Technical Requirement for EPON Equipments of China Telecom (V2.0)

(Supposed for Advice)

China Telecom

9.2007

Contents

Preface

The standard is based on IEEE 802.3-2005 and our domestic standard for communication industry "Technical Requirement for Access Network –Ethernet Passive Optical Network based on the Ethernet method" so as to enhance the interoperability, operation and management ability of the EPON system, suggesting new and more specific requirement for PON interface protocol (MPCP and OAM extension, etc), DBA, QoS, Multicast, Security, Voice and TDM business, maintenance and management, etc.

This standard is specified by the technical department of China Telecom.

1 Coverage

The standard specifies reference model, business load, performance index, business interface types, system functions and protocols, operation maintenance and management and electric safety, etc of EPON based on Ethernet method whose rate is 1000Mbit, and gives specification for PMD sub-layer, RS sub-layer and protocol interoperability among MPCP, OAM and business layer.
The standard is used for OLT and ONU equipments of EPON system in the network environment of China Telecom.

2 Reference Documents for Standardizing

The items in the files as below will be the standards of this standard as referred by this standard. All following revision records (not including corrigendum) or revisions of all reference files with date noted are not applicable in the standard, but it is encouraged to confirm wthether to use the latest version of these files according to the protocols achieved by the standard and research of all parties. The latest version of the reference files without date noted is applicable to this standard.

YD/T 1128-2001	The whole specification for telephone switching equipments (Amendment 1)
YD/T 1292-2003	The control protocol of media network gateway based on H.248
YD/T 1475-2006	Technical Requirement for Access Network –Ethernet Passive Optical Network based on the Ethernet method (EPON)
YDN 021-96	The interface technical specification of V5.2 between digital switch and access network
YDN 065-1997	The whole technical specification for telephone switching equipments of the post and telecommunication department
ITU-T G.983	Broadband Passive Optical Network(BPON)
ITU-T Y.1291 (2004)	The architecture supporting QoS of packet network
ITU-T Y.1730 (2004)	The function requirements of Ethernet OAM
IEEE 802-2001	IEEE standard for LAN and Metropolitan Area Network (MAN): Overview and Architecture
IEEE 802.1D-2004	IEEE standard for LAN and MAN - Media Access Control Network Bridge
IEEE 802.1Q-2005	IEEE standard for LAN and MAN - Virtual LAN protocol
IEEE 802.1ad	IEEE standard for LAN and MAN - Virtual LAN protocol - Amendment File 4: Provider Network Bridge
IEEE 802.3-2005	Information Technology - Communication and data exchange among systems - Specific requirements for LAN and MAN - 3rd part: Access method of CSMA/CD and physical layer specification - Amendment files: For media access control parameters of user access network, physical layer and management
IETF RFC3985 (2005)	PWE3 Architecture
IETF RFC4197 (2005)	Requirements for Edge-to-Edge Emulation of Time Division Multiplexed (TDM) Circuits over Packet Switching Networks
IETF RFC4553 (2006)	Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)
RFC 1112	Host Extensions for IP Multicasting
RFC 2236	Internet Group Management Protocol, Version 2
RFC 3376	Internet Group Management Protocol, Version 3
DSL Forum TR-069	CPE WAN Management Protocol
DSL Forum WT-142	Framework for TR-069 enabled PON devices (Revision 3)

3 Abbreviation

The abbreviations as below are applicable to this standard.

ACS	Auto-Configuration Server	自动配置服务器
CATV	Community Antenna Television	有线电视系统
CDR	Call Detail Record	呼叫信息记录
CVLAN	Customer VLAN	用户(内层)虚拟局域网
DA	Destination Address	目的地址
DBA	Dynamic Bandwidth Allocation	动态带宽分配
DSL	Digital Subscriber Line	数字用户线
DTE	Data Terminal Equipment	数据终端设备
EPD	End_of_Packet Delimiter	帧结束定界符
EPON	Ethernet Passive Optical Network	基于以太网方式的无源光网络
FCS	Frame Check Sequence	帧校验序列
FEC	Forward Error Correction	前向纠错
FTTB	Fiber to the Building	光纤到楼宇
FTTBiz	Fiber to the Business	光纤到企业
FTTC	Fiber to the Curb	光纤到路边
FTTCab	Fiber to the Cabinet	光纤到交接箱
FTTH	Fiber to the Home	光纤到家庭用户
FTTO	Fiber to the Office	光纤到公司/办公室
GMII	Gigabit Media Independent Interface	千兆比媒质无关接口
HGU	Home Gateway Unit	家庭网关单元
IGMP	Internet Group Management Protocol	互联网组管理协议
IPG	Inter-packet Gap	帧间隔
LLID	Logical Link Identifier	逻辑链路标识
LSB	Least Significant Bit	最低位
MAC	Medium Access Control	媒质访问控制
MDI	Medium Dependent Interface	媒质相关接口
MDU	Multi-Dwelling Unit	多住户单元
MPCP	Multi-point control protocol	多点控制协议
MPCPDU	MPCP Protocol Data Unit	MPCP 协议数据单元
MSB	Most Significant Bit	最高位
MTU	Multi-Tenant Unit	多商户单元
NT	Network Terminator	网络终端
OAM	Operation, Administration & Maintenance	操作、管理和维护
ODN	Optical Distribution Network	光分配网络

OLT	Optical Line Terminal	光线路终端
ONU	Optical Network Unit	光网络单元
OSI	Open System Interconnection	开放系统互联
P2MP	Point to Multipoint	点到多点
P2PE	Point to Point Emulation	点到点仿真
PCS	Physical Code Sublayer	物理编码子层
PMA	Physical Medium Attachment	物理媒质附加(子层)
PMD	Physical Medium Dependent	物理媒质相关(子层)
PON	Passive Optical Network	无源光网络
PWE3	Pseudo Wire Emulation Edge-to-Edge	边缘到边缘的伪线仿真
QoS	Quality of Service	服务质量
RF	Radio Frequency	射频
RS	Reconciliation Sublayer	协调子层
RSTP	Rapid Spanning Tree Protocol	快速生成树协议
RTP	Real Time Protocol	实时传输协议
SA	Source Address	源地址
SBU	Single Bussiness Unit	单商户单元
SCB	Single Copy Broadcast	单拷贝广播
SFD	Start of Frame Delimiter	帧起始定界符
SFU	Single Family Unit	单住户单元
SLA	Service Level Agreement	服务等级协议
SLD	Start of LLID Delimiter	LLID 起始定界符
SPD	Start of Packet Delimiter	帧起始定界符
SNI	Service Node Interface	业务节点接口
SVLAN	Service VLAN	业务(外层)虚拟局域网
TDMA	Time Division Multiple Access	时分多址接入
TLV	Type-Length-Value	类型长度值
TQ	Time Quantum	时间量子
RTT	Round Trip Time	往返时间
UCT	Un-condition transition	无条件转移
UNI	User Network Interface	用户网络接口
VLAN	Virtual Local Area Network	虚拟局域网
VoIP	Voice over IP	IP 语音

4 Reference Model

Ethernet Passive Optical Network (EPON) is a kind of access network with bidirectional single optical fiber adopting the structure of Peer to Multiple Peers (P2MP), whose typical topology structure is tree.

The EPON system is composed of Optical Line Terminal (OLT) of central end, optical network unit (ONU) of user end and optical distribution network (ODN), which is a system with bidirectional single optical fiber. In the downlink direction (OLT to ONU), the signals sent by OLT arrive to all ONUs through ODN. In the uplink direction (ONU to OLT), the signals sent by ONU only arrive to OLT instead of other ONUs. In order to avoid the data collision and improve network usage, the uplink direction adopts multiple access methods of TDMA and arbitrates the data sending of all ONUs. ODN is composed of optical fibers, one or more passive optical devices like passive optical dividers, which provides optical channels between OLT and ONU.

The reference structure of EPON system is as figure 1.

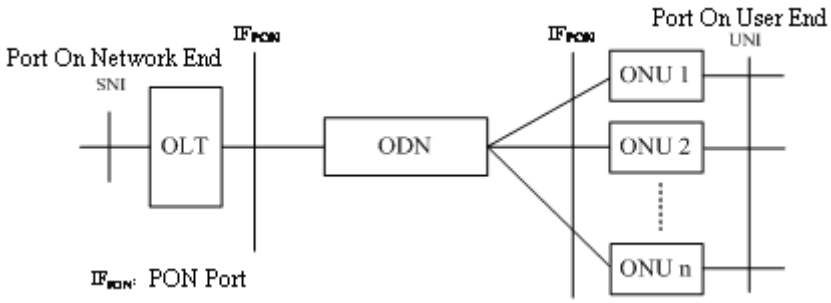


Figure 1 The reference structure of EPON system

According to the locations of ONU in the access network, EPON system can have several kinds of network application types: Fiber to the Cabinet (FTTCab), Fiber to the Building/Curb(FTTB/C), Fiber to the Home (FTTH) and Fiber to the Office (FTTO).

5 Business and Equipment Types

5.1 Business Type

The business types that the EPON sysem can hold include Ethernet/IP Business, Voice Business, TDM Business that is E1 line virtual business and CATV Business, etc. The EPON is supposed to be capable of hold Ethernet/IP Business, and supporting voice, TDM and CATV Business is optional.

5.2 Equipment Types

7.2.1ONU

There may be several types of ONU equipments. This standard has regulated 5 major types according to the current application situation of EPON equipments.

- SFU(Single Family Unit)Type of ONU

It is mainly used for Single Family users, only supporting the terminal function of broadband access with 1 or 4 Ethernet interfaces, providing Ethernet/IP Business, supporting VoIP (integrated with IAD) or CATV business, and it is mainly for FTTH environment (Used with the family network gateway for offering stronger business capabilities).

The 3 kinds of specific status of SFU type of ONU are as Table 1 below according to the business types and interface numbers of ONU.

Table 1 Specific status of SFU type of ONU

Number	Numbers of Ethernet interfaces	Numbers of POTS Interfaces	CATV RF Interface
SFU-1	1 (GE or FE)	0	Optional
SFU-2	4 (FE)	0	Optional
SFU-3	4 (FE)	2	Optional

(Note: When business clients do not need TDM business, SFU can also be used for business

clients.)

■ HGU (Home Gateway Unit) type of ONU

It is mainly used for Single Family users with the function of family network gateway, which is equal to a family network gateway with EPON uplink interface, having 4 ethernet, 1 WLAN and at least 1 USB interfaces, providing Ethernet/IP business, supporting VoIP (integrated with IAD), CATV business, TR-069 remote management and it is mainly for FTTH environment.

The 2 kinds of specific status of HGU type of ONU are as Table 2 below according to the business types and interface numbers of ONU.

Table 2 Specific status of HGU type of ONU

Number	Numbers of Ethernet interfaces	Numbers of POTS Interfaces	Numbers of WLAN Interfaces	Numbers of USB Interfaces	CATV RF Interface
HGU-1	4 (FE)	0	1	1	Optional
HGU-2	4 (FE)	2	1	1	Optional

(Note: This standard only regulates relative requirments of HGU type of ONU and EPON interface. Please refer to relative standards for China Telecom Family Network Gateway for other requirements.)

■ MDU (Multi-Dwelling Unit) type of ONU

It is mainly used for Multi-Dwelling users with the function of broadband access terminal, having several (at least 8) user end interfaces (including Ethernet, ADSL2+ or VDSL2 interfaces), providing Ethernet/IP business, supporting VoIP (integrated with IAD) or CATV business, and it is mainly for FTTB/FTTC/FTTCab environment.

The 5 kinds of specific status of MDU type of ONU are as Table 3 below according to the business types and interface numbers of ONU.

Table 3 Specific status of MDU type of ONU

Number	Numbers of Ethernet interfaces	Numbers of ADSL2+ interfaces	Numbers of VDSL2 interfaces	Numbers of POTS Interfaces	CATV RF Interface
MDU-1	8/16/24	0	0	0	Optional
MDU-2	8/16	0	0	8/16	Optional
MDU-3	0	16/24/32/48	0		0
MDU-4	0	16/24/32/48	0	16/24/32/48	0
MDU-5	0	0	8/16	8/16	0

ADSL2+ interfaces of MDU-3 should include divider.

In MDU-2, the number of POTS interfaces should be equal to the one of Ethernet interfaces.

(Note: When business clients do not need TDM business, MDU can also be used for business clients.)

■ SBU (Single Bussiness Unit) type of ONU

It is mainly used for Single Business users and Single Office in an enterprise, supporting terminal functions of broadband access, having 4 Ethernet and 4 E1 interfaces and providing Ethernet/IP and TDM business, and it is mainly for FTTO environment.

The 1 kind of specific status of SBU type of ONU are as Table 4 below according to the business types and interface numbers of ONU.

Table 4 Specific status of SBU type of ONU

Number	Numbers of Ethernet interfaces	Numbers of E1 interfaces
SBU-1	4	4

■ MTU (Multi-Tenant Unit) type of ONU

It is mainly used for Multi-Tenant users or multiple personal users in the same enterprise, supporting terminal functions of broadband access, having 8 or 16 Ethernet and 4 E1 interfaces and providing Ethernet/IP and TDM business, supporting VoIP business (integrated with IAD), and it is mainly for FTTB/FTTBiz environment.

The 2 kinds of specific status of MTU type of ONU are as Table 5 below according to the business types and interface numbers of ONU.

Table 5 Specific status of MDU type of ONU

Number	Numbers of Ethernet interfaces	Numbers of E1 interfaces	Numbers of POTS Interfaces
MTU-1	16	4	0
MTU-2	8/16	4	8/16

In MTU-2, the number of POTS interfaces should be equal to the one of Ethernet interfaces.

7.2.1OLT

The OLT equpment contains one or more PON interfaces. It is supposed to support Ethernet/IP business, provide Ethernet uplink interface. Multiple kinds of business like TDM business supporting line virtual method, etc are optional, and provide corresponding uplink interface

6 EPON Protocol Requirement

6.1 Protocol Stack

Figure 2 describes the relation between EPON system protocol layer and ISO/IEC OSI reference model.

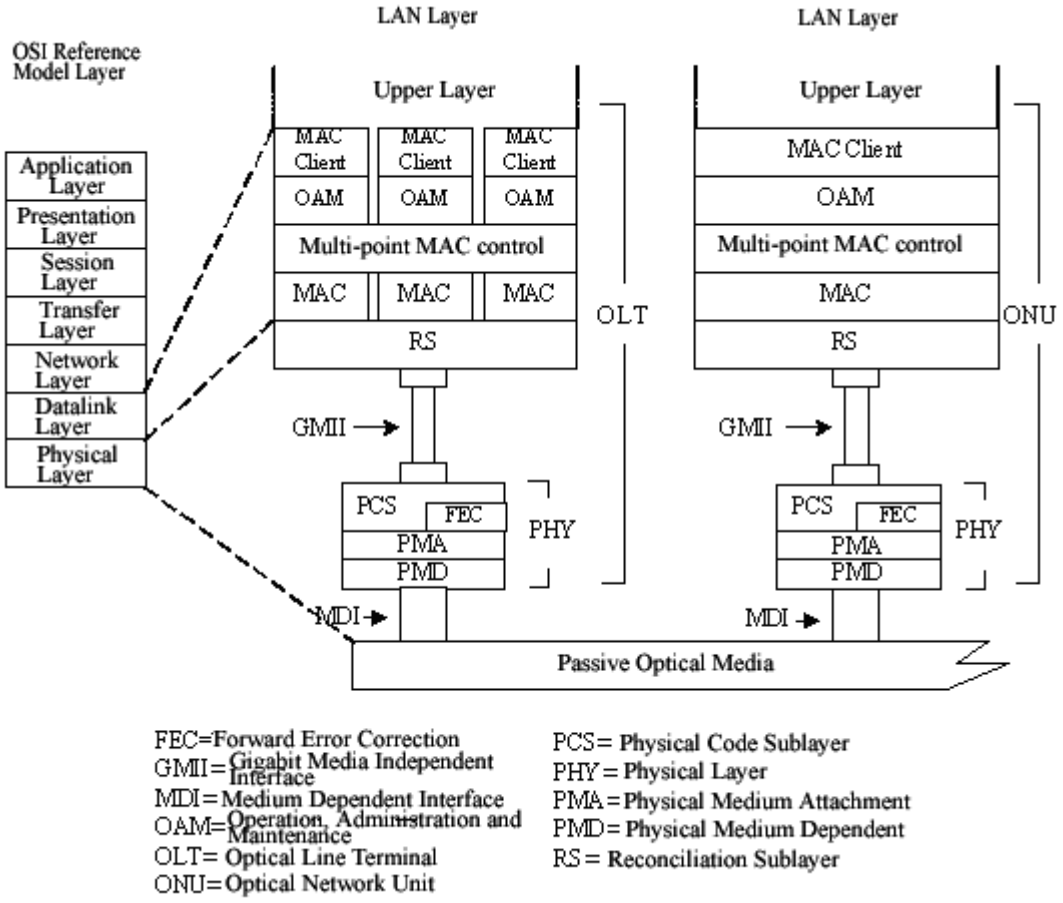


Figure 2 Relation between EPON protocol layer and OSI reference model

6.2 PMD Sublayer

EPON system is supposed to use single-mode optical fiber meeting the requirement of ITU-T G.652.

EPON is bidirectional single fiber system, whose downlink and uplink should use different wave length. Uplink wave length should be 1260-1360nm, while downlink should be 1480-1500nm. If 3rd wave length is used to implement holding CATC business, wave lenghth of 1540-1560nm should be used.

The physical layer interface of EPON system should use 1000BASE-PX20 (instead of 1000BASE-PX10 interface).

PMD sublayer of EPON system should meet the 60th chapter in IEEE 802.3-2005 and domestic communication standard "Technical Specification for Access Network-Ethernet Passive Optical Network (EPON)".

6.3 RS sublayer and PCS sublayer/PMA sublayer

RS sublayer and PCS sublayer/PMA sublayer of the EPON system should meet the regulations of 65th chapter in IEEE 802.3-2005. RS sublayer should meet the regulations as below:

The lead code of the data of extended RS sublayer is composed of the parts as below: SLD (LLID delimiter), LLID and CRC8. SLD is used to delimit LLID and CRC8. LLID domain is to recognize source MAC or destination MAC, while CRC8 is used to check. The specific format should meet the regulations of Clause 65.1.3.2 in IEEE 802.3-2005. The 4th byte of the lead code should be a reserved byte. The 6th and 7th bit in the 5th byte are used agitate the data recognition field (Enc, specified in para. 11.1). For the reception end, if the 4th byte in the lead code of the received Ethernet frame is not "0×55" or not recognized by OLT, ignorance operation should be done. The 5th byte in the lead code of the Ethernet frame should be processed by the regulations in para. 11.1 of this standard.

In the EPON system, the frame initial delimiter SPD must be located in an even byte. As the Ethernet rame can be in the position of an odd byte when it starts to be sent and can be in the position of an even byte, the 1000BASE-X PCS sending function can use the /S/ code group to replace the 1st byte of the lead code, or to dump the 1st byte and use the /S/ code group to replace the 2nd byte of the lead code, which depends on the need of odd and even alignment of PCS sending status diagram (refer to the regulations in the 36th chapter of IEEE 802.3.) The 1000BASE-PX PCS receiving function should be able to check and locate the Ethernet frame SPD of these 2 kinds of byte alignment styles and restore the /S/ code group under the 2 circumstances mentioned above to lead codes. From the 3rd byte of a lead code, the code flow is directly and transparently sent in the 1000BASE-X physical layer without modulation.

The EPON system should support bidirectional Forward Error Correction (FEC) and OAM remote configuration of uplink and downlink FEC for each ONU. The default of FEC is off. ONU should support auto adaption (mixed mode) reception of downlink business flow of FEC-coded and non-FEC-coded. OLT and ONU should support remote configuration of FEC according to the regulation in para. 6.5.4.6 of this standard.

6.4 MPCP

Multi-point control protocol (MPCP) defines the MAC control mechanism of point-to-multi-point network. The spedific regulations are in the 64th chapter of IEEE 802.3-2005.

Each PON interface of OLT should support at least 64 unicast LLID and adopt LLID of mode **=**

"1" , LLID="0×7FFF"as broadcast LLID.

For guaranteeing the interoperability, LLID should meet the requirement in Appendix A. In the default status, one ONU adopts one unicast LLID.

6.4.1 MPCP Discovery Procedure and Parameters

The discovery procedure of MPCP should meet the regulations in para. 64.3.3 in IEEE 802.3-2005.

When OLT receives the REGISTER_REQ message sent by ONU, OLT should send REGISTER message that contains LLID of ONU and syntime required by OLT to newly discovered ONU. Then OLT sends standard GATE message that is used to send authorization for message REGISTER_ACK to ONU. For the consideration that in the discovery procedure ONU needs

certain interval to process REGITSTER message and for the confirmation that ONU gets the authorization to send REGISTER_ACK, the revisions as below are made for MPCP discovery procedure, and there are 2 kinds of specific implementation methods: OLT should at least support one of them, and ONU Register Processing Time should be more than 20ms.

Method 1:

Parameters and Variables Definition:

Gate_tx: Integer Variable, the amount of Normal Gate sent by OLT in certain time in the discovery procedure of certain ONU in OLT state machine. Initial is set as 0.

Gate_Num: Integer variable, max amount of Normal Gate sent in the discovery procedure of ONU in connection with OLT; the value can be configured, whose range is 2-32 and default is 10.

GateTime: Integer vaviable, time interval of adjacent Normal Gate in the discovery procedure for certain ONU in OLT state machine. Its unit ms, whose range is 1-5ms and default is 2ms.

The product of GateTime and Gate_Num should be no less than 20ms and no more than 50ms.

Implementaion Procedure:

In the discovery procedure, if REGISTER_ACK message of ONU can not reach OLT before grantEndTime defined by Normal Gate and Gate_tx≤Gate_Num, OLT will send next Normal Gate (Force Report Reset)by interval of gateTime instead of causing ONU to re-register as fatal errors, and will re-calculate the value of grantEndTime while adding 1 to Gate_tx. If REGISTER_ACK message of ONU can not reach OLT before grantEndTime and Gate_tx≤Gate_Num, the fatal error will cause certain ONU registratin failure, and ONU can be registered again later. When Gate_tx≤Gate_Num, OLT will receive Register_ACK frame sent by ONU, and the discovery procedure will complete as well as Gate_tx will reset to 0. The revised MPCP discovery procedure is as figure 3.

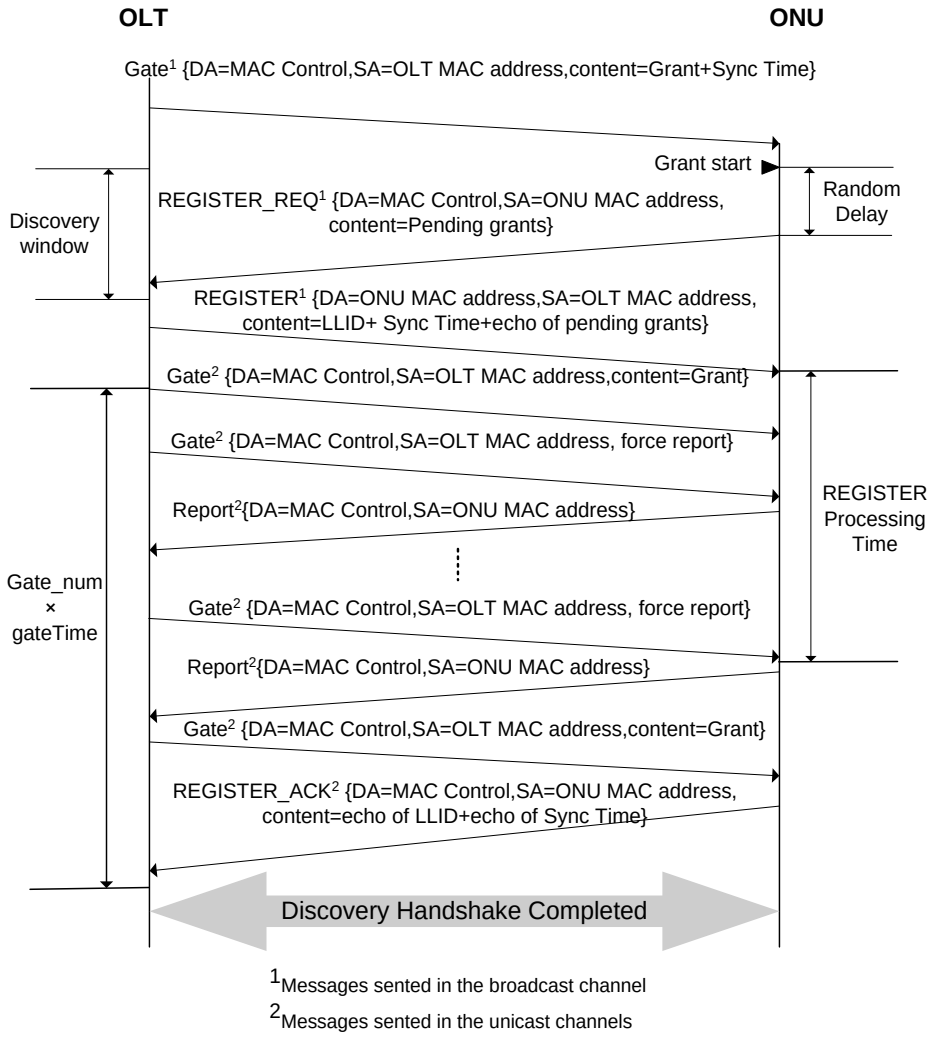


Figure 3 Handshaking Message Exchange of MPCP Discovery (Method 1)

The state machine for MPCP discovery procedue of OLT needs to be modified as stated in figure 4: When OLT is in WAIT FOR REGISTER_ACK state, if REGISTER_ACK sent by ONU is received before grantEndTime, OLT will jump to COMPLETE DISCOVERY state and the MPCP discovery procedure will be completed. If REGISTER_ACK message is still not received by grantEndTime and the amount of GATE messages sent by OLT is not more than Gate_Num, OLT will jump to WAIT FOR GATE state and prepare to send next GATE messsage. If the time reaches grantEndTime and the amount of GATE sent by OLT is beyond the amount of Gate_Num, it will be confirmed that the ONU has failed to be registered this time and OLT will switch to DEREGISTER state.

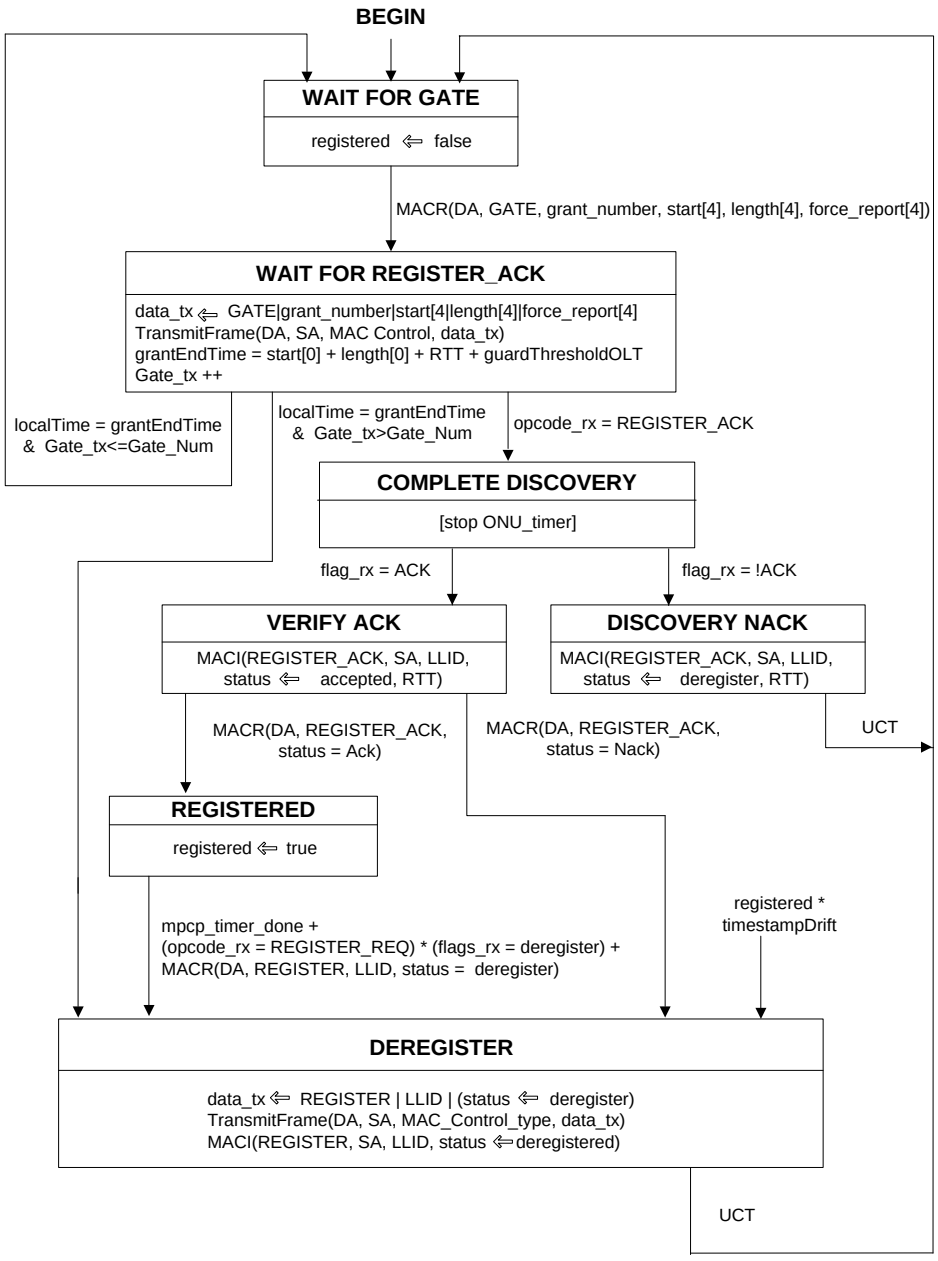


Figure 4 The Modified Final Registration Diagram of Discovery and Process of OLT (Method 1)

Method 2:

Definition of Variables and Parameters:

Gate_Register_Timeout: Integer variable, timeout period of registered timer on OLT, its unit is ms, whose value is configurable and default value is 20.

Implementation Procedure:

A timer Register_Gate_Timer is set on OLT. After OLT sends REGISTER message, the timer is started. After the timer is time out, OLT will immediately send a NORMAL GATE to ONU. If

ONU returns REGISTER_ACK in grant window of OLT, the registration of MPCP will be completed. If OLT does not receive REGISTER_ACK message in grant window, OLT will deregister ONU. The modified MPCP discovery procedure is as figure 5. The time out period of timer Register_Gate_Timer should be configurable, whose configuration range is from 2ms to 50 ms and default value is 20ms.
The state diagram of MPCP discovery procedure of OLT needs to be modified as stated in figure 6.

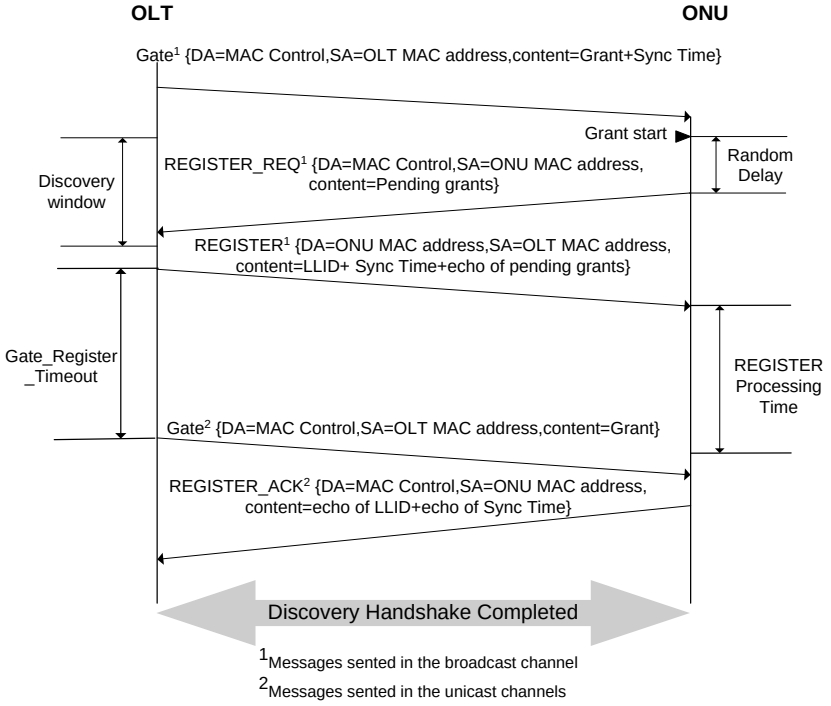


Figure 5 Handshaking Message Exchange of MPCP Discovery (Method 2)

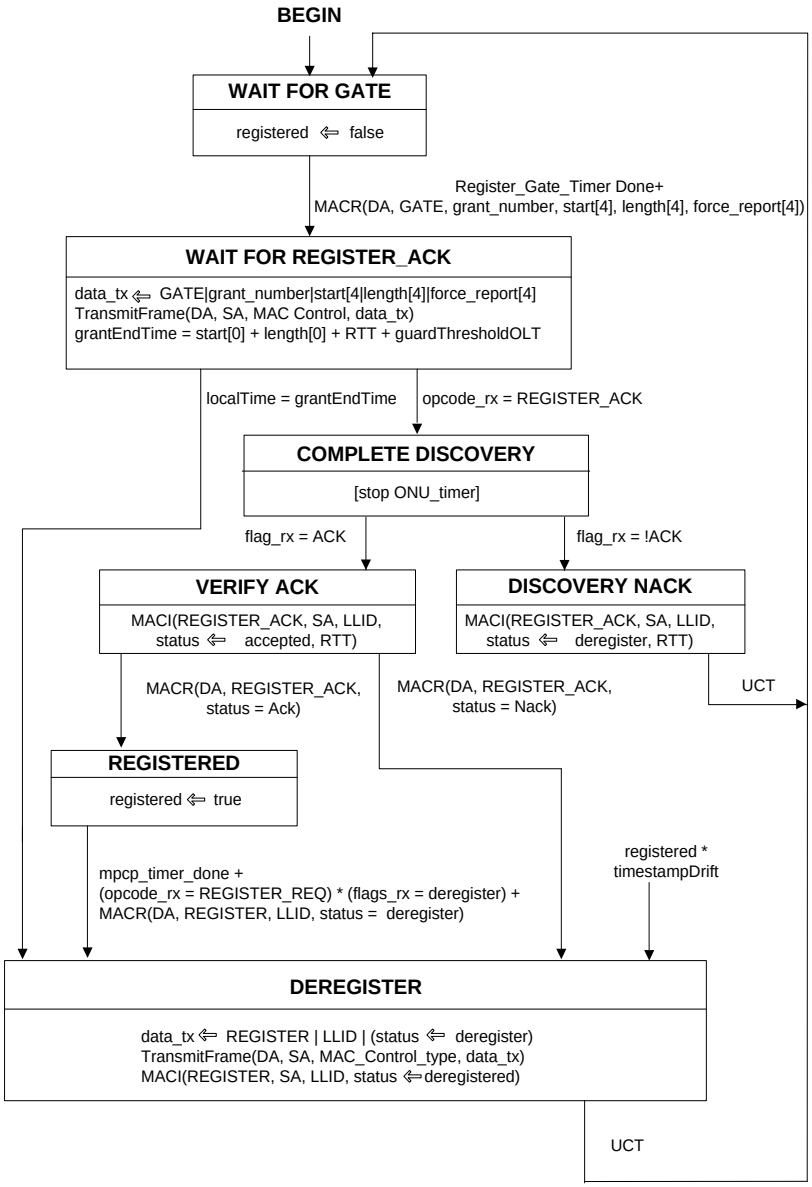


Figure 6 The Modified Final Registration Diagram of Discovery and Process of OLT (Method 2)

6.4.2 Format and Parameters of MPCPDU

For confirmation that ONU has sufficient authorization to send uplink data, in the circumstance of FEC disabled, the grantlength value of Normal Gate frame should be more than "0×6A+synctime" time quantitativenesses.

REPORT message should meet the regulations of para. 64.3.6 in IEEE 802.3-2005. In REPORT MPCPDU, Queue Set is used to indicate the queue length under multiple Thresholds.

Queue #n Report value in certain Queue Set indicates the whole length of a complete Ethernet frame of Queue n under the threshold this QueueSet corresponds to when Report message happens as well as Inter-packet Gap (IPG) needed and FEC consumption (If FEC is enabled.) Queue length of Queue #n Report should use cumulative style, indicating the whole length of a complete Ethernet frame and needed consumption from Queue starting point to this threshold.

Queue length value of Queue #n Report in multiple Queue Sets should use Incremental method, that is, for certain Queue #n, the queue length of Queue #n Report in the 1st Queue Set in a report frame is minimum, and the last Queue Set in a report frame is maximum.

For the last Queue Set in a Report frame, Queue #n report should describe the whole length of this queue.

When the whole length value of this queue (including the whole length of an Ethernet frame and its Inter-packet Gap (IPG) and FEC consumption) is more than 128Kbyte (maximum value 2

Octets can describe), the Queue #n Report value is 65535 TQ.
The number of uplink queques in ONU should be consistent User Priority regulated in IEEE 802.1Q-2005 (as described in para. 7.1.4 of this standard), that is, Queue #0 corresponds to the business whose User priority=0, and Queue #1 corresponds to the business whose User priority=1, etc.

6.4.3 Clock Requirement

MPCP counter (Counter) clock of ONU should be strictly synchronous with the downlink clock of OLT. The jitter index should meet the requirement of IEEE 802.3-2005 Clause 60.6.

6.5 Requirement of Extended OAM layer

6.5.1 Requirement of Functions of Extended OAM (Functions of Extended OAM)

EPON system should support the OAM functions regulated by Clause57 in IEEE802.3-2005 as well as Managed Object Class, Attribute and Action Organization, which are regulated by Clause30 in IEEE802.3-2005.
In addition, Organization Specific Extension mechanism should be used to implement extended ONU remote operation, Administration and Management function OAM needs, which are not regulated in IEEE802.3-2005:

- Extended OAM Discovery and Capability Notification;
- Basic information and capability notification of ONU;
- Key exchange, update and sunchronization relative to churning functions;
- DBA parameters reading and setting functions relative to DBA functions;
- Configuration of User Ports and Management;
- VLAN Configuration and Management;
- Configuration of Multicast Relative Functions;
- Relative Configuration of QoS, including business flow catalog and markings, etc;
- Action functions like Reset ONU, etc.;

Standard OAMPDU and extended OAMPDU should support the maximum frame length of 1518 bytes.

6.5.2 Extended OAM Discovery

EPON system should implement Extended OAM Discovery and Extended OAM Capability Notification through extending Information TLV of OAMPDU.
Extended OAM discovery procedure should be run after standard OAM discovery procedure, and only can the data business be transferred after standard and extended OAM are completed. Extended OAM discovery procedure includes OAM ability discovery, negociation not regulated by IEEE802.3-2005, extra data exchange and necessary ability confirmation procedures before running other extended OAM functions.
ONU and OLT implement extended OAM discovery through adding extra extended Information TLV in standard Information OAMPDU. All extended OAM discovery TLV adopt *Organization Specific Information TLV method*, and meet the standard of IEEE 802.3-2005 Clause 57 as stated in Table 6. For simplifying process procedure, *Organization Specific Information TLV* is not supposed to be filled OAMPDU. If there is organization (including all operators and manufacturers) extended INFO TLV in OAMPDU of Keep Alive, it should be ignored.

Table 6 Domain and its value of Organization Specific Information TLV

Size (Octets)	Field	Value
1	Type	0×FE (Organization Specific Information TLV)
1	Length (Octets)	Varies, including Type and Length
3	OUI	0×XX XX XX (to be defined)
1	ExtSupport	0×00/0×01
1	Version	0×00-FF Version of OAM Extension published by the organization
Varies	TLV type-specific data	Depends on Interop Type supported by the devices

ExtSupport byte is used to indicate whether to support OAM extension of this OUI. When ExtSupport is ‘0x01’, it indicates that it supports the extended OAM; When ExtSupport is ‘0x00’, it indicates that it doest not support the extended OAM; other values will be ignored. After it is confirmed that certain extended OAM is supported, further hand shaking procedures relative to the OAM will be executed.

As stated by Clause57 of 802.3-2005, Organization Specific Information TLV includes domains as below:

a) Information Type: 1 byte, type Organization Specific Information, used to indicate the data type held in the TLV. Its value is ‘0xFE’ for Organization Specific Information TLV (referred in IEEE 802.3-2005 Table 57–6.)
b) Information Length: 1 byte, used to indicate the length of the TLV. The length of Organization Specific Information TLV is not fixed.
c) Organizationally Unique Identifier OUI: 3 bytes, is Organizationally Unique Identifier OUI. The value is configurable, and OUI if China Telecom is undetermined.
d) Data Domain (Data/Organization Specific Value): Including the data of Organization Specific Information TLV, whose length and content is undetermined.

The data domain of Organization Specific Information TLV used to extend OAM discovery includes ExtSupport byte and a supported list of OUI-Version. OUI-Version list is used to provide extended OAM notification function, stating that the device supports the OAM extension distributed by the organization indicated by the OUI and its version. The value of OUI of Supported Extension should be equal to the OUI (the OUI after Length domain of the Information TLV and before Data domain as the diagram below) in the Orgnization Specific Information TLV. In the Organization Specific Information TLV, there is no requirement for the sequence of OUI-Version.

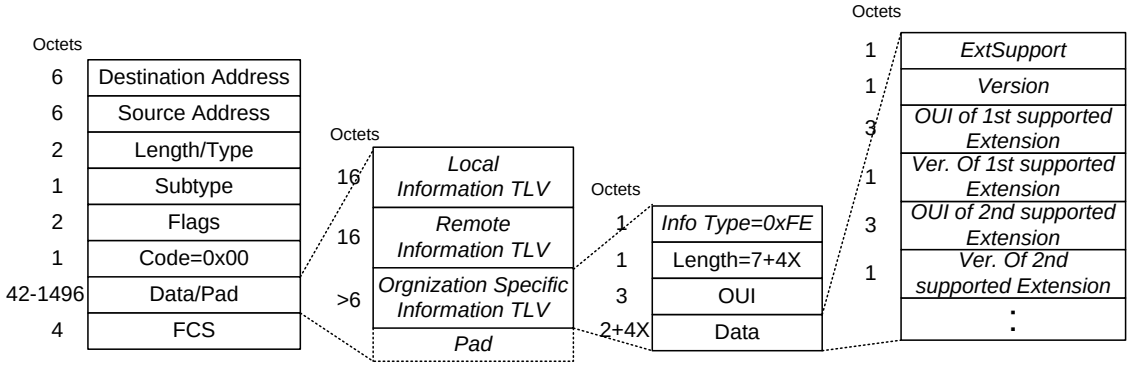


Figure 7 Organization Specific Information OAMPDU and Extended Organization Specific Information TLV format

The extended OAM discovery procedure is as figure 8. After completing OAM discovery, OLT will trigger the extended OAM discovery procedure. OLT will first send OAM Ext_INFO message, notifying OLT that OUI of OAM extension, version and supported OUI-Version list. OLT will return an OAM Ext_INFO according to the received OLT information, setting OUI as OUI of OLT Ver.=0×00 and repoting the OUI-Version list supported by ONU to OLT. If ONU supports the OUI, ExtSupport=0×01, or ExtSupport=0×00. According to the ONU reported information, if ExtSupport=0×01, ONU supports the current OUI version and wirites Ext_INFO->OUI and OAM Ext_INFO-〉Ver.Z to OAM, the message will be sent ONU and finally ONU will receive the message about OUI and version selected by OUI and return confirmation information so as to complete the discovery procedure of extended OA M. If ExtSupport=0×01 and ONU does not support the current OUI version of OLT, or ExtSupport=0×00, OLT will give out a warning and report it to the network administrator.

OLT supporting the extended OAM discovery procedure and the state machine of ONU are repectively as presented in figure 9 and 10.

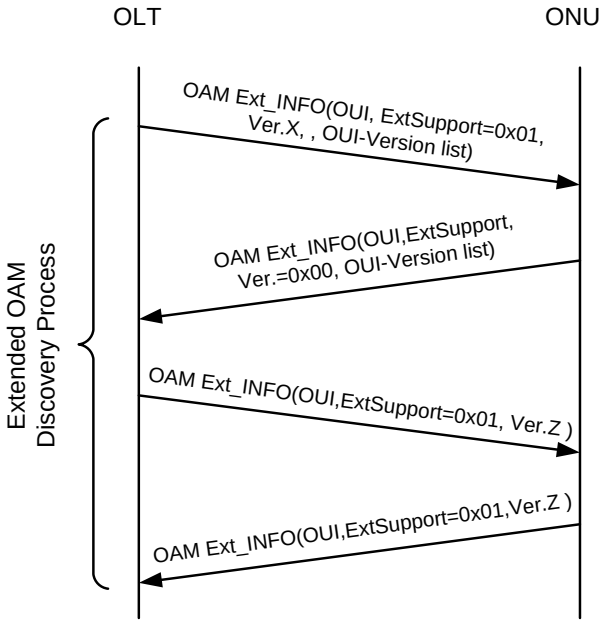


Figure 8 Extended OAM Discovery Procedures

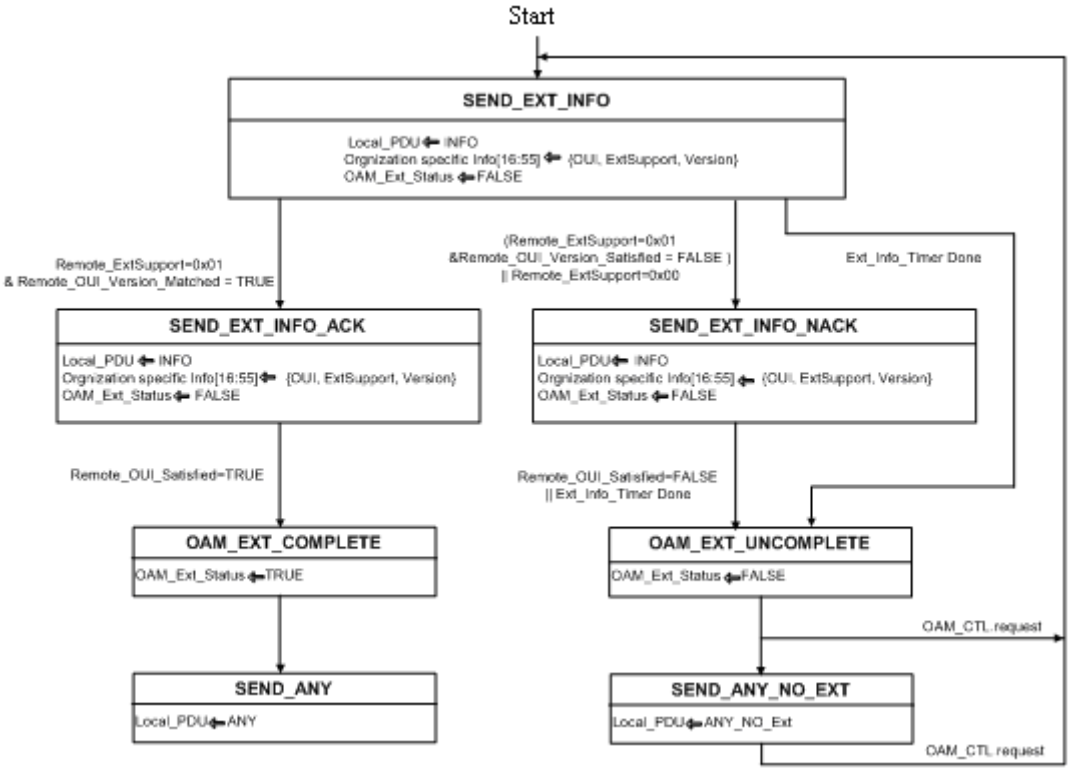


Figure 9 State Machine of Extended OAM Discovery Procedure of OLT

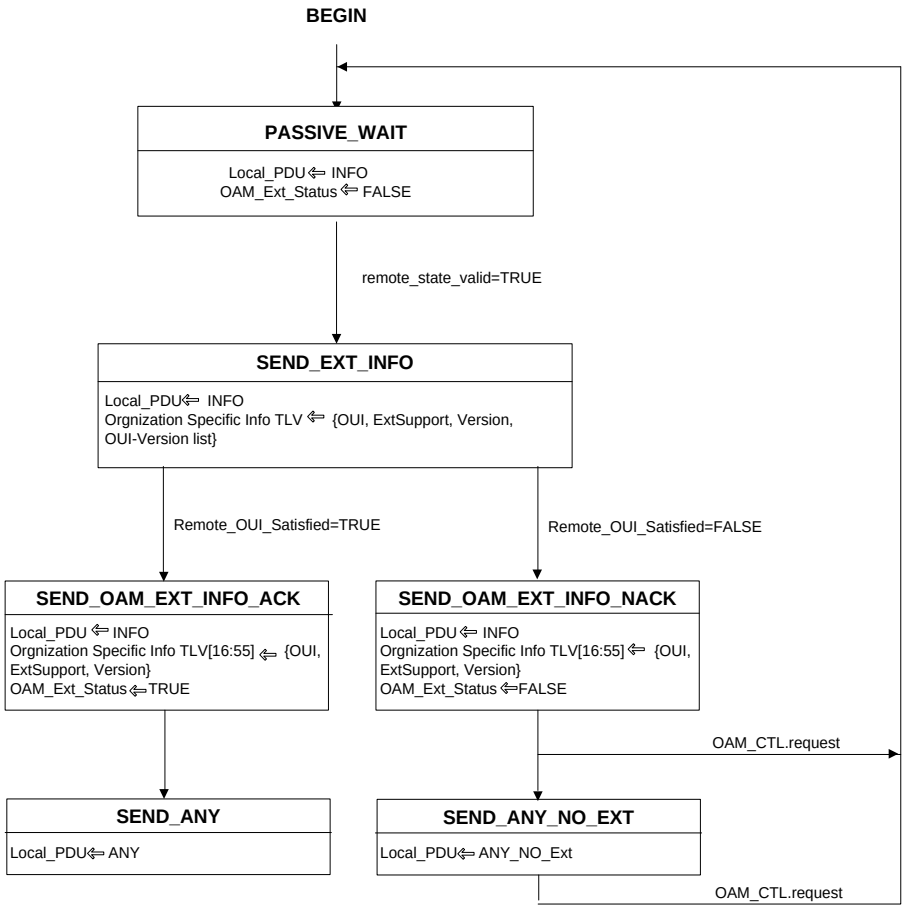


Figure 10 State achine of Extended OAM Discovery Procedure of ONU

6.5.3 Remote Management Features of Extended OAM

6.5.3.1 Object,Attribute & Action

The objects that extended OAM needs to manage include Port, Churning, DBA Negotiation, FEC, VLAN, Multicast and QoS, etc. The OAM extension relative to Churning is in the 11th chapter of this standard.

The management objects involded in extensions include certain amount of extra attributes that are regulated by 802.3 Clause30. Except for churning and DBA relative attributes, these attributes are stated by Variable Descriptor. These extension attributes of ONU can not only be dealt with read operation of Extended Variable Request OMAPDU by OLT but also be dealt with write operation of Set Request OAMPDU.

6.5.3.2 The format and message definition of Extended OAM

Extended OAM message should meet the regulations about OAM extension in IEEE802.3-2005 Clause57.4.3.6. Organization Specific OAMPDU includes one 3-byte OUI field. There is a 1-byte extended operation code (Ext. Opcode) used to indicate extended operation type. There is its specific operation content after Ext. Opcode. The format of Organization Specific OAMPDU is shown in figure 11, whose specific OUI value should be configurable. The OUI value of China Telecom is undetermined. The structure of Organization Specific Extension OAMPDU defined by the standard is shown in the diagram below whose specific definiation is as below:

a) Destination Address (DA): DA in OAMPDU is the address of Slow_Protocols_Multicast whose usage and coding specification is in IEEE 802.3-2005 Annex 43B;
b) Source Address (SA): SA in OAMPDU is an independent MAC address that is associated with the port sending OAMPDU;
c) Length/Type: OAMPDU adopts Type code and hold the value of Slow_Protocols_Type domain (0×8809.) The usage and coding specification is in IEEE 802.3-2005 Annex 43B;
d) Subtype:Specific Slow Protocol encapsulated by Subtype domain ID;

e) Flag: Flags domain includes state bit;
f) The field contains effective load of OAMPDU that includes OUI, Extended Operation Code (Ext.Opcode), payload and Padding, etc. When these bytes are not used, it will be filled with 0 during sending and be ignored during receiving;
g) FCS: The domain is the Frame Check Sequence generally generated by low level of MAC.

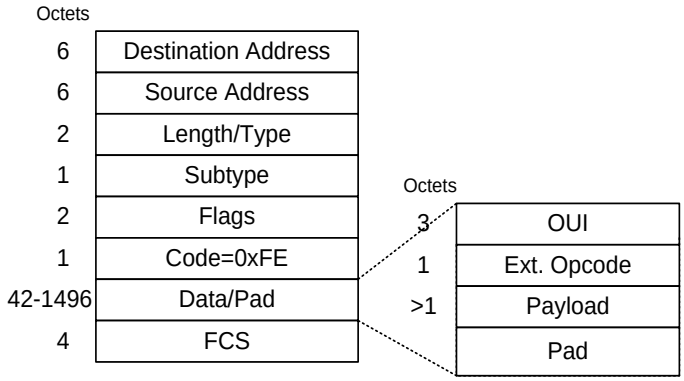


Figure 11 Frame Format of Organization Specific OAMPDU

Ext. Opcode of extended OAMPDU includes Extended Variable Request, Extended Variable Response, Set Request, Set Response, Churning and DBA, etc. Specific Ext.Opcode is Table 7.

Table 7 Operation Type of Extended OAMPDU

Ext. Opcode	Value (Hex)	Definition
Reserved	0×00	Ignored on reception.
Extended Variable Request	0×01	Used for OLT to inquire of ONU extended attributes
Extended Variable Response	0×02	Used for ONU to return extended attributes to OLT
Set Request	0×03	Used for ONU to extend attributes/operations to ONU configuration
Set Response	0×04	Used for ONU to return confirmation for extension attributes/operation configuration to OLT
Churning	0×09	Key exchange relative to Triply-Churning
DBA	0×0A	DBA parameters configuration and query
Reserved for future use	Other Values	Reserved

Extended Operation Description:

- Extended Variable Request: Extended Variable Request can read standard and extended object attributes. Each data domain in PDU of Variable Request message of IEEE 802.3-2005 contains a serie of Variable Descriptor and instance index of management object TLV (if the instance index of management object TLV is required; the defination of the instance index of management object is in para. 8.5.2.) the format of Variable Descriptor should meet IEEE802.3-2005 Clause57.
- Extended Variable Response: Extended Variable Response is the response for remote Variable Request. Each data domain in PDU of Variable Request message of IEEE 802.3-2005 contains a serie of Variable Containers. The format of Variable Container should meet IEEE802.3-2005 Clause57.
- Set Request: OLT sends Set Request message to write the parameters of remote management objects of remote ONU. The format of Payload domain in Set Request message is similar to Variable Response message, including a serie of Variable Container used to point Variable needed to set and instance index of management objects TLV (if necessary). The data field of Container includes setting values for the variable.
- Set Response: ONU sends Set Response to OLT for confirmation of whether write operations succeed. Set Response message includes a serie of Variable Container and instance index of

management objects TLV (if necessary) with return codes for each Set Request and Action corresponding to Variable Set message. A typical container includes Branch/Leaf ID, whose Value/Length field contains an operation confirmation code. Specific operation confirmation code is described in para. 6.5.4.7 of this standard.

- Churning: Used for key exchange of churning procedures and synchronize the protocol exchange procedure needed by synchronization. The specific specification is in Chapter 11.1.
- DBA: Used to implement the functions of DBA parameters read and setting needed by DBA interoperability. The specification is Chapter 6.5.5.

This standard temperarily does not fix the updating function of software/firware based on OAM.
The messages of Extended Variable Request, Extended Variable Response, Set Request and Set Response can include the extension attributes defined in this standard as well as standard attributes defined in IEEE 802.3.
Standard OAM frames and extended OAM frames can support the maximum frame length of 1518 bytes.

6.5.4 Extended Management Objects, Attributes and Operation

6.5.4.1 Extended Object Class

According to the rules of IEEE802.3, define the extended management objects as listed in Table 8.

Table 8 Ecxtended OAM Management Objects

Object	Discription	Leaf Code
ONU	Basic information of ONU (Vendor, Chipset, firmware, Capability Notification etc.)	0×0001 - 0×000F
Port	Port configuration (POTS, Open/Close of E1 Port, Flow Control of Ethernet Port, policing, etc)	0×0011 - 0×001F
	VLAN Configuration Management	0×0021 - 0×002F
	Business Classification and Marking, etc relative to QoS	0×0031 - 0×003F
Multicast	Multicast Function	0×0041 - 0×004F

6.5.4.2 Instance Index of Management Object

There may be multiple instances in certain management objects described as above. For example, for Port objects, each ONU may have multiple physical ports. The Instance Index of Management Object is used to identify the instances of management objects of later standards or that extended attributes and operations use. The Instance Index of Management Object adopts the same TLV format with Variable Container regulated in IEEE802.3-2005 Clause57. The spefic format of the Instance Index of Management Object TLV is shown in Table 9.

Table 9 The format of the Instance Index of Management Object TLV

(Octets)	**Field**	**Note**
1	Branch	0×36, indicating the TLV is the instance index of management objects
2	Leaf	Type of Management Objects (Specific Leaf Value is in Table 10)
1	Variable Width	The value is 0×01
1	Value	Number of specific instance of management objects

Leaf coding specified for all kinds of management objects is in Table 10. Value indicates the number of the specific instance of the management object. For example, when the management object is port (Port , Leafvalue is 0x0001, the Value will be the number of specific PON port, Ethernet port, VoIP port and E1 port. Only the instance index function specified for ports is regulated. Part of extended multicast management OAMPDU also needs to use the port index. No new definition is made, and the same TLV with instance indexes of port objects is used.

Table 10 Management Objects Coding

Object	Leaf Value	Note
Port	0×0001	The management objects are PON port, Ethernet port, VoIP port and E1 port.
	Other	Reserved; leaf code of other management objects are undetermined.

There can be multiple Variable Descriptors or Variable Containers of Attribute/Action specified for the instance after the instance index TLV of each management object. In one OAMPDU, all Variable Descriptors or Variable Containers after one instance index of management object are specified for the attribute and actions of the instance until the data part of the OAMPDU ends (Padding appears) or another instance index of management objects or another Variable Descriptor/Container of one management object appears.

In the EPON system, the instance index of management objects are only in the form of Variable Container. The instance index of management objects of the Variable Descriptor with only 2 fields of Branch (value is 0x36) and Leaf. If there is this kind of Variable Descriptor in OAMPDU, the receiving end should do Ignore operation with this OAMPDU. When OAMPDU sent by OLT to ONU contains Variable Container of the instance index of management objects and Variable Container/Descriptor of specific attributes/action corresponding to this instance, The OAMPDU returned by ONU to OLT should adopt the same Variable Container of the instance index of management objects. Figure 12 gives the OAMPDU format used for query of flow control functions of Ethernet Interface 1. Figure 13 gives the format of Extended GET Variable Response OAMPDU corresponding to the query OAMPDU.

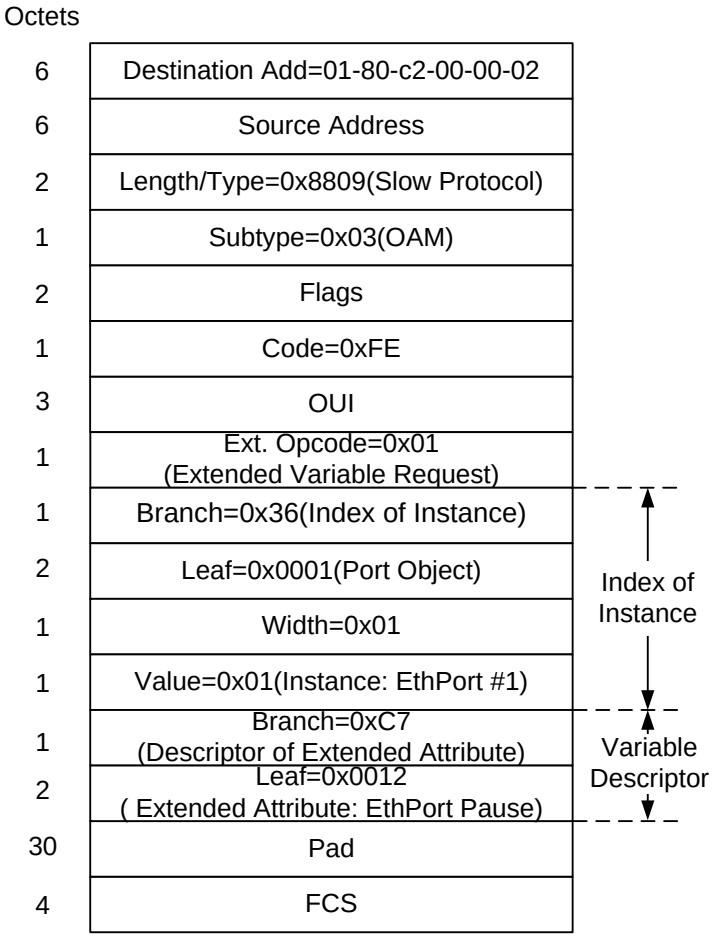


Figure 12 Format Example of Extended GET Variable Request OAMPDU with Instance Index of Management Objects

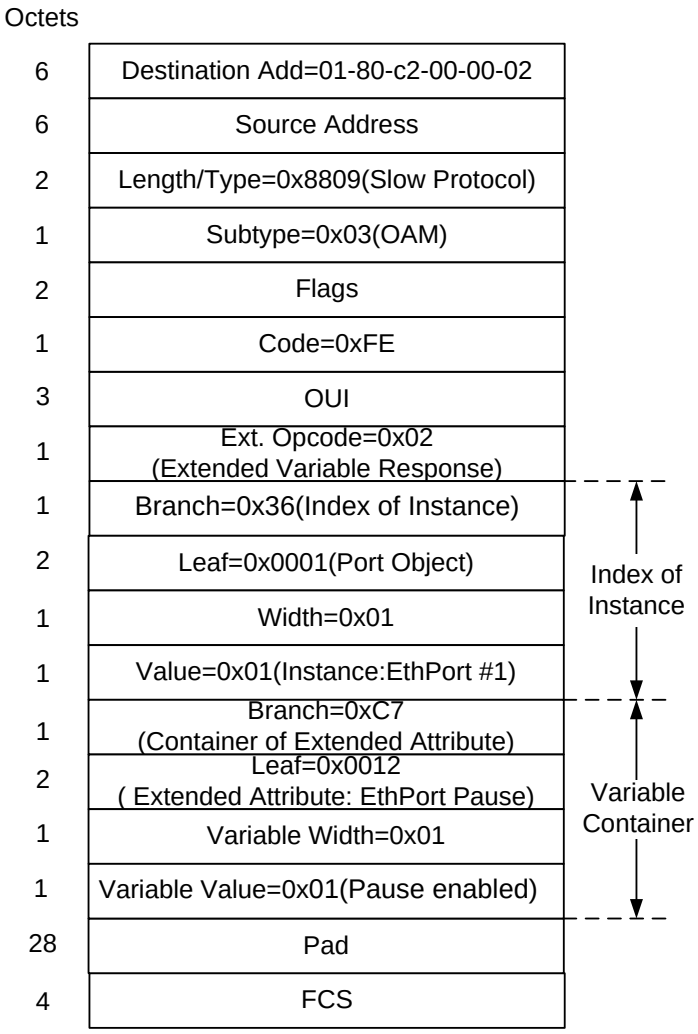


Figure 13 Format Example of Extended Variable Response OAMPDU with Instance Index of Management Objects

In the extended OAM message, there may be one or more instance indexes of management objects, or may be not. For the ONU management objects, because there are not multiple instances, it is not necessary to regulate its specific instance index, and there can be not instance index of management objects TLV in the extended OAM message. For example, for standard attributes like aFECAbility and aFECmode, etc and some extended attributes as below (attributes ONU SN, FirmwareVer, Chipset ID, ONU Capability and Action Reset ONU), it is not necessary to add Instance Index of Management Objects before Variable Container of specific attributes. Figure 14 gives the format example of Set Request OAMPDU without Instance Index of Management Objects TLV with ResetONU action as the example. Parts of the multicast functions are specified for ports, so the Instance Index of Management Objects TLV (interface) needs to be adopted. As the other parts of multicast functions (like Attributes MulticastSwitch、MulticastControl) are specified for ONU, the Instance Index of Management Objects TLV should not be adopted.

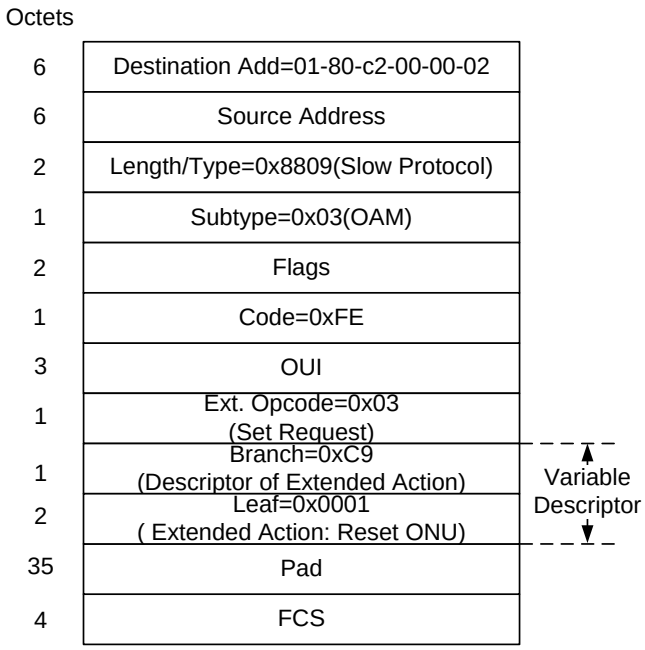


Figure 14 Set OAMPDU Format without Instance Index of Management Objects

When a port identified by certain Instance Index of Management Objects in Get/Set Variable Request OAMPDU received by ONU does not exist, ONU will do Ignore Action with this TLV and Variable Descriptor/Container specified for the port after TLV, and return VarBadParameters (0×86.)

The Instance Index of Management Objects is not only used for extended attributes and actions regulated by this standard but also used for some standard attributes and actions regulated by IEEE 802.3-2005 Clause30. For example, there is no regulation about how to do actions of UNI state function management and configuration like aPhyAdminState and acPhyAdminControl, etc. for specific UNI ports in IEEE802.3, so extended OAM message can be adopted to manage and set with the Instance Index of Management Objects TLV. The specific example is in para. 6.5.4.6.

6.5.4.3 Extended Attributes and Actions

For all kinds of ONU attributes and action management of objects, the branch code of its Variable is shown in Table 11:

Table 11 Branch Code of Variable

Hex	Definition of Branch	Definition
0×07	Standard Attribute	Standard Attributes regulated by IEEE 802.3 Clause 30
0×09	Standard Action	Actions regulated by IEEE 802.3 Clause 30
0×C7	Extended Attribute	CTC extended attributes, Get and (or) Set can be executed
0×C9	Extended Action	CTC Extended Actions

ONU extended attributes and its codes are shown in Table 12:

Table 12 ONU extended attributes and its codes

Attribute Name	Description	Management Object	Leaf	Requirement (Whether it is Optional)	Get	Set
ONU SN	ONU ID	ONU	0×0001	Required	o	
FirmwareVer	Firmware Version of ONU	ONU	0×0002	Required	o	
Chipset ID	PON Chip Manufacturer and Version of ONU	ONU	0×0003	Required	o	
ONU Capabilities	Port Type and Basic Functions supported by ONU	ONU	0×0004	Required	o	
EthLinkState	Link Status of Ethernet User Port	Port	0×0011	Required	o	
EthPort Pause	Flow control function and parameters of Ethernet Port	Port	0×0012	Required	o	o
EthPort Policing	Speed Limit Function of Ethernet Port (Uplink)	Port	0×0013	Required	o	o
VoIP Port	VoIP Port Management	Port	0×0014	If supporting VoIP, required	o	o
E1 Port	E1 Port Management	Port	0×0015	If supporting TDM, required	o	o
VLAN	VLAN Function of ONU	Port	0×0021	Required	o	o
Classification&Marking	Classification and Marking of Business Flow	Port	0×0031	Required	o	o
Add/Del Multicast VLAN	Multicast VLAN Configuration of Ethernet Port of ONU	Multicast	0×0041	Required	o	o
MulticastTagStripe	VLAN TAG Processing for Multicast Data Message vy ONU	Multicast	0×0042	Optional	o	o
MulticastSwitch	Multicast Switch	Multicast	0×0043	Required	o	o
MulticastControl	Multicast Business Control based on channels	Multicast	0×0044	Required	o	o
Group Num Max	Multicast Group Number supported by ONU or Port	Multicast	0×0045	Optional	o	o

6.5.4.4 Definition of Extended Attributes

The structure of Variable Discriptor applied to extended variable and action of action Get Variable Request should meet IEEE802.3-2005 Clause57, composed of Branch (0XC7 or 0XC9) and Leaf (0×0001-0×00AF), which is not specified in the paragraph. The regulations as below are made for the definition of Extended Variable and Action, Variable Container structure and actions corresponds to ONU:

1) ONU SN:

Definition: Sequence Number of ONU. The sequence number is composed of 3 parts: 3 fields as ONU Vendor ID, ONU Version and ONU MAC Address. The specific structure of Variable Container is shown in Table 13:

Table 13 Format of ONU SN variable container

Octet (s)	**Field**	**Notes**
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0001)	ID of ONU
1	Variable Width	Value is 38.
4	Vendor ID	Vendor ID is string, used to identify certain ONU manufacturer,

		whose code adopts the standard of ANSI T1.220 that adopts ASCII/ANSI string code. (The code set for the Vendor_ID is specified in ANSI T1.220. The 4 characters are mapped in the 4-byte field by taking each ASCII/ANSI character code and concatenating them.)
4	ONU Model	ONU Model, whose code is defined by the manufacturer,
6	ONU ID	The MAC address of ONU is used to be as the ID of ONU.
8	HardwareVersion	The hardware version number of ONU equipments, made by ASCII code. If the version number is less than 8 bytes, its value will be place in the lowest order of this field according to alignment of the lowest order.
16	SoftwareVersion	The software version number of ONU equipments, made by ASCII code. If the version number is less than 16 bytes, its value will be place in the lowest order of this field according to alignment of the lowest order.

2) FirmwareVer:
Definition: the firmware version of the ID chip. The specific structure of Variable Container is shown in Table 14:

Table 14 FirmwareVer variable container format

Octet (s)	**Field**	**Notes**
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0002)	Firmware Version ID of ONU chip
1	Variable Width	When it is used to indicate the field length of Variable value, its value is chagable;
X	Version	The specific value of Firmware version, Hex value

3) Chipset ID:
Definition: Identify the PON chipset used by ONU, including 2 fields as Chipset Vendor ID and Chip Model. The specific format of Variable Container of Chipset ID is as shown in Table 15:

Table 15 Chipset ID variable container format

Octet (s)	**Field**	**Notes**
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0003)	Chipset ID
1	Variable Width (0×08)	When it is used as Variable Indication, its value is as the definition in ONU SN variable;
2	Vendor ID	Vendor ID is string, sued to identify certain chipset manufacturer, whose code adopts JEDEC ID
2	Chip Model	Chipset Model, whose code is defined by manufacturers
1	Revision	Chipset Revision Case
3	IC_Version/Date	The Version of Chipset (Hardware.) If there is no version number, it can be the design time, whose format is YY/MM/DD.

4) ONU Capabilities
Definition: Describe main functions supported by ONU, including port number, port and business type, number of uplink queue, number of max queue of uplink port, allocated step length of uplink queue, number of downlink queue, number of max queue of downlink port and allocated step length of downlink queue. The specific Variable Container of ONU Capabilities variable is as shown in Table 16:

Table 16 ONU Capabilities variable container format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0004)	ONU Capabilities Attributes
1	Variable Width	Value is 0×1A;

1	ServiceSupported	Business Type supported by ONU, whose value is in the form of bitmap:
		bit0 = 1 indicates that ONU supports 1000M Ethernet FE interface; bit0=0 indicates that ONU does not provide GE interface;
		bit1=1 indicates that ONU supports Ethernet FE interface (max rate is 100M without GE interface); bit1=0 indicates that ONU does not provide FE interface;
		bit2 = 1 indicates supporting VoIP business, bit2=0 indicates not supporting VoIP business;
		bit3 = 1 indicates supporting TDM CES business, bit3=0 indicates not supporting TDM CES business.

1	Number of GE Ports	Number of 1000M Ethernet UNI ports
8	Bitmap of GE Ports[1]	Deployment of 1000M Ethernet UNI ports
1	Number of FE Ports	Number of 100M Ethernet UNI ports
8	Bitmap of FE Ports	Deployment of 100M Ethernet UNI ports
1	Number of POTS ports[1]	Number of POTS ports of IAD
1	Number of E1 port[1]	Number of E1 Port
1	Number of US Queues	Number of upstream queues
1	QueueMax per US Port	Maximum queues per port upstream
1	Number of DS Queues	Number of downstream queues
1	QueueMax per DS Port	Maximum queues per port downstream
1	Battery Backup	Whether ONU has a backup battery; 0×00: No backup battery; 0×01: Has backup battery;

Note 1: 8-byte “Bitmap of GE Ports” indicates the Deployment of 1000M Ethernet UNI ports in the form of bitmap. While bitX=0 indicates that the port of ONU Port Number=X is not GE interface, bitX=1 indicates that ONU Port Number=X port is GE interface. The bit coding form of field “Bitmap of GE Ports” is the highest order (the highest order of the 1st byte of this field) is bit 64, while the lowest order (the lowest order of the 8th byte of this field) is bit0 analogously. For example, if field “Bitmap of GE Ports” is 0×0000000000000800, it indicates port 12 as GE port; if field “Bitmap of GE Ports” is 0×0000000000000C00, it indicates port 12 and 11 are GE ports. In the same case, 8-byte “Bitmap of FE Ports” indicates Deployment of 100M Ethernet UNI ports as well as in the form of bitmap, whose coding form is the same as the one of “Bitmap of GE Ports”. For instance, if field “Bitmap of FE Ports” is 0×00000000000007FF, it indicates that port 1 to 11 of this ONU are all FE ports; if field “Bitmap of FE Ports” is 0×00000000000003FF, it indicates port 1 to 10 of this ONU are all FE ports. For practically existed Ethernet ports, the bit values in the 2 8-byte fields should not be the same. In other words, bitmap value indicates the port capability. If GE is supported, the corresponding bit of “Bitmap of GE Ports” is 1 and the bit in “Bitmap of FE Ports" is 0; if certain port only supports FE instead of GE, the corresponding bit of “Bitmap of GE Ports” is 0 while the bit in “Bitmap of FE Ports" is 1 (although GE ports can work in the state of FE, the corresponding bit in “Bitmap of FE Ports" should not be duplicated.) For instance, when port 1 to 10 are FE ports, port 11 and 12 are ONU of GE ports, its field of “Bitmap of GE Ports” is 0×0000000000000C00 and “Bitmap of FE Ports” is 0×00000000000003FF.

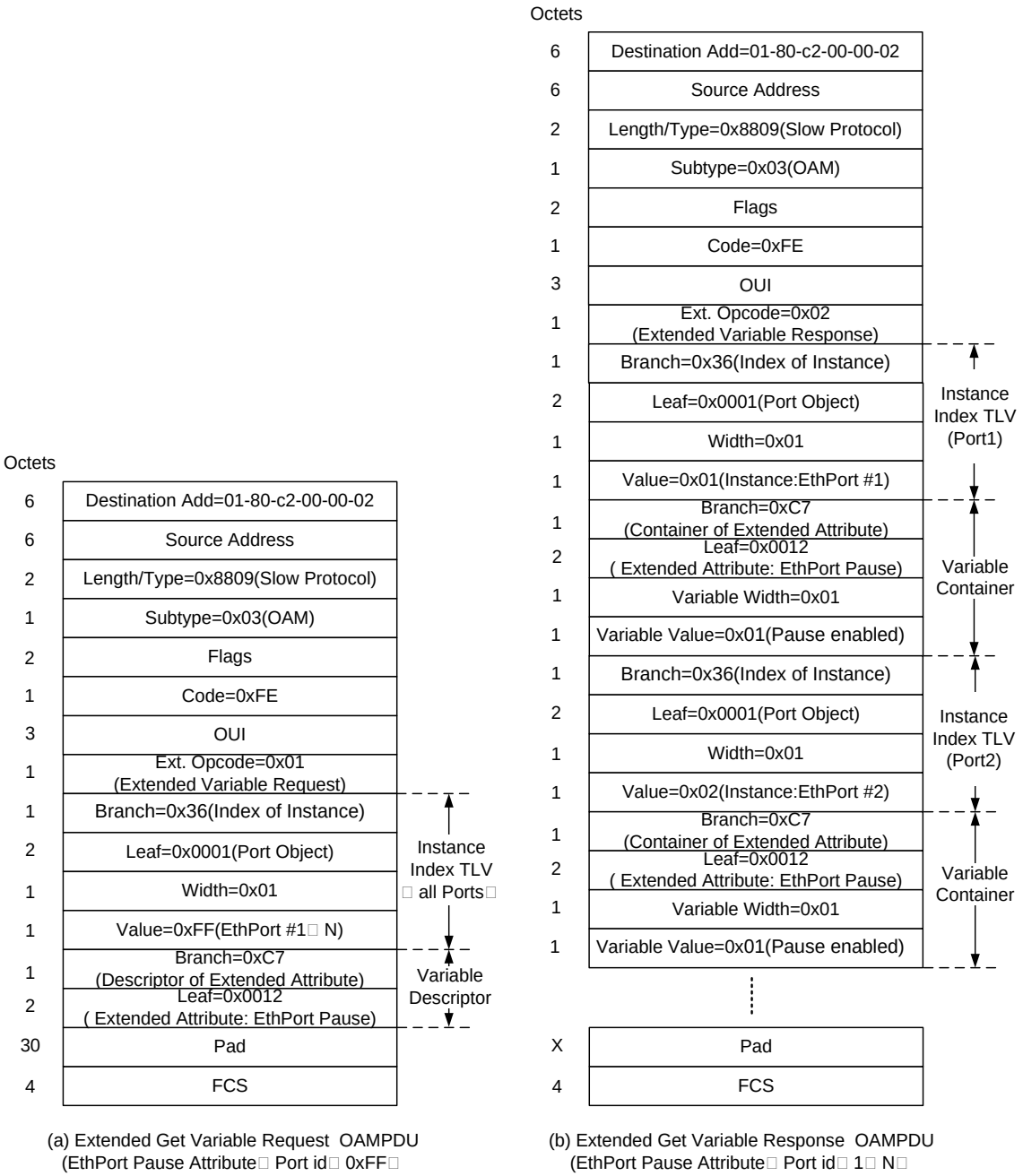
In the fields “Bitmap of GE Ports” and “Bitmap of FE Ports”, the values of bits whose corresponding practical ports do not exist are all set as 0. For example, if field “Bitmap of GE Ports” of ONU is 0×0000000000000C00 and “Bitmap of FE Ports” is 0×00000000000003FF, it will then indicate that this ONU only has 12 Ethernet interfaces (2 GE ports that are repectively port 11 and 12; 10 FE ports are from port 1 to port 10.) There are not port 13, 14, …, 64 on ONU.

For easy management, Ethernet ports, VoIP ports, E1 ports and PON ports are unifiedly numbered. The number rule is as shown in Table 17. The range of Ethernet ports is 0×01-0×4F, while the number of Ethernet UNI number is from 0x01 by sequence. The range of VoIP ports is 0×50-0×8F (from 0×50.) The range of E1 ports is 0×90-0×9F (from 0×90); The number of PON ports is 0, and the range of the reserved port numbers is 0×A0-0×FE.

Table 17 List of Port Number of ONU

Port Type	**Port Number Range**	**Note**
PON Port	0×00	Default PON Port
Ethernet Port	0×01-0×4F	Ethernet UNI Port
VoIP Port	0×50-0×8F	POTS Interface
E1 Port	0×90-0×9F	E1 Port
Reserved Ports	0×A0-0×FE	The number range reserved for other types of ports, such as ADSL ports and reserved PON ports, etc.
All Ethernet Ports	0×FF	All Ethernet physical UNI ports on ONU (Port 1-N)

Besides, the numbers of Ethernet UNI ports in the extended OAM message should be strictly corresponding to the port numbers on the ONU panel. For instance, When managing the specific attributes of Ethernet ports whose panel number is 1, the number field of the corresponding port in the OAM message should be 0x01 (Port number of OAM panel should be from 1 to 79.)
Port 0xFF indicates the set of all Ethernet physical UNI ports (Port 1-N) on the ONU. The attrubutes management and actions for Port 0×FF are for every Ethernet physical ports. The method that Port 0xFF indicates all Ethernet physical ports is only used for Get Variable Request OAMPDU, Set Request OAMPDU and Set Response OAMPDU. The method can not be used for Get Variable Response OAMPDU. In Get Variable Response OAMPDU, the attributes of each Ethernet physical port should be read respectively (read.) As shown in figure 15, OLT inquires the flow control status of all Ethernet ports of ONU through the combination of “Instance Index of Management Objects TLV (branch = 0×36 , leaf = 0×0001, value of Port id = 0×FF)+ EthPort Pause Descriptor”. When ONU returns (GET) its information of all port flow control status, ONU should report the flow control status of all ports for Ethernet ports through the combination of multiple “Port Instance Index TLV (Value of Port ID=1-N) + EthPort Pause Container.”

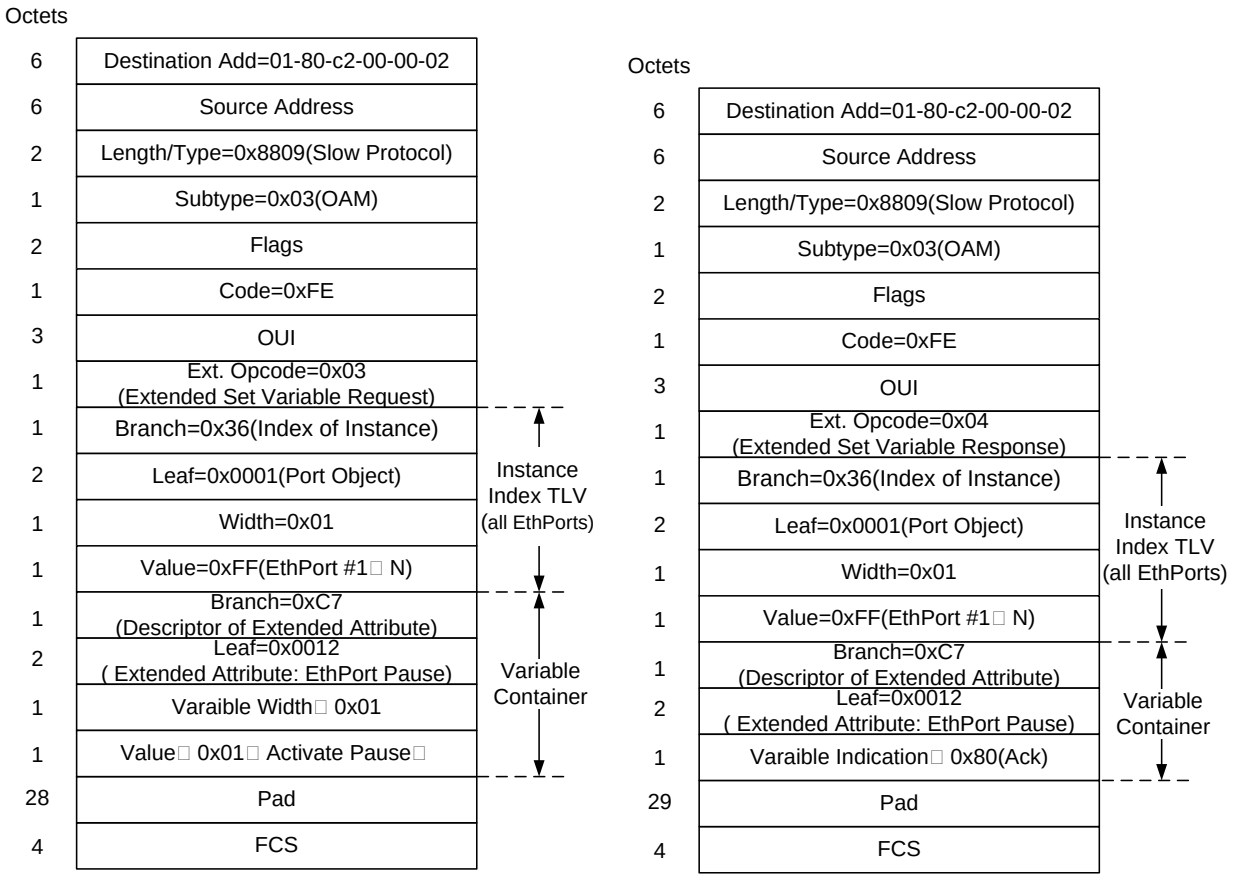


(a) Extended Get Variable Request OAMPDU (EthPort Pause Attribute□ Port id□ 0xFF□

(b) Extended Get Variable Response OAMPDU (EthPort Pause Attribute□ Port id□ 1□ N□

Figure 15 Port 0xFF is used to indicate Get Variabe Request and Get Variable Response OAMPDU examples of all Ethernet ports

In Set Response OAMPDU of using Port 0×FF to indicate all Ethernet physical ports, the method is only used for confirmation of the same attributes configuration/action for all Ethernet ports by OAM. For instance, if it is enabled that Set Request OAMPDU uses Port 0×FF to configure the flow control status of all Ethernet physical ports, it will asky for confirmation from OLT through the port instance index TLV of Value of Port id **=** 0×FF and EthPort Pause Container after ONU completes the relative configuration of all Ethernet physical ports successfully. The specific instance is as shown in figure 16.



(a) Extended Set Variable Request OAMPDU (EthPort Pause Attribute Port id 0xFF)

(b) Extended Set Variable Response OAMPDU (EthPort Pause Attribute Port id 0xFF)

Figure 16 Port 0×FF is used to indicate Set Request and Set Response OAMPDU examples of all Ethernet ports

The numbering rule is applied for all attributes management and actions specified for ports in the specification.

5) EthLinkState

Definition: Link running status of Ethernet ports. OLT uses the attribute to inquire the link status of Ethernet UNI interface. Its specific Variable Container format is as shown in Table 18:

Table 18 EthLinkState Variable Container Format

Octet (s)	**Field**	**Notes**
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0011)	Ethernet Port Link Operation Status
1	Variable Width	When it is used as Variable width, its value is 1;
1	LinkState	0×00—The Ethernet link connected with the Ethernet port is DOWN; 0×01—The Ethernet link connected with the Ethernet port is UP;

As this attribute is needed to designate the specific instance of its management objects (Ethernet port), the instance index TLV of management objects needs to be used.

6) EthPort Pause

Definition: Flow Control of Ethernet Port. Its specific Varaible Container format is as shown in Table 19:

Table 19 EthPort Pause Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0012)	Ethernet Port flow control
1	Variable Width	When it is used as Variable width, its value is 1;
1	1st Port Back Pressure Operation	0×00—Flow Control disabled or to deactivate the function, 0×01—Flow Control enabled or to activate the function,

As this attribute is needed to designate the specific instance of its management objects (Ethernet port), the instance index TLV of management objects needs to be used.
The relative parameters of Pause flow control of Ethernet ports on ONU such as Back Pressure Time and Back Pressure Occur/Clear Queue Threshold, etc are regulated by equipment manufacturers themselves.

7) EthPort Policing
Definition: The Ingress Policing function of upstream business of Ethernet ports. UNI ports of EPON system adopt single rate Poicing method, whose specific Variable Container is as shown in Table 20:

Table 20 Format of EthPort Policing Variable Container

Octet(s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0013)	Ethernet Port policing (upstream)
1	Variable Width	When it is used as Variable width, its value is 1 (when Port Policing operation field is 0x00)or 10 (Port Policing operation field is 0×01);
1	Port Policing operation	0×00—Policing disactivated or to deactivate the function, 0×01—Policing activated or to activate the function, The default value of this field is 0x00.
3	Port Policing CIR	This parameter indicates the committed Information Rate of the port. The parameter indicates the rate in Kbps. Values: 0×000000 to 0×FFFFFF. When field Port Policing Operation is “0×00”, there is not this field.
3	Port Policing bucket depth (CBS)	This parameter identifies the depth of this token bucket to tolerant the certain burst. The unit of CBS is byte。 When field Port Policing Operation is “0×00”, there is not this field.
3	Port Policing extra burst size (EBS)	This parameter identifies the extra token to permet the forwarding engine to finish the packet being sent when the CBS is exhausted. Here the Unit of EBS token is byte. The unit of EBS value here is byte. When field Port Policing Operation is ‘0x00’, there is not this field.

As this attribute is needed to designate the specific instance of its management objects (Ethernet port), the instance index TLV of management objects needs to be used.

8) VoIP Port
Definition: Management of VoIP ports (open or close), whose Variable Container format is as shown in Table 21:

Table 21 VoIP Port Variable Container Format

Octet(s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0014)	POTS (based on VoIP)Port management.
1	Variable Width	When it is used as Variable width, its value is 1;
1	Lock/Unlock	0×00—Port disactivated or to disactivate the port 0×01—port activated or to activate the port The default value of this field is 0x00.

As this attribute is needed to designate the specific instance of its management objects (Ethernet port), the instance index TLV of management objects needs to be used.

9) E1 Port

Definition: Management of E1 TDM Port (Open or Close), whose Variable Container format is as shown in Table 22:

Table 22 E1 Port Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0015)	E1 (based on CESoP) Port management.
1	Variable Width	When it is used as Variable width, its value is 1;
1	Lock/Unlock	0×00—Port disactivated or to disactivate the port 0×01—port activated or to activate the port The default value of this field is 0×00.

As this attribute is needed to designate the specific instance of its management objects (Ethernet port), the instance index TLV of management objects needs to be used.

10) VLAN

Definition: VLAN configuration of Ethernet ports including modes of transparent、tag and translation, etc. Its variable Container format is as shown in Table 23. The actions for VLAN are specified for ports. Each Variable Container can contain VLAN management of only one port. Here is specified for unicast VLAN not involving configuration and query of multicast VLAN. A Vlan configuration command of a certain port is encapculated by a Container. For certain ports, the VLAN configuration of a new VLAN Container will replace the original one.

Table 23 VLAN Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0021)	Configure the VLAN function of ONU.
1	Variable Width	When it is used as Variable, its value is (1+X);
1	VLAN mode	0×00: Transparent mode 0×01: Tag mode 0×02: Translation mode The other modes are undetermined.
X	VLANConfig Parameters	Corresponding to different configuration parameters of VLAN mode.

There is no VLAN operation Parameters domain (X=0) for Transparent mode.

For Tag mode, add VLAN tag for input Ethernet frames; X=4, is added VLAN tag value including fields of TPID, CFI, Pri and VID, etc.

For Translation mode, X=4+8Y, Y is the item amount of VLAN Translation, whose first 4 bytes are for default VLAN (including TPID VID, CFI and Pri, etc.) There are several translation entries then, each of which contains 8 bytes, whose first 4 bytes are VLAN tag prepared to be removed (old VID to be striped) and after 4 bytes is added VLAN tag (new VID to be add); Then ONU supports multiple VLAN configuration for single port.

The specific ONU action for all kinds of VLAN modes is regulated by para. 8.2.2.

As this attribute is needed to designate the specific instance of its management objects (Ethernet port), the instance index TLV of management objects needs to be used.

11) Classification&Marking

Definition: Rules of upstream business flow classification, mapping and Ethernet priority (IEEE 802.1D) marking of specific Ethernet ports on ONU. The business flow classification and marking can be specified for physical ports as well as for specific domain in the frame head. A classification rule can contain 1 or more entries, all of which associate classification entries with mapping queue (Queue) according to the description method of field-value-operator and by the method of if-then. The categorized Ethernet frame is mapped to different queues (queque numbers are in "QueueMapped".) The specific Variable Container format is as shown in Table 24.

Table 24 Classification&Marking Variable Container Format

Octet (s)	**Field**	**Notes**
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0031)	Configure the rules of traffic classification and priority marking.
1	Variable Width	Changeable (>=1)
1	Action	Action types of Classification, Queuing&Marking control list for Variable Container: 0×00: Delete Classification, Queuing&Marking control rules below (used in Set Variable Request message); 0×01: Add Classification, Queuing&Marking control rules below (used in Set Variable Request message); 0×02: Clear Classification, Queuing&Marking control list of the ONU port (Deletye all classification, queue and marking rules of the ONU); The action type is only used in Set Variable Request message. When this container is of the action type, there is not other data after the byte; 0×03: List all Classification, Queuing&Marking control items of the port (used in Get Variable Request/Response message); when this container is used in Get Variable Response, there are all classification, queue and marking rules after the byte; Other value: Reserved
1	Number of rules in the container	The amount of "classification, queue and marking" rules contained by this Container is integer, whose minimum value is 0 (when OLT inquires Classification&Marking rules of a certain port and the port has not been configured with Classification&Marking rules, Field Number of rules in the container of Classification&Marking Variable Container in Variable Response OAM message is 0. In the other circumstances, the field value should be more or equal to 1).
1	Precedence of Rule No.1	Priority of "Classification, Queue and Marking". When the byte is 1, it indicates that the rule is the most prior. For each Ethernet frame, ONU should use the matching rule of the most prior to confirm the queue mapping method and marking priority, while all the other sequence will be ignored. (Generally speaking, multiple "Classification, Queue and Marking" rules of a certain port should not conflict. When a conflict occurs–a message belongs to2 or more rules at the same time-it is to be determined by the sequence priority.) If one Precedence value of newly added ''Classification, Queue and Marking" is equal to the Precedence value of certain current rule of ONU, the rules originally occupying the Precedence value and all Precedence values with lower priority rules are added by 1 (All lowered by one level compared with the original sequence.) New rules will occupy the Precedence value. If one current rule is deleted, the precedence values of the rules with lower priority after the rule will decrease by 1 (All raised by one level compared to the original sequence).

		If adding new rules causes the rules amount to be beyond the ONU or port capability, ONU will automatically delete the rule with the lowest priority. For instance, as for the Ethernet port 1 of ONU, the maximum amount of rules it can support is 8, and the port has been configured with 8 rules (the Precedence values are from 1-8.) If a new rule with the Precedence value that is 4, the Precedence values of the rules whose original Precedence values are from 4 to 7 will be 5-8. The rule with Precedence value that is 8 will be deleted. If the Container is Delete action, it is only necessary to give out the amount of rules needed to be deleted (Number of Rules) and the Precedence values of these rules (multiple rules can be deleted at the same time, that is, multiple Precedence values will be listed) and not necessary to specify the rule content. Note: In this circumstance, multiple Precedence bytes should be arranged by sequence after Field Number of rules in the container. No data is supposed to be filled between adjacent Precedence bytes, and there is not requirement for the sequence of Precedence values. (Of course, Set Request executing delete action can also involve the specific content of each rule needed to be deleted, but its all parameters must be exactly the same as what ONU stores so as to be valid, or ONU will return 'Invalid Parameter (0×86)' code. It is not forced to require that ONU has the capability of analyzing this kind of Variable Container and of relative processing.)
1	Length of Rule No.1	Length of the first rule, whose unit is byte. The value does not involve Byte Length of Rule itself.
1	QueueMapped (Rule No.1)	Queue number the Ethernet frame meeting the regulation is to map (the value should be the Number of Queue to be mapped). For example, if it is to map the business flow of classification rules meeting the description below to Queue 7, the byte value will 0×07.
1	EthernetPriorityMark (Rule No.1)	Priority marking for the Ethernet frame conforming to the rule (IEEE 802.1D), whose value is 0×00-0×07. The default value of the byte is 0×00; If the byte value is 0xFF, it is meant not to do priority marking for the frames conforming to the entry. If the Ethernet frame entering Classifier is of no tag, VLAN tag and Pri will be signed on it, whose VLAN ID is the default value (1);
1	Number of entries (Rule No.1)	The amount of rules (entries) that the rule needs to meet. If there are multiple entries, there will then be multiple field-value-operator domains below, which means that multiple entries below must be met at the same time so as to execute the actions as mentioned above.
1	Field Select (1st)	Field that the first entry corresponds to (field): 0×00: Based on the classification of DA MAC; 0×01: Based on the classification of SA MAC; 0×02: Based on the classification of Ethernet priority Pri (IEEE 802.1D) 0×03: Based on the classification of VLAN ID; 0×04: Based on the type of Ethernet (0×8808, 0×8809 and 0×88A8, etc, which mainly mean the original Length/Rther Type of Ethernet frame, not including TPID domain in VLAN tag); 0×05: Based on the classification of destination IP address; 0×06: Based on the classification of source IP address; 0×07: Based on the IP protocol type (IP, ICMP and IGMP, etc.); 0×08: Based on the classification of IP TOS/DSCP (IP V4); 0×09: Based on the classification of IP Precedence (IP V6); 0×0A: Based on the PORT classification of L4 source; 0×0B: Based on the PORT classification of L4 destination; Other methods are undetermined.
6	Match Value (1st)	The matching value of the 1st entry. If the corresponding field is less

		than 6 bytes (For example, VLAN Pri=1 as the matching field), its matching value by the lowest order alignment will be put in the lowest position of the byte (the matching value is 0x00 00 00 00 00 01.)
1	Validation Operator (1st)	Operator used by the 1st entry, whose specific coding is as shown in Table 20.
1	Field Select (2nd)	Corresponding field of the 2nd entry;
6	Match Value (2nd)	The matching value of the 2nd entry;
1	Validation Operator (2nd)	Operator used by the 2nd entry;
¦	¦	¦
1	Precedence of Rule No.2	Priority of "Classification, Queue and Marking" rules.
1	Length of Rule No.2	Length of the 2nd rule
1	QueueMapped (Rule No.2)	As above
1	EthernetPriorityMark (Rule No.2)	As above
¦	¦	¦

As the action object of the attribute is port and it is also necessary to designate the specific instances of management objects, the instance index of management objects is needed to be used.

Classification&Marking rule should be integrate. It is not allowed to divide one rule into 2 or more Variable Containers.

ONU is configured in the unit of Container, that is, the rules (may be multiple) in the same Container can be configured into its Classification、Queuing and Marking list. The case of Precedence value conflict will be handeled by the way mentioned above. After all Classification, Queuing&Marking rules in certain Variable Container are configured successfully, ONU is to confirm through sending Set Variable Response OAMPDU including return codes to OLT. (As regulated in para, 6.5.4.7)

If OLT receives Set Variable Response OAMPDUs of SetOK return code including specific Variable Container in certain period (the specific time value should be configurable) after OLT sends out Set Variable Request OAMPDU used for Classification&Marking configuration, OLT will confirm the configuration of relative classification/marking rules that ONU has completed, or OLT will treat the configuration as incomplete.

The value of QueueMapped is the number of queue needed to be mapped, which is hex. The more the value is, the higher the schedule priority is. Besides, TDM business and Network Control business should be fixed to enter the queue of the highest priority in ONU. VoIP business should enter the queue of the highest or the second highest priority.

Each classification rule may involve one or more matching entries. ONU must support one matching entry currently.

The part provides "Classification, Queue&Marking" rules based on Combination of Entries. The function of "Classification, Queue&Marking" rules based on Combination of Entries is optional.

Table 25 Codes of validation operators

Field Value	**Symbol**	**Description**
0×00	F	Never match
0×01	= =	Field Equal to value
0×02	!=	Field Not equal to value
0×03	<=	Field Less than or equal to value (Optional)
0×04	>=	Field Greater than or equal to value (Optional)
0×05	exists	True if field exists (value ignored)
0×06	!exist	True if field does not exist (value ignored)
0×07	T	Always match

If the upstream Ethernet packets reveived by UNI interface does not involve the field used in classification or the field value is not displayed in classification rules, the frame will be mapped the queue with the lowest priority and not marked with Ethernet priority.

12) Add/Del Multicast VLAN

Definition: Multicast VLAN configuration of Ethernet Port of ONU, whose Variable Container cotainer is as shown in Table 26:

Table 26 Add/Del Multicast VLAN Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0041)	Multicast VLAN management
1	Variable Width	When it is used as Variable width, its value is 1+2X.
1	Multicast VLAN Operation	0×00—Delete the Multicast VLAN as shown below (Used for Set Variable Request message)； 0×01—Add the Multicast VLAN as shown below (Used for Set Variable Request message)； 0×02—Clear the Multicast VLAN of the port; The action type is only used in Set Variable Request OAM message. When the container is of the action type, there is no other data after the byte; 0×03—List the Multicast VLAN of the port as shown below (for Extended GET Variable Request and GET Variable Response OAM messages). When the container is used in Get Variable Request, there is no other data after the byte; when the container is used for Get Variable Response, there are all classification, queue and marking rules of the port after the byte; Other data-Reserved.
2	1st multicast VLAN ID	The 1st multicast VLAN ID Ethernet port corresponds to. The riority bits of CFI and Ethernet are both 0.
¦	¦	¦
2	Xth multicast VLAN ID	The xth multicast VLAN ID Ethernet port corresponds to.

As the action object of the attribute is port, it is necessary to designate specific instances of management objects and also necessary to use the instance index TLV of management objects.
In addition, the number of Multicast VLAN ONU supports should not be less than 4.

13) MulticastTagStripe

Definition: In certain circumstances, if users use an independent home network gateway equipment to connect the Ethernet port of ONU to run IPTV business, the home network gateway generally needs multicast business flow with multicast VLAN TAG. In the case, ONU should not clear VLAN TAG of downstream multicast messages. In other circumstances, if users directly connect the multicast aplication terminal (such as set-top box) to EPON system through Ethernet UNI port, ONU then needs to clear VLAN TAG of downstream multicast messages. The OAM message is used to control whether to clear VLAN TAG of multicast messages when ONU forwards multicast message to Ethernet UNI ports. The Variable Container format is as shown in Table 27.

Table 27 MulticastTagStripe Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0042)	Whether to clear VLAN TAG of downstream multicast messages
1	Variable Width	Changeable, its value is 1.
1	TagStriped	Whether to clear VLAN TAG of multicast business message of Ethernet port controlling ONU: 0×00: Not clear VLAN TAG of multicast business message; 0×01: Clear VLAN TAG of multicast business message; Other values: Reserved, ignored when received.

As the action object of the attribute is port, it is necessary to designate specific instances of management objects and also necessary to use the instance index TLV of management objects.

14) MulticastSwitch

Definition: Used to control that ONU uses the managable multicast protocol regulated by the standard or IGMP snooping mechanism. Its Variable Container format is as shown in Table 28.

Table 28 MulticastSwitch Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0043)	Multicast MAC management
1	Variable Width	Changeable, its value is 1.
1	Switch	The switch for the member management protocol of multicast group of ONU: 0×00: Activate IGMP snooping protocol to manage the multicast group member; 0×01: Activate the manageable multicast protocol of CTC to manage multicast group members; Other values: Reserved, ignored when received.

As the management objects the attribute corresponds to are for multicast of ONU, it is not necessary to use the instanve index of management objects.

15) MulticastControl

Definition: OLT makes use of that MulticastControl OAMPDU dynamicly manage the local multicast contro list of ONU, so as to control the forwarding method for downstream multicast messages by ONU. Its Variable Container format is as shown in Table 29:

Table 29 MulticastControl Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0044)	Multicast MAC management
1	Variable Width	Chagable, its value is 1 or 3+10X (if Multicast Control Type is Set Variable Request of 0×02 or 0×03, Variable Width is 1.)
1	Action	MulticastControl action type of the Variable Container: 0×00: Delete multicast control items as below (used for Set Variable Request message); 0×01: Add multicast control items as below (used for Set Variable Request message); 0×02: Clear the multicast control list of ONU (delete all multicast control items of the ONU); the action is only used for Set Variable Request message. When the container is of this action type, there is no other data after the byte but padding; 0×03: List all multicast control items of the ONU (used for Get Variable Request and Get Variable Response messages.) When the container is used for Get Variable Request, there is no other data

		after the byte but padding; when the container is used for Get Variable Response, there are all multicast control items of the ONU. Other values: Reserved.
1	MulticastControl Type	The method of implementing multicast business control: 0×00: Only based on GDA MAC(DA MAC only) 0×01: Based on GDA MAC + Multicast VLAN ID (Only is the container format by the method regulated currently, and other methods are undetermined) 0×02: Based on GDA MAC+SA MAC (Optional, IGMP V3)
1	Number of Entries	Number of multicast control items
2	Port /User ID of 1st Entry	Port/user ID of the 1st item, whose value is Port ID of the port of the IGMP control message received by ONU (the same with the VID marked on corresponding IGMP Report/Leave message).
2	Multicast VLAN ID of 1st Entry	Multicast VLAN ID of the 1st Entry.
6	GDA of 1st Entry	Multicast MAC Address of the 1st Entry.
2	Port/User ID of 2nd Entry	Port/User ID of the 2nd Entry, whose value is Port ID of the IGMP Message received by ONU (the same with the VID marked on corresponding IGMP Report/Leave message.)
2	Multicast VLAN ID of 2nd Entry	Multicast VLAN ID of 2nd Entry
6	GDA of 2nd Entry	Multicast MAC Address of the 2nd Entry.
⋮	⋮	⋮
2	Port/User ID of Xth Entry	Port/User ID of the Xth Entry, whose value is Port ID of the IGMP Message received by ONU (the same with the VID marked on corresponding IGMP Report/Leave message).
2	Multicast VLAN ID of Xth Entry	Multicast VLAN ID of Xth Entry
6	GDA of Xth Entry	Multicast MAC Address of the Xth Entry.

As the management objects the attribute corresponds to is the Multicast funtion of ONU, it is not necessary to use the instance index TLV of management objects.
OLT adds or delete ONU, or lists the entries of the access control list of multicast channels of certain Ethernet ports on ONU through Set request OAM messages involving this Variable Container.
When ONU reports the current multicast control list to OLT through GET Variable Response OAMPDU, if the entry number is beyond the capacity of a Variable Container (>12), you can use multiple Variable Container involved in the same OAMPDU to read (Multiple OAMPDU cascade connection is not required to be supported.) In this circumstance, the value of Field Number of Entries in the first MulticastControl Variable Container in Get Variable Response OAMPDU is the total amount of multicast control entries of this ONU (such as 16), and this Variable Container contains 12 multicast control entries; the value of Field Number of Entries in the second MulticastControl Variable Container in Get Variable Response OAMPDU is the value of the total amount of multicast control entries of this ONU reduced by 12 (such as 16-12=4), and so on. If the number of multicast control entries is beyond 24, 3 or more Variable Container cascade connections will be used. OLT is to determine the total amount of multicast control entries involved by ONU by the relations among the values of Number of Entries of several MulticastControl Variable Containers in the OAMPDU and will assemble multiple MulticastControl Variable Containers.

16) Group Num Max
Definition: The multicast group amount the Ethernet port of ONU supports at the same time, whose Variable Container format is as shown in Table 30:

Table 30 Group Num Max Variable Container Format

Octet (s)	Field	Notes
1	Branch (0XC7)	Extended attributes branch
2	Leaf (0×0045)	the multicast group amount the Ethernet port of ONU supports at the same time
1	Variable Width	When it is used as Variable width, its value is 1;
1	1st Max Num of Group	Allowed multicast group amount of ordering programming

As the action object of this attribute is Port, it is necessary to designate specific instances of its management objects and to use the instance index TLV of management objects.

6.5.4.5 Extended Action (ACTION)

Besides the standard actions regulated in IEEE802.3, EPON should also support the extended actions like Reset ONU. The extended action and its code is as shown in Table 31, while other extended actions are undetermined.

Table 31 Extended action and its code

Action	Description	Object	Value
ResetOnu	Reset ONU, as from power on	ONU	0×0001

The format of Variable Discriptor and Variable Container implementing extended actions (if there is other extended actions, there may be Variable Container used to implement extended actions) should meet the relative regulations of IEEE Std 802.3.

1) ResetOnu

For ResetOnu action, after ONU receives OAM request from ResetONU, it is not necessary to send acknowledge OAM message (Ack) but restart immediately.

6.5.4.6 Other Standard Attributes and Actions needed to be supported.

Besides the extended attributes and actions mentioned above, the EPON system should also support some standard attributes and actions regulated in IEEE 802.3-2005. The attibutes as shown in Table 32 is the attributes and actions the EPON system needs to support as regulated by this standard. The variable discriptor/container format of these standard attributes and actions should conform to IEEE 802.3-2005.

Table 32 The standard attributes and actions the EPON system needs to support

Attribute/Action	Description	Management Object	Branch	Leaf	Get	Set
aPhyAdminState	Inquire the status of Ethernet ports	Port	0×07	0×0025 (37)	○	
acPhyAdminControl	Set and change the status of Ethernet physical ports	Port	0×09	0×0005 (5)		○
aAutoNegAdmin State	The status of Ethernet ports (self negotiation)	Port	0×07	0×004F (79)	○	
aAutoNegLocalTechnologyAbility	actual port capabilities	Port	0×07	0×0052 (82)	○	
aAutoNegAdvertisedTechnologyAbility	Port Self Negotiation Capacity Notification	Port	0×07	0×0053 (83)	○	
acAutoNegRestartAutoConfig	Enforced Link Re-negotiation	Port	0×09	0×000B (11)		○
acAutoNegAdminControl	Turn on/off the self negotiation function of PHY ports	Port	0×09	0×000C (12)		○
aFECAbility	FEC function query (IEEE 802.3-2005 Clause 30.5.1.1.13)	ONU	0×07	0×0139 (313)	○	
aFECmode[1]	Turnon/off the bydirectional FEC function(IEEE 802.3-2005 Clause30.5.1.1.14)	ONU	0×07	0×013A (314)	○	○

The standard attributes and actions mentioned above should be the same as the extended attributes and actions regulated by the standard and loaded in Get Variable Request/Response and Set Request/Response OAMPDU.
The format and action definition of variable discriptor/container of these standard attributes and actions should the regulation in IEEE802.3-2005 and ASN.1. For example, according to the regulation in IEEE802.3-2005 and ASN.1, the data length of enumeration type is 4-byte, so the Variable Width of standard attibutes of enumeration type as mentioned above is 0x04; the data of SEQUENCE type involves a serie of data of enumeration type, and the VARIABLE Width of the attribute of SEQUENCE type is multiple of 4, while other types of data should also meet ASN.1.
The Variable Container format of some standard attributes are listed as below:

1) aPhyAdminState

Attribute aPhyAdminState is of enumeration type, whose Variable Container format is as shown in Table 33.

Table 33 Variable Container format of aPhyAdminState

Octet (s)	Field	Notes
1	Branch (0X07)	Standard attributes branch
2	Leaf (0×0025)	aPhyAdminState attribute.
1	Variable Width	the value is 4;
4	Value	Enumeration type of data, indicating the status of Ethernet physical ports of ONU: 0×00000001: Disabled 0×00000002: Enabled

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

2) acPhyAdminControl

acPhyAdminControl is of enumeration type, whose Variable Container format is as shown in Table 34.

Table 34 Variable Container format of acPhyAdminControl

Octet (s)	Field	Notes
1	Branch (0X09)	Standard attributes branch
2	Leaf (0×0005)	acPhyAdminControl attribute.
1	Variable Width	The value is 4;
4	Value	Enumeration type of data, indicating the open or close action of Ethernet port of ONU: 0×00000001: Deactivate the Ethernet Port 0×00000002: Activate the Ethernet Port

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

3) aAutoNegAdminState

aAutoNegAdminState attribute is of enumeration type, whose Variable Container format is as shown in Table 35:

Table 35 Variable Container Format of aAutoNegAdminState

Octet (s)	Field	Notes
1	Branch (0X07)	Standard attributes branch
2	Leaf (0×004F)	aAutoNegAdminState attribute.
1	Variable Width	The value is 4;
4	Value	Enumeration type of data , indicating the self negotiation status of Ethernet port of ONU (whether to open): 0×00000001: Disabled (IEEE 802,3-2005 Clause Annex 30 Page716) 0×00000002: Enabled (IEEE 802,3-2005 Clause Annex 30 Page716)

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

4) aAutoNegLocalTechnologyAbility

aAutoNegLocalTechnologyAbility attribute is of SEQUENCE type, which is enumeration value list of AutoNegTechnology that is AutoNegTechnologylist. The Sequence format should meet the requirement of IEEE802.3-2005 and ASN.1. The enumerated AutoNegTechnology code should meet IEEE802.3-2005 Annex30B (P171.) Table 36 gives a Variable Container example of aAutoNegLocalTechnologyAbility attribute.

Table 36 Variable Container Format of aAutoNegLocalTechnologyAbility

Octet (s)	**Field**	**Notes**
1	Branch (0X07)	Standard attributes branch
2	Leaf (0×0052)	aAutoNegLocalTechnologyAbility Attribute
1	Variable Width	The value is multiple of 4 (4+4X, X of which is the amount of involved enumeration type of data.) Variable Width of the Container example is 16.
4	Number of the Enumerated	The amount of enumeration type of data
4	1st Enumerated AutoNegTechnology	The 1st enumeration value AutoNegTechnology. For example, when the byte is 0×00000028 (40), it indicates that 1000BASE-T UTP PHY regulated in IEEE802.3-2005 Clause 40 is supported.
4	2nd Enumerated AutoNegTechnology	The 2nd enumeration value AutoNegTechnology. For example, when the byte is 0×00000192 (402), it indicates that 1000BASE-T UTP PHY regulated in IEEE802.3-2005 Clause 40 is supported.
4	3rd Enumerated AutoNegTechnology	The 3rd enumeration value AutoNegTechnology. For example, when the byte is 0×00000142 (322), it indicates that Full duplex 100BASE-T2 regulated in IEEE802.3-2005 Clause 31 and 32 is supported.

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

5) aAutoNegAdvertisedTechnologyAbility

aAutoNegAdvertisedTechnologyAbility attribute is SEQUENCE type of data, which is enumeration value list of AutoNegTechnology that is AutoNegTechnologylist. The Sequence format should meet the requirement of IEEE802.3-2005 and ASN.1. The enumerated AutoNegTechnology code should meet IEEE802.3-2005 Annex30B (P171.) Its Variable Container format is the same as Table 36 (Leaf value is 0×0053.)

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

6) acAutoNegRestartAutoConfig

OLT forces Ethernet UNI port to start the re-negotiation of link through acAutoNegRestartAutoConfig action. Command acAutoNegRestartAutoConfig sent by OLT uses Variable Descriptor format as shown in Table 37.

Table 37 Format of acAutoNegRestartAutoConfig Variable Descriptor

Octet (s)	**Field**	**Notes**
1	Branch (0X09)	Standard attributes branch
2	Leaf (0×000B)	acAutoNegRestartAutoConfig Action.

Opposite to SET acAutoNegRestartAutoConfig Request OAM message sent by OLT, Set acAutoNegRestartAutoConfig Response OAM message returned by ONU uses Format acAutoNegRestartAutoConfig Variable Container. The Container includes 3 fields of Branch (0×09), Leaf (0×000B) and Variable Indication (Codes of 0×80 or 0×87, etc.)

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

7) acAutoNegAdminControl

acAutoNegAdminControl attribute is of enumeration type, whose Variable Container format is as shown in Table 38:

Table 38 Format of acAutoNegAdminControl Variable Container

Octet (s)	Field	Notes
1	Branch (0X09)	Standard attributes branch
2	Leaf (0×000C)	acAutoNegAdminControl Action.
1	Variable Width	The value is 4;
4	Value	Enumeration type of data, indicating the auto negotiation function of opening or closing Ethernet ports of ONU: 0×00000001: Deactivate (IEEE 802,3-2005 Clause Annex 30 Page716) 0×00000002: Activate (IEEE 802,3-2005 Clause Annex 30 Page716)

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

8) aFECability Attribute

aFECability attrubute is of enumeration type, whose Variable Container format is as shown in Table 39:

Table 39 Variable Container Format of aFECability

Octet (s)	Field	Notes
1	Branch (0X07)	Standard attributes branch
2	Leaf (0×0139)	aFECability Attribute.
1	Variable Width	The value is 4;
4	Value	Enumeration type of data, indicating whether ONU supports FEC: 0×00000001: Unknown—Initializing, true state not yet known; 0×00000002: Supported—FEC supported; 0×00000003: Not supported—FEC not supported. (IEEE802.3-2005Annex30B, P719)

The management object of this attribute is Port, so it is necessary to add the instance index of management objects TLV before this Container/Descriptor.

9) aFECmode Attribute

aFECmode is used for the configuration of bidirectional FEC for the specific EPON PHY interface. The attribute is able to be read and written (read-write), whose value indicates the FEC work mode of the ONU. Read (GET operation) should return the current FEC work status of the ONU, while Write (SET operation) will change the FEC work status of the ONU. Its VariableContainer format is as shown in Table 40.

Table 40 Variable Container Format of aFECmode

Octet (s)	Field	Notes
1	Branch (0X07)	Standard attributes branch
2	Leaf (0×013A)	aFECmode Attribute.
1	Variable Width	The value is 4;
4	Value	Enumeration type of data, indicating Open and Close of FEC of the ONU: 0×00000001: Unknown—Initializing, true state not yet known; 0×00000002: Enabled—FEC Enabled (for Get Response)OR Activate FEC(for Set Request);

		0×00000003: Disabled—FEC Disabled (for Get Response)OR Deactivate FEC (for Set Request) (IEEE802.3-2005Annex30B, P719)

The management objects of the attribute is ONU, so it is not necessary to add the instance index of management objects TLV before the Container/Descriptor. The meaning of the attribute values is:

- If aFECMode=UNKNOWN: ONU is in the initial stage, so its FEC status is unknown.
- If aFECMode=Enabled: The upstream and downstream frames sent by ONU are both FEC coded (FEC-coded); the receivers of ONU and OLT can both receive FEC-coded and non-FEC-coded frames.
- If aFECMode=Disabled: The upstream and downstream frames sent by ONU are both non-FEC-coded; the receivers of ONU and OLT should still be able to receive FEC-coded and non-FEC-coded frames.

6.5.4.7 Action Confirmation in Set Response Message

For implementing confirmation of Set variable request, extension is done for Variable Indication (bit7=1) of Variable Container as below:

When variable indication is 0×80, it indicates confirmation for set variable request or Action (SetOK); when Variable Indication is 0×86, it indicates Set request or VarBadParameters of Action; When Variable Indication is 0×87, it indicates ValidParameters of Set Request or Action, but the current status of ONU will make the action incomplete (VarNoResource.)

For the other case of unsuccessful Set variable request action, its returned Variable Indication code should meet the regulations in IEEE 802.3-2005 Subclause57.6.5. As similar to the regulation for Variable Container by IEEE802.3-2005 Subclause57.6.2, there is no Variable Value field for Variable Container of extended Set Variable Response in this chapter.

Additional return code (Return Code, Variable Indication) in specific Set Response message is as shown in Table 41:

Table 41 Additional Return Code applied to Set Response (Variable Indication)

Additional Variable Indication	Value (Hex)	Description
SetOK	0x80	Set Variable Request Action Succeed
VarBadParameters	0x86	Invalid Parameters of Set request or Action.
VarNoResource	0x87	Valid parameters of Set request or Action, but the current status of ONU makes the request or action not completed.

When OLT sends Set Request OAMPDU, it can involve attributes specified for multiple management objects or multiple management instances for setting or action, and can set or act multiple attributes of the same management instance. For example, set attributes and actions, such as acPhyAdminControl, EthPort Pause and acAutoNegAdminControl, etc, of multiple Ethernet ports through one OAMPDU.

ONU should return confirmation codes of all attributes settings and actions in Set Variable Request OAMPDU to OLT through sent Set Response OAMPDU. When request variable is returned, OAM client will at least generate one or more Variable Response OAMPDU for each received Variable Request OAMPDU. (The original words in IEEE802.3-2005 Clause57.6: In returning requested variables, an OAM client generates at least one and perhaps additional Variable Response OAMPDUs per received Variable Request OAMPDU. If a Variable Container does not fit within a Variable Response OAMPDU, an error code is returned.) When Set Request OAMPDU received by ONU involves multiple attributes settings or actions (multiple variable Container applied to attributes or actions is involved not including TLV indicating the instance index of management objects), ONU can not multiple Variable Containers for confirmation specified for multiple Set/Get Variable Request OAMPDU into one Set Response OAMPDU for confirmation. OLT determines whether each attribute/action of each instance of each management object is successful, which means that the attribute setting/action held in the same OAMPDU is independent. The determination of whether it is successful by OLT is also based on Variable Container of each independent hattribute setting/action for confirmation.

For Set command with the instance index of management objects TLV, there should also be the instance index of management objects TLV before Variable Container with corresponding

confirmation code (Variable Indication Code) in Set Response ONU returns. If it is needed to divide multiple attribute setting/actions used to confirm the same management object instance into 2 or more OAMPDU, each OAMPDU needs to be with the instance index of management objects TLV before corresponding Variable Container.

6.5.4.8 Timing Requirment of OAM Action (GET and SET)

In order to make OAM GET and SET actions more effective, the response time after remote OAM Client receives OAMPDU must be limited. The specific implementation method is as below:

OLT should have a response time out mechanism for sent GET/SET Request OAM messages. OLT sets a timer remote_response_timer for each GET/SET Request OAM message sent by each remote OAM Client (ONU) or each attribute/action (Attribute/Action). After OLT sends an OAM message, corresponding remote_response_timer will be activated immediately. If OLT receives GET/SET Response OAM specified for this GET/SET Request OAM message or the Attribute/Action sent from remote OAM client before the timer is time out, remote_response_timer will reset and relative processing will be done for Response OAM message. If OLT does not receive GET/SET Response OAM specified for this GET/SET Request OAM message or the Attribute/Action sent from remote OAM client before the timer is time out, OLT will report the response_timeout alarm to the network administrator, and GET/SET Response OAM message received after time-out will be dumped.

For correct action, after receiving OAM carrying GET/SET Variable Request action (not only carrying standard attribute/action and extended attribute/action of CTC, but also carrying link monitor, remote circuit, remote failure indication and other OAM message of OAM action regulated in IEEE802.3-2005), ONU should complete corresponding actions in 1 second (read of attribute value, setting, Action Validation and Circuit Status Change, etc), and send GET/SET Response OAM message (without consideration of the interval of upstream and downstream transfer of OAM message.)

The time=out period of remote_response_timer should be configurable, whose default is 1 second.

6.5.5 Remote management of DBA parameter of ONU

6.5.5.1 DBA Configuration Functions Definition and Procedure

The management attributes of DBA involve Queue Set number supported by Report frame of ONU and Threshold each Queue Set corresponds to. The OAM extension of DBA negotiation mainly involves Queue Set number ONU needs to support and its Threshold for actions.

In the configuration procedure of DBA parameters of ONU, OLT should work in Active mode, while ONU works in Passive mode. OLT does Read and Set actions for DBA parameters of ONU through get_DBA_request and set_DBA_response messages, while ONU responds to the request of Read and Set actions of OLT through get_DBA_request and set_DBA_response messages.

After ONU receives get_DBA_request message, it should send get_DBA_response message to OLT that contains its current DBA parameters.

When ONU receives set_DBA_request, it should set the local DBA parameters according to the DBA parameters defined by set_DBA_request message and send set_DBA_response message, so as to confirm whether it has already completed the DBA parameters settings.

6.5.5.2 Message Definition of Remote Management Procedure of DBA parameters (DBA Configuration Message Format)

In EPON system, the data of remote management of DBA parameters used for ONU is held by the data unit of OAM protocol (OAMPDU.) Organization-Specific Extension is used to implement its interaction procedure, whose extension action code (Ext. Opcode) is “O×0A”. The Data/padding format of Organization-Specific Extension OAMPDU used for DBA parameters of ONU is as shown in Table 42. DBA code further identifies the message type the configuration function of DBA parameters of ONU needs.

Table 42 Format of payload part in Organization-Specific Extension OAM message used for DBA

Payload Octets	Payload	Value	Notes
3	OUI	0×XX XX XX	The Value to be applied
1	Ext. Opcode	0×0A	DBA configuration
1	DBA code	0×00-0×03: DBA configuration Message 0×04-0×FF: Reserved, ignored on reception	Get/set Configuration Action
4	Data/Pad		Dependent on the DBA Code

Organization Specific Extension OAM message of DBA parameters configuration used for ONU has 4 types, whose specific message code is as shown in Table 43:

1. Request Frame for DBA parameter (get_DBA_request)
2. Response Frame for DBA parameter (get_DBA_response)
3. Request Frame for DBA parameter Setting (set_DBA_request)
4. Acknowledge Frame for DBA parameter setting (set_DBA_response)

Table 43 Value of DBA Code field and its corresponding message type in Organization-Specific Extension OAM message

bit	Definition	Description
[7:2]	Reserved	The default values are all 0.
[1:0]	Message Code	00-Request Frame of DBA Parameters (get_DBA_request) 01-Response Frame of DBAParameters (get_DBA_response) 10-Request Frameof DBA Parameters Setting (set_DBA_request) 11-Acknowledge Frame of DBA Parameters Setting (set_DBA_response)

The specific definitions of these 4 types of messages are as below:

1) Request Frame of DBA Parameters(get_DBA_request)

OLT appoints ONU to report the current DBA parameters by Request Frame of DBA Parameters (Queue Set amount in Report Frame and Threshold.) The structure of DBA Parameters Request OAMPDU is as shown in figure 17. The specific definition of Field Data/Pad is as below:

a) OUI: 3 bytes, containing 24-bit Organizationally Unique Identifier. The specific OUI value is undetermined;
b) Extension Operation Code (Ext. Opcode): 1 byte, used to identify the action type of extension. Its value is “0×0A” for extended OAMPDU used for DBA parameters configuration;
c) DBA code: 1 byte, used to identify specific types of DBA parameters actions. Its value is “0×00 for” get_DBA_request message.
d) Filling Byte (PAD): 0-30 bytes, used to fill the rest fields in the OAM frame to make the total length of the OAM frame up to 64 bytes, and the filling content is “0×00”.

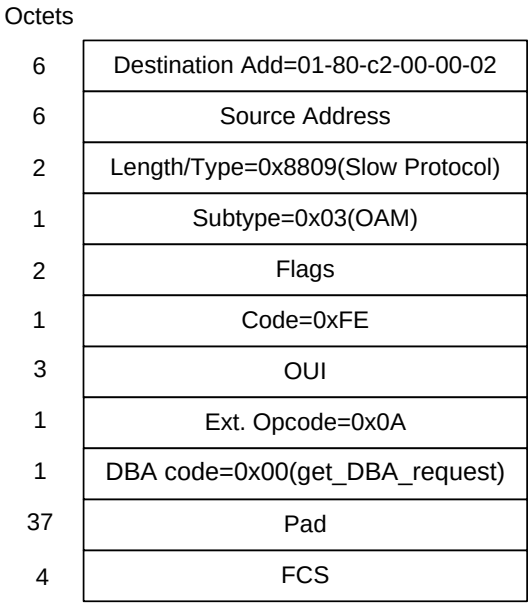


Figure 17 Frame Format of get_DBA_request OAMPDU

2) Response Frame of DBA parameters (get_DBA_response)

ONU uses Response Frame of DBA parameters to report the current DBA parameters to OLT (Queue Set Amount and Threshold in Report Frame.) The structure of Response Frame of DBA parameters is as shown in figure 18, and the specific definition of field Data/Pad is as below:

a) OUI: 3 bytes, containing 24-bit Organizationally Unique Identifier. The specific OUI value is undetermined;
b) Extended Operation Code (Ext. Opcode): 1 byte, used to identify extended operation type. The value of the extended OAMPDU of DBA parameters configuration is “0×0A”;
c) DBA code: 1 byte, used to identify specific operation type of DBA parameters. The value of get_DBA_response is “0×0A”;
d) Number of Queue Sets: 1 byte, used to describe the number of Queue Sets in Report frame sent by ONU, whose value range is “0×02” to “0×04”;
e) Report Bitmap: 1 byte, one 8-bit marking register, used to designate which queues Report MPCPDU involves as shown in Table 44;

Table 44 Definition of Field Report bitmap in OAMPDU used in DBA parameters management

bit	Marking	Value and its Meaning
0	Queue 0	0 - queue 0 report is not present 1 - queue 0 report is present
1	Queue 1	0 - queue 1 report is not present 1 - queue 1 report is present
2	Queue 2	0 - queue 2 report is not present 1 - queue 2 report is present
3	Queue 3	0 - queue 3 report is not present 1 - queue 3 report is present
4	Queue 4	0 - queue 4 report is not present 1 - queue 4 report is present
5	Queue 5	0 - queue 5 report is not present 1 - queue 5 report is present
6	Queue 6	0 - queue 6 report is not present 1 - queue 6 report is present
7	Queue 7	0 - queue 7 report is not present 1 - queue 7 report is present

f) Queue ＃n Threshold: 2 bytes, indicating the threshold Queue Set corresponds to on Queue n;

g) PAD: 37 bytes, used to fill the rest fields in OAM frame to make the total length of OAM frame up to 64 bytes. The filling content is “0×00”.

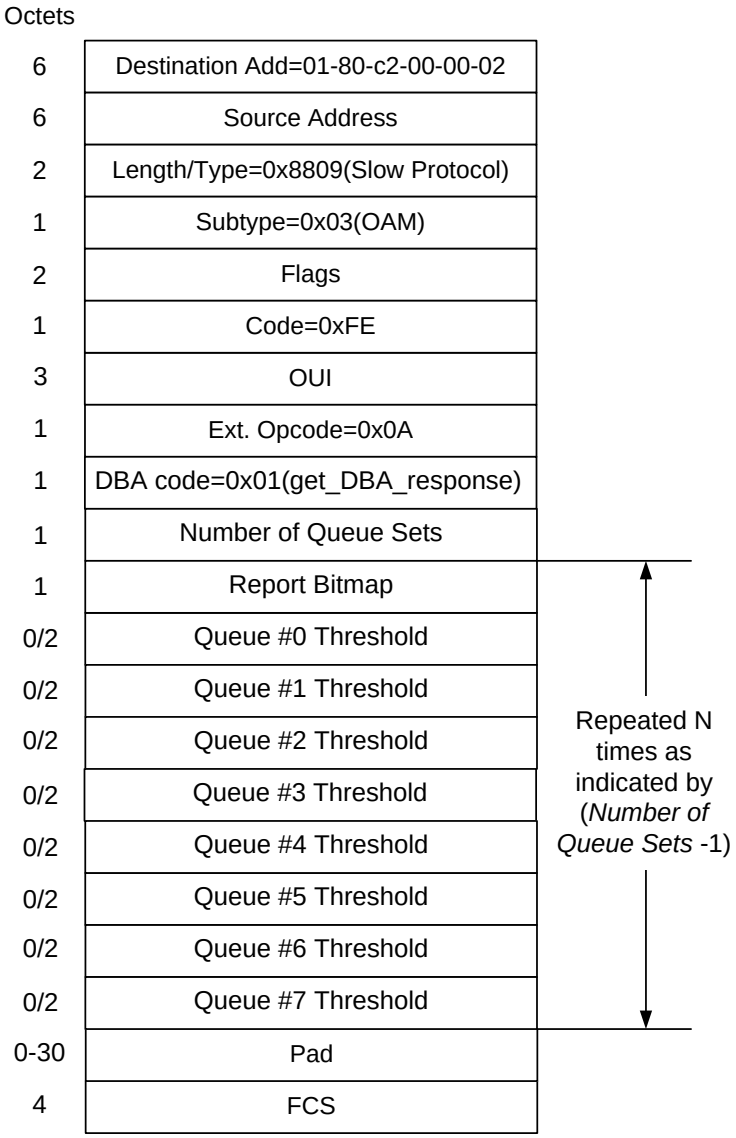


Figure 18 Frame format of get_DBA_response OAMPDU

3) Request Frame of DBA parameters setting(set_DBA_Request)

OLT uses Request Frame of DBA parameters setting to appoint ONU to set its DBA parameters (Queue Set number and Threshold in Report frame.) The structure of Request Frame of DBA parameters setting is as shown in the figure below. The specific definition of field Data/Pad is as below:

a) OUI: 3 bytes, containing 24-byte Organizationally Unique Identifier. The specific OUI value is undetermined;
b) Ext. Opcode: 1 byte, used to identify extended operation type. The extended OAMPDU used in DBA parameters configuration is “0×0A”;
c) DBA code: 1 byte, used to identify specific operation type of DBA parameters. The value of set_DBA_request message is “0×02”;
d) Number of Queue Sets: 1 byte, used to describe the number of Queue Sets in Report frame sent by ONU, whose value range is “0×02” to “0×04”. ONU should set its Queue Set Number in its Report frame according to the value;
e) Report Bitmap: 1 byte, one 8-bit marking register, used to designate which queues Report MPCPDU involves as shown in Table 5;
f) Queue ＃n Threshold: 2 bytes, indicating the threshold Queue Set corresponds to on Queue n;

queue #n of the first QUEUE set should be less than the queue＃n threshold of the second queueset, and so on;

g) PAD: 37 bytes, used to fill the rest fields in OAM frame to make the total length of OAM frame up to 64 bytes. The filling content is “0×00”.

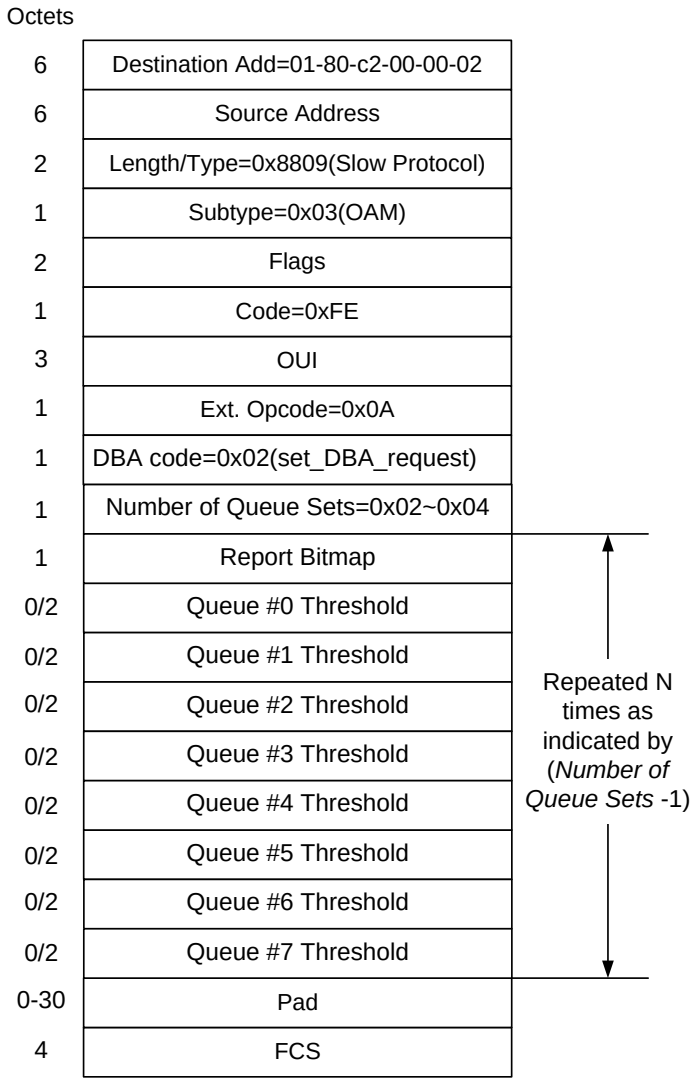


Figure 19 Frame format of set_DBA_request OAMPDU

Note: The standard regulates: The last Queue Set in Report frame format is used to fill the total length of all queues, so the number of Queue＃n Threshold in set_DBA_request frame is (*Number of Queue Sets*-1.)

4) Acknowledge Frame of DBA Parameters Setting (set_DBA_response)

ONU sends Acknowledge Frame of DBA Parameters Setting (set_DBA_response) to OLT to notify whether DBA parameters are set successfully. The structure of Acknowledge Frame of DBA Parameters Setting is as shown in figure 20. The specific definition of Field Data/Pad is as below:

a) OUI: 3 bytes, containing 24-byte Organizationally Unique Identifier. The specific OUI value is undetermined;
b) Ext. Opcode: 1 byte, used to identify extended operation type. The extended OAMPDU used in extended OAMPDU of DBA Parameters Configuration is “0×0A”;
c) DBA code: DBA code: 1 byte, used to identify specific operation type of DBA parameters. The value of set_DBA_request message is “0×03”;
d) Set Acknowledgement (Set ACK): 1 byte, used to indicate whether DBA parameter setting is successful; When SET ACK is “0×00”, it indicates that DBA parameters setting is not completed or is rejected (Nack); When Set ACK is “0×01”, it indicates that DBA parameters setting has been completed (Ack);

e) Number of Queue Sets: 1 byte, used to describe the number of Queue Sets in Report frame sent by ONU, whose value range is “0×02” to “0×04”. ONU should set its Queue Set Number in its Report frame according to the value;
f) Report Bitmap: 1 byte, one 8-bit marking register, used to designate which queues Report MPCPDU involves as shown in Table 5;
g) Queue ＃n Threshold: 2 bytes, indicating the threshold Queue Set corresponds to on Queue n; queue #n of the first QUEUE set should be less than the queue＃n threshold of the second queueset, and so on (if involving 3 or more Queue Set);
h) PAD: 0-29 bytes, used to fill the rest fields in OAM frame to make the total length of OAM frame up to 64 bytes. The filling content is “0×00”.

Octets		
6	Destination Add=01-80-c2-00-00-02	
6	Source Address	
2	Length/Type=0x8809(Slow Protocol)	
1	Subtype=0x03(OAM)	
2	Flags	
1	Code=0xFE	
3	OUI	
1	Ext. Opcode=0x0A	
1	DBA code=0x03(set_DBA_response)	
1	Set ACK=0x00/0x01	
1	Number of Queue Sets=0x02~0x04	
1	Report Bitmap	Repeated N times as indicated by (*Number of Queue Sets* -1)
0/2	Queue #0 Threshold	
0/2	Queue #1 Threshold	
0/2	Queue #2 Threshold	
0/2	Queue #3 Threshold	
0/2	Queue #4 Threshold	
0/2	Queue #5 Threshold	
0/2	Queue #6 Threshold	
0/2	Queue #7 Threshold	
1-29	Pad	
4	FCS	

Table 20 Format of Acknowledge Frame of DBA Parameter Setting

Note: The standard regulates: The last Queue Set in Report frame format is used to fill the total length of all queues, so the number of Queue＃n Threshold in set_DBA_request frame is (*Number of Queue Sets*-1.)

6.5.6 Initial Auto Configuration of ONU

When ONU is online, OLT should automatically deliver all necessary configuration data to ONU. After ONU completes MPCP registration, standard and extended OAM discovery procedure, OLT should inquire of ONU ONU ID, Firmware of ONU Chipset, ONU Chipset ID and ONU Capacity, etc. Then triple churning function is activated, and DBA Parameter Configuration is handled. After completing triple churning and DBA Parameter Configuration, OLT should remotely

configure functions and parameters as below according to business requirement: Open of Ethernet Port/E1/VoIP Port, VLAN Configuration of Ethernet Port, Classification/Queue/Marking rules of each port business flow of ONU, Upstream Policing of Ethernet Port, Flow Contol of Ethernet Port and Multicast relative functions, etc.

6.5.7 Default Configuration of ONU

In the default status, ONU adopts configuration as below:

1. Ethernet Port Status (aPhyAdminState): Disabled;
2. E1/VoIP Port Status: Disabled;
3. VLAN Configuration: Transparent Mode;
4. Multicast Control: Disabled; (Dynamic Managable Multicast Protocl: Disabled; IGMP Snooping Method: Enabled)
5. Classification & Marking: Disabled;
6. FEC Function (aFECmode): Disabled
7. Port Auto Negotiation: Enabled;

Default values of other attributes are undetermined.

7 Port Requirement of Network End and User End

7.1 Port Requirement of OLT Network End

The network end of OLT must support GE port. 10/100BASE-T and 10GBASE-X are optional.
When OLT has multiple PON ports, it should provide at least 2 GE uplink ports.
For multi-business OLT equipments providing private line business of TDM data, the network end should support E1 or STM-1 port.

7.1.1 GE Port

GE port can be one or more kinds of 1000BASE-LX、1000BASE-SX、1000BASE-CX and 1000BASE-T ports. The port types should meet the regulations of IEEE 802.3-2005.

7.1.2 10/100BASE-T Port

10/100BASE-T Port should conform to IEEE 802.3-2005.

7.1.3 10GBASE-X Port

10GBASE-X Port should conform to IEEE 802.3-2005.

7.1.4 E1 Port

E1 Port should conform to ITU-T G.703 or GB7611-2001.

7.1.5 STM-1 Port

STM-1 Port should conform to ITU-T G.707.

7.2 Port Requirement of ONU User End

7.2.1 Port Type of ONU User End

The port types of ONU User End include ports such as 10/100BASE-T, GE, E1, V.35, Z/Za, DSL and CATV RF, etc.

7.2.1.1 10/100BASE-T Port

10/100BASE-T Port of User End should conform to IEEE 802.3-2005.

7.2.1.2 GE Port

GE port can be one or more kinds of 1000BASE-LX, 1000BASE-SX, 1000BASE-CX and 1000BASE-T ports. The port types should meet the regulations of IEEE 802.3-2005.

7.2.1.3 E1 Port

E1 Port should conform to ITU-T G.703 or GB7611-2001.

7.2.1.4 Z/Za Port

Z Port should conform to para. YD/T 1054-2000 10.1.1.
Za Port should conform to para. YD/T 1054-2000 10.1.2.

7.2.1.5 DSL Port

DSL Port includes ADSL2+ and VDSL2 ports.
ADSL2+ Port should conform to ITU-T G.992.5.
Port should conform to ITU-T G.993.2.

7.2.1.6 CATV RF Port

The specific standard of CATV RF port is undetermined.

7.2.1.7 Other Ports

Other port requirements relative to HGU ONU (such as WLAN, USB ports) are in the reative standards of China Telecom Home Network Gateway.

7.2.2 Port Requirement of ONU User End

All types and port number of ONU User End ports are in 5.2.1.

8 Ethernet Function Requirement

8.1 Ethernet Basic Function

8.1.1 MAC Exchange

8.1.1.1 MAC Address Exchange of OLT

OLT should support exchange by MAC address and dynamic study of MAC address. The study capability of MAC address should not be less than 1000/s.

The MAC address cache capability of each PON port of OLT should not be less than 2K. The MAC address cache capability of aggregated exchange part should not be less than 16K.

MAC address aging period of OLT should be configurable.

8.1.1.2 MAC Address Exchange of SFU/SBU Type of ONU

SFU/SBU Type of ONU with more than one Ethernet ports should support Exchange by MAC address and dynamic study of MAC address. The study capability of MAC address should not be less than 1000/s, and unicast MAC address cache capability should not be less than 32.

8.1.1.3 MAC Address Exchange of HGU/MTU/MDU type of ONU

HGU type of ONU should support Exchange by MAC address and and dynamic study of MAC address. The study capability of MAC address should not be less than 1000/s.

The Unicast MAC Address Cache capability of HGU/MTU type of ONU should not be less than 32x Ethernet ports, while the Unicast MAC Address Cache capability of MDU type of ONU should not be less than 32x User ports (including Ethernet Port, ADSL2+ Port or VDSL2 Port)

The MAC address aging period of ONU should be configurable.

8.1.2 Two-layer Switch Capability

8.1.2.1 Two-layer Switch Capability of OLT

OLT should support Two-layer Switch of Ethernet business, two-layer switch capability should assure the line speed forward of upstream and downstream business.

8.1.2.2 Two-layer Switch Capability of ONU

ONU with more than 1 Ethernet port should support Two-layer Switch Capability of Ethernet Business, and two-layer switch capability should assure the line speed forward of upstream and downstream business.

8.1.3 Frame Filter

8.1.3.1 Frame Filter of OLT

OLT should support frame filter of Ethernet data based on source and destination MAC addresses.

8.1.3.2 Frame Filter of ONU

HGU, MDU and MTU types of ONU should support frame filter based on physical port, source and destination MAC address, physical port and Ethernet data of source and destination MAC address, and support Open/Close of frame filter of Ethernet data based on each physical port and MAC address.

SFU and SBU types of ONU optionally support frame filter as mentioned above.

8.1.4 Two-layer Isolation

8.1.4.1 Two-layer Isolation of OLT

OLT should implement two-layer isolation among ONUs.

8.1.4.2 Two-layer Isolation of ONU

MDU and MTU types of ONU should support two-layer isolation among Ethernet ports.

8.1.5 Tree Spanning

8.1.5.1 Tree Spanning of OLT

When thenetwork end of OLT has multiple GE or 10/100Base-T ports, it should support Rapid Spanning Tree Protocol (RSTP) as required in IEEE 802.1D.

8.1.5.2 Tree Spanning of ONU

10/100Base-T and GE ports on HGU, MDU and MTU types of ONU user end should support Rapid Spanning Tree Protocol (RSTP) as required in IEEE 802.1D.

8.1.6 Flow Control

8.1.6.1 Flow Control of OLT

The network end port of OLT should support full duplex IEEE 802.3x flow control protocol, whose relative functions are configurable.

8.1.6.2 Flow Control of ONU

The network end port of ONU should support full duplex IEEE 802.3x flow control protocol, whose relative functions are configurable.

8.1.7 Local Aggregation of Network End

When OLT has multiple PON ports, it should support two-layer aggregation of Ethernet business of all business boards.

8.1.8 Link Aggregation Function

When there are multiple GE or 10/100Base-T ports on the network end of OLT, the link aggregation regulated in IEEE 802.3ad should be supported.

8.2 VLAN

8.2.1 VLAN of OLT

OLT should support IEEE 802.1Q protocol and support partitioning VLAN by LLID of ONU. OLT should support VLAN marking/unmarking, VLAN transparent transfer, VLAN Swich-over, VLAN Priority Marking and VLAN Filter.

OLT should meanwhile support VLAN amount of 4K, and the range of VLAN ID is 1-4094.

OLT should support sufficient VLAN Translation entries (the value is suggested to be 4X the ONU number the OLT can support, whose maximum amount is 4094.)

The network end port of OLT should support VLAN Trunk.

8.2.2 VLAN of ONU

ONU should support IEEE 802.1Q protocol and support partitioning VLAN by LLID of ONU. OLT should support VLAN marking/unmarking, VLAN transparent transfer, VLAN Swich-over, VLAN Priority Marking and VLAN Filter.

8.2.2.1 Definition of VLAN Mode

The regulations for the specific bahaviours of all kinds of VLAN modes pf Ethernet Port are as below:

(1) VLAN Transparent Transfer Mode: In this mode, the process mode for the received upstream Ethernet frames by ONU is no action (no matter the Ethernet frame is with VLAN TAG) but transparent forwarding it to OLT. Transparent forward is also used for downstream Ethernet frames. The specific process method is in Table 45.

Table 45 ONU Processing Method in Transparent Mode

Direction	Whether the Ethernet packet is with Tag	Processing Method
Upstream	With VLAN tag	No change for Ethernet packet (Original VLAN TAG reserved), forward
	Without VLAN tag	No change for Ethernet packet, forward
Downstream	With VLAN tag	No change for Ethernet packet (Original VLAN TAG reserved), forward
	Without VLAN tag	No change for Ethernet packet, forward

(2) VLAN Marking Mode: In this mode, the process mode for the received upstream Ethernet frames by ONU is adding a network layer VLAN tag to it; for downstream Ethernet frames, ONU clears their VLAN Tags. The specific process method is in Table 46.

Table 46 ONU Processing Method in TAG Mode

Direction	Whether the Ethernet packet is with Tag	Processing Method
Upstream	With VLAN tag	Dumped
	Without VLAN tag	Marked with new VLAN Tag (the main parameter is VID), forward. In the curent circumstance, it is only required to make ONU able to configure VID values and ignore the fields such as TPID in Field VLANConfig Parameters in received VLAN Variable Container and Pri, etc. as well as to make as default TPID and Pri marked with Tag (TPID=0×8100，Pri = 0)
Downstream	With VLAN tag	Forward it to the corresponding UNI ports according to VID and clear tag
	Without VLAN tag	Dumped

(3) VLAN Translation mode: in this mode, ONU will transform VLAN TAG users in upstream Ethernet frames mark by themselves (the VID can not be dedicated, and there may be other users using the same VID in the same system) into unique VLAN Tag of network end, while ONU will do the opposite operation for downstream frames. When ONU supports VLAN Translation, its VLAN Translation should support that EtherType is 0×8100, and other EtherType values are supported optionally. The processing method for messages by ONU in VLAN Translation mode is as shown in Table 47:

Table 47 ONU Processing Method in VLAN Translation Mode

Direction	Whether the Ethernet packet is with Tag	Processing Method
Upstream	With VLAN tag	If VID of the original TAG has the corresponding entry in VLAN Translation list of ports (equal to the input VID), VID will be converted into corresponding VID by the list (output VID) and be forwarded; if VID of the original TAG has not the corresponding entry in VLAN Translation list of ports, it will be dumped. In the curent circumstance, it is only required to make ONU able to convert VID values, and the conversion of other fields (such as TPID, CFI and Pri) is not required temperarily. ONU ignores the fields TPID and Pri in Field VLANConfig Parameters in received VLAN Variable Container as well as to make as default the converted TPID and Pri (The TPID and Pri values before message conversion are not reserved.)
	Without VLAN tag	Untagged message is marked with default VLAN, and forward.
Downstream	With VLAN tag	If VID of the original TAG has the corresponding entry in VLAN Translation list of ports (equal to the input VID), VID will be converted into corresponding VID by the list (output VID) and be forwarded; if VID of the original TAG is the default VID, Tag will be cleared and forwarded; if VID of the original TAG has not the corresponding entry in VLAN Translation list of ports, it will be dumped; In the curent circumstance, it is only required to make ONU able to convert VID values, and the conversion of other fields (such as TPID, CFI and Pri) is not required temperarily. In the downstream conversion procedure, ONU reserves the original TPID and Pri values of the message.
	Without VLAN tag	Dumped

ONU should support remote configuration of VLAN mode through the extended OAM function regulated in para. 6.5.4.4 of this standard.
The User End Port of ONU optionally supports VLAN Trunk (adopting local configuration).

8.2.2.2 VLAN of SFU/SBU Type of ONU

ONU should support at least 8 VLAN IDs, whose range is 1-4094.

8.2.2.3 VLAN of HGU Type of ONU

ONU should support at least 8 VLAN IDs, whose range is 1-4094.

8.2.2.4 VLAN of MDU/MTU Type of ONU

ONU should support at least 8x user ports amout (involving Ethernet, ADSL2+ or VDSL2 ports) of VLAN ID whose range is 1-4094.
ONU has the function to forcibly modify the priority tag of data packets, and has the function to add the default priority tag to data packets without VLAN tag.

8.3 VLAN Stacking (IEEE 802.1ad)

8.3.1 VLAN Stacking of OLT

OLT should support VLAN Stacking meeting IEEE 802.1ad standard, and the outer TPID parameters of VLAN Stacking Ethernet frames should be configurable.
CVLAN priority tags are required to be mapped into VLAN. In general circumstances, SVLAN is to map business types, while CVLAN is to map user ports.
OLT should support being mapped to SVLAN ID based on CVLAN ID and CVLAN priority tags. For each LLID, OLT should support 8 SVLAN IDs.
The value of CVLAN and SVLAN OLT should support is 1-4094.
Ports of OLT network end should support SVLAN TRUNK.
Ports of OLT network end can be configured as one of the 2 modes of SVLAN TRUNK and VLAN TRUNK.

8.3.2 VLAN Stacking of ONU

MDU and MTU types of ONU should support VLAN Stacking meeting IEEE 802.1ad, and the outer TPID parameters of VLAN Stacking Ethernet frames should be configurable.

9 Dynamic Bandwidth Allocation(DBA)

9.1 General Requirement of DBA

EPON system should use Dynamic Bandwidth Allocation mechanism (DBA) to improve the system upstream usage and assure the business equity and QoS, and can allocate bandwidth authorization according to the queue status information of LLID reports.
DBA should support 3 kinds of bandwidth allocation as below:

1) Fixed Bandwidth: Periodicity of OLT sends fixed amount authorization to ONU. It is recommended to use short cycle time and high grant frequency to allocate the bandwidth. Fixed bandwidth is totally reserved for specific ONU or specific business of ONU. Even if ONU has not upstream business flow of fixed bandwidth, OLT still sends grant corresponding to the fixed bandwidth for the ONU, while the bandwidth can not be used by any other ONU. Fixed bandwidth is mainly used for ONU with TDM business (or LLID) to assure short transmission delay for the business.
2) Assured Bandwidth: Assured Bandwidth is to assure the bandwidth ONU can get, which is given through authorization from REPORT data of ONU. When te practical business flow of ONU has not reach the assured bandwidth, the DBA mechanism of OLT should be able to allocate the rest bandwidth to other ONU business.
3) Best Effort Bandwidth: When the bandwidth on EPON ports has not been used by other business with high priority, it is the bandwidth ONU can use. Best Effort bandwidth is allocated to ONU according to the REPORT information of all online ONU in PON system and the allocation status of bandwidth on PON ports. The system does not assure the bandwidth amount the ONU or specific business of ONU can get. It is the business type with the lowest priority.

DBA should support the combination of the 3 kinds of bandwidth mentioned above, which means that a certain ONU can provide business with kinds of bandwidth combination: Fixed+Assured, Fixed+Best Effort, Fixed+Assured+Best Effort, Assured+Best Effort and so on. The configuration parameters of upstream bandwidth of ONU involves FIR (Fixed Information Rate), CIR (Commited information rate), PIR (Peak Information Rate). All kinds of bandwidth and the relations among these configuration parameters are as below:

- Fixed Information Rate: FIR;
- Assured Bandwidth: CIR-FIR;
- Best Effort Bandwidth: PIR-CIR;

DBA optionally supports using different cycle and authorization period for different ONU under the same PON. For example, shorter cycle period and higher autorization frequency can be selected by ONU for existed TDM business.

DBA mechanism should support the constraint mechanism for bandwidth allocation in the system (When the configured system upstream "FIR+Assured Bandwidth" is beyond 1G, the notification should be given and stop excessive system bandwidth allocation.)

The DBA algorithm of EPON system should support equity mechanism and assure the surplus bandwidth according to 3 kinds of methods as below for allocation equity:

1. Weighting allocation of surplus bandwidth by priority;
2. Weighting allocation of surplus bandwidth by the assured bandwidth in SLA signed with different users;
3. Weighting allocation of surplus bandwidth by ONU types (SFU, HGU, MDU, SBU and MTU type of ONU) (Optional).

The standard does not temperarily make regulations for DBA algorithm.

The parameters of DBA algorithm should be configurable (specific parameters are undetermined), and have the functions of online updating algorithm by the need of business or online paramter adjustment.

For supporting QoS in the circumstance of multi-business access, OLT should allocate upstream bandwidth based on the report of the local queue status information from ONU, and ONU should be able to schedule the upstream business based on the local queue status and on bandwidth authorization allocated by DBA.

The minimum bandwidth chunk of DBA should not be more than 256kbit/s.

The minimum configurable bandwidth of DBA should not be more than 512kbit/s.

DBA Precision: Better than ±5%。

9.2 DBA function requirement of OLT

DBA mechanism of OLT should be able to allocate the upstream bandwidth of the LLID according to multiple queue status LLID corresponds to (The length of all queues in at least 2 Queue Sets in Report PDU) and business priority agreement.

OLT should be able to analyze the status information of all 8 queues of at least 2 Queue Set in Report frames for dynamic allocation of upstream bandwidth on ONU. The default amount of Queue Set supported by OLT is 2.

OLT should support configuration through the parameters like Queue Set amount of Report frames sent by ONU and Threshold by OAM. The configuration function should conform to para. 6.5.4.

Meanwhile, OLT should also support static bandwidth allocation, which means sending authorization of fixed size to each ONU in a fixed cycle period.

9.3 DBA Function Requirement of ONU

ONU should describe the status of all queues (8 queues) in Report Frame, and report to OLT the local queue status in the form that each Report frame involves 2 or more Queue Sets. It is suggetsed that ONU have capability of supporting 4 Queue Sets. The default amount of Queue Set supported by ONU is 2.

The schedule function of local upstream business of ONU is in the relative regulations in para 10.5.

The amount of Queue Set of ONU and Threshold all Queue Sets correspond to can be configured by OLT in the way of extended OAM. The specific configuration function should conform to para.

6.5.4.

10 QoS Mechanism of Multi-business

10.1 QoS General Requirement of Multi-business

EPON system should provide necessary QoS mechanism, so as to guarantee to provide QoS of all kinds of priority business according to SLA protocol in both the upstream and downstream direction.

EPON system should support the QoS mechanisms based on ITU-T Y.1291 including Traffic classification, Marking, Queuing and scheduling, Traffic shaping and policing, Congestion avoidance and Buffer management.

10.2 Service Level Agreement (SLA)

EPON should support setting SLA parameters specified for each user and business. For instance, the system can regulate SLA parameters such as different delay and dithering, Assuring Bandwidth and Max bandwidth, etc. specified for different users and business and should support respective settings of upstrea and downstream business.

10.3 Classification of Business Flow

10.3.1 Upstream Business Flow Classification of OLT

OLT should support classification of upstream business flow through relative parameters in Ethernet frames, and mark priority according to the requirement of para. 10.4. In the default status, OLT trusts the priority tag ONU provides, and the function is not activated.

The parameters that can be used for the parameters of business flow classification include: LLID，

MAC DA、MAC SA、User Priority(IEEE802.1D), Ethernet Type (such as PPPoE、PWE3、MAC Control), Destination IP address, Source IP address, IP Type (V4&V6), IP TOS/DSCP and L4 Protocol Port, etc. It is suggested to support the flow classification of depth check of messages (previous 80 bytes.)

OLT should support remote management of ONU business flow classification according to the extended OAM regulated in para. 6.5.

10.3.2 Upstream Business Flow Classification of SFU/SBU types of ONU

ONU should support classification of upstream business flow through relative parameters in Ethernet frames and baswed on Ethernet port, and mark priority according to the requirement of para. 10.4.

ONU should support remote management of OLT business flow classification according to the extended OAM regulated in para. 6.5.

The parameters of business classification that should be supported include: MAC DA, MAC SA, VLAN ID, User Priority (IEEE802.1D), Ethernet Type (such as PPPoE, PWE3, MAC Control), while the parameters of the optional supported business flow classification include: Destination IP address, Source IP address, IP Type (V4&V6), IP TOS/DSCP, Destination L4 Protocol Port and Source L4 Protocol Port, etc.

10.3.3 Upstream Business Flow Classification of MDU/MTU types of ONU

ONU should support classification of upstream business flow through relative parameters in Ethernet frames and baswed on Ethernet port, and mark priority according to the requirement of para. 10.4.

ONU should support remote management of OLT business flow classification according to the extended OAM regulated in para. 6.5.

The parameters of business classification that should be supported include: MAC DA, MAC SA, VLAN ID, User Priority (IEEE802.1D), Ethernet Type (such as PPPoE, PWE3, MAC Control), while the parameters of the optional supported business flow classification include: Destination IP address, Source IP address, IP Type (V4&V6), IP TOS/DSCP, Destination L4 Protocol Port and Source L4 Protocol Port, etc. It is suggested to support the flow classification of depth check of messages (previous 80 bytes) and IP Message Flow Classification with Option field.

10.3.4 Upstream Business Flow Classification of HGU type of ONU

The Upstream Business Flow Classification of HGU type of ONU should meet the relative regulations of China Telecom Home Network Gateway.

10.4 Marking Priority

OLT and ONU equipments should support priority marking of upstream business by flow classification based on para. 10.3, and have capability to forcibly modify priority marks. The mark should adopt IEEE 802.1D User Priority, and IP TOS and DSCP priority marks are supported optionally.

ONU should support remote management of ONU upstream business priority tag through extended OAM regulated in para. 6.5.

ONU should support local configuration of the business priority tag for all user ports, while ONU should support remote configuration of its priority tag by OLT through extended OAM regulated in para. 6.5.

In the default circumstance, User Priority of IEEE 802.1D and its mapping relations with all business are as shown in Table 48 (IEEE802.1Q-2005 Annex G.4):

Table 48 User Priority of IEEE 802.1D and its Mapping Relations with Business Type

User Priority	Abbreviation	Business Type	Note
7	NC	Network Control	Including TDM
6	IC	Internetwork Control	
5	VO	Voice (<10 ms latency and jitter)	VoIP
4	VI	Video (<100 ms latency and jitter)	IPTV, Video
3	CA	Critical Applications	
2	EE	Excellent Effort	
0 (Default)	BE	Best Effort	Common Network Business
1	BK	Background	

10.5 Priority Queue Mechanism

10.5.1 Priority Queue Mechanism of OLT

The upstream and downstream business of OLT should be mapped to different priority queues according to IEEE 802.1D User Priority Tag and be scheduled.

Ports of OLT network end should support 8 priority queues.

10.5.2 Priority Queue Mechanism of ONU

The upstream and downstream business of ONU should be mapped to different priority queues according to IEEE 802.1D User Priority Tag and be scheduled.

SFU, HGU and SBU types of ONU should support at least 4 priority queues.

For MDU and MTU types of ONU, ports of each user end should support at least 4 priority queues.

10.6 Flow Speed Restriction

10.6.1 Speed Restriction of Upstream Business Flow

10.6.1.1 Speed Restriction of Upstream Business Flow of ONU

Ethernet ports on user end of MDU and MTU types of ONU should support port Speed Restriction of upstream business.

Ethernet ports on user end of SFU, SBU and HGU types of ONU optionally support port Speed Restriction of upstream business.

Meanwhile, ONU schedules the upstream business flow according to DBA authorization of OLT in order to implement Speed Restriction of Upstream Business Flow.

10.6.1.2 Speed Restriction of Upstream Business Flow of OLT

OLT should support DBA mechanism in order to implement the Speed Restriction of Upstream Business Flow and upstream bandwidth allocation of each LLID.

When there are OLT equipments with L2 aggregation function, its upstream port (SNI) optionally supports the function of L2 Traffic Shaping.

10.6.2 Speed Restriction of Downstream Business Flow

10.6.2.1 Speed Restriction of Downstream Business Flow of ONU

Ethernet ports on user end of MDU and MTU types of ONU should support port Speed Restriction of downstream business and optionally supports speed restriction based on business flow.
Ethernet ports on user end of SFU, SBU and HGU types of ONU optionally support port Speed Restriction of downstream business.

10.6.2.2 Speed Restriction of Downstream Business Flow of OLT

For downstream business, OLT should support the rate control specified for users or different classification flows, and should support L2 Traffic Shaping or Policing Mechanism.

10.7 Priority Schedule

10.7.1 Priority Schedule of OLT

OLT should support the schedule function of downstream business according SLA. The downstream business by OLT should support strict priority policing (SP) queue schedule, Weighted Round Robin (WRR), and SP+WRR algorithm can be configured. SP+WRR is used by default.
The priority schedule of upstream business is completed by DBA of OLT and the local schedule function of ONU together.

10.7.2 Priority Schedule of ONU

ONU should have the function of local schedule of upstream business according to OLT bandwidth authorization, whose schedule algorithm should support SP algorithm as well as WRR or SP+WRR algorithm, and SP+WRR algorithm can be configured. SFU, HGU and SBU types of ONU use SP algorithm by default, while MDU and MTU types of ONU suggests that SP+WRR algorithm be used.
HGU, MDU and MTU types of ONU optionally supports the local schedule of downstream business; SP, WRR or SP+WRR should be supported, and SP+WRR is suggested to be supported.
For the system uses SP+WRR algorithm, OLT (upstream) and ONU (downstream) should use SP schedule for the business flow whose priority value is “7” and “6”. (such as network control protocol message and TDM business). WRR schedule mechanism is used for other priorities of business.

10.8 Cache management

10.8.1 Cache Management of ONU

ONU should support cache management; whoser specific mechanism is not regulated.
In any time, the total cache of up and downstream of each ONU should not be less than 256 KB.
The maximum available cache of up and downstream of ONU should not be less than 128Kbyte.
ONU should support congestion prevention mechanisms, whose algorithms are Tail-Drop, RED, WRED. Tail-Drop should at least be supported.

10.8.2 Cache Mangement of OLT

For assuring QoS, OLT should provide sufficient cache, whose capacity is not regulated.
ONU should support congestion prevention mechanisms, whose algorithms are Tail-Drop, RED, WRED. Tail-Drop should at least be supported by equipments.

11 Security

11.1 Data Security of PON Port

Downstream of EPON system uses broadcast, so maliciouse users can easily capture the information of other users in the system. In order to improve the security of user data, downstream should support Triple Churning. The system should support the churning function specified for each LLID that should have an independent key. Churning submits key update request from OLT, and ONU provides 3-byte churning key then OLT uses the key to complete churning. After churning is activated, all data frames and OAM frames will be churned.
Update and synchronization of keys adopts OAMPDU method based on Organization-Specific Extension.

11.1.1 Generatin of Churning Key

Churning key is the result from XOR of Add of 3-byte random number and 3-byte data got from upstream user data by ONU. The 24-byte code definition is {(MSB)X1-X8, P1-P16 (LSB)}.

11.1.2 Update and Synchronization Procedure of Key

5th byte in the lead code is as the identification field of churning data (Enc) to implement key synchronization, The modified frame format is as below:

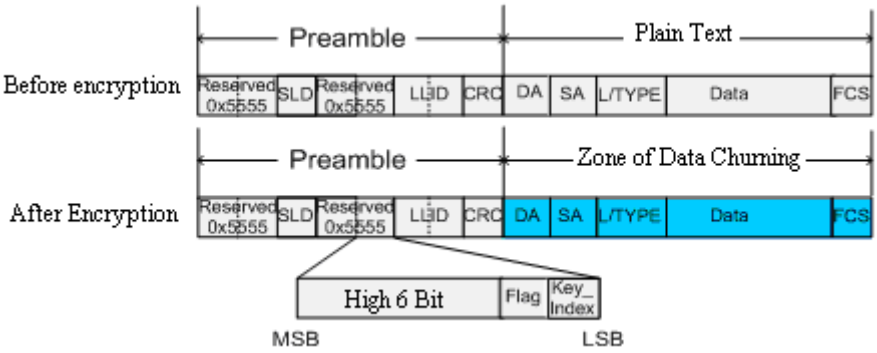


Figure 21 Definition of Enc Byte used for Key Synchronization in Churning Zone and Lead Code

The values of the high bits of Enc field still follow the standard of IEEE 802.3-2005. The definition of the low 2 bits is as below:

- Flag bit (bit 1): Churning Tag, indicating whether the frame is churned; 0: Plain Text; 1: Encryped Text.
- Key_Index bit (bit 0): Key index, indocating the key number of ONU needed to be used in the churning procedure. When the churning function is off, the value of Key_Index bit should be “1”.

Key updating is implemented by a new_key_request and a new_churning_key. OLT sends to ONU a new_key_request; after ONU receives a new_key_request, it sends to OLT a new_churning_key. If ONU receives new_key_request, it will send to OLT a new_churning_key. The new new_churning_key involves a new key and the key number indicating the sequence number of the current interaction key. After OLT receives a new_churning_key, the new key can be used to churn the following frames. Key synchronization is implemented by Enc field in each frame. As long as ONU receives the churning frame sent by OLT and Key_Index is equal to the key number in the new_churning_key, ONU will use the new key to churn. OLT has a timer used to control the cycle period of keys. When the timer is timed out, OLT will activate the key updating procedure as mentioned above.

OLT uses another timer as the mechanism of activating the next key updating request when new key request can not be received, so as to improve reliability of key updating. WhenOLT sends a new_key_request every time, Churning_Timer is activated. WhenOLT receives the correct new_key_request before the Churning_Timer is timed out, OLT will activate the new key and reset Churning_Timer. When OLT does not receive a new_key_request after the timer is timed out; it is treated as failure of key interaction and to reset Churning_Timer. When OLT does not receive a new_churning_key after the timer is timed out, it is treated as failure of key interaction and to reset Churning_Timer, and then OLT will send a new round of new_key_request. Before the new key interacts successfully, ONU will still use the original key, and report the interaction failure to the network administrator. If OLT has sent new_key_request for 3 times and still can not receive new_churning_key before timed-out, OLT should alarm the network administrator. Downstream business still uses the old key for churning.

The values of key updating cycle T_{key} and Churning_Time are configurable. The default value of Tkey is 10s.

The key updating and synchronization procedure is as shown in the figure below.

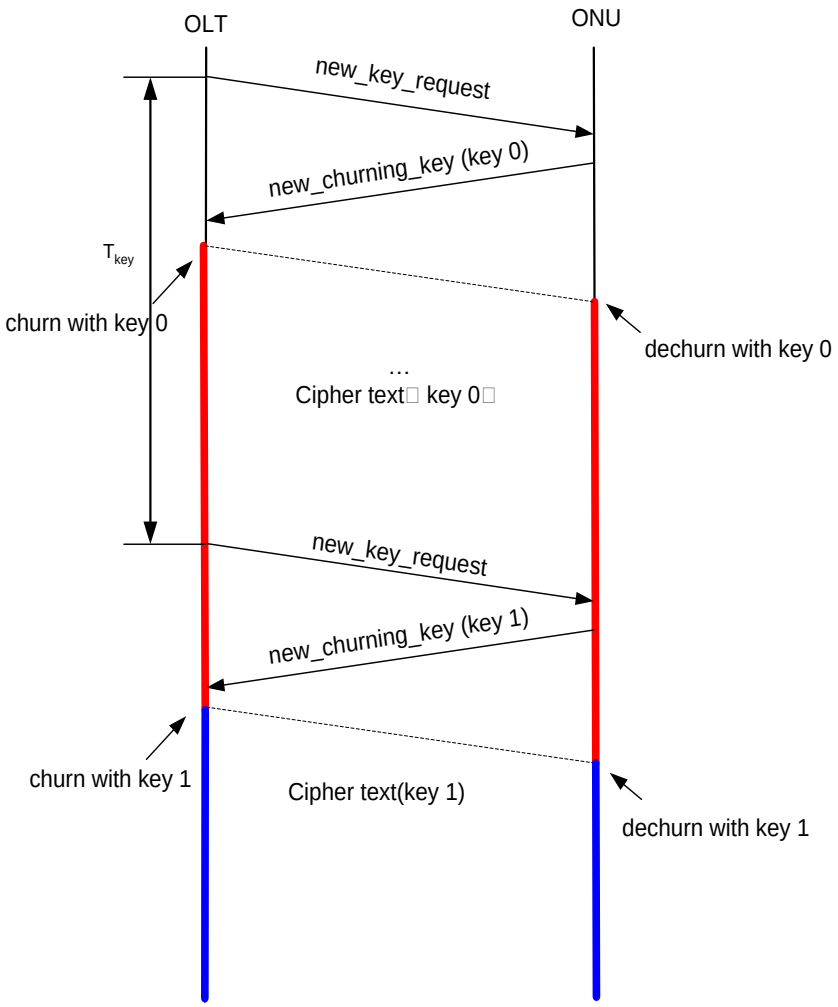


Figure 22 Churning Key Update and Synchronization based on extended OAMPDU Method

11.1.3 Churning and Dechurning

For improving the data security, EPON system should use triple churning on the base of churning. Triple churning algorithm is extended from single churning, adding the time domain association of data after churning so as to improve the security of user data.

Implementation of Single churning is as below:

Through logical calculation for X1-X8 and P1-P16, churning keys K1-K10 are generated. 14 bits of K1, K2, P1-P11 and P12 are used to churn with the data flow whose width is 8 bits. During Dechurning, the same 14 bits are used to Dechurn the churned data of 8 bits width (encrypted)

Churning starts from destination MAC Address field of Ethernet frames, and ends in FCS filed. After completing MPCP Discovery and OAM discovery, churning key exchange is started. After exchange of keys, all downstream data frames, MAC Control frames and OAM frames of the ONU should be churned.

Churning keys K1-K10 are generated according to the logics below:

K1 = (X1·P13·P14) + (X2·P13·not P14) + (X7·not P13·P14) + (X8·not P13·not P14)

K2 = (X3·P15·P16) + (X4·P15·not P16) + (X5·not P15·P16) + (X6·not P15·not P16)

K3 = (K1·P9) + (K2·not P9)

K4 = (K1·not P9) + (K2·P9)

K5 = (K1·P10) + (K2·not P10)

K6 = (K1·not P10) + (K2·P10)

K7 = (K1·P11) + (K2·not P11)

K8 = (K1·not P11) + (K2·P11)

K9 = (K1·P12) + (K2·not P12)

K10 = (K1·not P12) + (K2·P12)

“+” is Logical OR)，“·”is Logical AND，“not” is Logical NOT.

Churning and unchirning is implemented in the way as shown in figure 23.

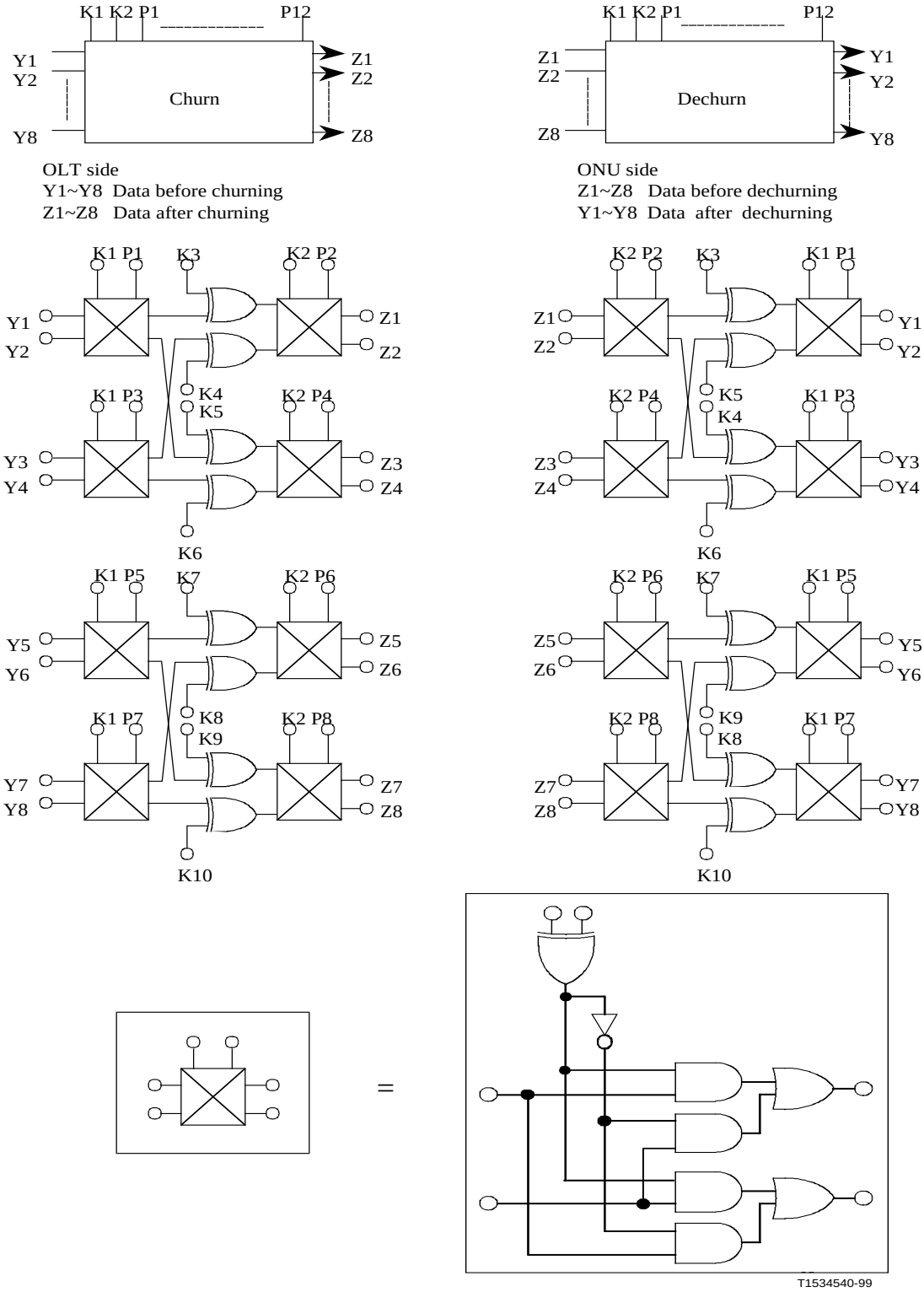


Figure 23 Implementaion of Churning and Dechurning

Implementation of Triple Churning is as shown in figure 24.

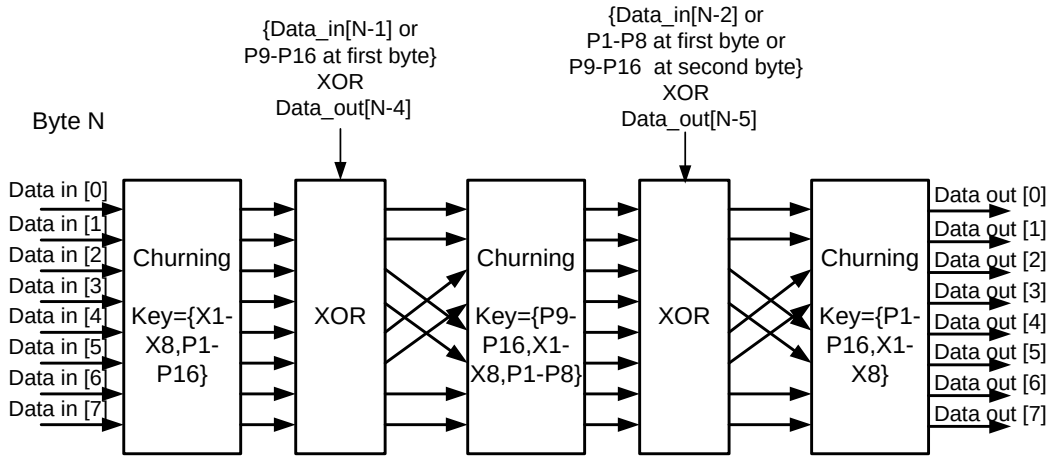


Figure 24 Implementation of Triple Churning

Triple churning adopts 3 churning ubits of cascade connection, each of which can execte single churning action as mentioned above and the key used for churning is different every time. The 1st churning unit adopts the original 24-bit key (X1-X8, P1-P16). The 2nd churning unit uses the key from cycle right moving 1 byte of the original 24-bit key (P9-P16, X1-X8, P1-P8.) The 3rd churning nit uses the key from cycle right moving 2 bytes of the original 24-bit key (P1-P16, X1-X8.)

The output of 1st churning engine churning_1 does XOR operation by bit with 2 8-bit vetors: the first vector is the previously input encrypted byte. When the encrypted byte is the first encryted byte of data frame, the vector will be the lowest byte of the key. The second vector is the output after triple churning before 4 bytes (the way can associate the current churning output with the previous output, and make some figure that repeatedly appears in the case of single churning not be detected in the case of triple churning, so as to improve the difficulty of crack.) For the first 4 bytes of a frame, "0" is used to take the place of data_out [N-4].

The output of XOR_1 is input into churning_2 after moving bits. The moving rule is as below: Exchange bit 2 and 4, 3 and 5; the positions of 0, 1, 6, 7 are not changed as shown in figure 24.

The output of the second churning engine Churning_2 does XOR operation by bit with 2 vetors: The first vector is the input encrypted byte before 2 bytes. When the encrypted byte is the first encryted byte of data frame, the vector will be the second lowest byte of the key. When the encrypted byte is the second encryted byte of data frame, the vector will be the lowest byte of the key. The second vetor is the data output after triple churning before 5 bytes. As for the previous 5 bytes in a frame, '0' is used to replace of data_out [N-5].

The output of XOR_2 still is input into the third churning engine churning_3 by moving bits. The moving rule is as above.

The data association of triple churning is as shown in the figure below.

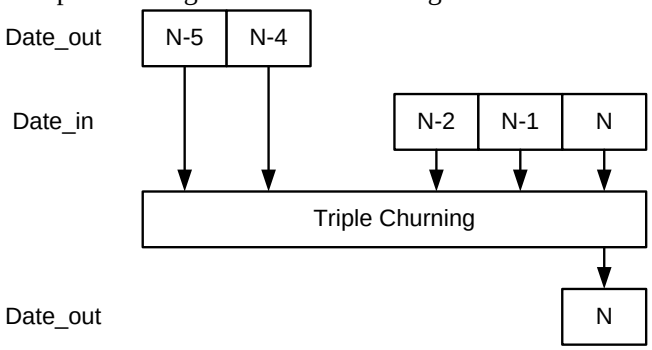


Figure 25 Relation between Data Input and Output of Triple Churning

Triple Dechurning is the simple mirror of triple churning, whose implementation is as shown in figure 26.

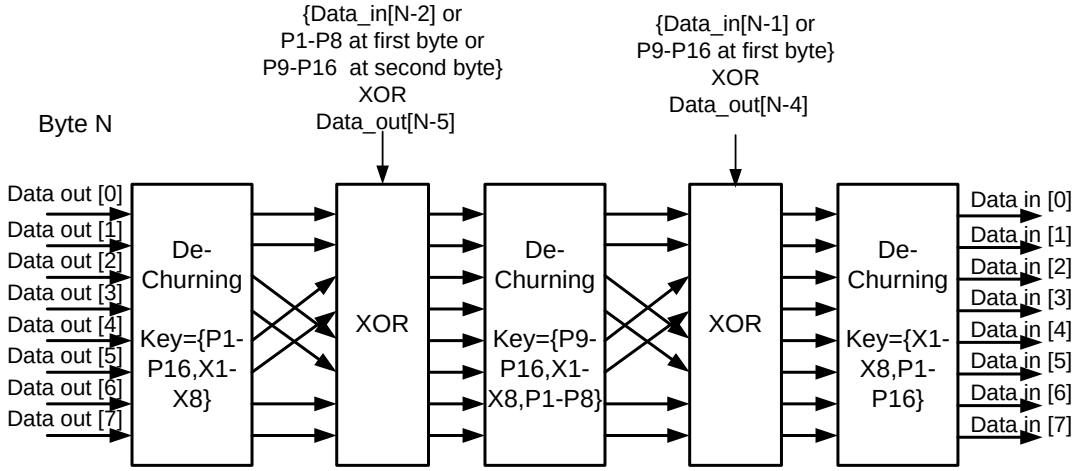


Figure 26 Implemantation of Triple Churning reverse Operation

11.1.4 Definition of Key Interaction Message

Key Interaction Message used for Churning has 2 kinds:

1) New_key_request
2) New_churning_key

For the key update and synchronization system based on Organization-specific Extension OAMPDU method, message types can be identified through “Organization Specific” OAMPDU (Code=0xFE) and Flag field.

Organization-Specific Extension format in OAM PDU frame in EPON system should meet the regulation of para. 6.5.3.

The Payload format in Organization-Specific Extension OAM message used for Churning in EPON system is as shoen in Table 49. The message type that Churning Code field corresponds to is as shown in Table 50.

Table 49 Payload format in Organization-Specific Extension OAM message used for Churning

Payload Octets	Payload	Value	Notes
3	OUI	0×XX XX XX	The Value to be applied
1	Ext. Opcode	0×09	churning
1	Churning code	0×00 - 0×01: Churning Message 0×02 - 0×FF: Reserved	0×02 - 0×FF: Ignored on reception
4	Data/Pad		Dependent on the Churning Code

Table 50 Field Churning Code and Its Corrsponding Message Type Used In Extended OAM Message Used for Churning

Bit	Definition	Description
[7:2]	Reserved	The default values are all 0
[1:0]	Message Code	00 - new_key_request 01 - new_churning_key

The regulations of OAM message relative to Churning are as below:

1) New_key_request

The definition of new_key_request is as shown in figure 27. When Churning_code=“0×00”, the

lowest bit of Byte In-use_Key_Index is used to indicate the key sequence number being used by OLT (“0” or “1”), while other bits are “0”. There are filling bytes after Field In-use Key Index.

Octets	
6	Destination Address=01-80-c2-00-00-02
6	Source Address
2	Length/Type=0x8809[Slow Protocol]
1	Subtype=0x03[OAM]
2	Flags
1	Code=0xFE
3	OUI
1	Ext. Opcode=0x09
1	Churning code=0x00(new_key_request)
1	In-use_Key Index
36	Pad
4	FCS

Figure 27 Frame Format of new_key_request

2) New_churning_key

The definition of new_churning_key is as shown I figure 28. Churning_code="0×01"; the lowest bit of New_Key_Index byte is used to indicate the equence number of the sent key ("0" or "1"), while other bits are "0"; 3-byte field Churning Key involves the new churning key needed to be replaced, while the transmission sequence is [(MSB)X1, X2,…, X8, P1, P2, …, P16 (LSB)]; There are filling bytes after Field Churning Key.

Octets	
6	Destination Address=01-80-c2-00-00-02
6	Source Address
2	Length/Type=0x8809[Slow Protocol]
1	Subtype=0x03[OAM]
2	Flags
1	Code=0xFE
3	OUI
1	Ext. Opcode=0x09
1	Churning code=0x01(new_churning_key)
1	New_Key_Index
3	Churning Key(X1, X2, ..., X8, P1,...,P16)
33	Pad
4	FCS

Figure 28 Frame Format of new_churning_key

11.2 Number Restriction of MAC Address

OLT should support the Number Restriction of MAC Address based on LLID, and the restricted MAC address number can be flexibly configured.

HGU, MDU and MTU types of ONU should support the number restriction of user MAC address based on ports, and the restricted MAC address number can be flexibly configured. When the number of MAC addresses is beyong the number restriction of OLT or ONU, OLT or ONU should support replacing the oldest MAC addresses with new ones, or support ignoring the new MAC addresses until there is a MAC address out of time.

11.3 Filter and Inhibition

OLT , MDU and MTU types of ONU should support frame filter and inhibition for broadcast ethernet frames of specific physical ports, multicast ethernet frame, unicast Ethernet frame according to MAC addresses (Source or Destination), VLAN ID. It optionally supports Access Control List based on Source/Destination IP Address, Source/Destination TCP or UDP ports and Protocol Number.

OLT, MDU and MTU types of ONU should support filter for illegal frames and illegal multicast source filter (such as user end multicast data flow).

MDU and MTU types of ONU should support the inhibition function of protocol messages such as IGMP, DHCP based on user ports.

ONU should support terminating and transparent transmission for BPDU (802.1D) messages received by user end ports, which is configurable.

OLT, MDU and MTU types of ONU should support dumping the Ethernet frames with unknown source MAC address, and prevent MAC address deceiving.

11.4 ONU Authentication

OLT should support authentication capability for ONU based on MAC addresses of ONU, and reject illegal ONU access. OLT should support Open and Close of the function. For the illegal ONU whose registration is rejected, it should reduce the nagative influnence of constant trying to register for the system, and the construction convenience should be considered while ONU will be given certain chances to try registration. The MPCP layer state machine of ONU should conform to IEEE802.3-2005, and the high-level protocol of ONU should support the silence mechanism after registration is rejected by OLT. The silence mechanism of ONU is implemented through the switch procedure between WAIT and DENIED states. The specific illegal ONU registration procedure and silence mechanism are as below:

1. OLT broadcasts a DiscoveryGate message to all ONUs. The ONU discovery window is opened;
2. ONU sends a Register_REQ message to OLT, which contains its MAC address information, and then ONU waits for OLY to send Register messages;
3. If ONU is an illegal ONU, OLT will send Nack Register message (flag=4);
4. After ONU receives Nack Register message, it should notify its upper level through MACI (REGISTER , status ⇐denied);
5. When the upper level of ONU receives the MACI message, a timer RegTmr will be started, which means starting the delayTs of the next time of registration procedure. Before the timer RegTmr is timed out, the upper level of ONU will not send MACR command (DA, REGISTER_REQ, STATUS<= REIGSTER); the value of Ts is 60s for the time being; before the upper level of ONU does not send the MACR (DA, REGISTER_REQ, STATUS<= REIGSTER) command, ONU should be in WAIT status;
6. When the next discovery window is opened, ONU will send REGISTER_REQ for registration. When RegTmr is timed out, the upper level of ONU will send out a MACR command (DA, REGISTER_REQ, STATUS<= REIGSTER), ONU will switch the status from WAIT to REGISTERING, and wait for OLT to send DISCOVERY GATE message. When the next discovery window is opened, ONU will send REGISTER_REQ message for registration.
7. Besides, after OLT finds illegal registration events of ONU, it should be reported to the management system of network.

12 Multicast

12.1 Implementation of Multicast

In EPON system, SCB+IGMP is used to implement business distribution, while multicast control messages based on OAM is used to implement the control and management of multicast business.

(1) On PON ports, OLT distributes the multicast content to all ONUs by Single Copy Broadcast (SCB) through LLID signal path.
(2) EPON system should support 2 kinds of multicast control methods as below: IGMP snooping and dynamic managable multicast regulated by the standard. The system works in one of the 2 methods, while OLT sets multicast control of ONU through extended MulticastSwitch OAMPDU.
(3) IGMP snooping is that OLT uses IGMP Proxy, while ONU uses IGMP snooping to implement the management of multicast group members. Dynamic Join/Quit and maintenance of multicast group members are implemented through IGMP Report/Leave and query message. EPON system implements simple authorization control of user multicast through the multicast VLAN configuration of UNI Port, while more sophiscated business authorization control is implemented by the IPTV business platform.
(4) The core thought of the dynamic managable multicast is that OLT authorizes users on the base of user identification information carried by IGMP control messages, and controls the multicast message forwarding of ONU through the extended OAM message. The principle is as mentioned below.
    - OLT maintains a authorization control list of user multicast business, managing the access rights for user multicast business. OLT is to identify ports (users) through LLID of users and VLAN ID carried by the upstream IGMO Report message, and determine whether the port (user) has the access right and its parameters of the multicast business applied for on the base of the authorization control list. OLT controls the OAM message to distribute the access right for multicast channels of a port (user) to ONU through the extended multicast control OAM message. ONU executes the forwarding and cutting off operations of multicast business flow of the port (user.) The multicast authorization control is managed by the network administration system on OLT end, while OLT is the majority of multicast authorization management and ONU is the operator of multicast authorization management. Meanwhile, OLT supports the combination of IGMP Proxy and upper level of multicast router, so as to implement the dynamic application and arrival of multicast business flow.
    - ONU maintains a filter list of multicast froup address and a multicast forwarding list (abbreviated as multicast forward list of ONU.) Opposite to the multicast control list of ONU, the list capacity is shorter, only supporting the current multicast business flow control in ONU and refreshing dynamicly according to the Multicast Control OAMPDU distributed by OLT. ONU marks VLAN tag identifying port (user) on the received IGMP Report/Leave message and tranfers it transparently to OLT. ONU receives the extended multicast control OAM message distributed by OLT (the message includes a serie of multicast control entries), and adds or deletes the local group address filter of ONU and multicast forward entries by the message, and then forwarding and cutting offof the relative multicast business flow are executed. Meanwhile, ONU should support untag operation for downstream multicast business flow (clear VLAN Tag in the multicast business flow.)
(5) EPON system should support multicast VLAN. Private VLAN of multicast is made on OLT, which means the multicast business uses one or more VLAN specified for multicast business to implement the isolation from other business. One multicast corresponds to one multicast channel or a channel group (a channel set managed unifiedly by an access right.) One multicast channel only belongs to one specific multicast VLAN. The multicast business flows transferred in SAB signal channel are all with multicast VLAN tag. Other data flows of users (including unicast business and upstream IGMP message, etc) are classified into additional unicast VLAN/CVLAN.

12.2 Multicast Protocol

Multicast Protocol should support IGMP V2 (RFC 2236), and optinally support IGMP V3 (RFC 3376) multicast administration protocol MIB (RFC2933.)

OLT should support the managable multicast mechanism regulated in para. 12.3 of the standard, and support IGMP Proxy and IGMP Snooping.

ONU should support the managable multicast mechanism regulated in para. 12.3 of the standard, and IGMP Snooping or IGMP Snooping with Proxy reporting or IGMP Proxy is supported.

12.3 Multicast Control

12.3.1 Implementation Procedure of Managable Multicast

When the multicast client (such as set-top box) applies for a specific multicast channel (for example, the IP address is XX.XX.XX.XX), it will send IGMP Report message to upstream. The Report message will enter the Ethernet User Port of ONU. As for SFU, HGU and SBU types of ONU, the ONU correspnds to a user while for MDU and MTU types of ONUs, one Ethernet User Port corresponds to a user.

After ONU receives the upstream IGMP Report message, VLAN tag is marked for identifying ports. The TPID value of VLAN Tag is 0x8100, while CFI is 0, Pri is 0, VID is the port number of Ethernet UNI ports receiving the IGMP control message. If the IGMP Report message is with VLAN Tag, its VID will be replaced with VLAN identifying user ports. For example, for Ethernet ort 1, ONU marks VLAN Tag of VID=1 on the upstream IGMP control message received by the port, and then forwards it up; for Ethernet Port 10, ONU marks VLAN Tag of VID=10 on the upstream IGMP control message received by the port, and then forwards it up, and so on. If te IGMP control message of VLAN Tag has been carried before entering the Ethernet ports of ONU (for example, a home network gateway is carried below Ethernet Port, and VLAN Tag has been marked on IGMP Control message), ONU will replace its VID with the port number of Ethernet UNI Port, and then ONU will transfer the IGMP Report message to OLT transparently.

After OLT reveives the IGMP Report message, OLT will inquire the access rights for the channel of the port (user) and its parameters according to port (user) identification, multicast IP address and source IP address of Report message (only used for IGMP V3, optional.) According to different access rights of users, several cases of the implementation procedure of EPON system are as below:

(I) When the access right for the channel of the port (user) is “Allowed””, OLT notifies ONU to add a multicast forward erntry through an extended multicast control OAM message (The message format is in para.6.5.4.4.) The entry indicates that the access right for the channel of the user port is “Allowed”.

- If the multicast business flow of the channel at the time has not been pushed to the uplink of OLT (No user is watching the channel under OLT), OLT will add IGMP to the message through MVR mechanism (Cross-VLAN Registration) in the way of IGMP Proxy and IGMP Snooping to forward to the source port of multicast VLAN so as to apply for the multicast business flow from the multicast router (or periphery router) , and establish the corresponding multicast forward entries. When the multicast bsiness flow of the channel is sent to the uplink board by the multicast router (or periphery router), OLT will forward it to the PON port where users are (the procedure can be with the action of marking multicast VLAN tag and switch of multicast VLAN), and map it to the broadcast LLID and send it to all ONUs on the PON port.
- If the multicast business flow of the channel at the time has not been pushed to the uplink of OLT but has not been pushed to the PON port where the user is (No user is watching the channel on other PON ports under OLT), OLT will forward the multicast business flow of the channel to the PON port where the user is , and map it to the broadcast LLID and send it to all ONUs on the PON port.
- If the multicast business flow of the channel has been pushed to the PON port where the user is at the time (There are users watching the program on the PON port), OLT will directly map the multicast business flow of the channel to the broadcast LLID and send all ONUs on the PON port.

ONU establishes the local multicast forward list according to the received multicast control OAM message, and forward the multicast data business flow received till the channel to the corresponding user port by the entries of this list as well as the Clear Tag action is run for the multicast data message (it is possible that the home network admionistrator needs to receive the business flow with Tag so that Clear Tag action doesn’t need to be done. The cases of “Forbid” and “Preview” are the same as mentioned above without specific description. The configuration of whether ONU clears Multicast VLAN TAG is made by Attribute MulticastTagStripe as shown in para. 6.5.4.4. The implementation procedure is as shown in figure 29.)

(II) When the OLT query result indicates that the access right of the user for the channel is “Forbidden”, OLT will not do any other action. When the multicast client (such as set-top box)

has not received any IGMP message and multicast business flow in certain time, the application for the channel is ended. The implementation procedure is as shown in figure 30.

(III) When OLT checking finds that the access right of the user for the channel is 'Preview', OLT will notify ONU to add a (temperary) multicast forward entry through an extended multicast control OAM message (the message format is in para. 6.5.4.3.) As the first case, OLT applies to the multicast server (or periphery router) for the multicast business flow (the multicast business flow of the channel has not been pushed to the uplink of OLT) through the MVR mechanism, and maps the multicast business flow to broadcast LLID and transmits it to ONU the user connects to, or directly forwards the applied multicast business flow to the PON port where the user is from the uplink of OLT (the multicast business flow of the channnel has been pushed to the uplink of OLT but not been pushed to the PON port where the user is) and maps the multicast business flow to broadcast LLID and transmits it to ONU the user connects to (the multicast business flow of the channel has been pushed to the PON port where the user is.) Meanwhile, OLT will activate a timer/counter used to control the preview time, preview times, preview interval of users. Time-out value $T_{Preview}$ of the timer and the owerflow value of the counter can be configured. ONU will forward the multicast business flow pushed by OLT to the corresponding user port according to the multicast forward entries OLT distributes, and Clear Tag action will be executed. After the preview timer/counter of OLT is timed out/overflowing, OLT will immediately noyify ONU to delete the original multicast forward entries and reset the timer/counter by an extended multicast control OAM message. Meanwhile, whether other users apply for the multicast business flow in the same PON determines whether to stop forwarding the multicast business flow to the PON port, and relatibe actions are to be made. Its procedure is as shown in figure 31.

In the forwarding procedure of multicast business flow, Multicast, OLTand Multicast terminal (such as set-top box) operate normal IGMP protocol message interaction like IGMP Query and Report, etc. The OLT activated with IGMP Proxy should send downstream IGMP Query message to ONU under PON ports (including general query message and specific group query message.) By IGMP Snooping, when ONU receives IGMP General Query Message without VLAN Tag, ONU should forward it to all Ethernet UNI ports, and the router reponse timer is activated for every multicast group. If the delivered IGMP Query message is with multicast VLAN Tag, ONU will broadcast the IGMP Query to all member ports of multicast VLAN (ONU is to determine which multicast VLAN each UNI port belongs to on the base of its entries of multicast forwarding list) (With consideration of the case, another simplified implementation is: ONU forwards the IGMP General QueryMessage of every multicast VLAN to all Ethernet ports of the ONU without consideration of whether each Ethernet port belongs to the multicast VLAN. In this case, one UNI port that does not belong to certain multicast VLAN will also receive the IGMP General message of the multicast VLAN without influencing the functions of multicast clients.) After ONU receives IGMP specific query message, ONU needs to forward the IGMP specific group query message to the group member ports of the multicast group inquired of (ONU is also to determine which multicat group each UNI port belongs to on the base of the current entries of multicast forwarding list), while the router response timer for the multicast group is activated. In addition, ONU should clear/reserve the multicast tag of IGMP Query message according to OLT control (by MulticastTagStripe OAM.) IGMP Group-Specific Query messages should be marked with multicast VLAN Tag by the multicast VLAN the chanel belongs to (held in broadcast LLID.) IGMP General Query should be delivered in all multicast VLANs in the EPON system, which means that OLT will copy every IGMP General Query message marked with different VLAN Tag and deliver them to all ONUs in broadcast LLID. For example, in an EPON system, there are 4 multicast VLANs of 1000, 1001, 1002 and 1003 holding different IPTV channel group. Each time the Query Interval timer (according the definition of RFC2236) is timed out, OLT will generate an IGMP General Query message and make 4 copies of it deliverd in 4 multicast VLANs. (Explanation: with generating multiple copies of IGMP General Query messages on the Ethernet UNI ports of ONU and on PON ports in the way, as there are less multicast VLANS that are generally 1 or more in EPON system and the default value of IGMP Query Interval is generally 125s, the whole cost can ignored. Multiple messages will not bring about negative effects on multicast clients and OLT state machine.)

When a user wants to leave the specific channel applied for, the multicast client (set-top box) will send upstream IGMP Leave message to ONU.

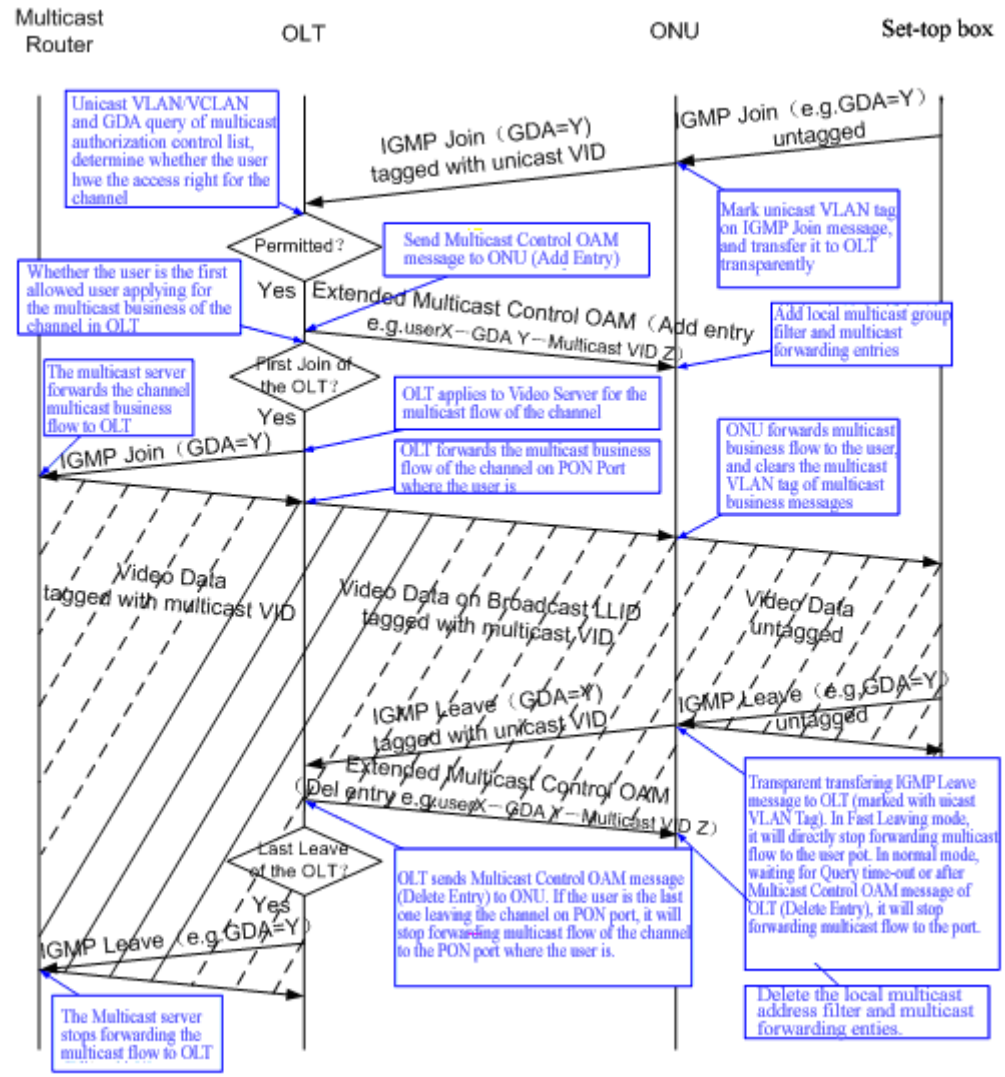
If ONU is with Fast-leave Enabled, ONU will immediatelt stop forwarding the multicast group businessflow to the user after receving IGMP Leave. (close the corresponding entry in the multicast authorization list of the ONU temperarily), while the ONU will mark the IGMP Leave message with VLAN Tag identifying the receiving port of the Leave message (VID value is the received UNI Port ID of the Leave message) and then send it to OLT transparently. After OLT receives the IGMP Leaving message, it will send a Multicast Control OAMPDU to the ONU (delete the corresponding entries of multicast authorization list of ONU.) When ONU receives the delivered Multicast Control OAMPDU (delete entries) from OLT, it will delete the corresponding entries from the local multicast authorization control list of ONU. (The method is mainlt used for the circumstance connecting only one multicast client under the Ethernet port of ONU).

If ONU is in Non-Fast-Leave mode (Normal IGMP Snooping), ONU will send group-specific query message to the UNI port that receives the Leave message after ONU receives IGMP Leave message and then the corresponding timer will e activated; in the case that [Last Member Query Interval] that [Last Member Query Count] group-specific query messages designate, ONU doest not receive the IGMP Report message sent by Multicast Client, ONU will treat it as there is no other group member under the port and delete the port from the multicast group (stop forwarding multicast business flow), and will mark IGMP Leave message with VLAN tag identifying users (VID also adopts Port ID) and send it OLT transparently.If before group-specific group query of ONU is timed out,the IGMP Report message corresponding to the multicast group is received from the port, ONU will reserve te original multicast forwarding list and keep forwarding the multicast business flow to the port with dumping the IGMP Leave message.

After OLT receives the IGMP Leave message, it will send a Multicast Control OAMPDU to the ONU (delete the corresponding entries of the multicast authorization list of ONU.) After ONU receives the deliverd Multicast Control OAMPDU (delete entries) from OLT, ONU will delete the corresponding entries from the local multicast authorization list of ONU (the method is mainyly used in the circumstabce connecting to Ethernet swicthes under the Ethernet ports of ONU that are connected with multiple multicast clients).

In the IGMP Proxy-like manner, OLT intercepts all IGMP Join/Leave messages between multicast router and hosts attached to the EPON system, and exchanges IGMP Join/Leave messages on its upstream interface with multicast router to dynamically Call for and call off multicast datagrams, respectively. Meanwhile, OLT forwards multicast flow by the group mamber status in the EPON system, which means that if there is no host belonging to certain specific group on certain PON port of OLT, the multicast business flow in the multicast group will be stopped forwarding to the PON port; if there is no host belonging certain specific group in the whole PON, the IGMP Leave message of the multicast group will be sent to the multicast router so as to stop the tranmission of the multicast business of the channel (except for EPON system adopting static arrival of multicast business flow).

If certain user is ordering some multicast channel business flow (the access right is “Allowed” or “Preview”) and the network administrator switches the access right of the user to “Forbidden” (OLT should have the capacity of determining whether a user is receiving the multicast flow), OLT should send an extended MulticastControl OAM message to ONU for notifying ONU to delete the original multicast forwarding entry, while executing relative operations according to whether there is a user applying for the multicast business flow and whether to stop forwarding the multicast business flow to the PON port.



Note: For convenience, the figure only provides the implementation procedure of managable multicast of OLT of the single-stage multicast structure. For the OLT of 2-stage or multi-stage multicast structure, when OLT receives IGMP Join/Leave message, it is also necessary to determine whether the user is the first Join/the last Leave one in the EPON port where the user is.

Figure 29 Implementation Procedure of Typical Multicast Business When Access Right of User is “Allowed”

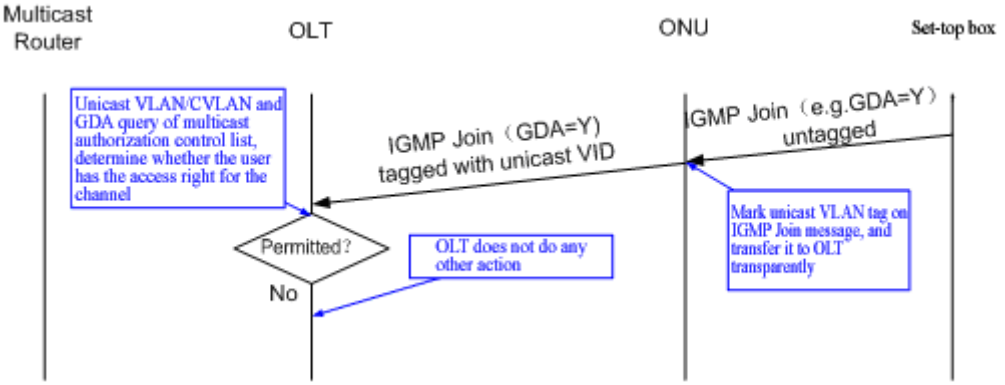
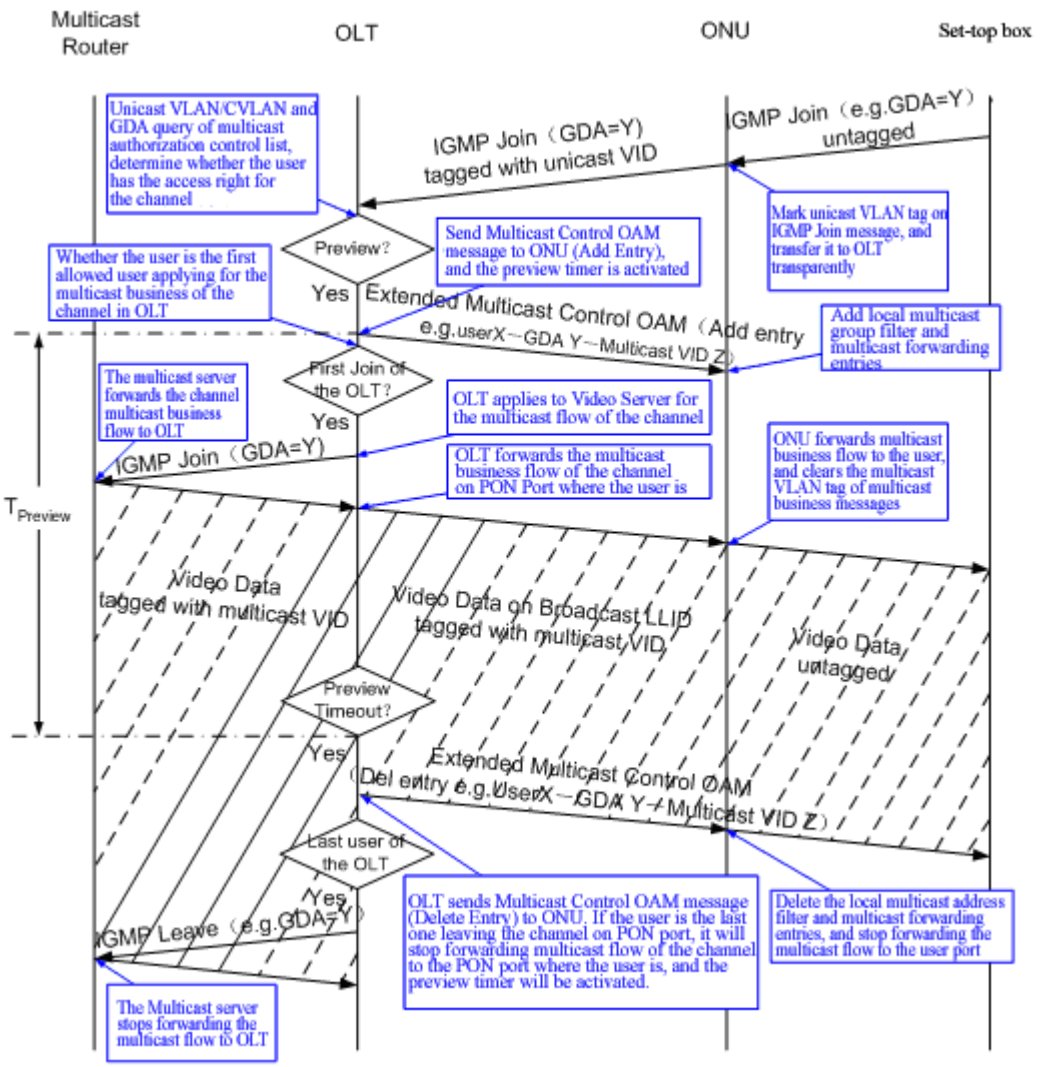


Figure 30 Implementation Procedure of Typical Multicast Business When Access Right of User is “Forbidden”



Note: In the case that a user positively leave but the preview is not timed out, the Leave procedure is the same as the one when the access right is “Allowed”.

Figure 31 Implementation Procedure of Typical Multicast Business When Access Right of User is “Preview”

As mentioned above, in Proxy mode, OLT intercepts all upstream IGMP Control messages (Report, Leave) with unicast VLAN tag of port (user), and determines whether to send IGMP messages to the upper-level multicast router after authorization. If it is necessary to request IGMP messages from the multicast router, OLT should mark specific VLAN tag of VID on its sent upstream IGMP Report message (The specific multicast signal of VLAN Loading is generally adopted between OLT and upper-level multicast routers.) The specific VID should be configurable.

12.3.2 Multicast Control of OLT

OLT should reserve the multicast authorization contrl list of users, so as to implement centralized control and management of user multicast. The entries of multicast authorization control list of OLT include parameters as below:

a) Multicast IP Address
b) Multicast VLAN ID
c) Source ID Address (Optional, only used for IGMP v3)
d) User ID (LLID+Unicast VLAN/CVLAN)
e) Access right for channels of users
f) Preview Template (Preview Time, Interval, Times)

The channel access right has Forbidden, Preview and Allowed.

Table 51 is an example of multicast authorization control list on OLT end:

Table 51 Example of Multicast Authorization Control List on OLT end

User ID	Slot ID - PON ID	ONU ID (LLID)	ONU Port ID (VID of IGMP Control PDU)	Multicast Group List	Multicast VLAN	Access Right	Parameter
Epxx (User A)	01-01	0001	1	224.1.1.1-224.1.2.1	4001	Allowed	The amount of channels applied for at the same time is not more than 2.
Epxx (User A)	01-01	0001	1	224.2.1.1-224.2.2.1	4002	Preview	The time length is 5 minutes.
Epxx (User A)	01-01	0001	1	224.3.1.1-224.3.2.1	4003	Forbidden	
EPyy(User B)	01-02	0002	1	224.1.1.1-224.1.2.1	4001	Allowed	
EPyy (User B)	01-02	0002	1	224.2.1.1-224. 2.2.1	4002	Allowed	
EPyy (User B)	01-02	0002	1	224.3.1.1-224.3.2.1	4003	Forbidden	
Epzz (User C)	02-01	0001	2	224.1.1.1-224.1.1.255	4001	Allowed	
Epzz (User C)	02-01	0001	2	224.1.2.1-224.1.2.255	4001	Forbidden	
EPzz (User C)	02-01	0001	2	224.2.1.1-224.2.2.1	4002	Forbidden	
Epzz (User C)	02-01	0001	2	224.3.1.1-224.3.2.1	4003	Forbidden	
…		…	…	…	…	…	…

Note: PON ID is used to indicate the slot where the user is and the PON interface.

OLT should support that the local CLI and EMS can inquire and configure the multicast authorization control list, so as to implement the functions of Read, Add, Delete and Modify for the entries of the multicast authorization control list of local and remote users.

OLT should dynamically manage the group member information by IGMP Proxy according to the access right for specific channels of users in PON ports, so as to applyfor and cancel multicast flow. Its specific function should meet the requirement as mentioned in the previous paragraph.

The channel preview can be set with duration of once preview, preview times, preview interval and the whole duration of preview. It should have the reset function of preview access right, which can be reset automatically through setting the time.

OLT should support CDR (Call Detail Record), which records the basic access information of users (including OGMP Request Type (Join, Leave), IGMP Request Time, User ID, Channel Applied for, Channel Access Right, Success/ Failure of IGMP Request, Leave Style (Forced, By self) and CDR Record Generation Time.)

Multicast Join and Leave of short time can not be recorded, whose time parameter can be configured; No requirement for multicast preview of short time, whose time parameter can be configured.

Three methods should be supported to synchronize the CDR information timing with the management system, so as to assure that the CDR information will not be lost:

Method One, timing of report;

Method two, automatic report after recording certain amount of data;

Method three, the administrator manually forces OLT to report CDR.

OLT should support the control of the channel amount of multicast business applied for at the same time by each user (one counter), and the channel amount of multicast business applied for at the same time by each user should be configurable.
OLT should support OLT should support 2 kinds of business transmission meythods of the static directional arrival of multicast business and dynamic application arrival.
OLT should support merging multiple multicast control containers of different users specified for the same ONU into one OAMPDU for delivery to ONU, so as to overcome the weakness of slow OAMPDU interaction and to remove group delay and Leave. The specific implementation should conform to para. 6.5.4.2.

12.3.3 Multicast Control Function of ONU

ONU should support analyze the broadcast LLID.
SFU, HGU and SBU types of ONU manage the local multicast goup member by IGMP Snooping, and forward the multicast flow according to the local multicast address filter and multicast forwarding control list. ONU should support the extended Multicast Control OAM and dynamically update the local multicast group address filter and multicast forwarding list according to the requirement of the OAM message. The specific requirement is as described in the paragraph above.
ONU should support local settings of Fast Leaving, which means that ONU can be configured as Fast Leaving mode and as Time-out mode (when for multiple query periods the multicast client has not sent Report message, the client will be treated as Leave, and the forwarding multicast flow of the port will be stopped.)
The entries of the local dynamic multicast forwarding list of ONU are the parameters as below:
a) Multicast MAC Address
b) Multicast VLAN ID
c) User End Identification
The examples of local multicast authorization control list on ONU end is as shown in Table 52.

Table 52 Examples of multicast authorization control list of ONU

ONU Port ID	Multicast VLAN	Multicast MAC (GDA)
1	4001	0x01005e010101
2	4002	0x01005e010102
6	4002	0x01005e010108
…	…	…

12.4 Performance Requirement of Multicast

OLT equipments should support over 255 multicast groups.
For MDU and MTU types of ONU, the multicast group number supported by each user port at the same time is not less than 4. The total multicast group number of ONU is 4×User Port number (The capacity of the local multicast control list of ONU should not be less than the Ethernet port number×4 of the ONU.)
For SFU, HGU and SBU types of ONU, the total amount of multicast group supported at the same time is not less than 16 (the capacity of the local multicast control list should not be less than 16.)
The capacity of processing IGMP protol message of OLT equipments every second should not be less than 32×PON Port Number×25%. (Temperary)
In the case that multicast flow has been sent to ONU equipments, the time of sending multicast message to the user client from sending IGMP request messages to ONU equipment starting should not be over 100ms.
In Fast Leave mode, the time of sending multicast message to the user client from sending IGMP request messages to ONU equipment stopping should not be over 100ms.

12.5 Extended OAM Requirement relative to Multicast

Multicast control is loaded by extended Get request/Response, Set request/response OAMPDU, which involves one or more Multicast relative Variable Containers, including attributes of Add/Del Multicast VLAN, MulticastTagStripe, MulticastSwitch, MulticastControl and Group Num Max, in which Add/Del Multicast VLAN and Group Num Max can only be used for traditional EPON system by IGMP Snooping; MulticastControl is used in the EPON system by the dynamic

manageable multicast regulated in the standard; MulticastTagStripe can be used in The VLAN TAG management of these two kinds; MulticastSwitch is used to control ONU by one of the 2 kinds of methods. The specific Variable Container format relative to multicast is in para. 6.5.4.4.

(VLAN question of general query: Broadcast by multicast one by one, or distribute only in specific multicast VLAN, or distribute without tag?

Is it possible that standard IGMP Snooping in ONU also needs to deliver a group or a corresponding list of multicast VLAN?)

13 Fiber Protection and Switch-over (optional)

13.1 Function Requirement of Fiber Protection and Switch-over

For improving the network reliability and viability, the fiber protection and swich-over mechanism can be used in the EPN system. Fiber protection and switch-over can done by 2 methods as below:

a) Automatic Switch-over: Triggered by failure, such as signal lost or poor signal, etc;
b) Compulsory Switch-over: Triggered by management events

13.2 Type of Fiber Protection and Switch-over

There are mainly 3 kinds of fiber protection:

1) Type a: Main fiber redundancy protection (as figure 32-a):
   - OLT: Single PN port is adopted, 1x2 laser switch is integrated in PON port, OLT checks the line status (checking method is undetermined;)
   - Laser bypass: 2:N bypass is used;
   - ONU: No specific requirement
2) Type b: Redundancy protection of OLT PON port and main fiber (as figure 32-b):
   - OLT: The spare OLT PN ports is in the cold spare status, OLT checks the line status (checking method is undetermined;), OLT PON port status, the switch-ober should be completed by OLT.
   - Laser bypass: 2:N bypass is used;
   - ONU: No specific requirement.
3) Type c: Full protection (OLT PON port, main fiber, bypass, layout fiber redundancy) (as figure 32-c)
   - OLT: The main and spare OLT PON ports are both in working status;
   - Laser bypass: 2:N bypass is used;
   - ONU: The laser switch device is integrated before PON Port, OLT checks the line status (checking method is undetermined), OLT PON port status, the switch-ober should be completed by OLT.

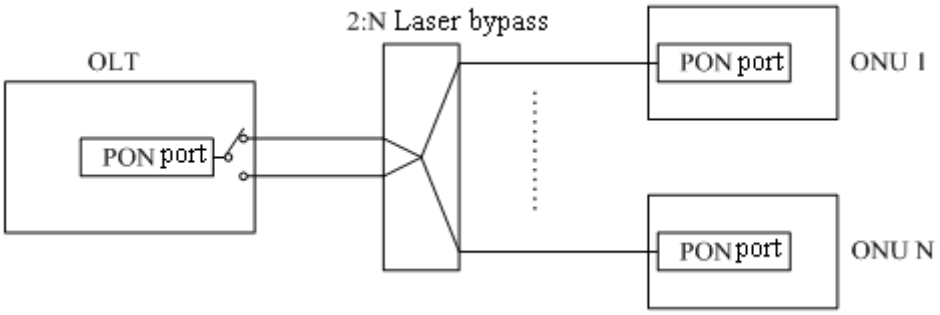


Figure 32-a Fiber Protection and Switch-over: Main fiber redundancy protection

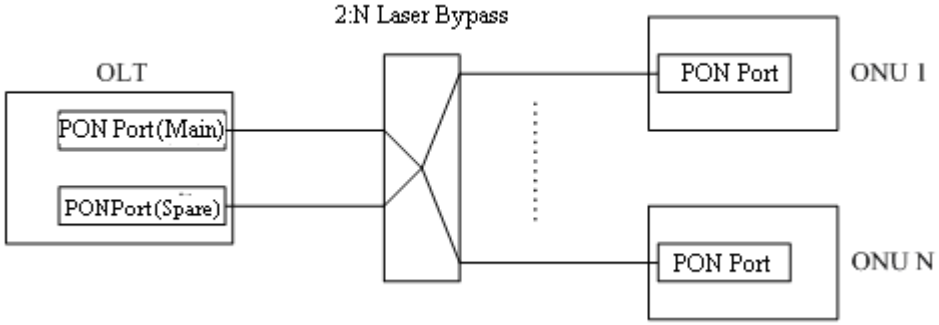


Figure 32-b Fiber Protection and Switch-over:

Redundancy protection of OLT PON port and main fiber

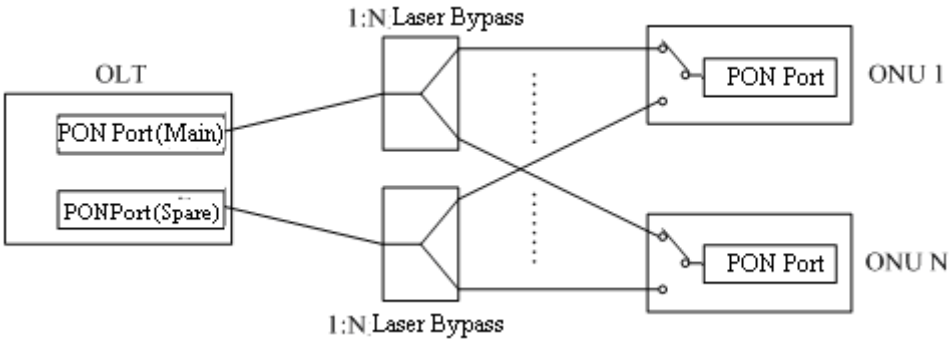


Figure 32-c Fiber Protection and Switch-over: Full protection

13.3 Fiber Protection and Switch-over Rule

In EPON system, when fiber protection type a, b, c meet one of the conditions as below, fiber protection and switch-over must be done:

1) Lost of Signal;
2) Poor Signal Path:
   - The input signal power is too high or too low;
   - Error code rate is beyond the limit;
   - Other conditions are undetermined.

13.4 Fiber Protection and Switch-over time

In EPON system, for different types of fiber protection when it occurs, the path switch-over time should meet the requirement as below:

1) Type a: Less than 50ms (temp)；
2) Type b: Less than 100ms (temp)；
3) Type c: Less than 100ms (temp)；

13.5 Return Mechanism of Protection Switch-over

All protection switch-over mechanism of EPON system can support automatic and manual return function for the protected business. For the automatic return method, after the failure that causes switch-over is cleared and a certain period of waiting time (WTR), the protected business should automatically return to the original work routing, while WTR should be configurable.

The business interuption caused by return action should be less than 50ms.

14 Voice Business Requirement (Optional)

If EPON system provides voice business, VoIP must be supported. SFU, HGU and SBU types of ONU should adopt SIP protocol, while MDU and MTU types of ONU should adopts H. 248.

MTU type of ONU is integrated with IAD Suggestion Suport Centrex.

Voice grouping is implemented by ONU for VoIP business in EPON system.

The ONU supporting VoIP loading that is to implement H.248 protocol should conform to YD/T 1292-2003 and H.248 Protocol Regulation of China Telecom.

The ONU supporting VoIP loading that is to implement SIP protocol should conform to IETF RFC 3435 and SIP Protocol Specification of China Telecom.

The voice business should be marked as high priority business, so as to assure the transmission quality of VoIP. Strict priority schedule is used for voice business.

15 TDM Business Requirement (Optional)

The EPON system optionally supports TDM. As for SBU and MTU types of ONU used for business clients, TDM should be supported.

When EPON system holds data private line business (E1 or n×64kbit/s data business), PWE3 of IETF should be adopted. The implementation should conform to IETF RFC3985(2005) and RFC4197(2005). The encapsulation method should adopt RFC4553 (SATOP) or

Draft-ietf-pwe3-cesopn-02.txt (CESOPSN), whose specific implementation should be configured by OLT and the local network administrator of ONU. The TDM business held by EPN system should adopt self-adapting clock restoration, that is, restore the clock from the clock poke from data packet.
PWE3 data packet of EPON system contains RTP header of certain length. The format of RTP and definition of byte field should conform to RFC3550. The byte length of clock pokes used by 2 ends of IWF of TDM circuit uses 4 bytes, while the synchronization data unit of clock poke is bit.
For guaranteeing the inerconnection requirement based on TDM, OLT and ONU equipments should be respectivel set with adopted standard, E1 number of encapsuation, corresponding IP address of CESoP, MAC Address, VLAN.
As for OLT equipments providing loading function of TDM business, the interconnection function of TDM (E1 and n×64Kbps) business is optionally supported.

16 Performance Index Requirement of Business Load

16.1 Performance Index Requirement of Ethernet/IP Business

The performance indexes of Ethernet/IP business mainly involve transmission delay, capacity, Packet Loss Rate and long-term packet loss rate.

16.1.1 Capacity

When EPON system is only loaded with Ethernet/IP business, the upstream capacity of PON port should not be less than 900Mbit/s (any packet length from 64Byte to 1518Byte), while the downstream capacity of PON Port should not be less than 950Mbit/s (any packet length.)

16.1.2 Transmission Delay

When EPON system is only loaded with Ethernet/IP business, in the case that the flow volumn is not beyonf 90% of the system capacity, the upstream transmission (UNI to SNI) delay should be less than 1.5ms (any Ethernet packet length from 64Byte to 1518Byte), while the downstream transmission (SNI to UNI) delay should be less than 1ms (any Ethernet packet length)

16.1.3 Packet Loss Rate

When the EPON system only loads Ethernet/IP business, in the case that the upstream and downstream flow volumn are both 1Gbit/s the packet loss rate of upstream of PON Port should be less than 10% (any Ethernet packet length), while the packet loss rate of downstream of PON Port should be less than 5% (any Ethernet packet length).

16.1.4 Long-term Packet Loss Rate

When the EPON system only loads Ethernet/IP business, the long-term (24 hours) packet loss rate should be 0 under certain flow volumn (90% of the capacity).

16.2 Performance Index Requirement of Voice Business

When the EPON system loads voice business by VoIP, the performance index requirement as below should be met.

a) Dynamic switch time of voice code <60ms.
b) Supposed to have the storing capacity of 80ms cache, for guaranteeing voice interuption and dithering not to occur.
c) Objective Evaluation of Voice
   - When the network environment is pretty good, the average of PSQM<1.5;
   - When the network environment is poor (packet loss rate=1%, ditheing=20ms, delay= 100ms), the average of PSQM<1.8;
   - When the network environment is pretty bad (packet loss rate=5%, ditheing=60ms, delay=400ms), the average of PSQM<2.0.
d) Subjective Evaluation of Voice
   - When the network environment is pretty good, MOS>4.0;
   - When the network environment is poor (packet loss rate=1%, ditheing=20ms, delay= 100ms), MOS>3.5;

- When the network environment is pretty bad (packet loss rate=5%, ditheing=60ms, delay=400ms), MOS>3.0.

e) Coding Rate
- G.711, Coding Rate = 64kbit/s;

- It is required that the coding rate <18kbit/s for G.729a.
- It is required that the coding rate of G.723.1(5.3)<18kbit/s, G.723.1(6.3)<15kbit/s for G.723.1.

f) Delay Index (Circle Delay)

The delay of VoIP involves coding/decoding delay, input cache delay of receivibg end and internal queue delay, etc.

- When G.729a is adopted, the circle delay<150ms;
- When G.723.1 is adopted, the circle delay<200ms.

16.3 n×64Kbit/s digital connection and performance index of E1 channel by Circuit Simulation

16.3.1 Code Error Rate

In the normal working condition, the error code rate of n×64Kbit/s digital connection and performance index of E1 channel of the EPON system is 0 with the testing time is 24 hours.

16.3.2 Transmission Delay

In the normal working condition, the transmission delay of n×64Kbit/s digital connection and 2048kbit/s path<1.5ms from the user end port to the network end one.

16.3.3 Dithering Transmission Characteristics

The Dithering Transmission Characteristics of E1 Port should meet the regulation in figure 33 and Table 55.

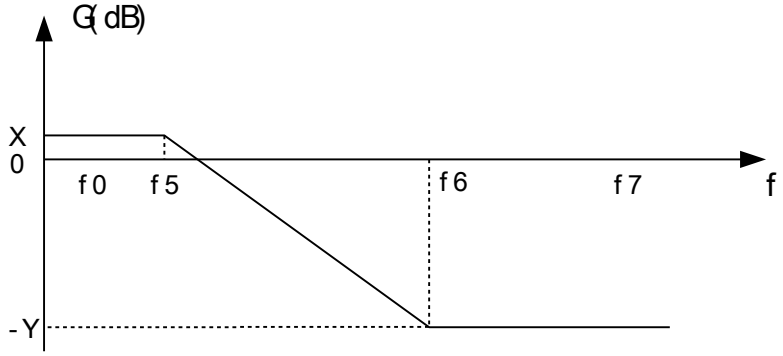


Figure 33 The Dithering Transmission Characteristics of E1 Port

Table 53 Dithering Transmission Characteristics of E1 Port

Port Rate	Frequency f (Hz)				Gain G (dB)	
(kb/s)	f0	f5	f6	f7	X	-Y
2048	*	40	400	/	0.5	-19.5

Note: '*' value is provided by equipment provider, but f0 should not be less than 20Hz.

17 Requirement for Operational Management and Maintenance

The operational maintenance and management of EPON system should support configuration, failure, performance and safety management of OLT and ONU. The operational management and maintenance of OLT is mainly implemented through EPON Element Management System (EMS, also Equipment Network System). There are two modes for achieving ONU's operational management and maintenance, namely, local management and remote management. Local management generally refers to that maintenance personnel execute local configuration, failure, performance, and safety management for ONU via PCs. Remote management means that system administrator implements remote management (involving configuration, failure, performance, safety, etc.) for ONU via EMS. There are also many ways for enabling ONU's remote management:

- As the proxy of network administration system, OLT implements ONU's remote management in the Ethernet OAM mode as specified in IEEE 802.3;
- The network administration system implements ONU's remote management via SNMP protocol for the SNMP functions enabled by ONU;
- Implement remote management for ONU by Automatic Configuration Server (ACS) in the

TR-069 mode specified by DSL Forum;

For ONUs of various types, the modes for implementation of remote management are different. See Section 17.2 for details of Requirement.

17.1 Requirement for OLT's Operational Management and Maintenance

The operational maintenance and management of OLT should support configuration, failure, performance and safety management of OLT and also remote management for ONU in the OAM mode.

The network management of OLT should support the OAM features as specified in SNMP protocol and IEEE 802.3-2005, in other words, the communications between OLT and EMS should adopt standard SNMP protocol to achieve relevant management functions and in the meanwhile, OLT, with SNMP Agent function enabled, implements OAM discovery with ONU, link status monitoring (mainly Remote Failure Indication) and Remote Loopback through standard OAM channels. In addition, OLT should achieve extended OAM discovery, key update and synchronization of churning, DBA parameter management, etc. via OAM functional extension (Organization Specific Extension). Other management functions are to be determined, including software/firmware downloading, user interface management, FEC function control, VLAN, traffic classification and marking, traffic dispatching, protection switching, TDM CES traffic administration, VoIP service management, etc.

The OAM functions for OLT and ONU should meet specifications of IEEE802.3-2005 Clause 57 and comply with Requirement for OAM functions as set forth in Sections 6.5 and 11.1 hereof.

17.2 EMS Requirement

17.2.1 General EMS Requirement

1) Management Protocol and Equipment Management Interface
   a) EMS should operate, manage and maintain EPON system through SNMP v2c network management protocol with V3 release as optional; network administration options in TELNET or WEB mode are supported;
   b) EMS should support access to OLT equipment in both outband and inband modes. The outband mode offers all functions available to the inband mode. In addition, the outband mode should have access control enabled to protect against authorized access;
   c) One DCN access mode of Ethernet, DDN (N×64kbit/s 1≤N≤30, V.35 interface) and 2Mbit/s (G.703 codirectional interface) should be adopted between EMS and OLT; it is advised that Ethernet access mode be supported;
   d) EMS management system should keep available configuration management, failure management, performance management and safety management for equipment;
   e) OLT should support users to implement outband operational maintenance via CONSOLE port attached.
2) Access modes and capability for operational users (hereinafter referred to as "Users", EMS operators)
   a) EMS should support users' local and remote accessing;
   b) EMS should support concurrent operations of many users (16 users at least).
3) Requirement for software and hardware platforms

a) OS and database for EMS

Operating system (OS) for the EMS platform of EPON adopts one of UNIX, Linux, Windows 2000/XP/2003/Server, Mac OS, Solaris, etc.; EMP should support database management, capable of controlling all database systems within network administration system; also support one of such databases as MS SQL Server 2000/2005, MySQL and Oracle and its compatible version.

b) Hardware

Requirement for EMS server: run regularly with the configuration of PC (P4 2.0G/512M Memory/20G Hard Disk) or SUN UltraSPARC III 1.2G/1G memory.

Hardware Requirement for network administration terminal: run regularly with the configuration of PC (P4 2.0G/512M Memory/20G Hard Disk) or SUN UltraSPARC III 1.2G/1G memory.

c) Software

EMS system software should meet Requirement for forward compatibility; in other words, it can manage all network elements currently running on the network, and all data in systems of a lower version can migrate automatically to systems of a higher version, when software version is upgraded.

Either specialized client-side software mode or the Web mode may be adopted for the user side.
Network administration system should offer self-management services such as system startup, initialization, closing and backup.
If OLT equipments support mixed plug-in of DSL interface cards, EMS should support unified management of DSLAM and OLT equipment.

d) Management capacity

The typical configuration for EMS platform should enable the capacity for managing OLTs no less than 1000 and ONUs no less than 100000. It is suggested that the capacity in support of 1000000 threads be supported. To increase number of network elements managed imposes no remarkable impact upon system performance within maximum equipment capacity range.

e) Processing capability

EMS keeps available strong data processing capabilities of warning, performance, order, etc., meeting the following Requirement at least:

- Average alarm response time: no longer than 10s from network element warning to EMS alarm display;
- Alarm record capacity: no less than 5,000,000 entries or no shorter than 6 months;
- Performance record capacity: no less than 10,000,000 entries or no shorter than 6 months;
- Order log record capacity: no less than 150,000 entries or no shorter than 6 months;
- Other processing capability parameters: to be determined.

4) Reliability

EMS should meet Requirement for reliability below:

a) EMS should support database backup, recovery and copy. Backup data designated to the peripheral memory designated manually or automatically. The peripheral memory may include magnetic disc, magnetic tape, database, etc., and provides convenient data recovery operational interface (when necessary) to recover storage information of the peripheral memory designated to system (from various storage media or geographical locations).

b) Support (1+1) hot-standby and warm-standby configurations. The primary standby switching duration for hot backup is no longer than 10 minutes. Two options are available to support floating IP settings.

c) Provide the services for monitoring the links between EMS server and network elements. Once any failure of EMS itself or the links with network elements arises, EMS should remind users promptly. When the links are recovered, EMS should provide related safety and recovery functions.

d) Network administration system should implement continuous or intermittent testing, observation and monitoring for each part of the system to discover failure or performance weakening. EMS makes available monitoring services for the CPU, memory and database adopted for EMS system.

e) Investment and exit of EMS imposes no impact upon traffic flows of network elements.

f) Regular operations of network elements and normal services of network can't be affected when system abnormalities are over.

5) Software Management

a) Provide management functions for self-contained software. Included are:

- Software and patch installation management (GUI): provide detailed and user-friendly software and patch installation wizard and generate relevant log files;
- Provide information of self-contained software version;
- Backup original programs in patch installation process;
- Effect automatic upgrade of local terminal and remote client side after server-side upgrade.

b) Implement remote maintenance for software on the network elements governed. Included are:

- Inquire about software version information of network elements;
- Online software upgrade;
- Hot software patch upgrade;
- Batch backup/recovery/upgrade for software;
- Batch upgrade and management for patches.

6) Data Management

a) Copy and export the databases of configuration, warning, performance, etc. manually and automatically.

b) Provide print setup and print function for printout of the data of configuration, warning,

performance, etc.

7) User Interface

a) EMS chooses the interface in Chinese in priority with the interface in English as optional;

b) The man-machine interface adopts the modes of window, icon, menu and cursor, being concise and user-friendly and rendering rich and accurate online help;

c) All elements of the network governed have a common management software platform. Areas authorized for management can be monitored in one operating window.

d) Screen protection: manual and automatic lockout of the screen at the client side is available. When an operator stops operating the system or has no operations in a specific period, the screen can be locked to protect other users from access. In addition, the function for screen activation and reentry is available (with password required) with the screen to be activated through touching upon mouse/keystroke. When an operator stops operations for a period, the system can make the user log out automatically.

8) Time Synchronization

a) The system should ensure EMS system time and network element time synchronous and set time synchronization in an automatic way via NTP protocol and in a manual way;

b) Time stamp is measured with second (s) as the unit.

9) Northward Interface

EMS chooses and provides northward interface in priority with interface protocol as CORBA, XML or SOAP. Northward interface should provide the features of log-in, topology, service distribution, warning, stock statistics, performance statistics, etc., to assure extensibility, consistency and easy to operate of NMS access service, diversity of EMS services and easy to configure of various equipment and various service types.

17.2.2 EMS Configuration Management Function

EMS system of EPON should make available configuration management function for OLT and ONU with specific Requirement as below:

1) Topology management

a) Display in icons all network elements, element groups (a network element may be divided into uncrossed element groups due to display demands) or subnets governed; if possible, display the rack/sub-rack components of network elements with sub-rack sequence, exact slot, unit disk, etc. included and marked with relevant names. Adopt different icons to mark nodes of various types (network elements, subnets or others). An operator, through clicking on network element icons, obtains detailed configuration information of network elements, or implements network element configuration and other management functions.

b) Network topologies can display running status and conditions of the network elements governed in a dynamic and real-time way.

- Reflect in a real-time way the changes to network topology structure and network element configuration. Variations of network topology structure (such as ONU upper line/lower line) and those of network element configuration information can be advised of users in topological graphs in certain conspicuous modes.
- When any failure arises from the communications between EMS and network elements, the failure can be reflected in topological graphs.

c) EMS can provide flexible and convenient topologic editing functions such as array, addition, deletion, modification and movement:

- Add and delete network elements on topologies manually;
- Add, modify and delete the connecting lines among network elements on topologies manually;
- Define, modify, move and delete positions and names of network elements manually;
- Provide automatic array of network elements;
- Add network elements through automatic query.

d) Topology view function:

- Customize background maps;
- Zoom in and out topological graphs;
- Select if certain network elements are displayed or hidden according to Requirement.

2) Network element management

a) Create, modify, delete and inquire about configuration of network elements;

b) Inquire about and/or information of network elements including whether unit disks are installed in OLT slots (e.g., type, model and status of a unit disk in slot, with protection or not, and guard mode);
c) Implement inquiry and configuration operations of boards. Inquire, add and delete a single board; inquire about CPU utilization conditions of boards; conduct reset operations of boards'
d) Inquire about and modify ONU configuration information including ONU online status, addition mode (manual/automatic), remote reset of ONU, etc.;
e) EMS should be able to configure parameters of OLT's interface at the network side, e.g.,
   - Port implementation
   - Full duplex/half duplex of port
   - Port flow control
   - VLAN function
   - MAC binding and ACL filtration
   - Rate limiting
   - RSTP feature
   - Link aggregation
   - Port mirror image
f) EMS can manage attributes of the UNI port of ONU in remote OAM mode. Included are:
   - Port status management, e.g., Enabled/Disabled, operating rate, flow control, duplex and self-negotiation
   - Port VLAN management
   - Classification & Marking function of port
   - EthLinkStatus connected to port
   - Multicast function management of port
g) PON interface management, mainly including:
   - Reset PON interface
   - Set the polling rates of DBA on various priority levels
   - Triple churning management (Enabled/Disabled)
h) Unit protection switching management. Assign, delete and modify system protection functions:
   - Main controller;
   - PON interface disk (optional)
   - Power module
i) Configure the environmental monitoring parameters of network elements, e.g., board temperature inquiry, temperature warning threshold, etc. Temperature thresholds for automatic turn-on and turn-off of fans can be set.
j) Support off-line inquiry about various information of ONU. All configuration information should be configured automatically when ONU is recovered from power failure.

3) User and service management

a) Support ONU service configuration in the mode of service template, and select different templates (optional) according to Requirement. Service templates should function in self-defining, and customized templates can be applicable to full network equipment;
b) Function to configure users or SLA parameters of each service of users, e.g., assured bandwidth, maximum bandwidth and service priority. Maximum assured bandwidth configured should not exceed maximum system bandwidth of PON;
c) Function to configure Ethernet services of user or port, e.g., VLAN, frame filtration and multicast;
d) Function to support management of such safety functions as frame filtration, capable of configuring frame filtration according to source MAC address, target MAC address, Ethernet type, VLAN marking, IP protocol type, source IP, target IP, L4 source port, L4 target port, DSCP (Differentiated Service Code Point), life cycle and target physical port;
e) Function to configure PON system function such as churning and optical protection switching;
f) Function in automatic update when network topology structure changes;
g) QoS management of services include traffic flow classification rule, queuing rule, priority marking method, dispatching algorithm, rate limiting parameter, etc.;
h) Support IPTV and multicast service management: Enable/Disable of multicast services,

IGMP feature, controllable multicast protocol configuration for China Telecom and management of relevant parameters; EMS should also support management Requirement for multicast services below (some for performance management):

- Display of multicast information: Online multicast group, group members and status;
- Statistics of multicast information: Request times, total request time length and average request time length for f each multicast group; request times, total time length and average request time length for each user port;
- Multicast log display and storage: user port, multicast address, status, time for entrance and exit;
- User configuration template: Configure authorities for each user port in different multicast groups inclusive of permission, forbiddance and preview;
- Preview: Included are four parameters, in other words, maximum duration for single preview, times of the previews permitted, preview interval, preview reset time;
- Pre-join group: Transmit messages to uplink port automatically to joint pre-configured multicast group;
- Trans-VLAN multicast: When users and uplink ports (program sources) or users are respectively in different VLANs, users may also order multicast programme.
- EMS optionally supports and monitors the following controllable multicast information of network equipment: statistics of multicast upstream groups; number of user online request ports; log information of user requests as counted on the basis of ports; multicast template configuration; statistical information of multicast as per port and group; multicast preview parameter configuration and display; multicast port implementation configuration; upstream group information statistics; upstream port information statistics (CDR function).

i) EDM configuration (optional): configure and inquire about TDM service data;
j) VoIP configuration (Optional): configure and inquire about user data such as physical address (port No.), protocol address, V5 serial number, service type and telephone number;
k) Management of broadcast suppression, etc.;
l) Function to mark various dedicated service lines, client data, etc. in network administration configuration information for rapid inquiry;
m) Support management of DHCP 60 and 82 features.

4) Resource management

EMS should support resource management for the whole network. Mainly included are occupancy statistics and management of the equipment resources such as network elements, slots and boards, PON interface, ONU/ONT and the UNI port of ONU/ONT. Provide the features of report statistics and report storage and printout.

5) Data management configuration

a) Configure data validity check: When network or equipment configuration is altered, check validity of network element configuration data:
   - Whether such configurations can be made available;
   - Whether any conflict with other configurations exists;
   - Whether enough authority exists;
   - If any error occurs, report to user promptly and generate relevant logs.
b) Copy configuration data: Copy successfully arranged configuration data of a network element to one or more network elements of the configuration same with or similar to this network element and then modify configuration data. For example, copy configuration of an OLT or ONU and then copy it to newly added OLT or ONU. Then, modify certain attributes (including rate, etc.) and further generate services.
c) Uploading and downloading functions:
   - Each network element stores relevant network element data in its control disk;
   - User can obtain configuration data of network elements via certain orders to make configuration data of MES consistent with data on the network elements;
   - User can also use existing data of EMS to download network element configuration information to control disk of network elements;
   - EMS provides template data, and directly downloads template data to network elements

or downloads it to network elements after modifying it.

6) Periodical configuration inspection

The periodical configuration inspection (every half a month or a month) for EMS (optional) compares existing configuration of equipment (especially ONUs) and previously stored backup data (or configuration data in user database) to gain the collection of configuration modifications.

17.2.3 Failure Management Requirement

1) Failure inspection function: network administrator should be able to implement continuous or intermittent test, observation and monitoring for each part of the system, to discover failure or performance weakening. For example, the system should produce an alarm when the physical layer performance (such as optional channel BER) of PON interface is weakened greatly. When ONU suddenly powers down, the alarm Dying Gasp should be made. EMS should support detection of the alarm Dying Gasp.
2) Failure synchronization function: manual and automatic failure synchronization should be supported between EMS and network elements. Manual synchronization means that network administrator functions to synchronize the alarms generated on network elements manually. Automatic synchronization: network administrator functions to synchronize the alarms generated on network elements automatically, once the system is restored after EMS fails or the links between EMS and network elements fail.
3) Failure locating and analysis function: EMS should function to determine the occurrence time and position of failure and pinpoint causes to the failure to the extent possible.
4) Alarm display

a) EMS should display an alarm in many ways after the alarm arises, displaying alarms in different sounds and colors according to types and levels of them.
   - Provide a sound setup switch. Volumes and duration of alarms on various levels are tunable.
   - Provide Requirement for colors. Alarms on various levels are marked in different colors.

b) Alarm display filtration: display current or historical alarm events selectively in accordance with filtration conditions set. Filtration conditions may be alarm source, alarm level, alarm type, alarm time, management area (*), alarm status lamp and any combination thereof.

5) Alarm sorting function: EMS should function to indicate equipment failures through indicating lamps and alarm signal indication devices. Different failure causes correspond to different alarm information.

Alarms are classified into the five types below, as recommended:

a) Equipment alarm
b) Service quality alarm
c) Communications alarm
d) Environmental alarm
e) Processing failure alarm

The system should function to assign (or re-assign) levels of seriousness for alarms in the light of warning causes. The levels of seriousness are classified into the five types below:

a) Critical alarm
b) Major alarm
c) Minor alarm
d) Warning
e) Cleared

According to alarm status, alarms can be classified into the four types below:

a) Current alarm
b) Historical alarm
c) Alarm confirmed
d) Alarm unconfirmed

6) Alarm processing

EMS should support the alarm log function. In case any failure occurs, the operations concerned should be recorded into logs. Statistical list of system alarm logs processes alarms in a staged way on the basis of failure severity, failure cause and time segment.

EMS supports processing rules for customized alarms, e.g., alarm forward shifting rule (notice

made in E-mail or SMS) , alarm latency reporting rule, alarm enumeration (new alarms are generated automatically when alarms are accumulated to a certain number), automatic alarm identification rule, automatic alarm clearing rule, and alarm suppression rule.
Relevant alarm information of system administration system should be removed automatically after failure events are recovered. In addition, manual removal is supported. For manual removal, the operation should be recorded into logs.

7) Alarm polling and statistics

a) EMS should support polling and statistics for current or historical alarms. The conditions for polling or statistics are the information below or any and/or combination thereof:
   - Alarm source;
   - Alarm occurrence time;
   - Alarm severity level;
   - Alarm causes;
   - Alarm status;
   - Alarm clearing time;
   - User identification;
   - Alarm duration (optional) ;

b) EMS should support output of polling or statistics of alarms. Alarm output conditions, alarm output destination and alarm output mode can be set. The modes for output of alarm polling/statistics reports include “Printout” and “Save as a file”. Alarm output conditions include the information below and any and/or combination thereof:
   - Alarm type
   - Severity level
   - Alarm source

17.2.4 Performance Management Requirement

EMS should make available 15 minute /24-hour performance monitoring for ports on network side, PON interface at the endpoint of OLT, PON interface at the endpoint of ONU and ports at the endpoint of subscriber. In addition, it should offer report statistics of historical performance data and such graphical performance analysis means as line graph, histogram and piegraph. Performance monitoring should cover Ethernet basic performances, PON performance, environmental monitoring performance, etc. As EMS system requires, real-time monitoring of Ethernet ports should be available, and graphical interface should be provided to display real-time variation tendency of Ethernet port rate, flow, etc. Function to inquire about historical records of system performance in view of different conditions and to store inquiry and statistics results into external files for output. Please describe details of the support to above Requirement.

1) Real-time performance collection

Network administration system should be able to initiate measurement of particular performance parameters for particular monitoring objects (network elements, unit disks, ports, functional blocks, etc. designated) and implement analysis and processing of measured data. The results may be displayed in broken line graph or histogram.
There are the following ways for performance parameter collection:

a) Support the two modes for collection of performance parameters (15 minute and 24-hour options);
b) Set the start and stop time for performance parameter collection;

2) Parameters for performance monitoring;

EMS should allow users to set, inquire about and modify the attributes of network element performance monitoring below:

a) Performance monitoring objects (network elements, unit disks, ports, channels, functional blocks, etc. designated);
b) Names of the parameters to be monitored;
c) Monitoring cycle (15 minutes or 24 hours);
d) Monitoring status (On/Off);
e) Time started;
f) Closing time;
g) Automatic reporting or not.

3) PON interface performance collection parameters

a) The statistical parameters should include PON interface performance parameters, interface parameters on the network side, etc.;
   - MPCP frame statistics (optional)
   - OAMPDU statistics (optional)
   - Number of the byte packets received and sent
   - Statistics of the sizes of various frames received and sent

b) Statistics of utilization of PON system and bandwidth of each ONU;

c) Measurement of optical transmit power and received optical power (optional).

4) Collection and monitoring of Ethernet performance parameters (optional)

The system optionally supports collection and monitoring of the following Ethernet performance parameters for interfaces on network side and those at the endpoint of subscriber (optional):

a) Statistics of packets of various lengths

b) Overall performance statistics
   - Unicast packets received
   - Multicast packets received
   - Broadcast packets received
   - Unicast packets sent
   - Multicast packets sent
   - Broadcast packets sent
   - PAUSE flow control frames received
   - PAUSE flow control frames sent
   - Total bytes of good packets received
   - Total bytes of good packets sent
   - Total bytes of bad packets received
   - Total bytes of bad packets sent

c) Collision and error
   - Number of monitor's data packet loss events detected
   - Verification error number
   - Frames correctly sent after single collision
   - Frames correctly sent after many collisions
   - Graphical display provided by Ethernet performance monitoring (optional)

5) Environmental monitoring

EMS should function in monitoring such environmental parameters as temperature of equipment or particular components, fan operating status and power supply status.

6) Performance data threshold

The system should be able to set threshold for statistical performance data, which produces relevant alarms when such data is beyond the threshold.

7) Performance monitoring data reporting

Network elements should support reporting of performance monitoring data. Reporting of such data can be conducted in accordance with relevant instructions given by MES. It's also feasible that network elements report automatically performance data within the cycle after each monitoring cycle (e.g., 15 minutes) arrives. (The former necessarily chosen and the latter optional)

EMS has performance data stored into database with performance data including:

a) Monitoring objects;

b) Monitoring attributes and the values;

c) Monitoring cycle;

d) Closing time for monitoring interval.

8) Polling and statistics of performance data

a) The system should be able to inquire historical records of system performance. The inquiry results can be displayed optionally in such tables and graphics as broken line graph, histogram and piegraph.

b) The system can store inquiry and statistical results into external documents for output.

c) Print out inquiry and statistical results.

9) Performance data storage

a) Performance data is stored in EMS storage device (15 minute and 24-hour options).
   - Measured data with measurement cycle as 15 minutes: 30 days;
   - Measured data with measurement cycle as 24 hours: 60 days.

b) Set storage life and storage capacity of performance data. Prompt users to archive and delete the performance data beyond time limit or capacity.
c) Dump measured performance data to the storage media of large capacity (such as magnetic tape units) in text or table form for off-line analysis by users. (Optional)

17.2.5 Security Management Requirement

1) User Access Authority Management

The network administration system provides the security measures for access of Administrator/OS through defining personal access right, in order to deny the logging on of illegal users and the ones with wrong passwords. The administrators of different levels have different access right, assuring that the asker of access request can execute management operations only in his access authority. Sensitive information, authentication attributes of fixed user terminal, database and configuration data can only be handled by authorized personnel and the management system.

The system optionally supports the division of management field, allocating different resources to different management fields and managing the corresponding resource in different management fields. The authority assignment of all management operations should be supported, and the access rights of query and configuration can be assigned respectively.

Locking User Supported. If a user input the wrong password for 3 times, the user will be locked and can not try to log on.

User Account Rules can be customized, such as Limit of Password Length, Weak Password Policy and Password Expiration Rules, etc.

2) User Level Management

EMS should categorize users into several levels, the users of which have different access right and high level users have higher operation access right. For instance, users can be catrgorized into the levels as below:

a) System Management. Responsible for the management of the network administration system, can control the network and set the passwords of all levels of users, add , modify, delete users and manage logs.
b) System Maintenance. Responsible for daily maintenance work of the system, can access, backup and manage the data of dabase.
c) System Operation. Responsible for business maintenance, can New or Clear users and their business configuration, deal with alarms, select configuration and manage failures.
d) System Monitoring. Can only monitor the system alam status, observe and explore all monitoring results and the access results of all reports. These operations is major in check (read.)

3) Operation Log

a) The operation log records all operations of users executed in the system, for preventing error operations of users. The system makes specific records for all kinds of oerations of users executed in the system.
b) The operation log should record all operations of users including user name, operation time, oeration type. Security alarms should be made when an illegal user logs on the network admiistration, and the attempt of unauthorized oerations will be recorded by the system log and security alarms will be made for notification.
c) The save time and amount of log files for operation, alarm, event,security and performance can be set.
d) The system can inquire and delete the oeration log according to given conditions;
e) The operation log should be able to be backed up to peripheral storage devices.

17.2.6 Log Management

1) The log operation should be supported, such as query and backup (Add, Delete, Modify Operations are not suitable o logs);
2) The log management should support the management for operation log, security log and system log;

3) The operation log shoild record the specific information of user operations includind Log ID, Operation Level, User Name, Operation Name, Host Address, Command, Specific Information, Operation Result, Failure Reason, Access Method, Operation Objects, Start Time of Operation, End Time of Operation and Associated Log;
4) The security log can record thebsecurity events of the system, such as User Log On and Log Off (icluding logging on of illegal users), Change Access Authority of Users, EMS System Attacked;
5) The system log should be able to record all system events of EMS system, including System On and Off, Software and Harware Update, OS Failure (such as the events during system starting), Network Administration Software Failure, Harware Failure, Load Failure of Certain Application during Booting.
6) Authority management of log operations should be supported (Regulated in 17.2.5 Security Management.)

17.2.7 Policy Management

1）Two types of policies should be supported: Timed Policy, Policy Trggered by Event.

2）User customization policy should be supported.

17.3 Remote Management of ONU

17.3.1 Implementation for Remote Management of SFU and SBU types of ONUs

The protocols for SFU and SBU types of ONUs are OAM of IEEE802.3-2005 and DSL Forum TR-069. SFU and SBU of ONUs must support OAM, SFU with VoIP is suggested to support TR-069.

1) OAM: With OLT as SNMP proxy, the remote management of ONU is implemented through OAM (including the standard OAM regulated in IEEE802.3-2005 and the extended OAM regulated by the standard.) The extended requirement for OAM should conform to para. 6.5 and 11.1, while other management functions are undetermined.
2) TR-069: The remote management of ONU is implemented by ACS through TR-069.

About the relation and work division between OAM and TR-069, WT-142(Revision 3) should be refered to：For the configuration and management of PON ONT, 802.3ah OAM still play the role for which they have been designed. The TR-069 protocol (CPE WAN management protocol) only complements OAM for the configuration and management of subscriber services, meaning services for layer3+ and above. TR-069 is also used for the configuration and management of other customer premise devices (VoIP, STB, network storage element, …) as explained in TR-106. In order to avoid possible conflicts, OAM SHOULD NOT be used for layer 3 and higher layers parameters configuration. If OAM would be used for layer 3 and higher layer parameters configuration, TR-069 would by default overwrite the values configured by OAM for those layer 3 and higher layer parameters.) TR-069 also provides Software/Firmware Download, Status and Performance Monitoring and Failure Diagnosis the current OAM does not support. The specification of SFU and SBU types of TR-069 is undertermined.

As for the SFU that does not has VoIP but only support Ethernet/IP Business, TR-069 is optionally supported, so as to implement Software/Firmware Download, Status and Performance Monitoring and Failure Diagnosis.

17.3.2 Implementation of Remote Management of HGU Type of ONU

The remote management protocol of HGU type of ONU should adopt OAM of IEEE802.3-2005 and DSL Forum TR - 069.

1) OAM: With OLT as SNMP proxy, the remote management of ONU is implemented through OAM (including the standard OAM regulated in IEEE802.3-2005 and the extended OAM regulated by the standard.) The extended requirement for OAM should conform to para. 6.5 and 11.1, while other management functions are undetermined.)
2) TR-069: The remote management of ONU is implemented by ACS through TR-069. As described in 17.3.1, About the relation and work division between OAM and TR-069, WT-142(Revision 3) should be refered to. OAM is in charge of remote management of L2 of HGU and L2 Lower Layer function, and ACS is to implement remote management of L3 of ONU and higher level functions. The specific requirement specified for TR-069 of HGU.

17.3.3 Implementation of Remote Management of MDU and MTU Types of ONU

Remote Management of MDU and MTU Types of ONU should support 2 kinds of OAM of SNMP and IEEE802.3-2005.

1) OAM: With OLT as SNMP proxy, the remote management of ONU is implemented through OAM (including the standard OAM regulated in IEEE802.3-2005 and the extended OAM regulated by the standard.) The extended requirement for OAM should conform to para. 6.5 and 11.1, while other management functions (such as Software/Firmware Download) are undetermined.
2) SNMP: ONU is as an SNMP entity, while EMS implements the remote management of ONU on the base of SNMP protocol. SNMP protocol should support SNMP V2c and optionally support V3 version.

As for the remote management of MDU and MTU types of ONUs, the work division and relations between OAM and SNMP are as below: the OAM function of MDU and MTU types of ONU should only support the remote management relative to PON Port (such as triple churning, DBA Parameter Configuration, Report of ONU Basic Information and FEC Management, etc), while other remote management functions relative to ports and business are implemented by SNMP (VLAN, Multicast, Port Management and QoS, etc.)

The SNMP management of MDU and MTU types of ONU should be integrated into the EMS system of the manufacturer, so as to form a unified management platform.

17.4 Requirement of ONU Local Management System

17.4.1 Basic Requirement

1) ONU should maintain its local operation through the attached Ethernet User Port or Console Port;
2) The operation maintenance management of ONU should have the functions of Configuration Management, Failure Management, Performance Management and Security Management;
3) Chinese, Web or Graphic interface is recommended to be used in the management system.

17.4.2 Configuration Management Requirement

1) The port parameters on user end should be able to be configured, such as the configuration of Open/Close of User End Ports, Open/Close of Pause Flow Control, Ethernet/ADSL2+/VDSL2 Ports of MDU and MTU types of ONU (Rate, Noise Remains);
2) The configuration of business QoS should be optionally supported, such as the settings of Upstream Business Category, Queue, Marking, Schedule, Dowenstream Business Queue, Schedule and Speed Restriction, etc;
3) The configuration of DBA parameters can be optionally supported, such as Queue Set Number, Report Threshold of Queues;
4) The Ethernet function configuration is recommended to be supported, such as VLAN, Frame Filter, Multicast and MAC Address Aging Time, etc;
5) The PON port function like setting fiber protection and seitch-over can be optionally supported;
6) ACL configuration of ONU is suggested to be supported;
7) Local software/firmware update should be supported.

17.4.3 Performance Management Requirement

1) The performance measurement of user ports, collecting and processing measurement data and analyzing measurement results are supposed to be activated;
2) The counters of every 15 minutes of that day and the previous day and 24 hours for the performance management events of the system are supposed to be supported. The statistics parameters should include the parameters of PON Port Performance and Business Port Performance on User End, etc;
3) The statistics of the bandwidth usage of the PON system and ONU should be made enabled;
4) Record and Report for power failure should be supported; when power is returned, the power failure records should be updated;
5) The measurable laser power of sending and receiving can be measured by OLT and ONU (Optional);

17.4.4 Failure management Requirement

1) When the physical performance of PON Port or UNI Port (the error code rate of optical channel) drops dramatically or the link layer is invalid, the system should generate alarms;

2) The ONU failure should be indicated by the indicator light, while different failure causes correspond to different alarm information;
3) After it is restored from a failure event, the corresponding alarm information should be cleared automatically.

17.4.5 Security Management Requirement

1) The local management of ONU should security measurement for administrator/OS access through defining personal access right, denying the local operation maintenance and management of illegal users and the ones with wrong passwords;
2) The local management of MDU and MTU types of ONU should record the operation of all users, including User Name, Operation Time, Operation Type, and report them to the EPON network management system. The security alarms should be generated when illegal users log on, while unauthorized operations attempts will be recorded by the system log and security alarm notification will be generated. It is suggested that SFU, HGU and SBU types of ONU also have the log function as above.

18 ONU Harware Requirement

18.1 Indicator Light Requirement

SFU/SBU/HGU types of ONU should have sufficient indicator lights, so as to easily indicate the running state of ONU. The specific requirement is as shown in Table 54.

Table 54 Indicator Light Requirement of ONU

Indicator Light Name	Color	Identification Text	Display	Note
Power	Green	“Power”or “电源”	ONU is not on ; Always On: ONU is normally on.	
PON State	Green	PON	Off: ONU has not completed the discovery and registration of MPCP and OAM ; Always On: The links of MPCP and OAM have been activated ; Blink: ONU is trying to establish connections.	
Ethernet Port State	Green	LAN x (x=1-N, N is the Ethernet number)	Off: The system is not on or the port is not connected to a terminal equipment (such as PC, Set-top box); Always On: The port is connected, but no data is tranfered; Blink: Data transferred on the port	Each Ethernet port corresponds to the indicator light of an Ethernet Port
POTS Port State	Green	“POTS” or “电话”	Off: The system is not on or has not been registered to the soft switch; Always On: It’s been registered to the soft switch but there is no business flow; Blink: There is business flow transferred.	Each POTS port corresponds to the state light of an POTS Port
USB Port State	Green	USB x (x=1-M, M is the Ethernet number)	Off: The system is not on or not connected to USB port; Always On: The USB is connected and working in HOST mode, but no data is transferred. Blink: Data is transferred.	Only for HGU type of ONU, each USB port corresponds to a USB port state light.
WLAN Port State	Green	WLAN	Off: The system is not on or the wireless port is disabled; Always On： The wireless port has been started; Blink: Data is transferred.	Only for HGU type of ONU
WPS State	Green of Colorful	WPS	The specific requirement is in the relative regulations of China Telecom Home Network Gateway.	Only for HGU type of ONU
Spare Battery Indicator Light	Green	“Battary”or “电池”	Off: The system has not a spare battery or the spare battery is not effective; Always On: ONU has a spare battery and the battery status is normal; Blink: ONU has a spare battery but the battery status is abnormal (such as too-low-voltage light.)	Only for SFU/HGU/SBU types of ONU with a spare battery
CATV RF State	Green	CATV	Off: The system is not on or the CATV RF port is disabled; Always On: The CATV RF port has been activated.	Only for the ONU with a CATV RF port

18.2 Switch and Button

1) The overall power switch is a must;
2) As for HGU type ONU, there is an independent function switch for wireless modules (WLAN), and there must be independent WLAN WPS Push-Button button, whose size and position are convenient for users and corresponding light indication is for the button operations.

19 Other Requirement

19.1 Environment Requirement

19.1.1 Requirement for Fiber Temperature Alternation

When the fiber between OLT and ONU is in the environment with temperature alternation of -25℃--55℃, OLT and ONU can function normally, and the business performance should be worsened or interupted.

19.1.2 Temperature, humidity requirement

When equipments should function normally in the environment as below, OLT should at least support Category 1, and ONU should support one of the 3 categories:

Category 1: Temperature: 0℃-40℃ Relative Humidity: 10%-90% (not condense)
Category 2: Temperature: -30℃-40℃ Relative Humidity: 10%-90% (not condense)
Category 3: Temperature: -10℃-55℃ Relative Humidity: 10%-90% (not condense)
Note: The temperature above is 2m above the ground and 0.4m in front of the equipment.

19.1.3 Dustproof Requirement

In the dustproof environment as below, EPON equipments should be able to work normally:
The desity of dust whose particle diameter is more than 5μm $\leq 3\times10^{4}/m^{3,}$ not electric, magnetic or erosive

19.1.4 Atmospheric Pressure

In the environment with atmospheric pressure as below, equipments should be able to function normally:
86kPa-106kPa

19.2 Power Requirement

OLT should support direct and alternating current, and can work normally in a) or b) condition.
ONU should support AC, and can function normally in b) condition. The spare battery is optionally supported.

a) Requirement for AC and its dithering range:

Nominal Voltage: -48V

Voltage Dithering: The -48V voltage tested on the DC input end allows the range of -57V—-40V.

b) Requirement for AC Voltage and its Dithering Range:

Single Phase 220V±10% ,Frequency 50Hz±5% ,Aberation rate of line voltage wave should be less than 5%.

In the normal circumstance, the insulating resistance between the equipment shell and the power should not be less than 50MΩ.

19.3 Electric Safety Requirement

19.3.1 Insulating Resistance

In the normal circumstance, the insulating resistance should not be less than 50MΩ.

19.3.2 Requirement for Earth Connection of Equipments

The Earth Connection of Equipments should be less than 5Ω.

19.3.3 Power Interuption Notification of ONU

ONU should have Dying Gasp by OAM so as to notify OLT the self power interruption event.

19.3.4 Overvoltage and Overflow Protection

Equipments should be installed with protectors of overvoltage and overflow. The protectors of overvoltage and overflow protect the kernel part of equipments when the external power is abnormal.

Equipments should meet the requirement for simulation lightning strike, power line induction and power line contact.

19.3.5 Electromagnetic Compatibility

The electromagnetic compatibility of equipments should conform to GB 9254-1998 and GB/T 17618-1998.

Appendix A
(Standard Appendix)
Interoperability Requirement of LLID

For assuring the interoperability, LLID should meet the requirement as below:

1. Each LLID has an independent MAC address;
2. Each LLID should support standard MPCP discovery and registration procedure and standard Gate Message processing and Report Message based on LLID;
3. Each LLID has an independent OAM link for LLID management;
4. Each LLID has an independent authentication procedure, independent key, key exchange protocol and independent DBA Configuration Procedure;
5. Associaton between ONU and multiple LLID is established, whose specific mechanism is undetermined.