, network design, 440
    global firms, 440–448
    multinational firms, 462–471
    pan-European firms, 449–461
Catalyst 6000 Voice T1 module, 388
CBR (constant bit rate), 308
CBWFQ (class-based weighed fair queuing), 354–355
ccfrf11 function calls, displaying, 297, 299
CCM (Cisco CallManager), admission control, 381–383
CCS (common channel signaling), 80, 317, 418–419
ccs connect command, 217
ccswvoice function calls, displaying, 299–300
CDR (call detail recording), 421
cells (ATM), SAR, 309
CELP (code excited linear predictive) coding, 63
centralized control PBXs, 403
centum call seconds, 416
channel banks, drop-and-insert, 12
characteristics
    of access layer, 9
    of distribution layer, 10
Chord, 60
CIPT (Cisco IP Telephony Solutions), 373
CIR (committed information rate), 260
    configuring on PVC/SVC, 280
circuits, local loop, 28–32, 39
circuit-switching, 13, 414
Cisco 1750 series routers, 91
Cisco 2600 series routers, 92–94
    configuring, 147–148
    digital T1/E1 packet voice trunk, 103–104
    PVDM (Packet Voice DSP Module), 103
    VICs, 102
    voice/fax network module, 101–102
Cisco 3600 series routers, 95
    Cisco 3620 modular access routers, 95
    Cisco 3640 modular access routers, 95
    Cisco 3660 modular access routers, 95
    configuring, 148, 150–151
    digital T1/E1 packet voice trunk, 103–104
    hardware, verifying installation, 156
    PVDM (Packet Voice DSP Module), 103
    VICs, 102
        assembly, 155
        port addressing, 155
        selecting, 154–155
    VNMs
        assembly, 155
        selecting, 152
    voice/fax network module, 101–102
Cisco 7200 series routers, 112–114
Cisco 7500 series routers, 114, 117
Cisco AS5300 routers, 107
    feature cards, selecting, 171–172
Cisco AS5800 routers, 110–112
Cisco conference bridges, AVVID, 391–392
Cisco IP Phones, 375. *See also* IP Phones
    model 7910, 384
    model 7960, 385
Cisco MC3810 router, 105–107
Cisco MCM (Multimedia Conference Manager), , 107, 133–134, 139
Cisco MCS-7822, 389
Cisco MCS-7835, 390
Cisco VG200 VoIP gateway, 387–388

Cisco voice-over routers
connection types
local, 123
off-net, 124
on-net, 123
on-to off-net, 126
PLAR, 124
tie-line, 125
trunk calls, configuring, 286–287
Cisco WebAttendant for AVVID, 392
Cisco Works Voice Manager, 134
Cisco's VoFR implementation, 262–264
Cisco's VoIP implementation, 347
class command, 271
classes of service (ATM), 308–309
minimizing delay, 310
classification schemes (packets), 349
CLECs (competitive local exchange carriers), 7
client/server-based PBXs, 407–408
clock source command, 215
clocking, T1 connections, 76–77
clustering technology, Cisco CallManager, 390
CO (central office), 6
local loop, 28–32
switches, 40–41
trunks, 47
codec command, 192
codec complexity command, 240
codecs (coder-decoders), 56
compression types, 193–194
coding, 61, 431
coloring, 265
combining voice and data traffic, 16–18, 131
comfort noise, 65
commands
atm pvc, 326
auto-cut-through, 191–192
cablelength long, 216
ccs connect, 217
class, 271
clock source, 215
codec, 192
codec complexity, 240
compand-type, 195
connection, 197
connection tie-line, 201
connection trunk, 202–203
controller, 215
cptone, 185
debug, 248, 331, 363
debug ccfrf11 session, 297, 299
debug ccswvoice vofr-debug, 299
debug ccswvoice vofr-session, 299
debug frame-relay fragment, 300–301
debug voice vofr, 301–302
description, 185, 216
destination-pattern, 224, 230
dial-peer voice, 224, 229–230
dial-peer voice voatm, 324
dial-type, 187
ds0-group timeslots type, 218–220
echo cancel coverage, 209
echo-cancel enable, 208
encapsulation, 320
encapsulation frame-relay, 270
forward digits, 228
frame-relay adaptive-shaping, 281
frame-relay bc, 281
frame-relay be, 281
frame-relay cir, 280
frame-relay fair-queue, 278–279
frame-relay fragment, 279–280
frame-relay interface dlci, 270–271
frame-relay mincir, 280
frame-relay traffic-shaping, 274
frame-relay voice bandwidth, 275
framing, 216
impedence, 208, 211
input gain, 206, 215
interface atm, 319
linecode, 216–217
loopback, 234
loop-timed, 216
loss plan, 206
loss-plan, 210
map-class frame-relay, 275
mode, 316, 318–319
mode cas, 317
mode ccs, 218
network-clock-select, 164
non-linear, 209
num-exp, 226
operation, 189
output attenuation, 206, 215

port, 225–226
prefix, 228
pvc name, 319
ring frequency, 187
ring number, 186
session target, 231–234, 324
show, 246–247, 329, 363
show atm pvc, 329
show dial-peer voice, 243
show frame-relay fragment, 294–295, 297
show frame-relay vofr, 292–293
show interface, 330
show running-config, 245
show voice port, 245
shutdown, 185
signal, 185, 189
signal pattern, 237
signal-type, 235
test, 248–249
timeout interdigit, 212
timeouts initial, 212
timing, 212–213
type, 190–191
vad, 227
vbr-rt, 322
vofr, 271–274
voice bandwidth, 276–278
voice class permanent, 236
voice confirmation-tone, 198
voice local-bypass, 214
voice vad-time, 213
voice-card, 239
voice-port, 182–183
companding, 59
compand-type command, 195
comparing
E1 and T1 lines, 80
key systems and PBXs, 398
voice compression techniques, 64
voice-capable and standards-based routers, 121
components
of AVVID, 372–373
access gateways, 375
CallManger, 373
Cisco IP Phones, 375
uOne, 374
of basic PBX architecture, 410
compression, 61, 431. *See also* companding
degradation of voice quality, 70
HCMs (high-performance voice-compression modules), 159–160
hybrid, 63–64
techniques
codecs, 193–194
comparing, 64
vocoder, 62–63
wave form, 62
concentrators, MC3810
analog voice cable connections, configuring, 166–167
BRI voice module, configuring, 163–164
digital chassis, configuring, 160–161
hardware installation, verifying, 167–168
interface ports, configuring, 156, 158, 160
MFT options, configuring, 162–163
trunk options, configuring, 161
configuration commands, ATM
dial-peer voice voatm, 324
encapsulation, 320
inarp parameter, 325
interface atm, 319
mode, 316, 318–319
pvc name, 319
session target, 324
vbr-rt, 322
configuring
ABCD bit pattern for trunks, 237, 239
analog voice ports, 182–183
Cisco 2600 routers, 147–148
Cisco 3600 routers, 148, 150–151
port addressing, 155
VIC selection, 154–155
VNM selection, 152
controllers, 215–216
dial peers, 223–224, 229–230, 244, 328–329
voice-over, 229–242
digital voice ports, 183
E1 controller settings, 217, 219
fragmentation, 358
end-to-end FRF.12, 283
Frame Relay, Cisco proprietary, 284
FRF.11 Annex C fragmentation for data traffic, 283
Frame Relay map classes, 275

FRF.11 trunk calls, 287–288
local dial peers, 224–227, 229
MC3810
BRI voice module, 163–164
digital chassis, 160–161
interface ports, 156, 158
MFT options, 162–163
WAN trunk options, 161
MC3810 for voice-over, 165
MLPPP, 361
packet classification schemes, 349
PQ-WFQ, 282, 356
private-line calls, 286–287
RTP header compression, 351
VoATM, 322
VoFR
CIR, 284
PVCs, 284–285
tandeming, 289, 291
voice cards, 239
voice ports
E&M, 189–195
ISDN PRI, 221, 223
tie-line connections, 201–202
voice-over dial peers, session targets, 233–234
WFQ, 282
confirmation tone, 38
congestion
BECN, 260
management, 350
telephone networks, 38
connection command, 197
connection sequence, H.323, 340–341
connection tie-line command, 201
connection trunk command, 202–203
connections
E1, 78
framing, 78
line coding, 79
FXO, 128
local, 123
off-net, 124
on-net, 123
on-to off-net, 126
PLAR, 124
T1, 71–72
clocking, 76–77
D4 framing pattern, 73
ESF, 74–76
line coding, 76–77
management channel, 74–76
Ones Density rule, 76–77
robbed bit signaling, 73–74
tie-line, 125
conserving bandwidth, 381–383
digital speech interpolation, 65
constant bit rate (CBR), 308
control complex, 400
control signaling, 418
controller command, 215
controllers, configuring, 215–216
conversational quality speech (ITU-T), 68
converting analog signals to digital
compression, 61
hybrid compression, 63–64
vocoder, 62–63
wave form compression, 62
encoding process, 60–61
quantization process, 58–60
sampling, 56–57
core layer, 11
in new-world networks, 19
correcting input levels on voice ports, 210
cost/benefit analysis, integrated voice/data networks, 439
global firms, 446, 448
multinational firms, 470–471
pan-European firms, 460–461
cptone command, 185
CPUs, PBX processing network design, 407
CQ (Custom Queuing), 353
creating peer configuration table, 328
CS-ACELP (conjugate structure-algebraic code excited linear predictive), 64, 432
CTIs (computer telephony interfaces), 401, 422–423

D

D4 framing pattern, 73
data link layer, VoIP protocol stack, 337
data networks, 6
  Frame Relay, 15–16
  leased-line, 7
  traffic shaping, 314
  voice/data integration, 132
  voice-date integration, 131
data queuing methods
  CBWFQ, 354–355
  CQ, 353
  FIFO, 352
  LLQ, 356–358
  PQ, 352
  WFQ, 353
data traffic, FRF.11 Annex C fragmentation, example configuration, 283
databases, SS7, 83
DE (Discard Eligible) bit, 265
debug ccfrf11 session command, 297, 299
debug ccswvoice vofr-debug command, 299
debug ccswvoice vofr-session command, 299
debug command, 331
debug commands, 248, 362–363
debug frame-relay fragment command, 300–301
debug voice vofr command, 301–302
decibel levels, calculating, 205
degradation of voice quality in compression schemes, 70
de-jitter buffers, 17, 259, 435
delay, 17
  ATM, minimizing, 310
  dejitter buffers, 435
  integrated voice/data networks, 427
  jitter, 431
  packetization delay, 436
  processing delay, 434
  propagation delay, 434
  queuing delay, 435
  serialization delay, 434
delay budget, 336
  calculating, 435, 437–438
delay-start signaling, 35
deregulated telecommunications markets, network cloud terminology, 7
description command, 185, 216
designing networks
  auditing current network, 428–429
    global firms, 440
    multi-national firms, 463
    pan-European firms, 449
  capacity planning, 438–439
    global firms, 445
    multinational firms, 468–470
    pan-European firms, 453, 456–458
  case studies, 440
    global firm, 440, 443, 446, 448
    multinational firm, 462–471
    pan-European firm, 449–461
  establishing technologies guidelines, 430–434
    delay budgets, 436–438
    global firms, 444
    multinational firms, 464–468
    pan-European firms, 452–453
  financial analysis, 439
    global firms, 446–448
    multinational firms, 470–471
    pan-European firms, 460–461
  reviewing technologies and services, 430
    global firms, 441–443
    multinational firms, 464
    pan-European firms, 450
  setting objectives, 429
    global firms, 441
    multi-national firms, 463
    pan-European firms, 450
destination pattern, 123
destination-pattern command, 224, 230
devices
  analog access gateways, 375
  AVVID
    Cisco conference bridges, 391–392
    Cisco WebAttendant, 392
    gateways, 386–387, 389
    IP Phones, 384–385
    media convergence servers, 389–390
  codecs, 56
  destination patterns, 123
  drop-and-insert, 12
  switches, 39
    CO, 40–41
    intermediate, 41

PBXs, 41
voice, 40
DHCP (dynamic host configuration protocol)
in AVVID, 376
dial peers, 179
call legs, 181
configuring, 223–224, 244, 328–329
E.164 telephone numbers, configuring, 225
example configuration, 242
local, configuring, 224–227, 229
POTS, 181
verifying configuration, 243
voice-over, 181
configuring, 229–242
session targets, 233–234
dial tone, 38
dialers, 27
dial-peer voice command, 224
dial-peer voice voatm command, 324
dial-type command, 187
DID (direct inward dial), 420
trunks, 48
wink start signaling, 418
DiffServ, 349
digital chassis (MC3810), configuring, 160–161
digital signals, conversion from analog
compression, 61–64
encoding process, 60–61
Nyquist theorem, 57
quantization process, 58–60
sampling, 56–57
digital trunks
gateways, 386
T1/E1 packet voice trunk, Cisco 2600/3600 series routers, 103–104
digital voice networks, 6
digital voice ports
configuring, 183–184
disabling, 185
dispersed control PBXs, 405
displaying
function calls
ccfrf11 , 297–299
ccswvoice, 299–300
VoFR call setup information, 301–302
distributed control PBXs, 404
distribution layer, 10
in new-world networks, 19
DLCIs (data-link connection identifiers)
assigning to Frame Relay subinterface, 270–271
bandwidth, reserving, 275
VoFR, enabling, 271–274
DPNSS (Digital Private Network Signaling System), 18
drop-and-insert, 12
ds0-group timeslots type command, 218–220
DS1, 71. *See also* T1
digital signal Superframe format, 72
DSCP (DiffServ Code Point), 265
DSP (digital signal processor) modules
digital speech interpolation, 65
on AS5300s, 170
selecting, 172
DTMF (dual-tone multi-frequency), 37
DVM (digital voice module)
architecture, 160–161
mode cas command, 317

E

E&M signaling
Type I lines, 42–43
Type II lines, 43
Type III lines, 44
Type IV lines, 44
Type V lines, 46
E&M trunk seizure, 32–36
delay-start signaling, 35
disconnect, 36
immediate-start signaling, 36
wink-start signaling, 34–35
E&M voice ports, 33–34
call completion, enabling, 191–193
Cisco 2600/3600 series routers, 102
configuring, 189–195
signaling type, specifying, 189
VICs, 127–129
E.164 telephone numbers, dial peer configuration, 225

E1
Catalyst 6000 Voice E1 module, 388
channel signaling, 78
comparing to T1, 80
controller settings, configuring, 217–219
framing, 78
line coding, 79
echo, 49–50
echo cancel coverage command, 209
echo-cancel enable command, 208
ECMA (European Computer Manufacturer's Association), 18
enabling
call completion on E&M voice ports, 191–193
Frame Relay on interfaces, 270
encapsulation, MLPPP, 132
encapsulation command, 320
encapsulation frame-relay command, 270
encoding, 60–61
end-to-end FRF.12 fragmentation, example configuration, 283
enterprise networks
FXO, 128
H.323, 139
hoot-and-holler applications, 138–139
OPX connections, 138
PBX implementations, 400–401
toll bypass, 137
enterprise telephony, 20
erlangs, 416
ESF (Extended Superframe Format), 74–76
establishing voice quality guidelines, 431
coding/compression, 431
fixed delay components, 434
MOS, 432–433
variable delay components, 435
Ethernet Phone, 130
example configurations
Cisco-trunk calls, 286–287
dial peers, 242
PQ-WFQ, 282
VoATM, 322, 326–328
VoFR
CIR, 284
Cisco proprietary fragmentation, 284
end-to-end FRF.12 fragmentation, 283
FRF.11 trunk calls, 287–288
PVCs, 284–285
tandeming, 289–291
WFQ, 282
Extended Superframes, 72–74
external networks, 401

F

fast busy signal, 38
fast packet switching, PBXs, 415
fax-to-fax connections, 130
FDM (frequency division multiplexing), 6
feature cards
circuit cards, PBX systems, 412
Cisco AS5300, 170
Cisco AS5800 Voice Feature card, 111
MICA (modem ISDN channel aggregation), 170
VOIP, selecting, 171–172
features of PBXs, 420–421
FECN (forward explicit congestion notification), 260
FIFO (First In First Out) queuing, 352
first-generation private telephony systems, 400
fixed delay
processing delay, 258
propagation delay, 257
serialization delay, 258
fixed prioritization, 314–316
formulas for calculating bandwidth, ATM, 312–314
forward-digits command, 228
fragmentation, 266, 358, 280
Cisco proprietary (Frame Relay), example configuration, 284
FRF.11 Annex C, example configuration, 283
MLPPP, configuring, 361
PDU size, calculating, 268–269
Frame Relay, 15–16. *See also* VoFR
fragmentation, 280
map classes, configuring, 275
frame synchronization, D4 framing pattern, 73
frame-relay adaptive-shaping command, 281
frame-relay bc command, 281
frame-relay be command, 281
frame-relay cir command, 280

frame-relay fair-queue command, 278–279
frame-relay fragment command, 279–280
frame-relay interface dlci command, 270–271
frame-relay mincir command, 280
frame-relay traffic-shaping command, 274
frame-relay voice bandwidth command, 275
frames, prioritizing, 260
framing command, 216
framing patterns
  DS1, 71
  E1, 78
  ESF, 74, 76
FRF.11 Annex C fragmentation, 260
  configuring for data traffic, 283
  subchannels, displaying information, 292–293
  trunk calls, configuring, 287–288
FRF.12 fragmentation, 260
  example configuration, 283
fricatives, 63
FRTS (Frame Relay traffic shaping), 260–261
FXO (foreign exchange office)
  Cisco 2600/3600 series routers, 102
  trunks, 47–48, 128
  voice ports
    dial type, specifying, 187
    terminating impedence, specifying, 208
FXS (foreign exchange station)
  applications, 129
  Cisco 2600/3600 series routers, 102
  trunks, 48
  voice ports
    impedence, adjusting, 211
    ring frequency, specifying, 187

G

G.711 standard (ITU-T), 66
gain, adjusting, 206
gatekeepers, 133–134, 338
gateways, 338–340, 386–389
  Catalyst 6000 Voice T1 module, 388
  Cisco AS5300, 107
  Cisco AS5800, 110–112
  digital trunk gateways, 386
  H.323, 141
  VG 200 VoIP gateway, 387–388
GF (Generic Feature), Q.SIG, 83
GF (generic functional) sublayer (QSIG), 419
glare, 30
goals of uOne, 374
ground start signaling, 30–32, 418
  specifying for voice ports, 186
GSTN (global system telephone network), 373
guaranteed traffic rates, FRTS, 261

H

H.225 protocol, 341
H.245, 341
H.323, 139, 338–342
  connection sequence, 340–341
  gateways, 340
  H.225, 341
  H.243, 341
  in AVVID, 377
  IP Phone, 130
  media formats, 379
  signaling, 340
  terminals, 339
handsets, 26
hardware
  AVVID
    Cisco conference bridges, 391–392
    Cisco WebAttendant, 392
    gateways, 386–387, 389
    IP Phones, 384–385
    media convergence servers, 389–390
  VoATM, 310–311
  MC3810
    analog voice cable connections, 166–167
    installation, verifying, 167–168
Hawking, Stephen, 63
HCMs (high-performance voice-compression modules), 159–160
  Cisco MC3810, 107
HDB3 (high density bit 3), 78
HDV (High Density Voice) NM, 103
high availability on MCS-7822 media convergence server, 389
high density bit 3 (HDB3), 78
high-utilization trunks (HUTs), 49
holding time per call, calculating, 417

hoot-and-holler, 138–139
hunt groups, 392
HUTs (high-utilization trunks), 49
hybrid compression, 63–64
    2- to 4-wire, balanced, 27, 49

I

IDF (intermediate distribution frame), 402
IMA cards, 311
immediate-start signaling, 36
impedence command, 208, 211
implementing
    IP voice installations, building blocks, 349–350
    VoIP with MGCP, 342
improving voice quality, 205–214
inarp parameter, 325
information signaling, 38, 417
    alerting indicators, 38
    call progress indicators, 38
input gain command, 206, 215
input power levels
    correcting on voice ports, 210
    baselining, 205
installation, verifying for Cisco 3600 series routers, 156
integrated voice/data networks
    delay, 427
        propagation delay, 427
    delay budget, calculating, 435, 437–438
    design process
        auditing network inventory, 428–429
        capacity planning, 438–439
        case studies, 440–471
        establishing technologies guidelines, 430–434
        delay budgets, 436–438
        financial analysis, 439
        reviewing technologies and services, 430
        setting network objectives, 429
interexchangenetworks, 401
interface atm command, 319
interface cards. *See* VICs
interfaces
    E&M, 33–34
    in PBXs, 413
    MC3810, configuring, 156–160
intermediate switches, 41
inter-office trunks (IOTs), 49
interpolation, 65
intertandem trunks (ITTs), 49
IOTs (inter-office trunks), 49
IP Phones, 375, 384–385
    Cisco IP Phone 7910, 384
    Cisco IP Phone 7960, 385
IP Precedence, 265, 337
IP protocols in AVVID
    DHCP, 376
    H.323, 377
    MGCP, 378–379
    SCCP, 379
    TFTP, 376
ISDN (Integrated Services Digital Network), 6
    BRI VoIP, 104
    network architecture, 81
    network protocols, 82
    PRI, voice port configuration, 221–223
ISO 3166 country name standards, 185
ITTs (inter-tandem trunks), 49
ITU-T Recommendation I.451, 419–420
IVR (interactive voice response), 20, 422

J-K-L

J1, 80
jitter, 17, 431
    dejitter buffers, 435

key systems, 397–399

large-scale voice/data routers
    Cisco 7200 series, 112–114
    Cisco 7500 series, 114, 117
    Cisco AS5800, 110–111
latency. *See* delay
layers of VoIP protocol stack, 337–338
LCR (least-cost routing), 420
LD-CELP (low-delay CELP), 63

LD-CELP (low-delay code-excited linear-predictive) algorithms, 432
leased line networks, 7
  point-to-point, 8
  multi-drop, 9
least-cost routing (LCR), 420
LECs (local exchange carriers), 6
legacy PBX systems, 397
legacy telephony systems
  PBXs, 399–401
  private key systems, 398–399
limitations of bandwidth, voice-grade telephony channels, 57
line circuit cards in PBX systems, 412
line coding
  E1, 79
  T1, 76–77
line interface circuitry, PBX systems, 411–412
line provisioning, 438–439
linecode command, 216–217
listener echo, 49–50
LLQ (Low Latency Queuing), 337, 356–358
local calls, 123
local connections, 123
local dial peers, configuring, 224–229
local loop, 39
  ground start signaling, 30–32
  loop start signaling, 28–30
local networks, 401
logical voice ports, 219
long data frames, 260
loop start circuits, 28
loop start signaling, 28–30, 418
  specifying for voice ports, 186
loopback command, 234
loop-timed command, 216
loss-plan command 206, 210
low-delay CELP (code excited linear predictive) coding, 63

M

main system controller (PBXs), 410
maintaining synchronization over digital interfaces, 81
make/break cycle, 36
management channel, T1 line coding, 74, 76
map classes, configuring, 275
map-class frame-relay command, 275
marking, 265
MC3810 routers
  analog voice cable connections, 166–167
  BRI voice module, configuring, 163–164
  digital chassis, configuring, 160–161
  fixed prioritization, 314–316
  hardware installation, verifying, 167–168
  interface ports, configuring, 156, 158, 160
  MFT (multiflex trunk module) options, configuring, 162–163
  synchronous serial connections, 167
  voice-over configuration, 165
  WAN trunk options, configuring, 161
MCM (Multimedia Conference Manager), 133–134, 139
MCS-7822, 389
MCS-7835, 390
MCU (multipoint control unit), 339
MDF (main distribution frame), 402
measuring
  PBX traffic handling, 416–417
  speech quality, 68, 70–71
    PSQM, 69
    subjective, MOS, 432–433
    telephone voice quality, 65
media convergence servers
  for AVVID, 389–390
  MCS-7822, 389
  MCS-7835, 390
media formats, H.323, 379
Meet-Me conferences, 391
Megaco, 342
MELCAS (Mecury Exchange Limited), 317
messaging
  Q.931 signaling, 419–420
  unified messaging, 141
  uOne, 374
  voice-mail systems, 422
MFT (Multiflex Trunk), 311
  configuring on MC3810, 162–163
  VWIC, 103

MGCP (Media Gateway Control Protocol), 18, 338, 342
configuring on MC3810, 162–163
MICA (modem ISDN channel aggregation, 170
minCIR (minimum committed information rate), 260
minimizing delay in VoATM, 309–310
MLPPP (Multilink Point-to-Point Protocol), 360
configuring, 361
encapsulation, 132
mode cas command, 317
mode ccs command, 218
mode command, 316, 318–319
modular wiring, PBX systems, 411
modulation, B8ZS, 77
monitoring commands, 329–331
MOS (mean opinion score), 68, 432–433
MTP (media termination point), 382
multicast conference bridges, 391
multi-drop networks, 8–9
multiflex trunking, 457
Multiframes, 79
multipoint controller, 339
multiservice networks
voice/date integration, 131
voice-over technology, selecting, 132
multiservice routers
Cisco AS5300, 107
Cisco MC3810, 105–107

N

network design
access layer requirements, 9
new-world networks, 18
auditing current network, 428–429
global firms, 440
multi-national firms, 463
pan-European firms, 449
capacity planning, 438–439
global firms, 445
multinational firms, 468–470
pan-European firms, 453, 456–458
case studies, 440
global firm, 440–448
multinational firm, 462–471
pan-European firm, 449–461
circuit-switched, 13
core layer requirements, 11, 19
distribution layer requirements, 10, 19
establish technologies guidelines, 430–434
delay budgets, 436–438
global firms, 444
multinational firms, 464–468
pan-European firms, 452–453
financial analysis, 439
global firms, 446–448
multinational firms, 470–471
pan-European firms, 460–461
reviewing technologies and services, 430
global firms, 441– 443
multinational firms, 464
pan-European firms, 450
setting objectives, 429
global firms, 441
multi-national firms, 463
pan-European firms, 450
shared, 12
traditional, 5
data, 6–7
voice, 5–6
network layer (VoIP protocol stack), 337
Network Module-Inverse Multiplex ATM (NM-IMA), 311
network protocols, ISDN, 82
network-clock-select command, 164
new-world telephony models, AVVID, 373
access gateways, 375
CallManager, 373
Cisco conference bridges, 391
Cisco IP Phones, 375
Cisco WebAttendant, 392
Cisco's role in, 18–20
DHCP, 376
gateways, 386–387, 389
H.323, 377
IP Phones, 384–385
media convergence servers, 389–390
MGCP, 378–379
SCCP, 379

signaling, 380
TFTP, 376
uOne, 374
NM-IMA (Network Module-Inverse Multiplex ATM), 311
NMs (network modules), HDV (High Density Voice), 103
non-linear command, 209
non-real time service classes, 314, 316
num-exp command, 226
Nyquist theorem, 56–57

O

off-hook state, 28
off-net calls, 124
off-net connections, 124
old-world telephony models, 371. *See also* new-world telephony models
PBXs, 397, 402
ACD, 421–422
adjunct control, 406
architecture, 408–414
automated attendant, 421
busy hour call handling, 415–416
callout, 416–417
centralized control, 403
circuit switching, 414
client/server-based, 407–408
CTI, 422–423
dispersed control, 405
distributed control, 404
fast packet switching, 415
features, 420–421
IVR, 422
line interfaces, 412
packet switching, 415
processing network design, 407
switching network design, 403
trunk interfaces, 413
Windows/Unix server-based, 407
wiring, 413–414
private systems
key systems, 398–399
PBXs, 399, 401
Ones Density rules, 76–77, 80
on-hook state, 28
on-net connections, 123
on-to off-net connections, 126
oos (out-of-service) receive pattern, 237
operation command, 189
options
dial-peer voice voatm command, 324
encapsulation command, 321
interface atm command, 319
mode command, 317
pvc command, 320
session target command, 325
vbr-rt command, 322, 324
OPX connections, 138
output attenuation command, 206, 215
output power levels, baselining, 205

P

packet switching, PBXs, 415
packetization delay, 436
packets
classification schemes, 349
fragmentation, 266, 358
SAR, 309
scheduling, 264
sequencing, 343–344
time-stamping, 343–344
payback period, calculating for capital investments, 460–461
PBXs (private branch exchanges), 6, 41, 397–399, 401–402
ACD, 421–422
architecture, 408, 410–414
cabinet/shelf controller, 409
main system controller, 410
wiring, 413–414
automated attendant, 421
busying out, 237
circuit switching, 414
CTI, 422–423
fast packet switching, 415
features, 420–421
grounding, 42
in enterprise networks, 401

IVR (interactive voice response), 422
legacy systems, 397
line interfaces, 412
local loop, 39
old-world telephony model, 371
packet switching, 415
processing methods
busy hour call handling, 415–416
callout, 416–417
circuit/packet switching, 414–415
processing network design, 407
client/server-based, 407–408
Windows/Unix server-based, 407
switching network design, 403
adjunct control, 406
centralized control, 403
dispersed control, 405
distributed control, 404
tandem switching, disadvantages in voice networks, 137
terminal interfaces, 400
tie-lines, 32
trunk interfaces, 413
trunks, 46–47
CO trunks, 47
DID/DOD trunks, 48
FXO trunks, 47–48
private trunk lines, 47
telco trunks, 48
voice-mail systems, 422
PBX-to-PBX calls, 125
peak options for voice traffic, calculating, 323–324
peer configuration table, VoATM, 328
Perceptual Speech Quality Measurement (PSQM), 69
permanent calls. PLAR connections, 199
per-VC queuing, enabling on PVCs, 274
physical connectivity, MC3810, 166–167
physical layer, VoIP protocol stack, 337
pilot number, 374
PINX (private integrated network exchange), 163–164
QSIG, 419
placing a call, 23–26
PLAR (private line automatic ring-down), 124, 198
off-premises extension, 200
point-to-point connections, enterprise networks, 138–139
point-to-point networks, 8
policing, 264
port addressing, Cisco 3600 routers, 155
port circuit cards, PBX systems, 412
controller, 410
port command, 225–226
POTS, dial peers, 181, 328
power failure transfer, 421
power supply, telephones, 40
PQ (priority queuing), 352
PQ-WFQ (priority queuing-weighted fair queuing), 355–356
example configuration, 282
prefix command, 228
presentation layer, VoIP protocol stack, 338
prioritizing voice frames, 260
private networks, 401
private phone systems, 397
private telephony systems
first-generation, 400
key systems, 398–399
PBXs, 399, 402
ACD, 421–422
adjunct control, 406
architecture, 408, 410–414
automated attendant, 421
busy hour call handling, 415–416
callout, 416–417
centralized control, 403
circuit switching, 414
client/server-based, 407–408
CTI, 422–423
dispersed control, 405
distributed control, 404
fast packet switching, 415
features, 420–421
IVR, 422
line interfaces, 412
packet switching, 415
processing network design, 407
switching network design, 403
terminal interfaces, 400
trunk interfaces, 413
Windows/Unix server-based, 407
wiring, 413–414

second-generation, 400
third-generation, 400
private trunk lines, 47
private-line calls, example configuration, 286–287
processing delay, 258, 434
processing methods, PBXs
busy hour call handling, 415–416
callout, 416–417
switching, 414–415
processing network designs (PBXs)
client/server-based, 407–408
Windows/Unix server-based, 407
propagation delay, 257, 434
integrated voice/data networks, 427
protocol stack, VoIP, 337–338
PSQM (Perceptual Speech Quality Measurement), 69
PSTNs (private switched telephone networks). *See also* old-world telephony
access code, 124
access numbers, pilot number, 374
FXO interfaces, 128
PTT (Post, Telephone, and Telegraph) agency, 7
pulsed digits, 36
pvc name command, 319
PVCs (permanent virtual circuits), 13
fragmentation, displaying information, 300–301
per-VC queuing, enabling, 274
traffic shaping, 260–261
virtual template parameters, 321
WFQ, enabling, 278–279
PVDM (Packet Voice DSP Module), 103

Q

Q.931 signaling, 419–420
Q.SIG, 83, 419
Q.SIG GF (Generic Features), 83
QoS (quality of service)
applying to VoFR, 264–265
fragmentation size, calculating, 268–269
quantization, 58–60
queue management, 350
CBWFQ, 354–355
data transmission
CQ, 353
FIFO, 352
PQ, 352
LLQ, 356, 358
PQ-WFQ, 355–356
RTP header compression, 350–351
WAN edge queuing techniques, 351
WFQ, 353
queuing, 264
delay, 259, 435
PQ-WFQ, example configuration, 282
WFQ, example configuration, 282

R

rate queues, 326
real time service classes, 314–315
RED (Random Early Detection), 350
regional offices, redesigning for voice traffic, 454
regulated telecommunications markets, network cloud terminology, 7
reorder, 38
reserving bandwidth on DLCIs, 275
residual echo suppression, 210
ring frequency command, 187
ring number command, 186
ring-back, 38
ringer, 27
robbed bit signaling, 73–74, 417
ABCD format, 74–76
rotary telephones
pulsed digits, 36
routers
Cisco 1750 series, 91
Cisco 2600 series, 92, 94
configuring, 147–148
digital T1/E1 packet voice trunk, 103–104
PVDM, 103
VICs, 102
voice/fax network module, 101–102

Cisco 3600 series, 95
Cisco 3620 modular access routers, 95
Cisco 3640 modular access routers, 95
Cisco 3660 modular access routers, 95
configuring, 148–151
digital T1/E1 packet voice trunk, 103–104
PVDM, 103
VICs, 102, 154–155
VNM, selecting, 152
voice/fax network module, 101–102
Cisco 7200 series, 112–114
Cisco 7500 series, 114, 117
Cisco AS5300, 107
Cisco AS5800, 110–112
Cisco MC3810, 105–107
signaling
between routers, 346
to PBX, 347
voice-over connection types, 123–126
RSVP (Resource Reservation Protocol), 344
RTP header compression, 343–344, 350
configuring, 351

S

sampling, Nyquist theorem, 56–57
SAP (Session Announcement Protocol), 342
SAR (segmentation and reassemby), 309
SCCP (signaling connection control part), AVVID, 379
scheduling, 264
second-generation private telephony systems, 400
selecting
DSP modules, 172
network technology, 430
global firms, 441, 443
multinational firms, 464
pan-European firms, 450
VICs, Cisco 3600 routers, 154–155
VNMs, Cisco 3600 routers, 152
voice-over technologies, 132
VoATM, 135–136
VoFR, 134
VOIP feature cards, 171–172
sequencing packets, 343–344
serialization delay, 258, 358, 434
server farms, 408
service circuit cards, PBX systems, 412
service classes (ATM), 308–309
minimizing delay, 310
non-real time, 314–316
real time, 314–315
service provider telephony, 20
VPNs, 402
session layer, VoIP protocol stack, 338
session target command, 231–234, 324
session targets, configuring on voice-over dial peers, 233–234
setting network objectives, 429
global firms, 441
multi-national firms, 463
pan-European firms, 450
shaping traffic, 264
shared networks, drop-and-insert devices, 12
show atm pvc command, 329
show commands, 246–247, 329, 362–363
show dial-peer voice command, 243
show frame-relay fragment command, 294–295, 297
show frame-relay vofr command, 292–293
show interface command, 330
show running-config command, 245
show voice port command, 245
shutdown command, 185
sidetone, 27
signal command, 185, 189
signal pattern command, 237
signaling, 27, 417
AVVID, 380
between routers, 346
CAS, 79, 317
CCS, 317, 418–419
delay-start, 35
DID wink start, 418
E&M
disconnect, 36
seizure, 32, 34–35
Type I lines, 42–43
Type II lines, 43
Type III lines, 44
Type IV lines, 44
Type V lines, 46
E1 channel, 78
from router to PBX, 347

glare, 30
ground start, 418
H.323, 338, 340–342
H.225, 341
H.245, 341
immediate-start, 36
information, 38
local loop
ground start signaling, 30, 32
loop start signaling, 28, 30
loop start, 418
Q.931, 419–420
Q.SIG, 83, 419
specifying type for voice ports, 185, 189
supervisory, 28
local-loop seizure, 28, 30, 32
VoIP, 345
wink-start, 34–35
signal-type command, 235
silence suppression, VAD, 227
SIP (Session Initiation Protocol), 18, 342
smoother circuits, 60
SOT (service order threshold), 353
specifying
BVMs as clock source, 164
confirmation tones for voice ports, 198
signaling type for voice ports, 185
speech quality
establishing guidelines, 431
coding/compression, 431
fixed delay components, 434
MOS, 432–433
variable delay components, 435
measuring, 65, 67
MOS (mean opinion score), 68, 70–71
toll-quality, 67
transparent quality (ITU-T), 67
SS7 (Signaling System 7), 82
SSCP (Skinny Station Control Protocol), 379
subjective speech measurement, MOS, 68–71, 432–433
sublayers of QSIG, 419
Superframes, 72
supervisory signaling, 28, 417
local-loop seizure, 28–32
SVCs (switched virtual circuits), 13
switch hook, 27
switched calls
PLAR connections, 199
tandeming, configuration, 289, 291
switching, 39, 400
circuit switching, 414
CO, 40–41
fast packet switching, 415
intermediate switches, 41
packet switching, 415
PBXs, 41–42
adjunct control, 406
centralized control, 403
dispersed control, 405
distributed control, 404
voice switches, 40
symptoms of poor QoS, 266
synchronization
D4 framing pattern, 73
time-slot, 80
synchronous serial connections, for MC3810, 167
synthetic quality speech (ITU-T standard), 68
system circuit cards, PBX systems, 412
system processor bus, PBX design, 409
system-wide PBX features, 420–421

T

T1 line coding, 71–72, 76–77
Catalyst 6000 Voice T1 module, 388
clocking, 76–77
comparing to E1, 80
controller settings, 216–217
D4 framing pattern, 73
ESF (Extended Superframe Format), 74, 76
management channel, 74, 76
Ones Density rules, 76–77
robbed bit signaling, 73–74
tagging, 265
talk slots, 417
talk spurts, 259
talker echo, 49–50
tandeming, 289–291
disadvantages in voice networks, 137
TCD (telephony call dispatcher), 392
TDM cross connect. *See* drop-and-insert
telco trunks, 48

telephony systems
confirmation tone, 38
devices, 26–27
glare, 30
GSTN (global system telephone network), 373
off-hook state, 28
old-world
key systems, 398–399
PBXs, 399, 401
on-hook state, 28
power supply, 40
private
first-generation, 400
PBXs, 402
second-generation, 400
third-generation, 400
switches, 39
CO switches, 40–41
intermediate switches, 41
PBXs, 41
voice switches, 40
third-generation, 400
terminal interfaces, 400
terminals, 339
test commands, 248–249
TFTP (trivial file transport protocol), AVVID, 376
third-generation private telephony systems, 400
tie-line connections, 32, 125, 129
voice port configuration, 201–202
time slots, 417
timeouts initial command, 212
timeouts interdigit command, 212
time-slot synchronization, 80
time-stamping, UDP packets, 343–344
timing command, 212–213
toll bypass, 137
toll quality speech
G.711 standard, 66
ITU-T standard, 67
ToS (type of service) bits, 349
traditional networks, 5
data networks, 6–7
delay, 17
jitter, 17
shared, 12
voice, 5–6
traffic
classes, 308–309
minimizing delay, 310
non-real time, 314–316
real time, 314–315
congestion management, 350
packet classification schemes, 349
policing, 264
queuing, 264
scheduling, 264
voice/data integration, 132
traffic shaping, 260–261, 264
ATM, 312
for data/video, 314
voice traffic
calculating average options, 323–324
calculating burst options, 323–324
calculating peak options, 323–324
transcoding, 389
transparent quality speech, 67
transport layer, VoIP protocol stack, 338
troubleshooting commands, 329–331, 362
debug commands, 363
show commands, 363
troubleshooting QoS, 269
trunks, 46–47
ABCD bit pattern, configuring, 237, 239
CO trunks, 47
DID/DOD trunks, 48
digital trunk gateways, 386
FXO trunks, 47–48
FXS trunks, 48
interfaces, 411–413
line provisioning, 438–439
MC3810, setting options for, 161
MFT (Multiflex Trunk), 311
private trunk lines, 47
service cards, 412
telco trunks, 48
voice classes, configuring, 236

tuning voice port quality, 205–207, 209–214
two-way communication, VoATM, 328
type command, 190–191
Type I E&M lines, 42–43
Type II E&M lines, 43
Type III E&M lines, 44
Type IV E&M lines, 44
Type V E&M lines, 46

U

UBR (unspecified bit rate), 308
UDP (user datagram protocol), time-stamping packets, 343–344
unacceptable telephone voice quality, 66
unicast conference bridges, 391
unified messaging, 141
Unix server-based PBXs, 407
unsatisfactory speech quality (ITU-T standard), 68
unspecified bit rate (UBR), 308
uOne, 374
upgrading networks, pan-European firms, 455–458
user features for PBX, 420–421

V

VAD (voice activity detection), 65
vad command, 227
variable bit rate (VBR), 308
variable delay
  de-jitter buffers, 259
  queuing delay, 259
  WAN/service provider delay, 259
variation. *See also* delay
VBR (variable bit rate), 308
VBR-nrt (non-real time), 308
VBR-rt (real time), 308
vbr-rt command, 322
VC (virtual circuit) queues, VoATM networks, 135
verifying
  dial peer configuration, 243
  hardware installation
    Cisco 3600 routers, 156
    MC3810, 167–168
VFCs (voice feature cards), Cisco AS5800, 111. *See also* feature cards
VG 200 VoIP gateway, 387–388
VICs (voice interface cards)
  assembly, 155
  Cisco 2600/3600 series routers, 102
  E&M, 127
  port addressin, Cisco 3600 routers, 155
  selecting, 154–155
virtual circuits (VCs), 13
VNMs
  assemby, 155
  selecting, 152
VoATM, 135–136
  bandwidth allocation, 309
  dial peers, configuring, 328–329
  example, 326, 328
  example configuration, 322
  hardware, 310–311
  peer configuration table, 328
  VC queues, 135
vocoder compression, 62–63
VoFR, 134
  CIR, example configuration, 284
  Cisco implementation, 262
    benefits of, 263
    restrictions, 264
  enablingn on specified DLCI, 271–274
  PVCs, example configuration, 284–285
  QoS, applying, 264–265
  tandeming, 289, 291
vofr command, 271–274
voice bandwidth command, 276–278
voice calls, calculating bandwidth, 359–360
voice cards, configuring, 239
voice class permanent command, 236
voice compression
  codec complexity, 240
  comparing techniques, 64
Voice Feature cards, Cisco AS5800, 111
voice gateways
  Cisco AS5300, 107
  Cisco AS5800, 110–112
voice local-bypass command, 214

voice networks, 5. *See also* integrated voice/data networks
  analog, 6
  capacity planning, 438–439
    global firms, 445
    multinational firms, 468–470
    pan-European firms, 453, 456–458
  delay, 427
  delay budget, calculating, 435, 437–438
  digital, 6
  echo, 49–50
  echo cancellation, 50
  echo suppression, 50
  financial analysis, 439
    global firms, 446–448
    multinational firms, 470–471
    pan-European firms, 460–461
voice ports, 179
  analog, configuring, 182
  call progress tone, setting, 185
  confirmation tones, specifying, 198
  connection mode, specifying, 197
  decibel levels, calculating, 205
  digital, configuring, 183
  disabling, 185
  E&M
    call completion, enabling, 191–193
    configuring, 189–195
  FXO
    dial type, specifying, 187
    impedence, adjusting, 211
    terminating impedence, specifying, 208
  FXS, specifying ring frequency, 187
  input/output power levels
    baselining, 205
    correcting, 210
  ISDN PRI, configuring, 221, 223
  logical, 219
  PLAR
    off-premises extension, 200
    specifying, 198
  residual echo suppression, 210
  signaling type, specifying, 185
  string description, adding, 185
  tie-line connections, configuring, 201–202
  timing parameters, adjusting, 212–213
  trunk connections, specifying, 202–203
  tuning, 205–214
voice quality
  establishing guidelines, 431
    coding/compression, 431
    fixed delay components, 434
    MOS, 432–433
    variable delay components, 435
  measuring, 65
voice switches, 40
Voice T1 and Services Module, 389
voice vad-time command, 213
voice/data integration, *See* integrated voice/data networks
voice/fax network module, Cisco 2600/3600 series routers, 101–102
voice-card command, 239
voice-confirmation-tone command, 198
voice-grade analog channels, bandwidth, 56
voice-mail systems, 422
  AVVID, 16
  uOne messaging, 374
voice-over technologies
  connection types
    local, 123
    off-net, 124
    on-net, 123
    on-to off-net, 126
    PLAR, 124
    tie-line, 125
  dial peers, 181, 229–242
  MC3810, configuring, 165
  selecting, 132
  VoATM, 135–136
  VoFR, 134
voice-port command, 182–183
voice-port tuning commands, 204
VoIP
  Cisco implementation, 347
  H.323, 338, 340–342
  ISDN BRI, 104
  signaling, 345
VPNs (virtual private networks), 402
VWICs, MFT (MultiFlex Trunk), 103

W-Z

WANs
    bandwidth, conserving over links, 381–383
    edge queuing techniques, 351
    fast packet switching, 415
    service provider delay, 259
wave form compression, 62
WFQ (weighted fair queuing), 353
    enabling for PVCs, 278–279
    example configuration, 282
WICs (WAN interface cards), MFT (MultiFlex Trunk) VWIC, 103
Windows server-based PBXs, 407
wink signals, 418
wink-start signaling, 34–35
wiring, PBX systems, 413–414
WRED (Weighted Random Early Detection), 350

X.25, 15–16