ZTE

XGS-PON Technical White Paper

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IGURES

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1 Executive Summary

This technical white paper introduces the requirements, physical layer, transmission convergence layer and OMCI of XGS-PON.

2 Abbreviations and Acronyms

Alloc-ID	Allocation identifier
BWmap	Bandwidth map
CATV	Community Antenna Television
CBU	Cell-site backhauling unit
DBA	Dynamic bandwidth assignment
DBRu	Upstream dynamic bandwidth assignment report
FTTx	Fiber to (B – building; H: home; C: optical cross connect cabinet, Cell: cell site)
FEC	Forward error correction
G-PON	Gigabyte Passive Optical Network
MDU	Multiple dwelling unit
MTU	Multi-tenant unit
NRZ	Non-Return to Zero
OAM	Operations, administration and management
ODN	Optical Distribution Network
OLT	Optical line terminal
OMCI	ONU management and control interface
ONT	Optical network terminal

ONU	Optical network unit
PLOAM	Physical layer operations, administration and maintenance
PMD	Physical medium dependent (protocol layer)
PSBd	Downstream physical synchronization block
PSBu	Upstream physical synchronization block
PSync	Physical synchronization sequence
RE	Reach extender
RF-Video	Frequency-Video
SBU	Small business unit
SFU	Single family unit
TC	Transmission convergence
T-CONT	Transmission container
WDM1r	Wavelength division multiplexor 1 revised (coexistence device)
XGEM	XGS-PON Encapsulation Method
XGS-PON	10-Gigabit-capable passive optical network, G.987 series
XGTC	XG-PON Transmission Convergence
XGS TC	XGS-PON Transmission Convergence

3 XGS-PON Standards

XG-PON is the next-generation evolution of the GPON technology. It was originally divided into two stages, the XG-PON1 (10G/2.5G) and XG-PON2 (10G/10G). However, only the XG-PON1 standard was formulated. The XGS-PON standard G.9807.1

10-Gigabit-capable symmetric passive optical network was released in June 2016. XG-PON refers to 10G/2.5G PON and XGS-PON refers to 10G/10G PON.

Different from other ITU-T PON standards, the XGS-PON standards was defined in G.9807.1 Annex.

- G.9807.1 10-Gigabit-capable symmetric passive optical network (XGS-PON)

  Definitions, abbreviations, and acronyms.

- G.9807.1 Annex A:

  General requirements of XGS-PON.

- G.9807.1 Annex B

  Physical media dependent (PMD) layer specifications of XGS-PON

- G.9807.1 Annex C

  Transmission convergence layer specifications of XGS-PON

- G.988

  ONU management and control interface (OMCI) specification

4 XGS-PON Application Scenarios

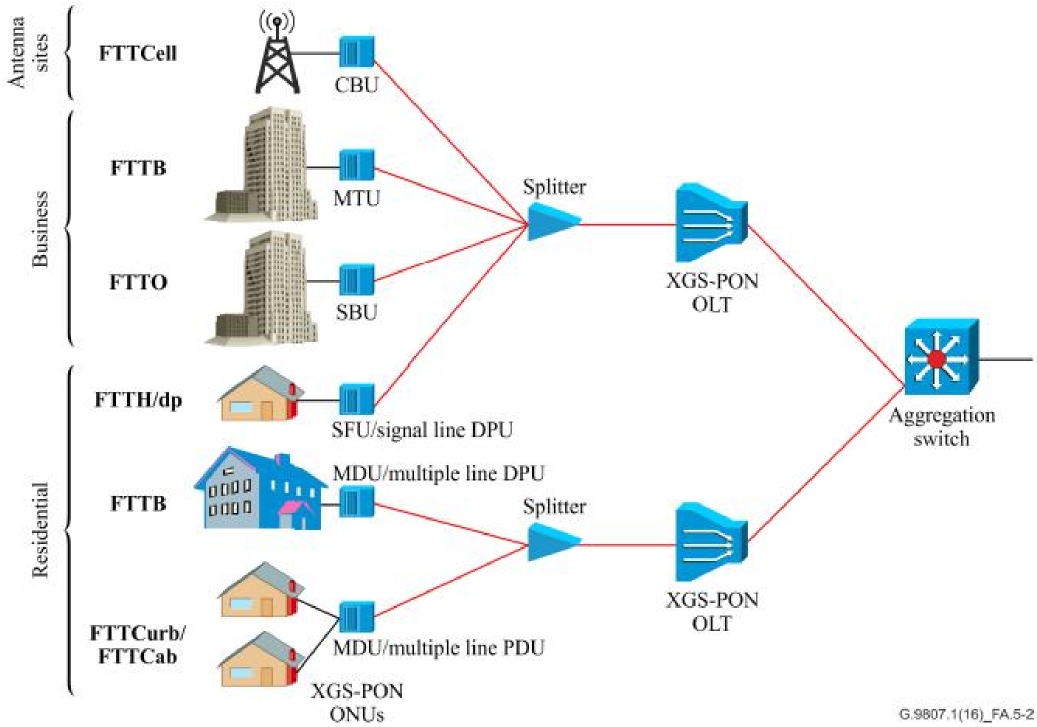
XGS-PON is the next-generation evolution of GPON; therefore the XGS-PON scenarios are similar with the GPON scenarios. XGS-PON application scenarios can be divided into three parts: the cell station users, the business users and the residential users.

The cell station user scenarios is FTTCell. The type of the ONUs used in the FTTCell scenario is called Cellular Backhaul Unit (CBU), which supports base station backhaul. CBU needs to support IEEE1588 and Synchronous Ethernet.

The commercial user scenarios include FTTB and FTTO. The types of the ONUs used in the commercial user scenarios are MTU and SBU, which support commercial data transfer, E1 services, commercial video conferencing, and commercial voice conferencing.

The residential user scenarios inculde FTTH, FTTdp, FTTB and FTTC. The types of the ONUs used in the residentail user scenarios are SFU and LAN based MDU as well as the DSL and G.fast based MDU, which provide high-speed Internet services, voice services and video services.

Figure 4-1 XGS-PON Application Scenarios (Excerpted from G.9807)



5 XGS-PON PMD Layer

5.1 Classes for Optical Path Loss

Table 5-1 Classes for Optical Path Loss

	‘Nominal1’ class (N1 class)	**‘Nominal2’ class (N2 class)**	**’Extended1’ class (E1 class)**	**“Extended2” class (E2 class)**
Minimum loss	14 dB	16 dB	18 dB	20 dB
Maximum loss	29 dB	31 dB	33 dB	35 dB

5.2 Line Rate

The line rates of XGS-PON are defined as 9.95328 Gbit/s in the downstream direction and 9.95328 Gbit/s in the upstream direction.

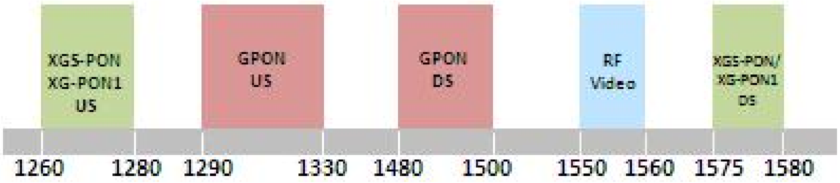
5.3 Line Code

The downstream and upstream line code of XGS-PON is non-return to zero (NRZ) code.

5.4 Wavelength Allocations

The wavelengths of XGS-PON are specified as 1575-1580 nm in the downstream and 1260-1280 nm in the upstream direction, which are the same as that of XG-PON.

Figure 5-1 Wavelength Allocations for XGS-PON, GPON and RF Video



5.5 XGS-PON Compatible ODN

Table 5-2 Physical Parameters of a Simple ODN (ODS)

Item	Unit	Specification
Fibre type	–	[ITU-T G.652], or compatible
Attenuation range	dB	N1 class: 14 – 29 N2 class: 16 – 31 E1 class: 18 –33 E2 class: 20 — 35
Maximum fibre distance between S/R and R/S points	km	DD20: 20
Minimum fibre distance between S/R and R/S points	km	0
Bidirectional transmission	–	1-fibre WDM
Maintenance wavelength	nm	See [ITU-T L.66]

5.6 Optical Interface Parameters of 9.95328 Gbit/s Downstream Direction

All of the following parameters are applicable to the optical interfaces with a maximum differential distance of 20 km. The parameters of the optical interfaces with a maximum differentiated distance of 40 km need to be defined.

Table 5-3 Optical Interface Parameters of 9.95328 Gbit/s Downstream Direction

Item	Unit	Value			
OLT transmitter (optical interface O_{ld})					
Nominal line rate	Gbit/s	9.95328			
Operating wavelength	nm	1575 – 1580			
Line code	–	NRZ			
Mask of the transmitter eye diagram	–	see ITU-T G.9807.1			
Maximum reflectance at S/R, measured at transmitter wavelength	dB	NA			
Minimum ORL of ODN at O_{lu} and O_{ld}	dB	more than 32			
ODN Class		N1	N2	E1	E2
Mean launched power MIN	dBm	+2.0	+4.0	+6	FFS
Mean launched power MAX	dBm	+5.0	+7.0	+9	FFS
Launched optical power without input to the transmitter	dBm	NA			
Minimum extinction ratio	dB	8.2			
Tolerance to the transmitter incident light power	dB	more than -15			
Dispersion Range	ps/nm	0-400			
Minimum side mode suppression ratio	dB	30			
Maximum Optical Path Penalty at 20km	dB	1.0			
Maximum Differential optical path loss	dB	15			
ONU receiver (optical interface O_{rd})					
Maximum reflectance at R/S, measured at receiver wavelength	dB	less than -20			

Item	Unit	Value			
Bit Error Ratio reference level	–	10^{-3}			
ODN Class		N1	N2	E1	E2
Minimum sensitivity at BER reference level	dBm	-28.0	-28.0	-28.0	FFS
Minimum overload at BER reference level	dBm	-9.0	-9.0	-9.0	FFS
Consecutive identical digit immunity	bit	more than 72			
Jitter tolerance	–	see ITU-T G.9807.1			
Tolerance to reflected optical power	dB	less than 10			

5.7 Optical Interface Parameters of 9.95328 Gbit/s Upstream Direction

Table 5-4 Optical Interface Parameters of 9.95328 Gbit/s Upstream Direction

Item	Unit	Value			
ONU transmitter (optical interface O_{ru})					
Nominal line rate	Gbit/s	9.95328			
Operating wavelength	nm	1260 – 1280			
Line code	–	NRZ			
Mask of the transmitter eye diagram	–	see ITU-T G.9807.1			
Maximum reflectance at R/S, measured at transmitter wavelength	dB	-10			
Minimum ORL of ODN at O_{ru} and O_{rd}	dB	more than 32			
ODN Class		N1	N2	E1	E2
Mean launched power MIN	dBm	+4.0	+4.0	+4.0	FFS
Mean launched power MAX	dBm	+9.0	+9.0	+9.0	FFS
Launched optical power without input	dBm	-45			

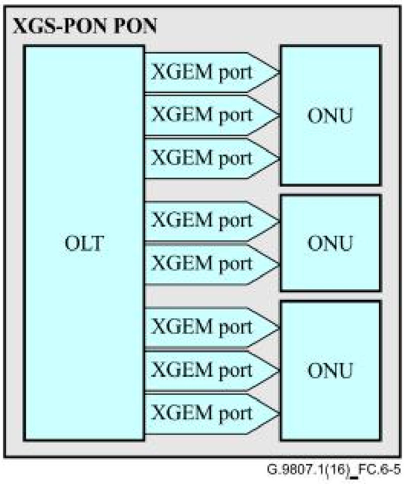
Item	Unit	Value			
to the transmitter					
Maximum Tx Enable	bits	1280			
Maximum Tx Disable	bits	1280			
Minimum extinction ratio	dB	6.0			
Tolerance to reflected optical power	dB	more than -15			
Dispersion Range	ps/nm	0 to -140			
Minimum side mode suppression ratio	dB	30			
Jitter transfer	–	see ITU-T G.9807.1			
Jitter generation	–	see ITU-T G.9807.1			
Maximum Optical Path Penalty at 20 km	dB	1.0			
OLT receiver (optical interface O_{lu})					
Maximum reflectance at S/R, measured at receiver wavelength	dB	-12			
Bit Error Ratio reference level	–	10^{-3}			
ODN Class		N1	N2	E1	E2
Minimum sensitivity at BER reference level	dBm	-26.0	-28.0	-30.0	FFS
Minimum overload at BER reference level	dBm	-5.0	-7.0	-9.0	FFS
Consecutive identical digit immunity	Bbit	more than 72			
Jitter tolerance	–	see ITU-T G.9807.1			

6 XGS-PON Transmission Convergence Layer

6.1 Time Division Multiplexing Architecture

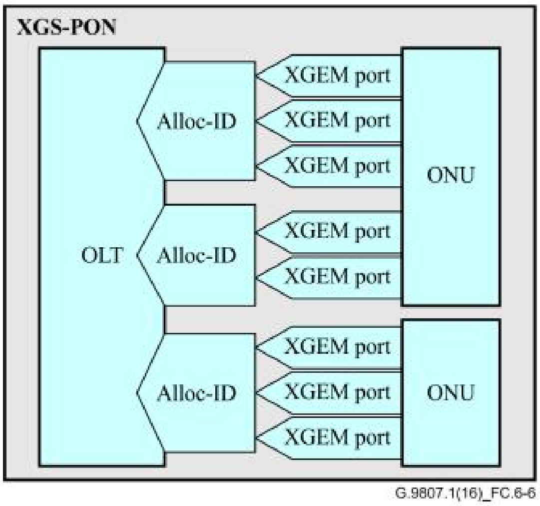
In the downstream direction, the OLT multiplexes the XGEM frames onto the transmission medium using XGEM Port-ID as a key to identify the XGEM frames that belong to different downstream logical connections. Multicast XGEM Port-IDs can be used to carry XGEM frames to more than one ONU. Multiplexing in the downstream is illustrated in Figure 6-1.

Figure 6-1 Downstream Multiplexing in XGS-PON



In the upstream direction, the OLT first grants bandwidth allocations to Alloc-IDs within the subtending ONUs based on DBA function. The bandwidth allocations to different Alloc-IDs are multiplexed in time as specified by the OLT in the bandwidth maps transmitted downstream. Within each bandwidth allocation, the ONU uses the XGEM Port-ID as a multiplexing key to identify the XGEM frames that belong to different upstream logical connections. The multiplexing in the upstream is illustrated in Figure 6-2.

Figure 6-2 Upstream Multiplexing in XGS-PON



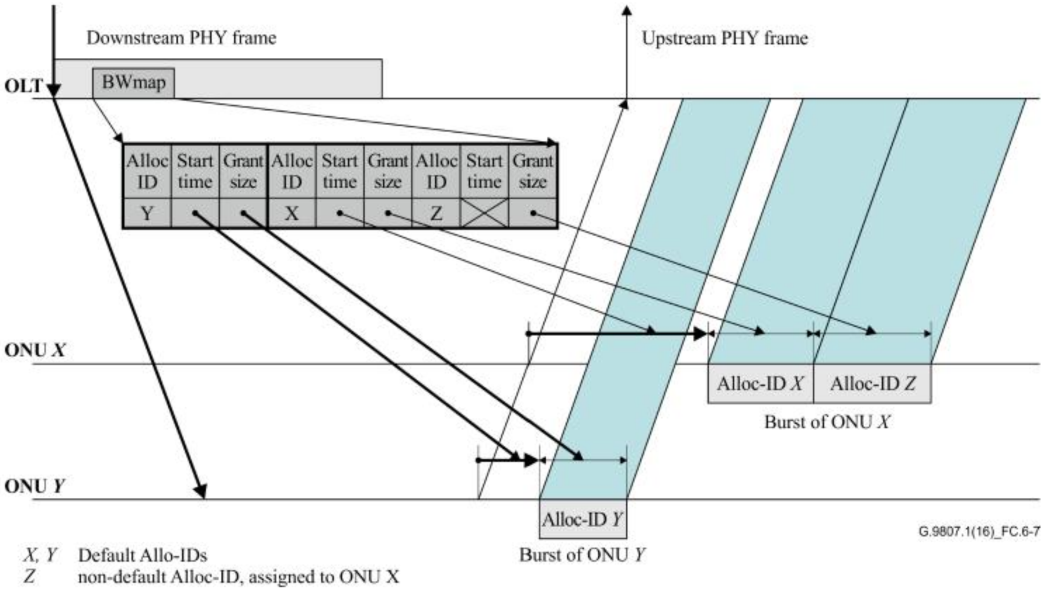
6.2 Media Access Control

The OLT transmits a downstream PHY frame every 125s. Because of the varying fibre distance, each given PHY frame reaches different ONUs at generally different moments of time. With each received downstream PHY frame, an ONU associates the corresponding upstream PHY frame. The individual equalization delays established in the course of ONU ranging serve to align the ONU views on the start of each upstream PHY frame in such a way, that upstream transmissions by any ONU occurring at fixed offset with the upstream PHY frame would reach the OLT at precisely the same time instant.

For each PHY frame, the OLT creates and transmits downstream a BWmap that specifies a sequence of non-overlapping upstream transmissions by different ONUs. A BWmap contains a number of allocation structures, each allocation structure being addressed to a particular Alloc-ID of a specific ONU. A sequence of one or more allocation structures addressed to Alloc-IDs that belong to the same ONU form a burst allocation series. Each burst allocation series contains a start pointer indicating the beginning of the burst within the upstream PHY frame and a sequence of grant sizes that the ONU is allowed to transmit. The start pointers refer to offsets within the upstream PHY frame, whereas the grant sizes pertain to the payload of XGTC frame. The start pointers and grant sizes are expressed in units of words (one word equals 4 bytes). The OLT may grant higher or lower effective data rates by controlling the size and frequency of the grants and may modulate the effective data rate via dynamic scheduling.

The media access control concept in an XGS-PON system is illustrated in Figure 6-3.

Figure 6-3 XGS TC Media Access Control Concept



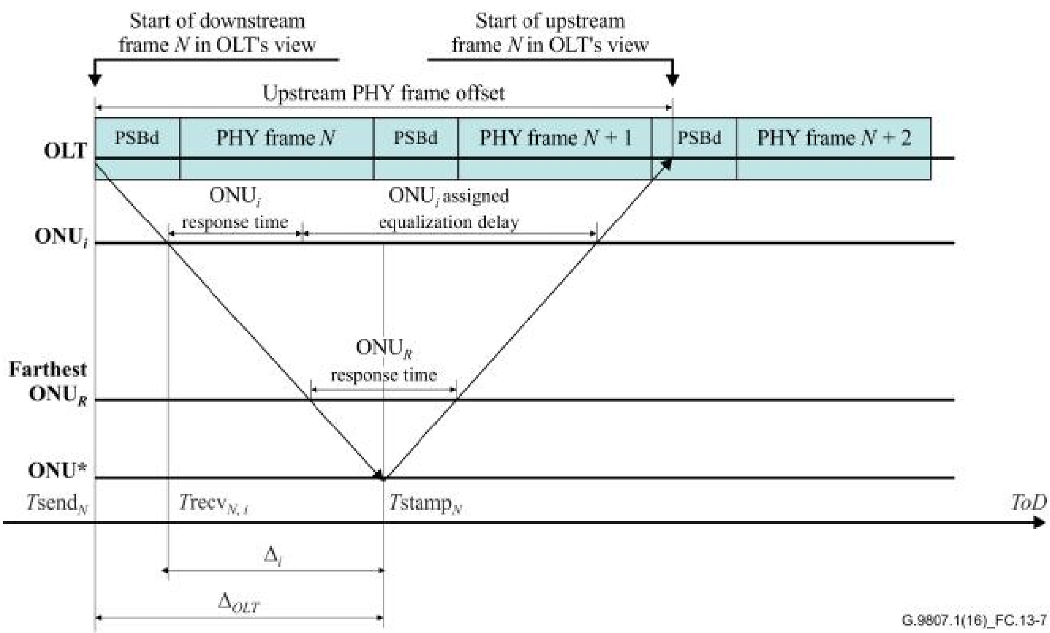
6.3 Ranging

The XGS-PON system leverages a P2MP architecture. Multiple ONUs are connected to one OLT and have different physical distances between the OLT. Upstream transmissions from ONUs with different physical distances between the OLT can potentially conflict with each other, even if the ONUs transmit in their own bandwidth allocations.

Ranging is a function to measure the logical distance between each ONU and OLT, and to adjust the logical distance to a unique one. Thus, the adjusted logical distances of all ONUs are unique and upstream transmissions from different ONUs in different bandwidth allocations will not conflict.

Figure 6-4 illustrates the basic ranging mechanism. An equalization delay is assigned to ONUi. When receiving bandwidth allocation, ONUi always delays the duration of equalization delay before transmitting in the upstream bandwidth. From the OLT's view, the logical distance between ONUi and OLT is the same as that between the farthest ONU and the OLT.

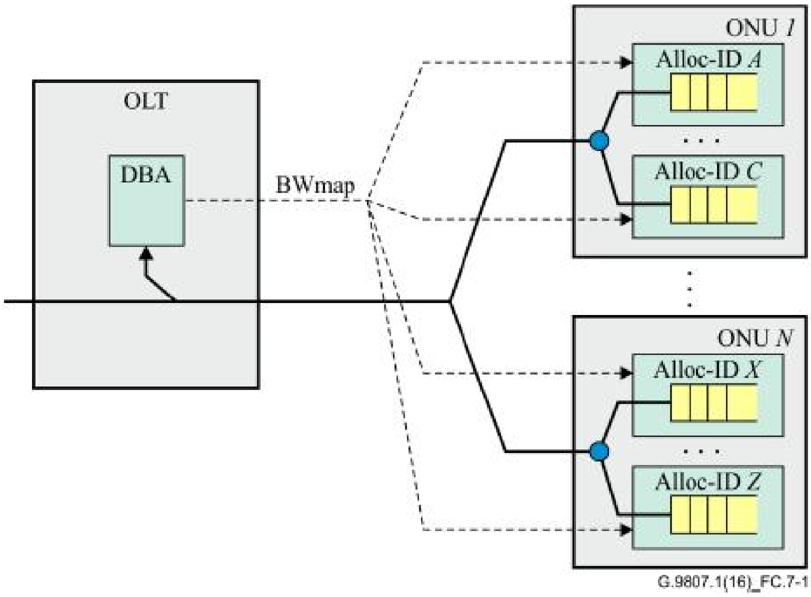
Figure 6-4 Ranging Mechanism



6.4 DBA

DBA in XGS-PON is the process in which the OLT allocates upstream transmission opportunities to the traffic-bearing entities within ONUs, as shown in Figure 6-5, based on dynamic indication of their activity and their configured traffic contracts. The activity status indication can be either explicit through buffer status reporting, or implicit through transmission of idle XGEM frames in place of upstream transmission opportunities.

Figure 6-5 DBA Abstraction

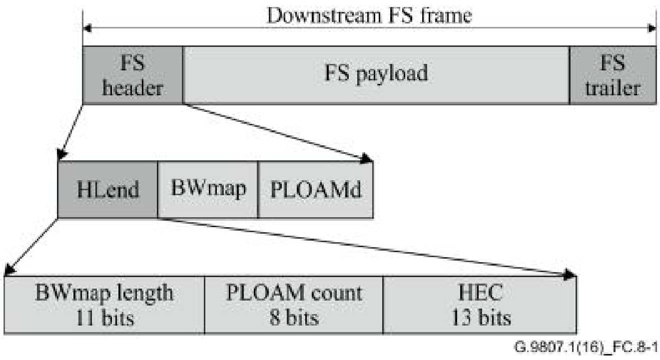


6.5 Downstream XGS TC Framing

The downstream XGS TC frame has the fixed size of 135432 bytes and consists of the XGS TC header, the XGS TC payload, and the trailer, as shown in Figure 6-6.

The downstream XGS TC frame header consists of a fixed size HLend structure and two variable size partitions: the Bandwidth map partition (BWmap) and downstream PLOAM partition (PLOAMd).

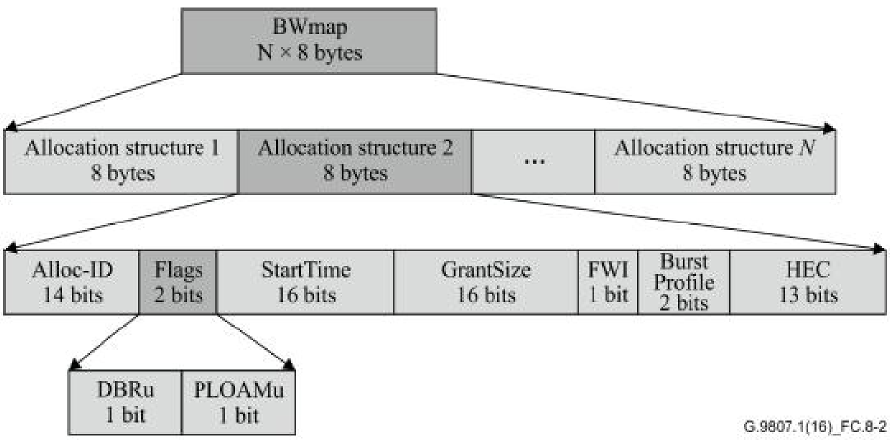
Figure 6-6 Downstream XGS TC Frame and Its Header



The BWmap is a series of 8-byte allocation structures. The number of allocation structures in the BWmap is given in the BWmap length field of the HLend structure. The actual length of the BWmap partition is 8*N bytes.

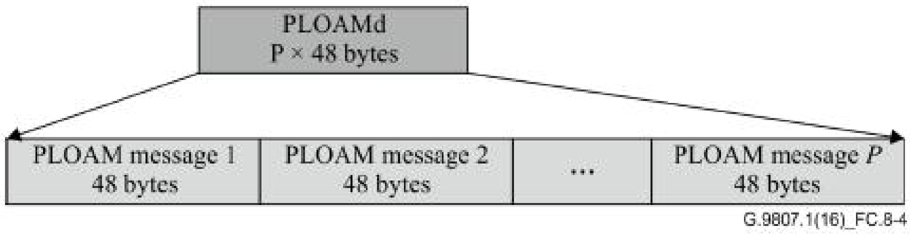
Each allocation structure specifies a bandwidth allocation to a particular Alloc-ID, the position and size of the bandwidth by StartTime and GrantSize and operational options including DBRu, PLOAMu, FWI, BProfile. The formats of the BWmap partition and an allocation structure are shown in Figure 6-7.

Figure 6-7 BWmap Partition and the Format of an Allocation Structure



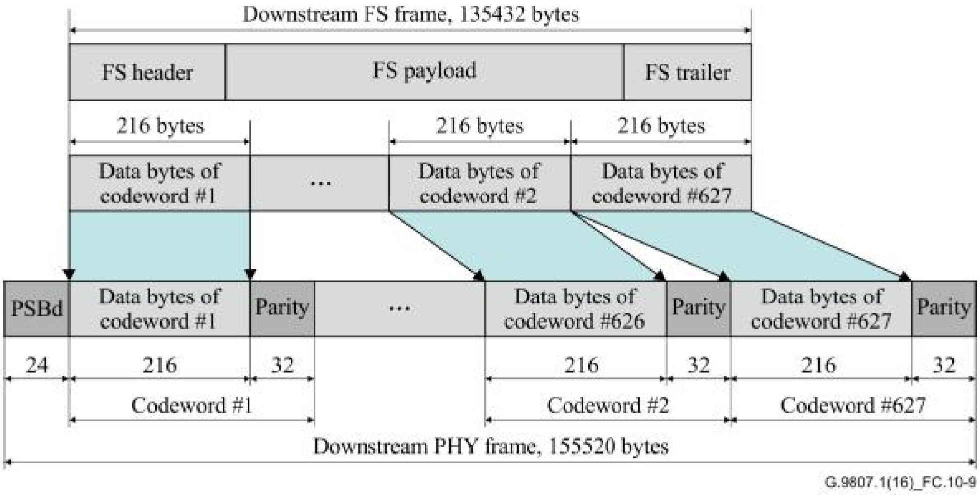
The PLOAMd partition contains zero, one or more PLOAM messages. The length of each PLOAM message is 48 bytes. The number of PLOAM messages in the PLOAMd partition is given by the PLOAM Count field of the HLend structure. The actual length of the PLOAMd partition is 48*P bytes.

Figure 6-8 Downstream PLOAM Partition



The size of a downstream PHY frame is 155520 bytes (38880 words). A diagram of the downstream PHY frame structure is shown in Figure 6-9. Based on the downstream XGS TC frame, PSBd and FEC parities are inserted accordingly. The PSBd field is 24-bytes long and contains an 8-bytes Physical Synchronization, an 8-bytes Superframe Counter and an 8-bytes operation control code.

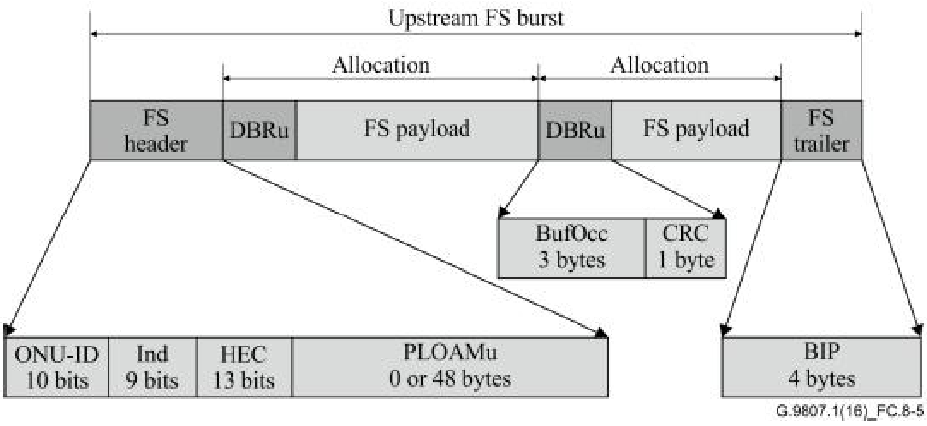
Figure 6-9 Downstream PHY Frame



6.6 Upstream XGS TC Framing

In the upstream direction, PDU of the Framing sublayer is represented by an upstream XGS TC burst. The upstream XGS TC burst transmitted by a given ONU has a dynamically determined size and consists of the upstream XGS TC burst header, one or more bandwidth allocation intervals, each being associated with a specific Alloc-ID, and the XGS TC trailer, as shown in Figure 6-10.

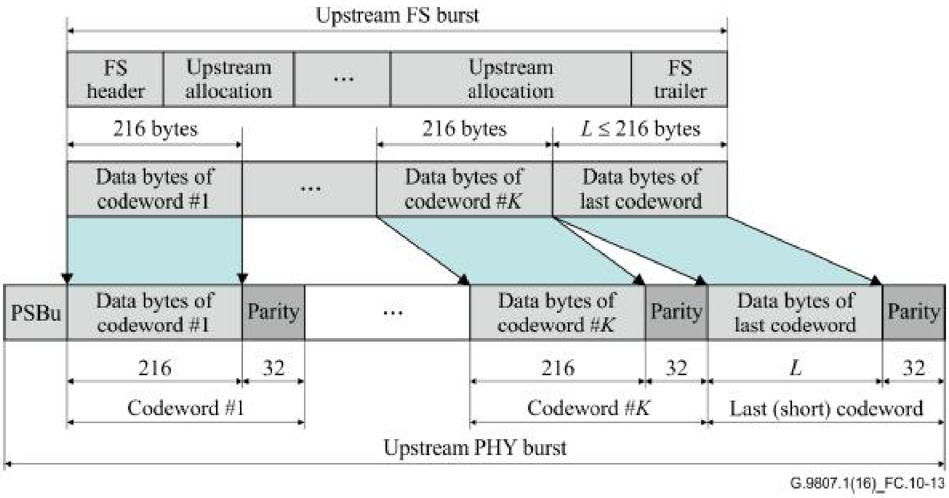
Figure 6-10 Upstream XGS TC Burst Header and Trailerframe Overhead Fields



The size of an upstream PHY frame is 155,520 bytes (38,880 words).

The relationship between PHY framing boundaries and the upstream PHY bursts of different ONUs is illustrated in Figure 6-11. Based on the upstream XGS TC frame, PSBu and FEC parities are inserted. The PSBu contains a Preamble and Deilimiter fields. In the upstream RS(248, 232), truncated RS(255, 239) FEC code is used.

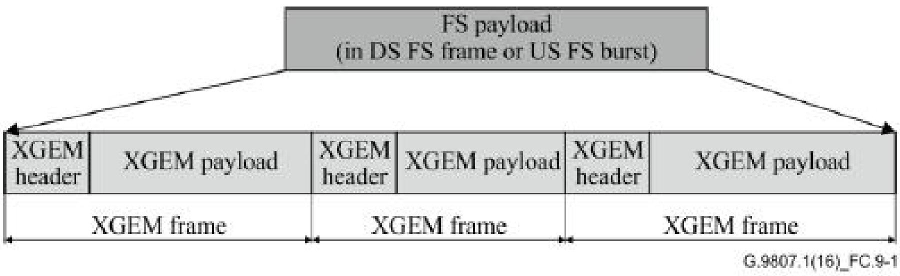
Figure 6-11 Upstream PHY Frame



6.7 XGEM Framing

The XGS TC payload, as shown in Figure 6-6 and Figure 6-10, contains one or more XGEM frames (see Figure 6-12).

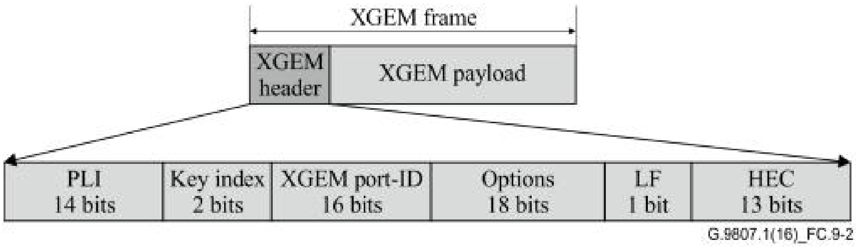
Figure 6-12 The Structure of XGS TC Payload



Each XGEM frame contains a fixed size XGEM header and a variable size XGEM payload field.

The size of the XGEM header is 8 bytes. The format of the XGEM header is shown in Figure 6-13, including Payload Length Indication (PLI) and Key Index.

Figure 6-13 XGEM Header Format



6.8 PLOAM Messaging Channel

The physical layer OAM (PLOAM) messaging channel in an XGS-PON system is an operations and management facility between OLT and ONUs that is based on a fixed set of messages transported within a designated field of the XGS TC frame header (downstream) and the XGS TC burst header (upstream). The PLOAM channel provides more flexible functionality than the embedded management channel and is generally faster than the OMCI channel.

The PLOAM channel supports XGS-PON TC layer management functions. It is based upon exchange of 48-byte messages that are transported in the PLOAM partition of the downstream XGS TC frame header and in the upstream XGS TC burst header.

The physical layer OAM (PLOAM) channel supports the following functions:

- Burst profile communication;
- ONU activation;
- ONU registration;
- Encryption key update exchange;
- Protection switching signaling;

- Power management.

6.9 ONU Activation

The outline of activation process events in their causal order is given below:

- The ONU entering the activation process listens to the downstream transmission and attains PSync and superframe synchronization. At that time the ONU learns PON-ID.
- The ONU listens to the Profile PLOAM messages, periodically issued by the OLT, to start learning the burst profiles specified for the upstream transmission.
- Once the ONU receives a serial number grant with a known profile, it announces its presence on the PON with a Serial_Number_ONU PLOAM message.
- The OLT discovers the serial number of a newly connected ONU and assigns an ONU-ID to it using the Assign_ONU-ID message.
- The OLT issues a directed ranging grant to a newly discovered ONU and prepares to accurately time the response time.
- The ONU responds with the Registration PLOAM message.
- The OLT performs initial authentication of the ONU based on the Registration ID, computes the individual equalization delay and communicates this equalization delay to the ONU using the Ranging_Time PLOAM message.
- The ONU adjusts the start of its upstream XGS TC frame clock based on its assigned equalization delay.
- OLT optionally performs the strong bidirectional authentication procedure by one of the available methods.
- The ONU completes activation and starts regular operation.

6.10 Security

6.10.1 Authentication

The XGS-PON system supports several mechanisms for authentication. The first mechanism is based on the registration ID, which provides a basic level of authentication for the ONU only and support is mandatory in all XGS-PON devices. The second mechanism is based on an OMCI message exchange, which provides mutual authentication. The third mechanism is based on an IEEE 802.1X message exchange, which provides mutual authentication and a wide range of extensible features.

6.10.2 XGEM Payload Encryption

The encryption key used for unicast traffic is generated by the ONU and transported to the OLT in PLOAM. When optional XGS-PON upstream encryption is employed, the same encryption key is used in both the upstream and downstream directions.

6.10.3 Message Integrity Check

The integrity (and data origin) of the PLOAM partitions in the upstream and downstream XGS TC headers is protected by the 64-bit secure Message Integrity Code (MIC) that appears at the end of each PLOAM message.

The integrity (and data origin) of the OMCI message in the upstream and downstream is protected by the 32-bit secure Message Integrity Code (MIC) that appears at the end of the OMCI message.

6.11 Power Saving

For a variety of reasons, it is desirable to reduce the power consumed by an ONU as much as possible.

- Over time, the natural evolution of technology tends toward more efficient realizations of given functions, a tendency that is offset, at least to some extent, by increasing levels of functionality and speed.
- If there is a way for the ONU to determine that a subscriber interface is idle, it is desirable for the ONU to power down the circuitry associated with that interface, while retaining the capability to detect subscriber activity on that interface. The details vary as a function of the interface type.
- The extent of feasible power reduction depends on the acceptable effect on service. The maximum possible savings occurs when a subscriber intentionally switches off an ONU, for example overnight or during a vacation.
- During failures of AC power, some degradation of service is generally acceptable. To conserve backup battery lifetime, it is desirable for the ONU to power down circuitry associated with all interfaces except those considered to be essential services. Different operators and customers will have different definitions of essential services, and will wish to prioritize the time before which services are powered down.

The preceding techniques for power management are a matter of ONU design and subscriber and operator practice, and are beyond the scope of this recommendation.

This clause addresses two additional means of power management, which do require TC layer support.

One is called Doze mode; the other is referred to as Cyclic Sleep mode. Both are statically provisioned through OMCI and either or both of these latter modes may be combined with any or all of the other power reduction techniques.

All G.987.3-compliant implementations are expected to support the Doze mode. Support of the Cyclic Sleep mode is optional for both OLT and ONU.

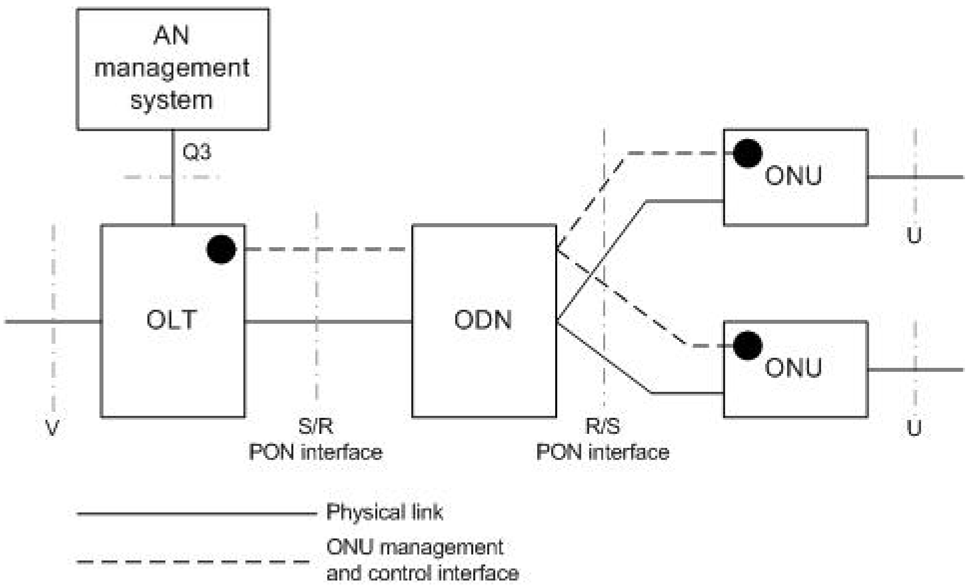
6.12 Protection Switchover

Similar to GPON, XGS-PON supports Type B and Type C protection switchover. Refer to G.984.1 for the protection implementation.

7 ONU Management and Control Interface (OMCI)

Optical network unit (ONU) management and control interface (OMCI) for optical access networks specifies the managed entities of a protocol-independent management information base (MIB) that models the exchange of information between an optical line termination (OLT) and an optical network unit (ONU). It covers the ONU management and control channel, protocol and detailed messages. OMCI fits into the network architecture reference model for PON described in [ITU-T G.984.1] and [ITU-T G.987 series] as illustrated in Figure 7-1. The dotted line shows a path for OMCI signals between an OLT and ONU.

Figure 7-1 Reference model, OMCI



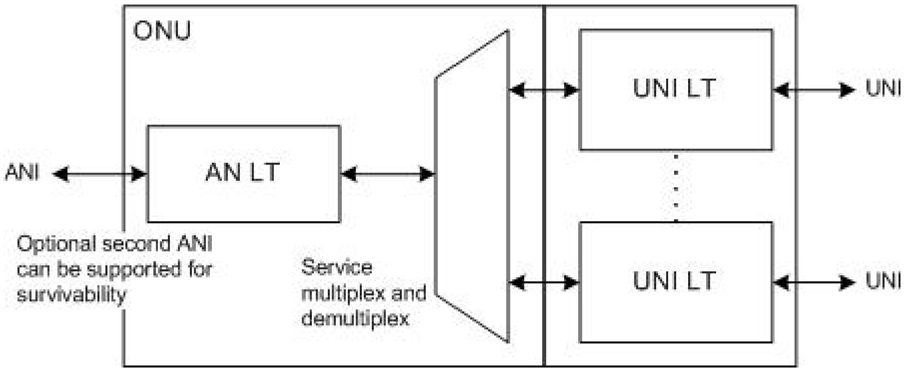
As shown in Figure 7-2, the functions of the ONU are:

1. access network line termination;

2. user network interface line termination, noting that in the fibre to the business case, the UNIs from one ONU may belong to different users;

3. service multiplexing and de-multiplexing.

Figure 7-2 ONU functional block diagram



The ONU management and control interface is used by the OLT to manage the ONU in the following areas:

1. configuration management;
2. fault management;
3. performance management;
4. security management.

This interface allows the OLT to:

1. establish and release connections across the ONU;
2. manage the UNIs at the ONU;
3. request configuration information and performance statistics;

The OMCI also allows the ONU to inform the OLT autonomously of alarms, performance threshold crossings and changes to the values of many of the MIB attributes. The OMCI protocol is asymmetric: the controller in the OLT is the master, while the ONU is the slave. A single OLT controller using multiple instances of the protocol over separate control channels typically controls multiple ONUs.

7.1 Configuration Management

Configuration management provides functions to identify the ONU's capabilities and exercise control over the ONU. Areas of configuration management include:

1. configuration of equipment;
2. configuration of PON and RE protection
3. configuration of the UNIs;
4. configuration of GEM port network CTPs in G-PON applications;
5. configuration of interworking termination points;
6. configuration of OAM flows;
7. configuration of physical ports;
8. configuration of GAL profiles in GPON applications;
9. configuration of service profiles;
10. configuration of traffic descriptors;
11. configuration of AAL profiles, when needed for ADSL UNIs.

7.2 Fault Management

As modelled by OMCI, the ONU detects and reports equipment, software and interface failures and declares the corresponding alarms. The OMCI supports failure reporting on many managed entities as described in clause 9. An alarm table is defined for each of these entities.

In addition to failure reporting, the OMCI supports test, measurement and in-service monitoring, including

1. Metallic tests of copper drops (voice and/or xDSL)

2. Optical and other parameters of the optical distribution network

3. [IEEE 802.1] connectivity fault management

4. Directed loopback, for example of DS1/E1 services

The OMCI also provides for reporting of protection switch events.

7.3 Performance Management

The ONU has only limited performance monitoring. The OMCI supports performance monitoring using a number of managed entities. These managed entities can be identified by the words “performance monitoring history data” or “extended PM” in their names. All performance monitoring related managed entities are created at the request of the OLT. All history data is maintained in the OLT. The ONU maintains only a current counter and one 15-minute previous-interval counter.

7.4 Security Management

Different access technologies specify differing degrees of security capability [ITU-T G.984 series], [ITU-T G.986], [ITU-T G.987 series]. OMCI supports a mechanism to allow mutual authentication of OLT and ONU and subsequent secure communication of encryption keys.

7.5 ONU Management and Control Protocol

G.988 defines two formats for OMCI messages, baseline and extended. GPON systems are free to use either the baseline or the extended OMCI message format. The baseline format is the default at initialization. Use of the extended format is then negotiated between OLT and ONU. Baseline messages have 48-byte fixed length PDUs, while extended messages have variable length PDUs. A receiver that does not support extended messages may therefore reject extended message based on nothing more than their length.

Both baseline and extended messages carry a message integrity check (MIC) in their final four bytes. This facilitates ad hoc recovery of both message types by a receiver. In G.984 systems, the MIC is an I.363.5 CRC; in G.987 systems, the MIC is a cryptographic hash as specified in G.987.3.

Baseline and extended messages are distinguished from one another by the device identifier field, which is in the same byte location in both message types. Baseline messages contain device identifier 0x0A, while extended messages employ device identifier 0x0B.

All GPON ONUs and OLTs are required to support the baseline format. During initialization, and whenever the ONU is re-ranged onto the PON, both entities use the baseline format to establish communications and to negotiate their capabilities. If both endpoints support extended messages, they may or may not choose to conduct all or some subsequent communications in the extended message set. Baseline messages may be used for any transaction, that is, any exchange of one or more related messages such as a get/get-next sequence.

Table 7-1 shows the baseline message format. The packet has a fixed length of 48 bytes.

Table 7-2 shows the extended message format. The packet has variable length N, up to 1980 bytes.

Table 7-1 Baseline OMCI Message Format

Byte number	Size	Use
1..2	2	Transaction correlation identifier
3	1	Message type
4	1	Device identifier
5..8	4	Managed entity identifier
9..40	32	Message contents
41..48	8	OMCI trailer

Table 7-2 Extended OMCI Message Format

Byte number	Size	Use
1..2	2	Transaction correlation identifier
3	1	Message type
4	1	Device identifier
5..8	4	Managed entity identifier
9..10	2	Message contents length
11..(N-4)	-	Message contents
(N-3)..N	4	Message integrity check MIC

8 Technical Differences among GPON, XG-ON and XGS-PON

Table 8-1 Technical Differences among GPON, XG-ON and XGS-PON

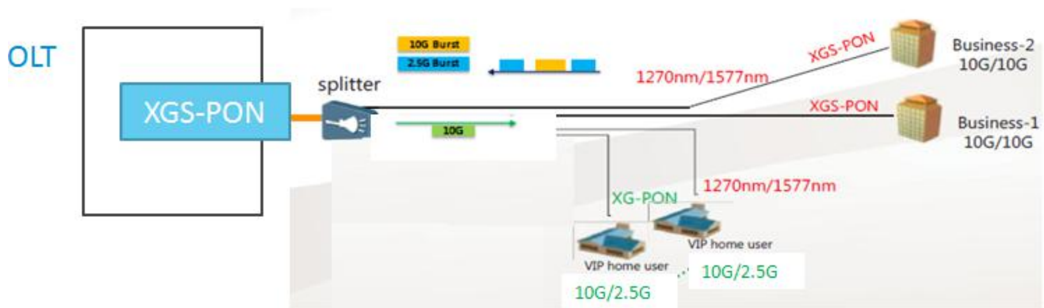
	GPON	XG-PON	XGS-PON
Standard	G.984	G.987	G.9807.1
Nominal line rate	DS: 2.5 Gbps; US: 1.25 Gbps	DS: 10 Gbps; US: 2.5 Gbps	DS: 10 Gbps; US: 10 Gbps
Split Ratio	1:64/128	1:64/128/256	1:64/128/256
Line code	NRZ	NRZ	NRZ
Operating wavelength	DS: 1480-1500 nm US: 1290-1330 nm	DS: 1575-1580 nm US: 1260-1280 nm	DS: 1575-1580 nm US: 1260-1280 nm
Max Distance/ Differential Distance	20 km/20 km	40 km	40 km/20 km (40 km to be defined)
Max logic Distance/ Differential logic	60 km 20 km	60 km 40 km	60 km 40 km

Distance			
Encapsulation Method	GEM	XGEM	XGEM
FEC	US/DS: RS (255, 239)	DS: RS (248, 216); US: RS (248,232)	DS: RS (248, 216); US: RS (248, 216);
Encryption	DS: AES	DS/US: AES	DS/US: AES
Multicast Encryption	No support	Support	Support
OMCI	Fix length	Fix length and variable length	Fix length and variable length

9 Migration towards XGS-PON

9.1 Compatibility between XG-PON and XGS-PON

Figure 9-1 Compatibility between XG-PON and XGS-PON

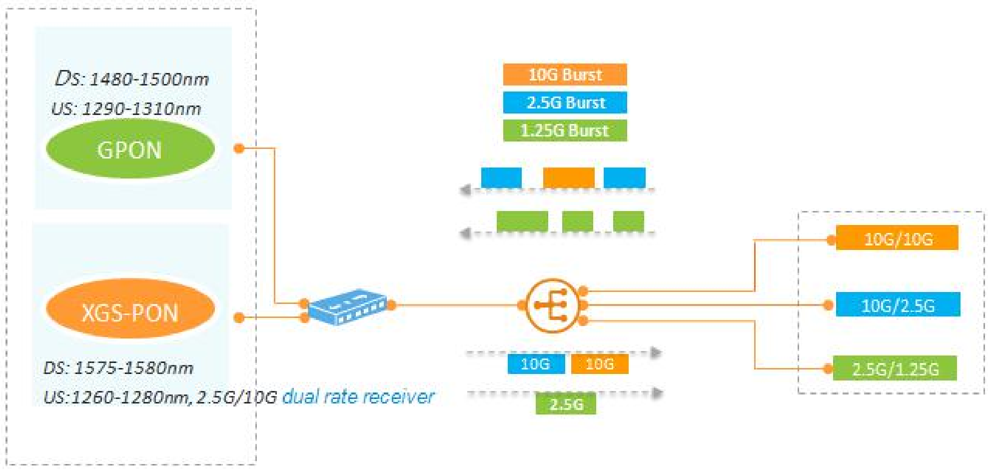


The OLT XGS-PON port supports the coexistence of XG-PON ONUs and XGS-PON ONUs via TDMA in upstream and downstream directions, and supports receiving the data burst at 9.953Gb/s and 2.488Gb/s, thereby suiting diversified scenarios. The same XGS-PON port supports accessing the business users who demand for symmetric bandwidth as well as the home users who demand for asymmetric bandwidth, which meets the requirements of different users and reduces the investment of the carriers on terminal devices.

9.2 Coexistence between XGS-PON and GPON through WDM1r

XGS-PON and GPON can coexist in the same ODN through external WDM1r.

Figure 9-2 Coexistence between XGS-PON and GPON through WDM1r



GPON and XGS-PON can coexist through WDM (Wavelength-Division Multiplexing). The XGS-PON wavelengths and GPON wavelengths in the upstream and downstream directions are completely isolated from each other. The four wavelengths can coexist in the same ODN without interfering with each other. WDM1r is a wavelength combiner, which combines the GPON downstream wavelength from the GPON interface and the XGS-PON downstream wavelength from the XGS-PON interface into the same fiber for transmission, and separates the GPON upstream wavelength and XGS-PON upstream wavelength from the same fiber to the GPON and XGS-PON interface respectively. This scenario supports the coexistence of XGS-PON ONUs and XG-PON ONUs under the same XGS-PON interface.

10 Conclusions

Based on ITU-T G.987 and ITU-T G.989 series PON standards, XGS-PON expands the capabilities, providing symmetric large-bandwidth services, and supporting the coexistence of GPON and RF video in the same ODN as well as the coexistence of XGS-PON ONUs and the XG-PON ONUs. With the coming of the Gigabit era, XGS-PON has been gradually mature and commercialized. ZTE takes the lead in XGS-PON productization and commercialization. The industry's first ASIC-based high-density XGS-PON service cards compatible with XG-PON ONUs launched by ZTE is an optimal choice for the operators to upgrade their networks to 10G-GPON.

11 References

ITU-T G.9807.1 (2016) 10-Gigabit-capable symmetric passive optical network (XGS-PON)

ITU-T G.988 (2010) ONU management and control interface (OMCI) specification

ITU-T G.984.5 Enhancement band for Gigabit capable Optical Access Networks