

Contents

About This Document..... iii

1 Feature Specifications and Limitations..... 1

2 GPON..... 2

2.1 Introduction to GPON..... 2

2.2 GPON Working Principle..... 4

2.3 GPON System Principle..... 6

2.3.1 GPON Basic Concepts..... 6

2.3.2 GPON Service Multiplexing..... 10

2.3.3 GPON Protocol Stacks..... 11

2.3.4 GPON Frame Structure..... 13

2.3.5 OMCI..... 17

2.4 Key GPON Techniques..... 21

2.4.1 GPON Ranging..... 21

2.4.2 GPON Burst Optical/Electrical Technology..... 22

2.4.3 GPON DBA..... 24

2.4.4 GPON FEC..... 25

2.4.5 GPON Line Encryption..... 26

2.4.6 GPON Energy Conservation..... 27

2.4.7 ONU Automatic Registration and Service Flow Creation..... 30

2.4.8 ONU Automatic Migration and Aging..... 32

2.5 GPON Terminal Authentication and Management..... 33

2.5.1 GPON Terminal Authentication (ONU Is Not Preconfigured)..... 33

2.5.2 GPON Terminal Authentication (ONU Has Been Pre-configured)..... 35

2.5.3 GPON Terminal Management..... 39

2.6 Continuous-Mode ONU Detection..... 47

2.7 Remote Software Commissioning (PON)..... 50

2.7.1 Introduction..... 50

2.7.2 Principles..... 51

2.7.3 Configuring Remote Software Commissioning (GPON)..... 53

2.8 GPON Configuration Guide (Profile mode)..... 54

2.8.1 Configuring a GPON ONT Profile (Profile mode)..... 54

2.8.1.1 Configuring a DBA Profile..... 55

2.8.1.2 Configuring a GPON ONT Line Profile (Profile Mode).....	55
2.8.1.3 Configuring a GPON ONT Service Profile (Profile Mode).....	60
2.8.1.4 Configuring a GPON ONT Alarm Profile.....	67
2.8.2 Configuring a GPON ONT (Profile Mode).....	69
2.8.3 Configuring a GPON Port.....	73
2.9 GPON Configuration Guide (Distributed mode).....	76
2.9.1 Configuring a GPON ONT Profile (Distributed Mode).....	76
2.9.1.1 Configuring a DBA Profile.....	77
2.9.1.2 Configuring a GPON ONT Capacity Profile (Distributed Mode).....	78
2.9.1.3 Configuring a GPON ONT Alarm Profile.....	79
2.9.2 Configuring a GPON ONT (Distributed Mode).....	81
2.9.3 Configuring a GPON Port.....	85
2.10 GPON Reference Standards and Protocols.....	88
3 XG(S)-PON.....	89
3.1 Introduction to XG(S)-PON.....	89
3.2 XG(S)-PON Network Structure.....	90
3.3 XG(S)-PON Working Principle.....	91
3.3.1 Basic Concepts.....	91
3.3.2 System Transmit Principles.....	92
3.3.3 Working Principles of Downstream.....	93
3.3.4 Working Principle of Upstream.....	94
3.4 XG(S)-PON Key Technologies.....	95
3.4.1 Ranging.....	95
3.4.2 Burst Optical/Electrical Technology.....	96
3.4.3 DBA.....	98
3.4.4 FEC.....	99
3.5 XG(S)-PON Security Technologies.....	100
3.5.1 Line Encryption.....	100
3.5.2 ONU Authentication.....	101
3.5.3 Continuous-Mode ONU Detection.....	102
3.6 Evolution From GPON to XG(S)-PON.....	104
3.6.1 Network Evolution Overview.....	104
3.6.2 Evolution Solution - Using XG(S)-PON Combo.....	106
3.6.2.1 What Is XG(S)-PON Combo?.....	106
3.6.2.2 XG(S)-PON Combo Working Principle.....	107
3.6.2.3 XG(S)-PON Combo Evolution Solution.....	107
3.6.2.4 XG(S)-PON Combo Configuration Guide.....	109
3.6.3 Evolution Solution-Using Flex-PON.....	110
3.6.3.1 What Is Flex-PON?.....	110
3.6.3.2 What Is 10G PON Port RTU?.....	111
3.6.3.3 Evolution Solution Overview.....	115
3.6.3.4 GPON Evolution to XG-PON.....	118

3.6.3.5 GPON Evolution to XGS-PON.....	119
3.6.3.6 GPON Evolution to XG-PON Combo.....	120
3.6.3.7 GPON Evolution to XGS-PON Combo.....	122
3.6.3.8 Flex-PON Configuration Guide.....	124
3.7 XG(S)-PON Reference Standards and Protocols.....	125
4 50G-PON.....	127
4.1 50G-PON Feature Updates.....	127
4.2 PON Technology Evolution.....	127
4.3 Introduction to 50G-PON.....	129
4.4 50G-PON System Architecture.....	130
4.5 50G-PON Working Principles.....	131
4.5.1 Basic Concepts.....	131
4.5.2 System Transmission Principles.....	132
4.5.3 Downstream Working Principles.....	132
4.5.4 Upstream Working Principles.....	133
4.6 Key 50G-PON Technologies.....	134
4.6.1 Ranging.....	135
4.6.2 Burst Optical/Electrical Technology.....	135
4.6.3 DBA.....	138
4.6.4 FEC.....	139
4.7 50G-PON Security Policies.....	140
4.7.1 Line Encryption.....	140
4.7.2 ONU Authentication.....	141
4.7.3 Continuous-Mode ONU Detection.....	143
4.8 50G-PON Evolution Solution.....	144
4.8.1 50G-PON Network Evolution Overview.....	144
4.8.2 Working Principles of 50G-PON Combo PON.....	145
4.8.3 Evolution Solution for XGS-PON Networks.....	146
4.9 50G-PON Service Configuration.....	147
4.10 50G-PON Standards and Protocols.....	148
5 Ethernet Networking Applications.....	150
5.1 P2P Optical Access.....	150
5.1.1 What Is P2P Optical Access.....	150
5.1.2 Networking Application.....	151
5.1.3 Configuring MDUs Cascaded to an OLT.....	153
5.2 NE Cascading.....	155
5.2.1 Introduction to NE Cascading.....	155
5.2.2 Principle of NE Cascading.....	156
5.2.3 Configuring NE Cascade and Uplink Transmission.....	157
5.3 Ethernet OAM.....	159
5.3.1 Introduction.....	160
5.3.2 Ethernet OAM Reference Standards and Protocols.....	161

5.3.3 Differences in Implementing Y.1731 and 802.1ag on Access Device.....	161
5.3.4 CFM (802.1ag and Y.1731).....	162
5.3.4.1 CFM Introduction.....	162
5.3.4.2 CFM Network Application.....	164
5.3.4.3 CFM Basic Concepts.....	165
5.3.4.4 CFM Principles.....	168
5.3.4.4.1 CC Principle.....	168
5.3.4.4.2 LT Principle.....	171
5.3.4.4.3 LB Principle.....	171
5.3.4.4.4 AIS Principles.....	174
5.3.4.4.5 LLF Principles.....	175
5.3.4.5 Configuring the Ethernet CFM OAM.....	179
5.3.5 EFM (802.3ah).....	187
5.3.5.1 EFM Introduction.....	187
5.3.5.2 EFM Basic Concept.....	189
5.3.5.3 EFM Principle.....	191
5.3.5.4 EFM Configuration.....	195
5.3.5.4.1 Configuring an EFM Remote Loopback.....	195
5.3.5.4.2 Configuring EFM Ethernet Link Monitoring.....	197
5.3.5.5 EFM Maintenance and Diagnosis.....	199
5.3.6 PM (Y.1731).....	199
5.3.6.1 PM Introduction.....	199
5.3.6.2 PM Networking Application.....	201
5.3.6.3 PM Basic Concepts.....	204
5.3.6.4 PM Principles.....	207
5.3.6.4.1 Performance Monitoring with Typical VLAN Planning.....	207
5.3.6.4.2 Performance Monitoring with Typical QoS Planning.....	211
5.3.6.5 PM Configuration.....	215
6 MPLS.....	222
6.1 Overview.....	222
6.2 MPLS Reference Standards and Protocols.....	223
6.3 MPLS Overview.....	225
6.3.1 Introduction.....	225
6.3.2 Principle.....	225
6.4 MPLS RSVP-TE.....	231
6.4.1 Introduction.....	231
6.4.2 Principle.....	232
6.5 MPLS OAM.....	234
6.5.1 Introduction.....	234
6.5.2 Principle.....	235
6.6 MPLS TE Reliability.....	237
6.6.1 RSVP-TE FRR.....	237

6.6.1.1 Introduction.....	238
6.6.1.2 Principle.....	238
6.6.2 TE Tunnel Protection Group.....	245
6.6.2.1 Related Concepts.....	245
6.6.2.2 Principle.....	245
6.6.3 CR-LSP Backup.....	248
6.6.3.1 Related Concepts.....	248
6.6.3.2 Principle.....	249
6.7 Configuring the MPLS Service.....	252
6.7.1 Configuring the Static LSP.....	252
6.7.2 Configuring the LDP LSP.....	255
6.7.3 Configure an RSVP-TE LSP.....	258
6.7.4 Configuring the MPLS RSVP-TE FRR.....	262
6.7.5 Configuring the MPLS OAM.....	268
6.7.5.1 Configuration Example for Detection of MPLS OAM for Static LSP Connectivity.....	269
6.7.5.2 Configuration Example of the MPLS OAM Protection Switching Function.....	273
7 SRv6.....	279
7.1 Feature Change History.....	279
7.2 Introduction.....	279
7.3 Basic Principles.....	281
7.4 IS-IS for SRv6.....	287
7.5 SRv6 VPN.....	289
7.6 Example for Configuring of SRv6 VPN.....	292
7.7 Example for Configuring SRv6 EVPN.....	295
8 VXLAN.....	298
8.1 VXLAN Overview.....	298
8.2 Basic VXLAN Concepts.....	300
8.3 VXLAN Implementation Principles.....	301
8.4 VXLAN Deployment.....	303
8.5 Configuring VXLAN.....	304
8.6 Configuring EVPN-VXLAN.....	305
9 VPN.....	310
9.1 PWE3.....	310
9.1.1 Introduction to PWE3.....	311
9.1.2 PWE3 Reference Standards and Protocols.....	311
9.1.3 PWE3 Principle.....	312
9.1.3.1 Basic Principle of PWE3.....	312
9.1.3.2 Principle of TDM PWE3.....	318
9.1.3.3 Principle of ETH PWE3.....	322
9.1.3.4 Traffic Label Principle.....	324
9.1.3.5 PW 1:1 Redundancy.....	326

9.1.3.6 PW Redundancy.....	327
9.1.3.7 PW OAM (VCCV).....	328
9.1.4 PWE3 Network Applications.....	331
9.1.5 Configuring the PWE3 Private Line Service.....	332
9.1.5.1 Configuring the PWE3 Outer Tunnel.....	333
9.1.5.2 Configuring the Tunnel Policy.....	334
9.1.5.3 Configuring the PWE3 Inner PW.....	335
9.1.5.4 Binding the Service to the PW.....	339
9.1.5.5 Configuring PW Protection.....	340
9.1.5.6 Configuring MPLS Tunnel Protection.....	341
9.1.5.7 Configuring CR-LSP Backup.....	344
9.2 Native TDM.....	346
9.2.1 Introduction to Native TDM.....	346
9.2.2 Native TDM Reference Standards and Protocols.....	347
9.2.3 Native TDM Principle.....	347
9.3 VPLS.....	348
9.3.1 What Is VPLS.....	349
9.3.2 VPLS Reference Standards and Protocols.....	349
9.3.3 VPLS Principles.....	349
9.3.3.1 Introduction to VPLS.....	349
9.3.3.2 VPLS Layer 2 Functions.....	356
9.3.3.3 LDP VPLS.....	359
9.3.3.4 VPLS PW Redundancy.....	362
9.3.4 VPLS PW Redundancy Applications.....	364
9.3.4.1 Application of VPLS Individual Access.....	364
9.3.4.2 Application of VPLS Enterprise Access.....	366
9.3.4.3 VPLS PW Redundancy for Protecting Multicast Services.....	367
9.3.4.4 VPLS PW Redundancy for Protecting Unicast Services.....	371
9.3.5 Configuring VPLS MP2MP Intercommunication.....	374
9.3.6 Configuration Example of VPLS.....	378
9.3.6.1 Configuration Example of the VPLS Internet Access Service.....	379
9.3.6.2 Configuration Example of the VPLS Multicast Service.....	384
9.3.6.3 Configuration Example of the VPLS Enterprise Private Line Service.....	389
9.4 VRF.....	395
9.4.1 Introduction to VRF.....	395
9.4.2 VRF Principle.....	396
9.4.3 Configuring IPv4 in VPN.....	398
9.4.4 Configuring IPv6 in VPN.....	402
9.5 BGP/MPLS IP VPN.....	407
9.5.1 Introduction to BGP/MPLS IP VPN.....	408
9.5.2 BGP/MPLS IP VPN Reference Standards and Protocols.....	409
9.5.3 Basic BGP/MPLS IP VPN.....	410

9.5.4 Related Concepts for BGP/MPLS IP VPN.....	411
9.5.5 BGP/MPLS IP VPN Principles.....	416
9.5.6 Hub & Spoke.....	418
9.5.7 MCE.....	422
9.5.8 BGP/MPLS IP VPN Label Distribution Modes.....	424
9.5.9 BGP Site of Original (SoO).....	426
9.5.10 Terms, Acronyms, and Abbreviations for BGP/MPLS IP VPN.....	427
9.6 GRE.....	430
9.6.1 Introduction to GRE.....	430
9.6.2 GRE Basic Principles.....	431
9.6.3 GRE Principles.....	435
9.6.3.1 Keepalive Detection.....	435
9.6.3.2 GRE Security Mechanism.....	435
9.6.4 GRE Applications.....	436
9.6.5 GRE Configuration.....	439
9.6.5.1 Example for Configuring a Static Route for GRE.....	439
9.6.5.2 Example for Configuring a L3VPN over GRE Tunnel.....	442
10 Layer 2 Forwarding.....	445
10.1 MAC Address Management.....	445
10.1.1 What Is MAC Address Management.....	445
10.1.2 MAC Address Management Process.....	447
10.1.3 Smooth MAC Address Expansion.....	450
10.2 VLAN.....	452
10.2.1 What Is VLAN.....	452
10.2.2 VLAN Basic Concepts.....	452
10.2.3 VLAN Communication Principle.....	456
10.2.4 VLAN Aggregation (Super VLAN).....	458
10.2.5 QinQ VLAN and Stacking VLAN.....	465
10.2.6 VLAN Translation.....	468
10.2.7 VLAN Planning Suggestion.....	470
10.2.8 VLAN Translation Policies Specifications.....	472
10.2.9 Configuring a VLAN.....	475
10.2.9.1 Creating a VLAN.....	477
10.2.9.2 Configuring the VLAN attribute.....	479
10.2.9.3 Configuring Upstream Port of a VLAN.....	483
10.2.9.4 Configuring a VLAN Service Profile.....	483
10.2.9.5 Example: Configuring the QinQ VLAN.....	488
10.2.9.6 Example: Configuring VLAN Stacking Multi-ISP Wholesale Access.....	493
10.2.10 VLAN Reference Standards and Protocols.....	498
10.3 Service Flow.....	498
10.3.1 Introduction to Service Flow.....	498
10.3.2 Service Flow Principles.....	499

10.3.3 Configuring Service Flow.....	504
10.3.3.1 Creating an Ethernet Service Flow.....	504
10.3.3.2 Creating a GPON Service Flow	507
10.3.3.3 Creating a GPON Service Flow (in Profile Mode with Universal Configurations).....	510
10.3.3.4 Creating a GPON Service Flow in Profile Mode with Simplified Configurations.....	514
10.3.3.5 Configuring Automatic Service Flow Creation (GPON).....	518
10.3.4 Maintenance and Diagnosis.....	527
10.4 Service Port Bundle.....	527
10.4.1 What Is Service Port Bundle.....	527
10.4.2 Schematic Diagram For Service Port Bundle.....	528
10.4.3 Configuring a Service Port Bundle.....	529
10.5 Layer 2 Forwarding Policy.....	530
10.5.1 Layer 2 Forwarding Policy Overview.....	531
10.5.2 Layer 2 Forwarding Policy Principles.....	531
10.5.3 Configuring a Layer 2 Forwarding Policy.....	533
10.6 Layer 2 User Bridging.....	535
10.6.1 Layer 2 User Bridging Overview.....	535
10.6.2 Layer 2 User Bridging Principles.....	535
10.6.3 Configuring VLAN-based Layer 2 User Bridging.....	537
11 Layer 3 Forwarding.....	539
11.1 IPv4.....	540
11.1.1 Introduction to IPv4.....	540
11.1.2 Principles to IPv4.....	540
11.1.2.1 ICMP.....	540
11.1.2.2 TCP.....	542
11.1.2.3 UDP.....	543
11.1.2.4 RawIP.....	543
11.1.2.5 Socket.....	544
11.1.3 IPv4 Reference Standards and Protocols.....	545
11.2 IPv6.....	545
11.2.1 Why IPv6 is Required.....	545
11.2.2 IPv6 network deployment.....	546
11.2.3 IPv6 Principles.....	547
11.2.3.1 IPv6 Highlights.....	547
11.2.3.2 IPv6 Addresses.....	550
11.2.3.3 IPv6 Packet Format.....	553
11.2.3.4 ICMPv6.....	556
11.2.3.5 PMTU.....	558
11.2.3.6 Dual Protocol Stacks.....	558
11.2.3.7 TCP6.....	559
11.2.3.8 UDP6.....	560
11.2.3.9 RawIP6.....	560

11.2.3.10 IPv6 Neighbor Discovery.....	561
11.2.4 Configuring Basic IPv6 Information.....	564
11.2.4.1 Configuring an IPv6 Address for an Interface.....	566
11.2.4.2 Configuring PMTU.....	568
11.2.4.3 Configuring IPv6 Neighbor Discovery.....	569
11.2.5 IPv6 Reference Standards and Protocols.....	572
11.3 ARP.....	573
11.3.1 Introduction.....	574
11.3.2 Principles.....	575
11.3.2.1 Basic Principles.....	575
11.3.2.2 Dynamic ARP.....	581
11.3.2.3 Static ARP.....	584
11.3.2.4 Gratuitous ARP.....	586
11.3.2.5 IP Address Conflict Detection.....	588
11.3.3 Configuring ARP.....	589
11.3.4 ARP Reference Standards and Protocols.....	590
11.4 ARP Proxy.....	591
11.4.1 Introduction to ARP proxy.....	591
11.4.2 Proxy ARP.....	591
11.4.3 Configuring ARP Proxy for Interworking.....	595
11.4.4 ARP Proxy Reference Standards and Protocols.....	599
11.5 DHCP Server.....	600
11.5.1 Feature Change History.....	600
11.5.2 Introduction to the DHCP Server.....	600
11.5.3 Basic Principles.....	601
11.5.4 Configuring the DHCP Server.....	602
11.6 DHCPv6 Server.....	604
11.6.1 DHCPv6 Server Feature Changes.....	604
11.6.2 Introduction to DHCPv6.....	604
11.6.3 DHCPv6 Server Principles.....	605
11.6.4 Configuring the DHCPv6 Server.....	607
11.7 DHCP Relay.....	608
11.7.1 DHCP Relay Overview.....	608
11.7.2 DHCPv4 Relay Principles.....	610
11.7.3 DHCPv6 Relay Principle.....	612
11.7.4 Configuring DHCPv4 Relay.....	613
11.7.4.1 Configuring the Standard Mode.....	615
11.7.4.2 Configuring the DHCP Option 60 Mode.....	618
11.7.4.3 Configuring the DHCP MAC Address Segment Mode.....	620
11.7.5 Differences Between DHCPv4 and DHCPv6 Configurations.....	623
11.7.6 DHCP Relay Standards and Protocols Compliance.....	624
11.8 DHCP Proxy.....	624

11.8.1 What Is DHCP Proxy.....	624
11.8.2 DHCP Proxy Principles.....	625
11.8.3 DHCP Proxy Standards and Protocols Compliance.....	628
11.9 BFD.....	628
11.9.1 Introduction to BFD.....	628
11.9.2 Principles to BFD.....	629
11.9.3 BFD Echo.....	632
11.9.4 Application Environment.....	634
11.9.4.1 BFD for IP.....	635
11.9.4.2 BFD for OSPF.....	635
11.9.4.3 BFD for IS-IS.....	636
11.9.4.4 BFD for BGP.....	637
11.9.4.5 BFD for RSVP.....	638
11.9.4.6 BFD for LAG.....	639
11.9.4.7 BFD for PW.....	639
11.9.5 Configuring the BFD.....	642
11.9.5.1 Configuring BFD Sessions.....	642
11.9.5.2 Configuring One-Arm BFD Echo Sessions.....	645
11.9.5.3 Configuring BFD for IPv4 Static Routes.....	647
11.9.5.4 Configuring BFD for OSPF.....	648
11.9.5.5 Configuring BFD for IS-IS.....	649
11.9.5.6 Configuring BFD for BGP or BGP4+.....	651
11.9.5.7 Configuring BFD for RSVP.....	653
11.9.5.8 Configuring BFD for LAG.....	655
11.9.6 BFD Reference Standards and Protocols.....	655
11.10 TWAMP.....	656
11.10.1 TWAMP Introduction.....	657
11.10.2 TWAMP Basic Concepts.....	658
11.10.3 TWAMP Principles.....	660
11.10.4 TWAMP for ONT.....	665
11.10.5 Configuring TWAMP.....	666
11.10.5.1 Configuring TWAMP Responder.....	666
11.10.5.2 Configuring TWAMP for ONT.....	667
11.10.6 TWAMP Reference Standards and Protocols.....	669
11.11 TWAMP Light.....	669
11.11.1 TWAMP Light Introduction.....	670
11.11.2 TWAMP Light Basic Concepts.....	670
11.11.3 TWAMP Light Principles.....	672
11.11.4 Configuring TWAMP Light Responder.....	675
11.11.5 TWAMP Light Reference Standards and Protocols.....	676
11.12 Routing.....	676
11.12.1 IP Routing Overview.....	676

11.12.1.1 Introduction to Routing.....	676
11.12.1.2 Routers.....	677
11.12.1.3 Routing Table and FIB Table.....	678
11.12.1.4 Routing Protocols.....	681
11.12.1.5 Priority-based Route Convergence.....	684
11.12.1.6 Load Balancing and Route Backup.....	686
11.12.1.7 Re-advertisement of Routing Information.....	687
11.12.1.8 Default Route.....	688
11.12.1.9 IP FRR.....	688
11.12.1.10 ECMP.....	689
11.12.1.10.1 Introduction to ECMP.....	689
11.12.1.10.2 ECMP Principle.....	690
11.12.1.10.3 ECMP Fast Switching.....	690
11.12.2 Static Route.....	691
11.12.2.1 Introduction.....	692
11.12.2.2 Components.....	692
11.12.2.3 Applications.....	693
11.12.2.4 Configuration Example of the IPv4 Static Route.....	695
11.12.2.5 Configuration Example of the IPv6 Static Route.....	696
11.12.2.6 Example for Configuring IP FRR for an IPv4 Static Route.....	698
11.12.2.7 Example for Configuring IP FRR for an IPv6 Static Route.....	700
11.12.3 RIP.....	702
11.12.3.1 Introduction.....	703
11.12.3.2 Principles.....	703
11.12.3.2.1 RIP-1.....	703
11.12.3.2.2 RIP-2.....	704
11.12.3.2.3 Timers.....	704
11.12.3.2.4 Split Horizon.....	705
11.12.3.2.5 Poison Reverse.....	707
11.12.3.2.6 Triggered Update.....	707
11.12.3.2.7 Route Summarization.....	708
11.12.3.2.8 Multi-Process.....	709
11.12.3.2.9 RIP NSR.....	709
11.12.3.2.10 RIP Authentication.....	709
11.12.3.3 Configuration Example of RIP.....	710
11.12.3.4 RIP Reference Standards and Protocols.....	713
11.12.4 RIPvng.....	713
11.12.4.1 Introduction.....	714
11.12.4.2 RIPvng Packet Format.....	714
11.12.4.3 Timers.....	716
11.12.4.4 Split Horizon.....	716
11.12.4.5 Poison Reverse.....	717

11.12.4.6 Triggered Update.....	717
11.12.4.7 Route Summarization.....	718
11.12.4.8 Multi-Process and Multi-Instance.....	719
11.12.4.9 Hot Standby.....	719
11.12.4.10 IPsec Authentication.....	719
11.12.4.11 RIPng NSR.....	720
11.12.4.12 Configuration Example of RIPng.....	721
11.12.4.13 RIPng Reference Standards and Protocols.....	725
11.12.5 IS-IS.....	725
11.12.5.1 Introduction.....	725
11.12.5.2 Principles.....	725
11.12.5.2.1 Basic Concepts of IS-IS.....	726
11.12.5.2.2 Basic Protocols of IS-IS.....	729
11.12.5.2.3 IS-IS Routing Information Control.....	736
11.12.5.2.4 IS-IS Overload.....	739
11.12.5.2.5 IS-IS Fast Convergence.....	739
11.12.5.2.6 IS-IS LSP Fragment Extension.....	741
11.12.5.2.7 IS-IS 3-Way Handshake.....	745
11.12.5.2.8 IS-IS NSR.....	745
11.12.5.2.9 IS-IS Wide Metric.....	746
11.12.5.2.10 IS-IS Authentication.....	747
11.12.5.2.11 IS-IS Control Messages.....	749
11.12.5.2.12 IS-IS for IPv6.....	755
11.12.5.2.13 IS-IS Auto FRR.....	755
11.12.5.3 Configuration Example of IS-IS.....	756
11.12.5.4 Configuration Example of IS-IS for IPv6.....	758
11.12.5.5 Example for Configuring IS-IS Auto FRR.....	760
11.12.5.6 Example for Configuring IPv6 IS-IS Auto FRR.....	763
11.12.5.7 IS-IS Reference Standards and Protocols.....	765
11.12.6 OSPF.....	767
11.12.6.1 Introduction to OSPF.....	767
11.12.6.2 Principles.....	769
11.12.6.2.1 Basic Concepts of OSPF.....	769
11.12.6.2.2 Basic Principles of OSPF.....	778
11.12.6.2.3 OSPF Route Control.....	785
11.12.6.2.4 OSPF NSSA.....	787
11.12.6.2.5 OSPF Fast Convergence.....	788
11.12.6.2.6 OSPF NSR.....	790
11.12.6.2.7 OSPF Authentication.....	790
11.12.6.2.8 OSPF Packet Format.....	792
11.12.6.2.9 OSPF LSA Format.....	799
11.12.6.2.10 OSPF IP FRR.....	805

11.12.6.3 Configuration Example of OSPF.....	807
11.12.6.4 Example for Configuring OSPF IP FRR.....	809
11.12.6.5 OSPF Reference Standards and Protocols.....	811
11.12.7 OSPFv3.....	812
11.12.7.1 Introduction.....	812
11.12.7.2 Principles.....	812
11.12.7.2.1 OSPFv3 Fundamentals.....	812
11.12.7.2.2 Comparison Between OSPFv3 and OSPFv2.....	818
11.12.7.2.3 OSPFv3 GR.....	820
11.12.7.2.4 OSPFv3 Authentication.....	821
11.12.7.2.5 OSPFv3 Packet Format.....	822
11.12.7.2.6 OSPFv3 LSA Format.....	828
11.12.7.2.7 OSPFv3 Auto FRR.....	838
11.12.7.3 Configuration Example of OSPFv3.....	839
11.12.7.4 Example for Configuring OSPFv3 Auto FRR.....	843
11.12.7.5 OSPFv3 Reference Standards and Protocols.....	846
11.12.8 BGP.....	847
11.12.8.1 Introduction.....	847
11.12.8.2 Principles.....	849
11.12.8.2.1 Basic Principle.....	849
11.12.8.2.2 BGP Route Processing.....	853
11.12.8.2.3 Peer Group.....	857
11.12.8.2.4 Route Dampening.....	858
11.12.8.2.5 Community Attribute.....	859
11.12.8.2.6 Route Reflector.....	860
11.12.8.2.7 BGP Confederation.....	864
11.12.8.2.8 MP-BGP.....	865
11.12.8.2.9 BGP GR.....	866
11.12.8.2.10 BGP Dynamic Update Peer-Groups.....	868
11.12.8.2.11 BGP NSR.....	870
11.12.8.2.12 4-Byte AS Number.....	872
11.12.8.2.13 BGP Best-external.....	876
11.12.8.2.14 BGP ADD-PATH.....	879
11.12.8.2.15 IP FRR.....	880
11.12.8.3 Configuration Example of BGP.....	882
11.12.8.4 Configuration Example of BGP4+.....	883
11.12.8.5 BGP Reference Standards and Protocols.....	888
11.12.9 Routing Policy.....	891
11.12.9.1 Introduction to Routing Policies.....	891
11.12.9.2 Principles.....	892
11.12.9.3 Applications.....	897
11.12.9.4 Configuration Example of the Routing Policy.....	898

11.12.9.5 Routing Policy Reference Standards and Protocols.....	900
12 Internet Access.....	901
12.1 DHCP Emulation.....	901
12.1.1 DHCP Emulation Overview.....	901
12.1.2 DHCP Emulation Principles.....	902
12.1.3 DHCP Emulation Usage Scenario.....	904
12.1.4 Configuring DHCP Emulation.....	907
12.1.5 DHCP Emulation Reference Standards and Protocols.....	910
12.2 PPPoE Dialup Emulation.....	910
12.2.1 PPPoE Dialup Emulation Introduction.....	910
12.2.2 PPPoE Dialup Emulation Principles.....	911
12.2.3 PPPoE Dialup Emulation Usage Scenario.....	913
12.2.4 Configuring PPPoE Dialup Emulation.....	915
12.2.5 PPPoE Dialup Emulation Reference Standards and Protocols.....	918
12.3 Traffic Burst Detection.....	918
12.3.1 Traffic Burst Detection Overview.....	918
12.3.2 Traffic Burst Detection Principle.....	918
12.3.3 Traffic Burst Detection Application Scenario.....	920
12.3.4 Configure Traffic Burst Detection.....	921
13 Multicast.....	924
13.1 Introduction to Multicast.....	924
13.2 Basic Multicast Concepts.....	926
13.3 Multicast Model.....	932
13.4 Implementation Principles of Multicast.....	936
13.4.1 IGMP.....	936
13.4.1.1 IGMP Protocol.....	936
13.4.1.2 IGMP Mode.....	943
13.4.1.3 IGMP Framework on the Device.....	945
13.4.2 PIM.....	946
13.4.2.1 Introduction.....	946
13.4.2.2 PIM-SM.....	949
13.4.2.3 PIM-SSM.....	954
13.4.2.4 PIM Control Messages.....	957
13.4.3 Multicast Forwarding.....	965
13.4.3.1 Join Flow.....	965
13.4.3.2 Leave Flow.....	966
13.4.3.3 Forwarding Framework on the Device.....	972
13.4.3.4 GPON Multicast Duplication.....	975
13.4.4 Multicast Upstream Interoperation.....	977
13.4.4.1 Multicast Cascading.....	977
13.4.4.2 Ring Network of Uplink Ports.....	983
13.4.4.3 Dual-homing of Upstream Ports.....	987

13.4.5 Advanced Multicast Technologies.....	987
13.4.5.1 Multicast Program Management.....	987
13.4.5.2 Multicast Rights Management.....	989
13.4.5.3 Multicast CAC.....	993
13.4.5.4 Multicast QoS.....	995
13.4.5.5 GPON ONT Multicast.....	996
13.4.5.6 Multi-instance Multicast.....	997
13.4.5.7 Charging Mode.....	1000
13.4.5.8 Double-VLAN Tag Multicast.....	1004
13.4.5.9 Transparent Transmission of Multicast Data.....	1006
13.5 IPv6 Multicast.....	1008
13.5.1 Introduction to IPv6 Multicast.....	1008
13.5.2 Principle.....	1008
13.6 Configuring the Multicast Service.....	1011
13.6.1 Differences Between IPv4 and IPv6 Multicast Configurations.....	1011
13.6.2 Configuring the Multicast Service on a Single NE.....	1013
13.6.2.1 Configuring Multicast Global Parameters.....	1015
13.6.2.2 Configuring the Multicast VLAN and the Multicast Program.....	1018
13.6.2.3 Configuring the Multicast GPON ONT.....	1026
13.6.2.4 Configuring a Multicast User.....	1028
13.6.2.5 (Optional) Configuring the Multicast Bandwidth.....	1030
13.6.2.6 (Optional) Configuring Multicast Preview.....	1032
13.6.2.7 (Optional) Configuring Program Prejoin.....	1034
13.6.2.8 (Optional) Configuring the Multicast Logging Function.....	1035
13.6.2.9 (Optional) Configuring the Maximum Number of Programs That Can Be Watched by the Multicast User.....	1039
13.6.2.10 (Optional) Configuring the Maximum Rate for Sending IGMP Packets.....	1040
13.6.3 Configuring the Multicast Service on a Cascading Network.....	1041
13.6.4 Configuring the Multicast Service in an MSTP Network.....	1043
13.6.5 Configuring the PIM Service.....	1045
13.6.6 Configuring the Layer 2 Reverse Multicast Service.....	1047
13.6.7 Configuring the Layer 3 Reverse Multicast Service.....	1050
13.7 Multicast Maintenance and Diagnosis.....	1054
13.7.1 Multicast Emulation.....	1054
13.7.1.1 Introduction.....	1054
13.7.1.2 Principles.....	1055
13.7.1.3 Usage Scenario.....	1057
13.7.1.4 Configuration.....	1064
13.7.1.5 Multicast Emulation Reference Standards and Protocols.....	1065
13.7.2 Video Quality Monitoring.....	1066
13.7.2.1 Introduction.....	1066
13.7.2.2 Basic Concepts.....	1067
13.7.2.3 Principles.....	1068

13.7.2.4 Configuring Video Quality Monitoring.....	1071
13.7.3 RTP Video Quality Monitoring.....	1072
13.7.4 eMDI Video Quality Monitoring for the Multicast Service.....	1076
13.7.4.1 Introduction.....	1076
13.7.4.2 eMDI Video Quality Monitoring Indicators.....	1078
13.7.4.3 Principle.....	1081
13.7.4.4 Configuring eMDI Video Quality Monitoring.....	1084
13.7.5 eMDI Video Quality Monitoring for the Unicast Service.....	1086
13.7.5.1 Introduction to eMDI for Unicast Services.....	1086
13.7.5.2 eMDI Monitoring Indicators for Unicast Services.....	1089
13.7.5.3 eMDI Interaction Process for Unicast Services.....	1094
13.7.5.4 Network Application of eMDI for Unicast Services.....	1095
13.7.5.5 Configuring eMDI Video Quality Monitoring.....	1097
13.7.6 Common Multicast Maintenance Methods.....	1100
13.8 Multicast Standards and Protocols Compliance.....	1103
13.9 Multicast Feature Updates.....	1104
14 Clock and Time.....	1105
14.1 Clock and Time Feature Updates.....	1106
14.2 Clock and Time Overview.....	1106
14.2.1 Network Synchronization Requirements.....	1106
14.2.2 Synchronization Overview.....	1107
14.2.3 Clock Synchronization.....	1108
14.2.4 Time Synchronization.....	1110
14.3 Physical Layer Clock/Time Synchronization.....	1112
14.3.1 Physical Layer Clock/Time Synchronization Principles.....	1112
14.3.1.1 Synchronous Ethernet.....	1112
14.3.1.2 External Time Source.....	1113
14.3.1.3 Clock Mode.....	1115
14.3.1.4 Clock Source Selection	1115
14.3.2 Physical Layer Clock/Time Synchronization Usage Scenarios.....	1118
14.3.2.1 Applications of Clock Output.....	1118
14.3.2.2 Clock Synchronization of the Synchronous Ethernet Service.....	1118
14.3.3 Configuring the Physical Clock.....	1119
14.3.3.1 Configuring the System Clock Based on the Priority.....	1119
14.3.3.2 Configuring the System Clock Based on the SSM Clock Source Selection Mode.....	1120
14.3.3.3 Configuring External Clock.....	1123
14.3.4 Physical Layer Clock/Time Synchronization Standards and Protocols Compliance.....	1124
14.4 1588v2 (based on IEEE).....	1125
14.4.1 Why Is 1588v2 Required.....	1125
14.4.2 1588v2 Basic Concepts.....	1126
14.4.2.1 Device Model.....	1126
14.4.2.2 Clock Domain and Clock ID.....	1128

14.4.2.3 1588v2 Messages.....	1128
14.4.3 1588v2 Principle.....	1134
14.4.3.1 Clock Synchronization Mechanism.....	1134
14.4.3.2 BMC Algorithm.....	1136
14.4.3.3 Delay Compensation Mechanism.....	1139
14.4.4 1588v2 Network Application.....	1140
14.4.4.1 Recommended: Synchronization Application (Network-wide 1588v2 and Synchronous Ethernet Deployment).....	1140
14.4.4.2 Synchronization Application (Network-wide 1588v2 Deployment).....	1141
14.4.4.3 Synchronization Application (Clock or Time Signal Injection from an OLT).....	1142
14.4.4.4 Time and Clock Synchronization Protection Application.....	1143
14.4.5 Configuring the 1588v2 Function.....	1145
14.4.6 Configuring 1588v2-related Delay Compensation for Asymmetric Fibers.....	1150
14.4.7 1588v2 Maintenance and Diagnosis.....	1152
14.4.8 1588v2 (based on IEEE) Reference Standards and Protocols.....	1152
14.5 1588v2 (Based on G.8275.1).....	1153
14.5.1 Basic Concept.....	1153
14.5.2 BMCA Algorithm.....	1154
14.5.3 Configuring 1588v2 (Based on G.8275.1).....	1155
14.5.4 1588v2 (Based on G.8275.1) Reference Standards and Protocols.....	1157
14.6 1588 ACR.....	1158
14.6.1 Why Is 1588 ACR Required.....	1158
14.6.2 1588 ACR Basic Concepts.....	1159
14.6.2.1 1588 ACR Messages.....	1159
14.6.2.2 PDV.....	1160
14.6.2.3 1588 ACR Modes.....	1161
14.6.2.4 1588 ACR Clock Source Selection Algorithm.....	1165
14.6.3 1588 ACR Principles.....	1166
14.6.3.1 1588 ACR Unicast Negotiation.....	1167
14.6.3.2 1588 ACR Principles.....	1168
14.6.4 1588 ACR Deployment Requirements.....	1169
14.6.5 1588 ACR Networking.....	1169
14.6.6 Configuring 1588 ACR.....	1171
14.6.7 1588 ACR Maintenance and Diagnosis.....	1175
14.6.8 1588 ACR Standard and Protocol Compliance.....	1175
14.6.9 Remote 1588 Packet Capture.....	1176
14.7 NTP.....	1176
14.7.1 NTP Introduction.....	1176
14.7.2 NTP Principle.....	1177
14.7.2.1 NTP Network Architecture.....	1177
14.7.2.2 NTP Operating Mode.....	1178
14.7.2.3 NTP Working Principle.....	1182
14.7.2.4 NTP Security Mechanism.....	1183

14.7.3 Configuring the Network Time.....	1185
14.7.3.1 (Optional) Configuring NTP Authentication.....	1186
14.7.3.2 Configuring the NTP Broadcast Mode.....	1187
14.7.3.3 Configuring the NTP Multicast Mode.....	1190
14.7.3.4 Configuring the Unicast NTP Client.....	1193
14.7.3.5 Configuring the NTP Peer.....	1195
14.7.3.6 Configuring the NTP Multicast Mode.....	1197
14.7.3.7 (Optional) Configuring NTPv4 Control Signaling KOD.....	1200
14.7.4 NTP Standards and Protocols Compliance.....	1202
15 QoS.....	1203
15.1 Introduction to QoS.....	1204
15.2 QoS Models.....	1204
15.3 QoS Scheme.....	1206
15.4 QoS Processing.....	1208
15.5 Traffic Classification.....	1211
15.5.1 Introduction to Traffic Classification.....	1211
15.5.2 Implementation Principle of Traffic Classification.....	1211
15.5.3 Configuring the Traffic Classification.....	1214
15.6 Priority Marking.....	1215
15.6.1 Introduction to Priority Marking.....	1215
15.6.2 Basic Concepts of Priority Marking.....	1216
15.6.3 Priority Sources.....	1219
15.6.4 Implementation Principle of Priority Marking.....	1221
15.6.4.1 Priority Processing for Data Packets.....	1222
15.6.4.2 Priority Processing for DHCP & PPPoE Packets.....	1223
15.6.4.3 Priority Processing for DHCPv6 Packets.....	1225
15.6.4.4 Priority Processing for IGMP Packets.....	1226
15.6.4.5 Priority Processing for ARP Packets.....	1228
15.6.4.6 Priority Processing for ND Packets.....	1230
15.6.5 Configuring the Priority Processing.....	1230
15.7 Traffic Policing.....	1232
15.7.1 Introduction to Traffic Policing.....	1232
15.7.2 Basic Concepts of Traffic Policing.....	1232
15.7.3 Implementation Principle: CAR.....	1234
15.7.4 Traffic Policing Mode.....	1239
15.7.5 Configuring the Traffic Policing.....	1245
15.7.5.1 Configuring Rate Limitation Based on Service Port.....	1245
15.7.5.2 Configuring Rate Limitation Based on Port+CoS.....	1248
15.7.5.3 Configuring User-based Rate Limitation.....	1248
15.7.5.4 Configuring Rate Limitation Based on Port+VLAN.....	1250
15.7.5.5 Configuring GPON Rate Limitation.....	1252
15.7.5.6 Configuring Rate Limiting Based on Priority Group.....	1255

15.8 Traffic Shaping.....	1256
15.8.1 Introduction to Traffic Shaping.....	1256
15.8.2 Basic Concepts of Traffic Shaping.....	1256
15.8.3 Traffic Shaping Implementation.....	1257
15.8.4 Configuring Traffic Shaping.....	1258
15.8.4.1 Configuring a Rate Limit for an ONT.....	1258
15.8.4.2 Configure Queue-based Traffic Shaping for an ONT.....	1259
15.8.4.3 Configuring Rate Limit for an Ethernet Port.....	1260
15.9 Congestion avoidance.....	1260
15.9.1 Introduction to Congestion avoidance.....	1260
15.9.2 Basic Concepts of Congestion avoidance.....	1261
15.9.3 Implementation Principle.....	1262
15.9.4 Configuring the Congestion Avoidance.....	1265
15.10 Congestion Management.....	1269
15.10.1 Introduction to Congestion Management.....	1269
15.10.2 Basic Concepts of Congestion Management.....	1269
15.10.3 Implementation Principle of Congestion Management.....	1270
15.10.4 Configuring the Congestion Management.....	1273
15.11 ACL.....	1275
15.11.1 Overview of ACL.....	1275
15.11.2 Basic Concepts of ACL.....	1276
15.11.3 ACL Rule Matching Sequence.....	1277
15.11.4 ACL Rule Matching Process.....	1279
15.11.5 Matching Principle for the User-defined ACL Rule.....	1282
15.11.6 Configuring Traffic Management Based on ACL Rules.....	1284
15.11.6.1 Configuration Differences Between IPv4 ACLs and IPv6 ACLs.....	1284
15.11.6.2 Configuring an ACL Rule.....	1284
15.11.6.3 Configuring ACL Matching for PPPoE Packets.....	1290
15.11.6.4 Controlling the Traffic Matching an ACL Rule.....	1293
15.11.6.5 Adding a Priority Tag to the Traffic Matching an ACL Rule.....	1294
15.11.6.6 Enabling the Statistics Collection of the Traffic Matching an ACL Rule.....	1294
15.11.6.7 Enabling the Mirroring of the Traffic Matching an ACL Rule.....	1295
15.11.6.8 Enabling the Redirection of the Traffic Matching an ACL Rule.....	1296
15.12 ACLv6.....	1297
15.12.1 Comparison Between ACLv6 and ACLv4.....	1297
15.13 HQoS.....	1297
15.13.1 Overview of HQoS.....	1297
15.13.2 Open Access of HQoS.....	1298
15.13.3 Basic Concepts of HQoS.....	1301
15.13.4 HQoS Service Model (Based on Port+VLAN).....	1301
15.13.5 HQoS Service Model (Based on a CAR Group).....	1302
15.13.6 HQoS Service Model (xPON Board).....	1304

15.13.7 HQoS Service Model (P2P Board).....	1305
15.13.8 Implementation Principle of HQoS.....	1305
15.13.8.1 Implementation Principle of HQoS based on Port+VLAN.....	1305
15.13.8.2 Implementation Principle of CAR-Group-based HQoS.....	1308
15.13.8.3 HQoS Implementation Principle on an xPON Board.....	1312
15.13.8.4 HQoS Implementation Principle on a P2P Board.....	1315
15.13.9 Networking Application of HQoS.....	1318
15.13.10 Reference Standards and Protocols of HQoS.....	1322
15.13.11 Configuring HQoS.....	1322
15.13.11.1 Configuring HQoS Based on Port+VLAN.....	1322
15.13.11.2 Configuring HQoS Based on CAR Group.....	1324
15.13.11.3 Configuring HQoS for an xPON Board.....	1326
15.13.11.4 Configuring HQoS for a P2P Board.....	1330
15.14 End-to-End QoS.....	1334
15.14.1 FTTH End-to-End QoS Policy.....	1334
15.14.2 FTTB/FTTC End-to-End QoS Policy.....	1339
15.14.3 QoS Solution for FTTH.....	1341
15.14.4 QoS Solution for FTTB/FTTC.....	1344
16 Reliability.....	1348
16.1 Reliability Solution Overview.....	1349
16.2 xPON Type B Protection.....	1351
16.2.1 Introduction to xPON Type B Protection.....	1351
16.2.2 Basic Concepts of xPON Type B Protection.....	1353
16.2.3 Single-Homing xPON Type B Protection Principles.....	1362
16.2.4 Dual-Homing xPON Type B Protection Principles.....	1364
16.2.5 Configuring xPON Type B Single-Homing Protection.....	1368
16.2.6 Configuring xPON Type B Dual-Homing Protection.....	1370
16.2.7 xPON Type B Protection Reference Standards and Protocols.....	1373
16.3 xPON Type C Protection.....	1374
16.3.1 Introduction to xPON Type C Protection.....	1375
16.3.2 Basic Concepts of xPON Type C Protection.....	1376
16.3.3 Single-Homing xPON Type C Protection Principles.....	1385
16.3.4 Dual-Homing xPON Type C Protection Principles.....	1389
16.3.5 Configuring xPON Type C Single-Homing Protection.....	1394
16.3.6 Configuring xPON Type C Dual-Homing Protection.....	1396
16.3.7 xPON Type C Protection Reference Standards and Protocols.....	1397
16.4 Redundancy Backup of Control Boards.....	1398
16.4.1 Introduction to Control Board Redundancy Backup.....	1399
16.4.2 Principle of Active/Standby Mode.....	1400
16.4.3 Principle of Load-sharing Mode.....	1404
16.5 Ethernet Port Protection Group.....	1405
16.5.1 Introduction to Protection Group of Ethernet Ports.....	1405

16.5.2 Principle of Timedelay Protection.....	1406
16.5.3 Configuring a Timedelay Protection Group.....	1408
16.6 Ethernet Link Aggregation.....	1409
16.6.1 Introduction to Ethernet Link Aggregation.....	1409
16.6.2 Principle of LACP.....	1410
16.6.3 Introduction to Load Bearing.....	1411
16.6.4 Introduction to LAG Type.....	1413
16.6.5 Introduction to Port Type.....	1415
16.6.6 Principle of LAG Setup Process.....	1416
16.6.7 Principle of LAG Link Switchover and Reversion.....	1418
16.6.8 Configuring Ethernet Link Aggregation.....	1419
16.6.9 Ethernet Link Aggregation Reference Standards and Protocols Compliance.....	1422
16.7 MSTP.....	1422
16.7.1 Introduction to MSTP.....	1422
16.7.2 Principle of MSTP.....	1423
16.7.3 Configuring the MSTP.....	1431
16.7.4 MSTP Reference Standards and Protocols.....	1435
16.8 ERPS.....	1435
16.8.1 Introduction to ERPS.....	1436
16.8.2 Basic Concepts of ERPS.....	1437
16.8.3 Principle of ERPS.....	1440
16.8.4 Configuring ERPS.....	1444
16.8.5 ERPS Reference Standards and Protocols.....	1448
16.9 VRRP Snooping.....	1449
16.9.1 Introduction to VRRP Snooping.....	1449
16.9.2 Principle of VRRP Snooping.....	1449
16.9.3 Configuring VRRP Transparent Transmission in the S+C Forwarding Mode.....	1451
16.9.4 VRRP Snooping Reference Standards and Protocols.....	1452
16.10 Ring Check.....	1452
16.10.1 Introduction to Ring Check.....	1452
16.10.2 Principle of Ring Check.....	1453
16.10.3 Configuring the Ring Network Detection.....	1456
16.11 Monitor Link.....	1457
16.11.1 Introduction to Monitor Link.....	1457
16.11.2 Principles of Monitor Link.....	1458
16.11.3 Configuring the Monitor Link Group.....	1459
17 802.1X Authentication.....	1461
17.1 Why Is 802.1X Authentication Required?.....	1461
17.2 Device Roles Defined in 802.1X.....	1461
17.3 Port-based Authentication.....	1462
17.4 802.1X Information Exchange.....	1464
17.5 Configuring 802.1X Authentication.....	1476

17.5.1 ONU Functioning as the 802.1x Authentication Device.....	1476
17.5.2 OLT Functioning as the 802.1X Authentication Device (Configured on the CLI).....	1480
17.5.3 Core Switch Functioning as the 802.1X Authentication Device.....	1484
18 AAA.....	1485
18.1 RADIUS.....	1487
18.2 HWTACACS.....	1489
18.3 Configuring the Local AAA.....	1492
18.4 Configuring the Remote AAA (RADIUS Protocol).....	1494
18.5 Configuration Example of the RADIUS Authentication and Accounting.....	1501
18.6 Configuring the Remote AAA (HWTACACS Protocol).....	1504
18.7 Configuration Example of the RADIUS AAA (802.1X access user).....	1508
18.8 Configuration Example of HWTACACS Authentication (Management User).....	1511
19 Device Management.....	1515
19.1 ANCP.....	1516
19.1.1 ANCP Introduction.....	1516
19.1.2 ANCP Principle.....	1517
19.1.3 Configuring ANCP.....	1521
19.1.4 ANCP Reference Standards and Protocols.....	1525
19.2 ANCP Proxy.....	1525
19.2.1 ANCP Proxy Introduction.....	1525
19.2.2 ANCP Proxy Principle.....	1527
19.2.3 Configuring ANCP Proxy.....	1529
19.3 LLDP.....	1531
19.3.1 Introduction.....	1531
19.3.2 LLDP Reference Standards and Protocols.....	1532
19.3.3 Basic Concepts.....	1532
19.3.4 Principles.....	1535
19.3.5 Network Application.....	1537
19.3.6 Configuring LLDP.....	1539
19.4 NETCONF.....	1541
19.4.1 Feature Updates.....	1541
19.4.2 Introduction.....	1541
19.4.3 Principles.....	1543
19.4.4 Networking Scenario.....	1545
19.4.5 Configuring NETCONF.....	1546
19.4.6 NETCONF Reference Standards and Protocols.....	1548
19.5 Telemetry.....	1548
19.5.1 Telemetry Feature Updates.....	1548
19.5.2 Introduction to Telemetry.....	1549
19.5.3 Telemetry Data Collection and Reporting Process.....	1550
19.5.4 Telemetry Data Model.....	1551
19.5.5 Key Telemetry Technologies.....	1552

19.5.5.1 UDP Transport Protocol.....	1552
19.5.5.2 GPB Encoding Format.....	1556
19.5.6 Telemetry Configurations.....	1558
19.5.6.1 Enabling NETCONF.....	1558
19.5.6.2 Configuring the Data to Be Sampled.....	1559
19.5.6.3 Configuring a Destination Collector.....	1560
19.5.6.4 Creating a Subscription.....	1562
19.6 Inband Management VPN.....	1565
19.6.1 Introduction to Inband Management VPN.....	1565
19.6.2 Principles to Inband Management VPN.....	1566
19.7 Remote Software Commissioning (Ethernet).....	1567
19.7.1 Introduction.....	1567
19.7.2 Principles (Based on DHCP).....	1570
19.7.3 Configuring NAC-based Remote Software Commissioning for Ethernet Upstream Transmission	1572
19.7.4 Remote Software Commissioning (Ethernet) Reference Standards and Protocols.....	1578
19.8 OLT ZTD.....	1578
19.8.1 Feature Updates.....	1579
19.8.2 Why the OLT Needs to Support ZTD.....	1579
19.8.3 OLT ZTD Application Scenarios.....	1580
19.9 Power Saving.....	1582
19.9.1 Introduction to Energy Saving.....	1583
19.9.2 Energy Saving Principles.....	1583
19.9.2.1 Energy Saving Principles.....	1583
19.9.2.2 Energy Saving Technology Description.....	1586
19.9.2.2.1 Automatic Shutdown of Unused High-speed Interfaces.....	1586
19.9.2.2.2 Automatic Zone-based Fan Speed Adjustment.....	1586
19.9.2.2.3 Automatic Shutdown of Unused Ports.....	1588
19.9.2.2.4 Automatic Shutdown of Unused Boards.....	1589
19.9.2.2.5 Automatic Shutdown of Unused Channels.....	1590
19.9.2.2.6 Dynamic Frequency Adjustment.....	1591
19.9.2.2.7 Intelligent Board Scheduling.....	1591
19.9.3 Energy Saving Modes and Constraints.....	1592
19.9.4 Principles of Power Savings and Power Estimation.....	1592
19.9.5 Energy Saving Configuration Description.....	1593
19.9.5.1 Energy Saving Configuration.....	1593
19.9.5.1.1 Configuring an Energy Saving Mode.....	1593
19.9.5.1.2 Configuring Custom Energy Saving Measures.....	1595
19.9.5.1.3 Querying Energy Saving Configurations.....	1596
19.9.5.1.4 Powering Off an Unused Port/Board.....	1599
19.9.5.2 Querying Energy Saving Results.....	1599
19.9.5.2.1 Querying Energy Saving Status.....	1599
19.9.5.2.2 Querying the Shutdown Status of a Board.....	1600

19.9.5.2.3 Querying the Shutdown Status of a Port.....	1600
19.9.5.2.4 Querying the Shutdown Status of a Channel.....	1601
19.9.5.2.5 Querying Zone-based Fan Speed Adjustment Results.....	1601
19.9.5.2.6 Querying Dynamic Frequency Adjustment Results.....	1601
19.9.5.2.7 Querying Intelligent Board Scheduling Results.....	1602
19.9.5.3 Energy Saving Configuration Examples.....	1603
19.9.5.3.1 Configuring the Deep Energy Saving Mode on an OLT.....	1603
19.9.5.3.2 Configuring the Deep Energy Saving Mode on the NMS.....	1604
19.9.6 Energy Saving Conditions.....	1607
19.9.6.1 Function Conditions.....	1607
19.9.6.1.1 Energy Saving Mode Conditions.....	1607
19.9.6.1.2 Energy Saving Measure Conditions.....	1608
19.9.6.1.3 Energy Saving Parameter Conditions.....	1610
19.9.6.2 Board Conditions.....	1610
19.9.6.2.1 Energy Saving Configuration Conditions.....	1610
19.9.6.2.2 Support for Energy Consumption Visualization.....	1611
19.9.7 FAQ.....	1612
19.9.7.1 Can the Custom Energy Saving Mode Be Configured on a Device?.....	1612
19.9.7.2 Does a Custom Energy Saving Measure Take Effect Immediately After Configuration?.....	1612
19.9.7.3 Link for the Manual of Configuring Custom Energy Saving Measures on the NMS.....	1613
19.10 Version and Data Management.....	1613
19.10.1 Introduction.....	1613
19.10.2 Principle.....	1613
19.10.3 ISSU.....	1615
19.11 Anti-theft.....	1617
19.11.1 Anti-theft Feature Updates.....	1617
19.11.2 Anti-theft Introduction.....	1617
19.11.3 Anti-theft Principles.....	1618
19.11.4 Configuring Anti-theft.....	1620
19.12 Environment Monitoring.....	1620
19.12.1 EMUB Monitoring Solution.....	1620
19.12.1.1 DCDU-12E PDB.....	1620
19.12.1.2 EMUB Monitoring Unit.....	1623
19.12.1.3 Checking the Environment Monitoring Cables of the EMUB.....	1633
19.12.1.4 Commissioning the EMUB.....	1635
19.12.2 Power3000 Monitoring Solution.....	1638
19.12.2.1 Monitoring Module CPMU01 of the Power3000.....	1638
19.12.2.2 Checking the Environment Monitoring Cable of the Power3000.....	1639
19.12.2.3 Configuring the Power3000 Environment Monitoring Mode.....	1640
19.12.3 ETP4890 Monitoring Solution (AC Power Supply).....	1643
19.12.3.1 ETP4890 Power System.....	1643
19.12.3.2 PMIB02 Sensor Transfer Box.....	1650

19.12.3.3 Checking Environment Monitoring Cables.....	1653
19.12.3.4 Configuring the Environment Monitoring Parameters of the ETP4890.....	1655
19.12.4 ETP48200 Monitoring Solution.....	1659
19.12.4.1 ETP48200-B2A1 Power System.....	1659
19.12.4.2 Checking the Environment Monitoring Cable.....	1669
19.12.4.3 Configuring the Environment Monitoring Parameters of the ETP48200.....	1671
19.12.5 Fan Tray Monitoring Solution.....	1675
19.12.5.1 Fan Tray Monitoring Principles.....	1675
19.12.5.2 MA5800-X17 Fan Tray.....	1676
19.12.5.3 MA5800-X15 Fan Tray.....	1679
19.12.5.4 MA5800-X7 Fan Tray.....	1682
19.12.5.5 MA5800-X2 Fan Tray.....	1685
19.12.5.6 Commissioning the Fan EMU.....	1687
19.13 RTU.....	1689
20 Slicing.....	1691
20.1 Slicing Solution Change Description.....	1691
20.2 Slicing Solution Overview.....	1692
20.2.1 Background of Slicing.....	1692
20.2.2 Benefits of the Slicing Solution.....	1694
20.2.3 Architecture of the Slicing Solution.....	1695
20.2.4 Implementation Principles of Access Network Slicing.....	1697
20.2.5 Key Technologies.....	1702
20.2.5.1 HDBA.....	1702
20.2.6 Typical Application Scenarios of the Slicing Solution.....	1704
20.2.6.1 Application Networking of the Slicing Solution.....	1704
20.2.6.2 Customized Network Services for Dedicated Network Slices.....	1705
20.2.6.3 Differentiated Service Experience of Service Slices.....	1707
20.3 Slice Lifecycle Management.....	1709
20.4 Slice Deployment and Configuration.....	1710
20.4.1 Dedicated Network Slice Deployment.....	1710
20.4.1.1 Example of Hard-Isolated Dedicated Network Slice Deployment (NCE).....	1710
20.4.1.2 Example of Hard-Isolated Dedicated Network Slice Deployment (CLI).....	1714
20.4.2 Service Slice Deployment.....	1721
20.4.2.1 Service Slice Deployment Example (NCE).....	1721
20.4.2.2 Service Slice Deployment Example (CLI).....	1728
20.5 Reference.....	1730
20.5.1 Parameter Reference for a Service Slice SLA Template.....	1731
20.5.2 Acronyms, Abbreviations, and Basic Concepts.....	1733
20.5.3 Reference Standards and Protocols for Slicing.....	1734
21 Aggregation Management.....	1735
21.1 Changes in Aggregation Management.....	1735
21.2 Hardware Version Description for Aggregation Management.....	1735

21.3 Introduction to the Aggregation Management Solution..... 1736

21.4 Basic Concepts of Aggregation Management..... 1738

21.5 Implementation Principle of Aggregation Management.....1740

21.6 Application Scenario of Aggregation Management..... 1743

21.7 Aggregation Management Configuration..... 1744

21.7.1 Digital Certificate Loading Process..... 1744

21.7.2 Typical Networking and Configuration Process..... 1745

21.7.3 Configuration Example..... 1749

21.7.3.1 Customized Configuration Example..... 1749

21.7.3.2 Batch Configuration Example..... 1752