

XG(S)-PON (XG-PON and XGS-PON)

Feature Guide

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Contents

1 About This Document.....	1
2 Technology Evolution.....	3
3 Introduction.....	5
4 Network Structure.....	7
5 Working Principle.....	8
5.1 Basic Concepts.....	8
5.2 System Transmit Principles.....	9
5.3 Working Principles of Downstream.....	10
5.4 Working Principle of Upstream.....	11
6 Key Technologies.....	12
6.1 Ranging.....	12
6.2 Burst Optical/Electrical Technology.....	13
6.3 DBA.....	14
6.4 FEC.....	15
7 Security Technologies.....	17
7.1 Line Encryption.....	17
7.2 ONU Authentication.....	18
7.3 Continuous-Mode ONU Detection.....	20
8 Evolution From GPON to XG(S)-PON.....	22
8.1 Network Evolution Overview.....	22
8.2 Evolution Solution - Using XG(S)-PON Combo.....	24
8.2.1 What Is XG(S)-PON Combo?.....	24
8.2.2 XG(S)-PON Combo Work Principle.....	24
8.2.3 XG(S)-PON Combo Evolution Solution.....	25
8.3 Evolution Solution - Using Flex-PON.....	26
8.3.1 What Is Flex-PON?.....	27
8.3.2 Evolution Solution Overview.....	28
8.3.3 GPON Evolution to XG-PON.....	30
8.3.4 GPON Evolution to XGS-PON.....	32
8.3.5 GPON Evolution to XG-PON Combo.....	34

8.3.6 GPON Evolution to XGS-PON Combo.....	36
9 Configuration Guide.....	39
9.1 Configuring a Service Board.....	39
9.2 Configuring the Port Attributes.....	40
9.3 XG(S)-PON Combo Configuration Guide.....	40
9.4 Flex-PON Configuration Guide.....	42
10 Reference Standards and Protocols.....	44

1 About This Document

Introduction

This document describes the benefits, basic concepts, application scenarios, implementation principles, and evolution solutions of the XG(S)-PON (XG(S)-PON that evolves from the GPON technology, including the XG-PON and XGS-PON technologies).

NOTE

This document does not provide the feature specifications of a specific product version. To view the feature specifications of a specific product version, use the online tool <Feature Spec Finder>.




Intended Audience



This document is intended for network planning personnel. The operator must have the following experience and skills:

- Be familiar with the networking of the current network and related device information.
- Have experience in maintaining the device and be familiar with the operation and maintenance (O&M) mode of the device.
- It has a certain foundation for the GPON technology.

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Symbol	Description
 NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance deterioration, or unanticipated results. NOTICE is used to address practices not related to personal injury.
 NOTE	Calls attention to important information, best practices and tips. NOTE is used to address information not related to personal injury, equipment damage, and environment deterioration.

Change History

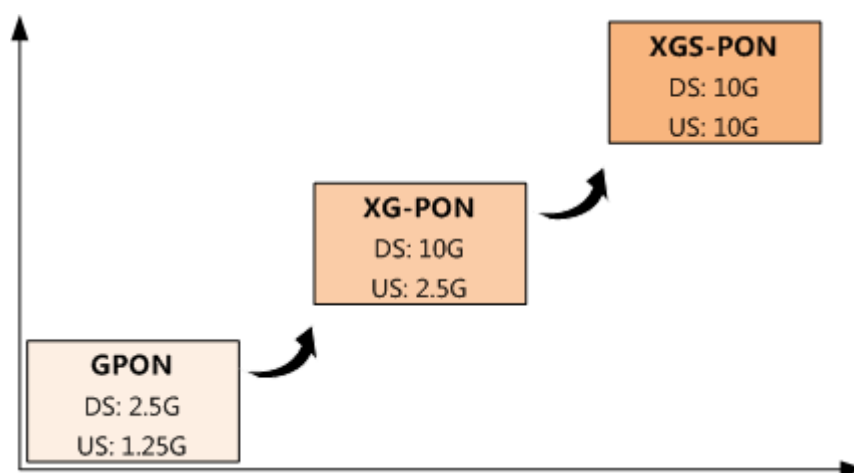
Issue	Date	Description
05	2019-06-03	Added: 8.3 Evolution Solution - Using Flex-PON Optimized: 8.2 Evolution Solution - Using XG(S)-PON Combo
04	2018-10-30	Added: Network Evolution.
03	2017-06-20	The structure and content of the document are optimized.
02	2015-06-10	Added: ONU Authentication.
01	2019-06-03	This is the first release.

2 Technology Evolution

GPON Technology Evolution

Figure 2-1 shows GPON technology evolution roadmap.

Figure 2-1 GPON Technology Evolution Roadmap



- XG-PON, 10-Gigabit-capable passive optical network, provides asymmetric 10G transmission (Maximum downstream line rate: 9.953 Gbit/s, Maximum upstream line rate: 2.488 Gbit/s).
- XGS-PON, 10-Gigabit-capable symmetric passive optical network, provides symmetric 10G transmission (Maximum downstream line rate: 9.953 Gbit/s, Maximum upstream line rate: 9.953 Gbit/s).

NOTE

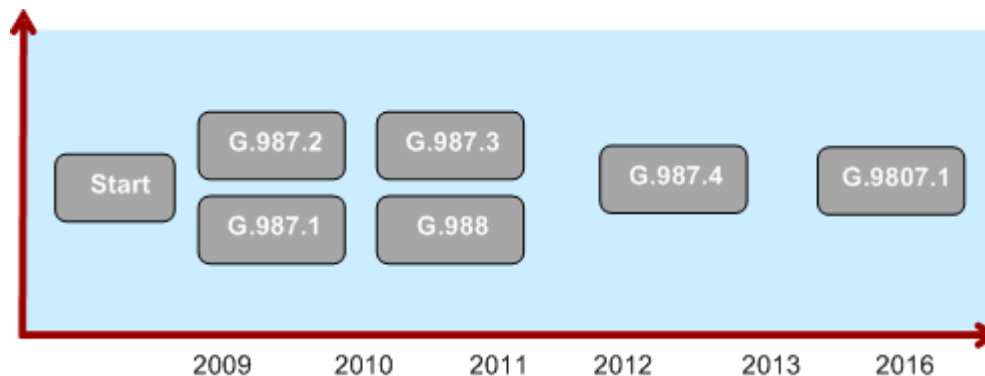
XG-PON and XGS-PON belong to the XG(S)-PON technology. Therefore, this document describes them as XG(S)-PON. However, this document describes them specifically for their differences.

Here only describes the technical evolution of the GPON, does not represent the current support capabilities of the product, the product capabilities please refer to the specific specifications.

Standard Formulation Progress

Figure 2-2 shows XG(S)-PON standard formulation progress.

Figure 2-2 XG(S)-PON Standard Formulation Progress



In 2004, International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) Q2 started to research and analyze the possibility of evolving GPON to XG-PON.

- In September 2007, Q2 officially released the enhanced wavelength plan to standardize the coexistence of GPON and XG-PON.
- In November 2007, Q2 confirmed the XG-PON standardization roadmap. With the goal of achieving low cost, high capacity, wide coverage, full service, and high communication capability, Q2 sped up the researching and finalizing of the XG-PON standard.
- In October 2009, Q2 officially released the phase 1 text for the XG-PON standard during the SG15 plenary meeting. The text contained overall requirements for XG-PON (G.987.1) and physical-layer physical media dependent (PMD) standard (G.987.2).
- In June 2010, Q2 released the convergence-layer transmission convergence (TC) standard (G.987.3) and the management-layer optical network terminal management and control interface (OMCI) standard (G.988) for XG-PON.
- In June 2012, released the XG-PON Reach extension TC layer standard (ITU-T G.987.4).
- In June 2016, released the 10-Gigabit-capable symmetric passive optical network (XGS-PON) standard (G.9807.1).

3 Introduction

What Is XG(S)-PON?

XG(S)-PON is evolved from the existing GPON technology, the factors promoting the technology evolution to XG(S)-PON are as follows:

- Developing services require higher bandwidths and the GPON technology cannot meet bandwidth requirements.
- Innovative access technologies on the user side require higher bandwidths and the GPON technology will face bandwidth bottlenecks.
- A greater split ratio and a longer transmission distance increase network construction investments.

Specification Differences Between GPON, XG-PON and XGS-PON

The following table lists specification differences between the two technologies.

 **NOTE**

Here only describes the technical specification of the GPON, XG-PON and XGS-PON, does not represent the current support capabilities of the product, the product capabilities please refer to the specific specifications.

Specification	GPON	XG(S)-PON	
		XG-PON	XGS-PON
Wavelength	<ul style="list-style-type: none"> ● Downstream: 1480-1500 nm ● Upstream: 1290-1330 nm 	<ul style="list-style-type: none"> ● Downstream: 1575-1580 nm ● Upstream: 1260-1280 nm 	<ul style="list-style-type: none"> ● Downstream: 1575-1580 nm ● Upstream: 1260-1280 nm
Center wavelength	<ul style="list-style-type: none"> ● Downstream: 1490 nm ● Upstream: 1310 nm 	<ul style="list-style-type: none"> ● Downstream: 1577 nm ● Upstream: 1270 nm 	<ul style="list-style-type: none"> ● Downstream: 1577 nm ● Upstream: 1270 nm
Maximum Line Rate	<ul style="list-style-type: none"> ● Downstream: 2.488 Gbit/s ● Upstream: 1.244 Gbit/s 	<ul style="list-style-type: none"> ● Downstream: 9.953 Gbit/s ● Upstream: 2.488 Gbit/s 	<ul style="list-style-type: none"> ● Downstream: 9.953 Gbit/s ● Upstream: 9.953 Gbit/s

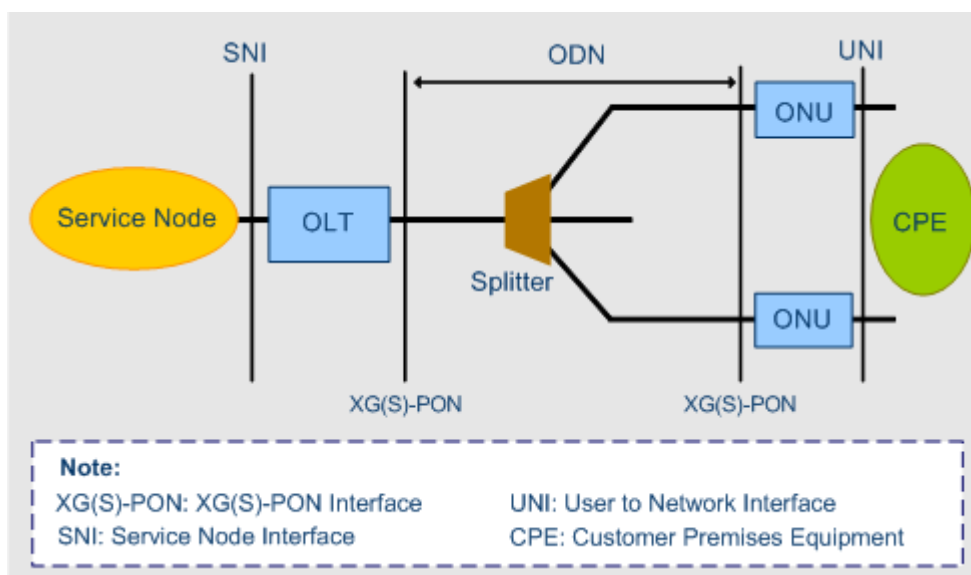
Specification	GPON	XG(S)-PON	
		XG-PON	XGS-PON
Frame Structure	GEM	XGEM	XGEM

4 Network Structure

Network Structure

A XG(S)-PON network is of the point-to-multipoint (P2MP) type, which is the same as that of a GPON network. [Figure 4-1](#) shows a XG(S)-PON network structure.

Figure 4-1 Network Structure



The XG(S)-PON network contains an optical line terminal (OLT), optical network units (ONUs), and an optical distribution network (ODN).

- The Optical line terminal (OLT) is an aggregation device located at the central office (CO) for terminating the PON protocol.
- Optical network units (ONUs) are located on the user side, providing various types of ports for connecting to user terminals.
- The Optical distribution network (ODN) is composed of passive optical components (POS) such as optical fibers, and one or more passive optical splitters. It interconnects the OLT and ONUs.

5 Working Principle

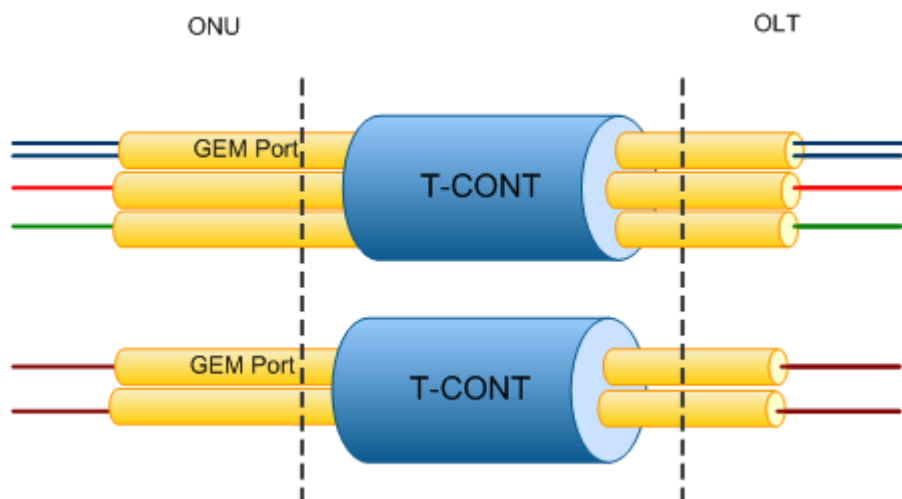
- 5.1 Basic Concepts
- 5.2 System Transmit Principles
- 5.3 Working Principles of Downstream
- 5.4 Working Principle of Upstream

5.1 Basic Concepts

Service Multiplexing

GEM ports and T-CONTs divide a PON network into virtual connections for service multiplexing, as shown in [Figure 5-1](#).

Figure 5-1 Working principles of service multiplexing



GEM Port

A GPON encapsulation mode (GEM) port is a virtual service channel that carries a service flow between the OLT and an ONU in an 10G PON system. The GEM port is similar to the virtual connection (identified by VPI/VCI) in asynchronous transfer mode (ATM). VPI is the acronym for virtual path identifier and VCI is the acronym for virtual channel identifier.

- Each GEM port is identified by a unique XGEM port ID.
- The XGEM port ID is globally allocated according to the 10G PON port by the OLT.
- A GEM port can carry one or more types of services.

T-CONT

A transmission container (T-CONT) is the basic control unit of upstream service flows in an 10G PON system, and is also the unit for carrying service flows in the upstream direction. All the GEM ports are mapped to T-CONTs, and the OLT uses dynamic bandwidth allocation (DBA) to schedule upstream transmission.

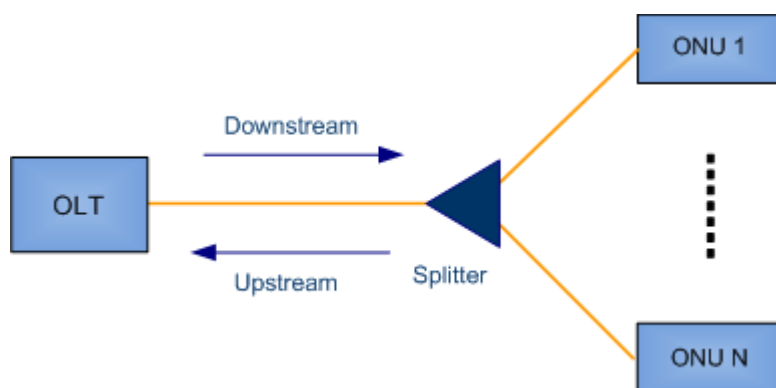
- A T-CONT can carry one or more GEM ports according to user configurations.
- A T-CONT is identified uniquely by Alloc-ID.
- The Alloc-ID is allocated according to the 10G PON port by the OLT.
- An ONU supports multiple T-CONTs configured for various service types.

5.2 System Transmit Principles

System Transmit Principles

XG(S)-PON uses wavelength division multiplexing (WDM) to transmit data in different wavelengths on an ODN network. [Figure 5-2](#) shows the system transmit principles.

Figure 5-2 System Transmit Principles



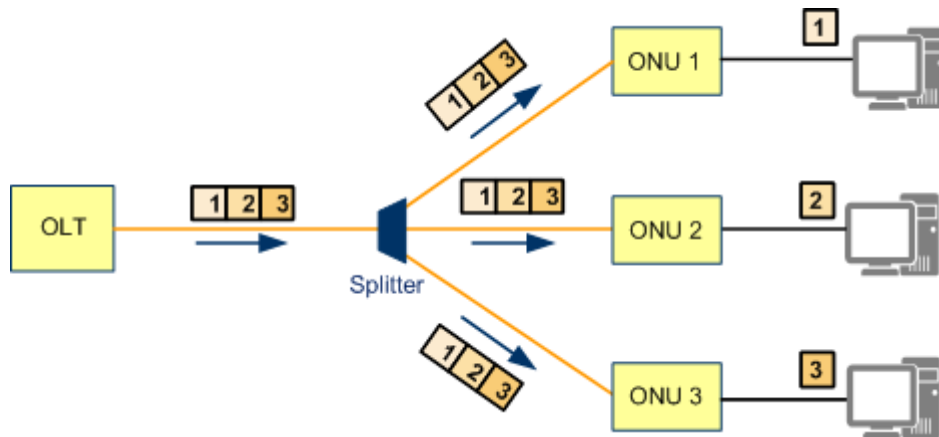
- Data is broadcast in the downstream direction.
- Data is transmitted in the TDMA mode (based on timeslots) in the upstream direction.

5.3 Working Principles of Downstream

Working Principles for Downstream Transmission

Figure 5-3 shows the XG(S)-PON working principles for downstream transmission.

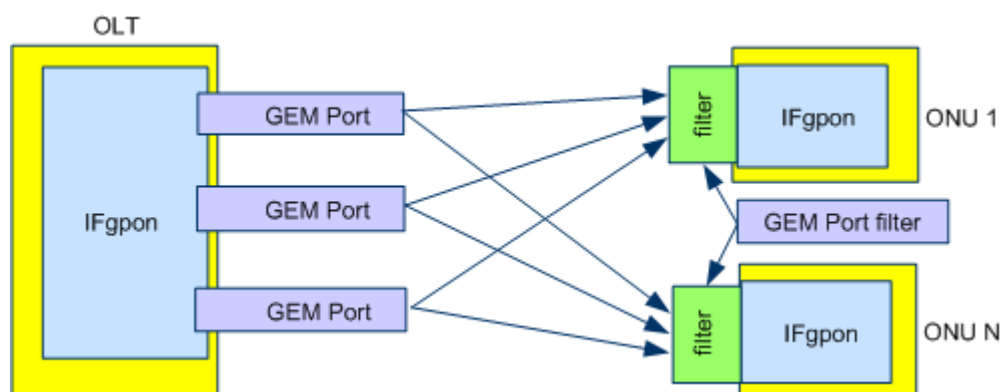
Figure 5-3 Working principles for downstream transmission



In the downstream direction, the OLT broadcasts data to all ONUs and the ONUs receive only desired data.

Data flow forwarding in the downstream direction

Figure 5-4 Data flow forwarding in the downstream direction



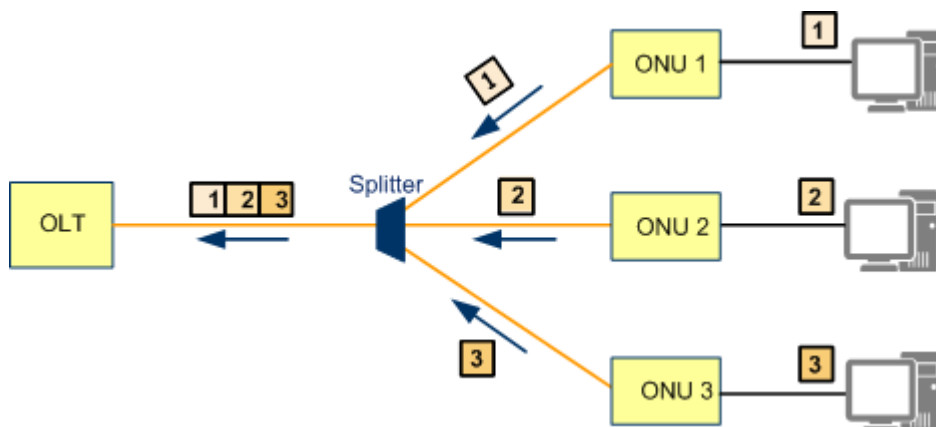
- On the OLT, data flows are encapsulated into GEM ports in service processing units.
- The OLT broadcasts the data to in the GEM ports to all ONUs.
- The ONU determines whether to process or discard the data according to the XGEM port ID.

5.4 Working Principle of Upstream

Working Principles for Upstream Transmission

Figure 5-5 shows the XG(S)-PON working principles for upstream transmission.

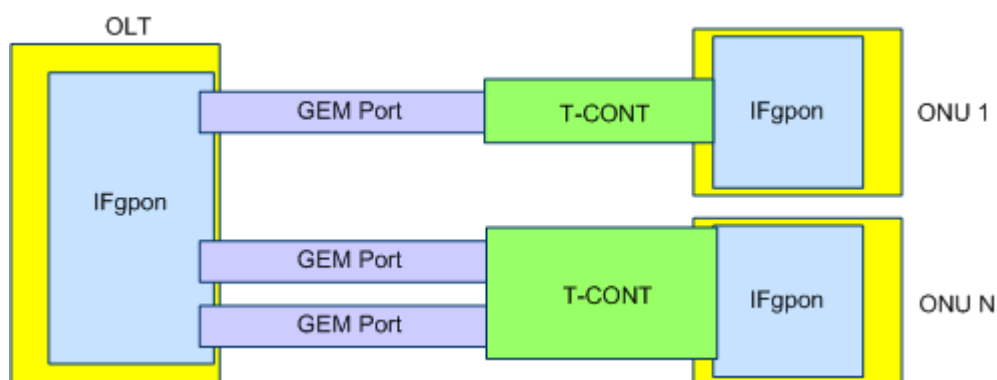
Figure 5-5 Working principles for upstream transmission



In the upstream direction, an ONU sends data to the OLT using an allocated timeslot. Such transmission ensures that all ONUs send data in a permitted sequence, which prevents upstream data collision.

Data flow forwarding in the upstream direction

Figure 5-6 Data flow forwarding in the upstream direction



- On the ONU, data flows are encapsulated into GEM ports and mapped to transmission containers (T-CONTs).
- The ONU sends data flows to the OLT according to T-CONTs.
- The OLT decapsulates the data flows and sends them to service processing modules.

6 Key Technologies

6.1 Ranging

6.2 Burst Optical/Electrical Technology

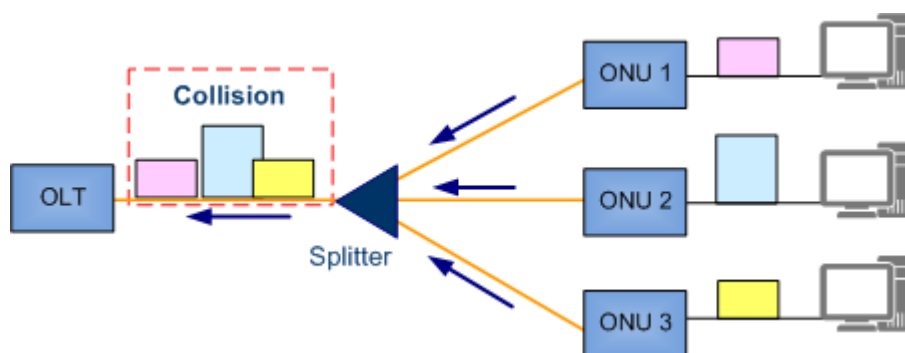
6.3 DBA

6.4 FEC

6.1 Ranging

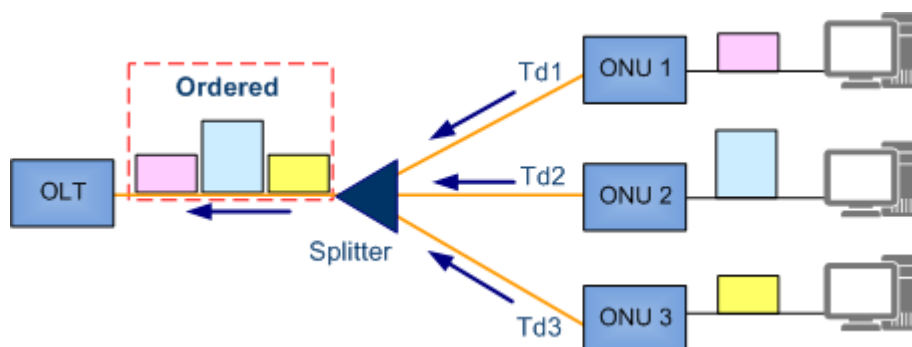
The logic reaches from optical network units (ONUs) to an optical line terminal (OLT) vary. The round trip delays (RTDs) between an OLT and ONUs also vary depending on time and environment. Therefore, collisions may occur when ONU sends data in TDMA mode (in this mode, only one of the ONUs connecting to a PON port sends data at a moment), as shown in [Figure 6-1](#).

Figure 6-1 Cell transmission without ranging



To prevent the collisions, ranging is enabled when an ONU registers for the first time. The OLT measures the RTD of each ONU in the ranging process and calculates the equalization delay (EqD) of each ONU to ensure that the values of T_{eqd} , which is equal to $RTD + EqD$, of all ONUs connected to the same PON port are the same. Therefore, the logic reaches from ONUs to an OLT are the same, preventing collisions during upstream transmission.

Figure 6-2 Cell transmission with ranging



NOTE

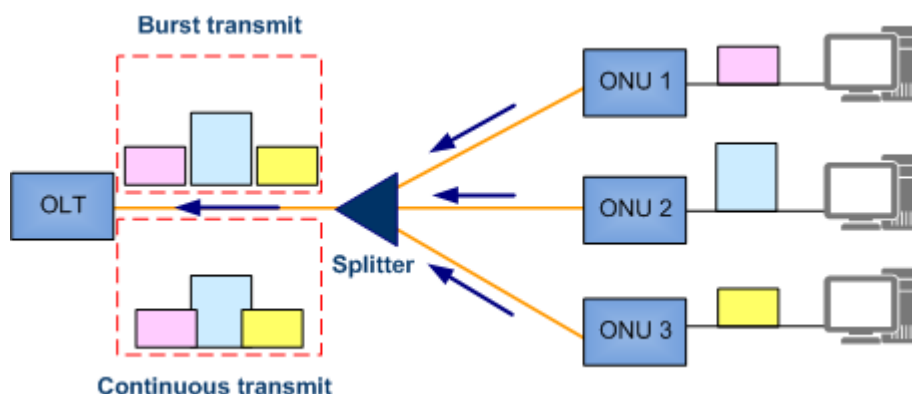
In the ranging process, the OLT must open a window and pause upstream transmission channels of other ONUs.

6.2 Burst Optical/Electrical Technology

In 10G PON upstream direction, Time Division Multiple Access (TDMA) is used. An optical network unit (ONU) transmits data only within the allocated timeslots. In the timeslots that are not allocated to it, the ONU disables the transmission of its optical transceiver to prevent other ONUs from being affected. The optical line terminal (OLT) then receives the upstream data from each ONU in a burst manner based on timeslots. Therefore, to ensure normal running of the 10G GPON system.

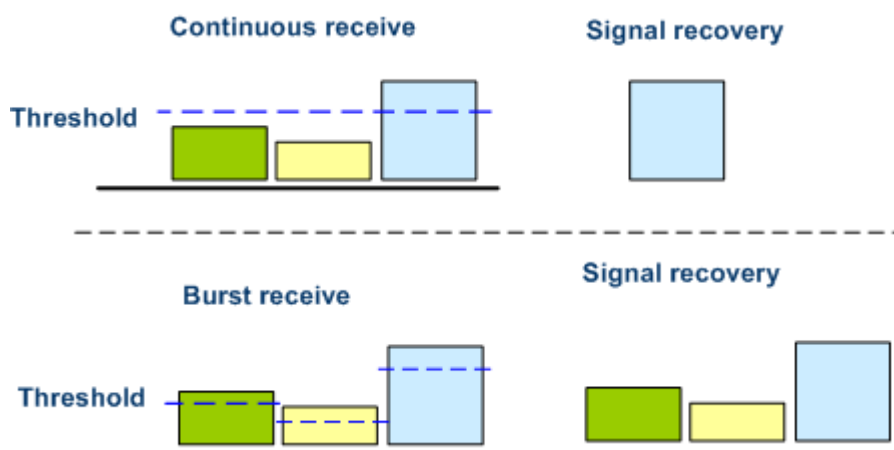
- **Figure 6-3** shows the burst transmit function supported by ONU-side optical modules.
- **Figure 6-4** shows the burst receive function supported by OLT-side optical modules.

Figure 6-3 Burst transmit function supported by ONU-side optical modules



Ranging can be implemented to prevent cells transmitted by different ONUs from conflicting with each other on the OLT. However, the ranging accuracy is ± 1 bit and the cells transmitted by different ONUs have a protection time of several bits (not a multiple of 1 bit). If the ONU-side optical modules do not support the burst transmit function, the transmitted signals overlap and distortion occurs.

Figure 6-4 Burst receive function supported by OLT-side optical modules



- The distance from each ONU to the OLT varies and therefore the optical signal attenuation varies for each ONU. As a result, the power and level of packets received by an OLT at different timeslots varies.
- If the OLT-side optical modules do not support the burst receive function, the OLT may restore incorrect signals because only the level greater than the threshold is considered valid and the signals with the level lower than the threshold cannot be restored.

NOTE

In the XG(S)-PON system, all data is broadcast downstream to ONUs. The transmission requires OLT-side optical modules to transmit optical signals continuously and ONU-side optical modules to receive optical signals continuously. Therefore, these optical modules are not required to support the burst receive and transmit function.

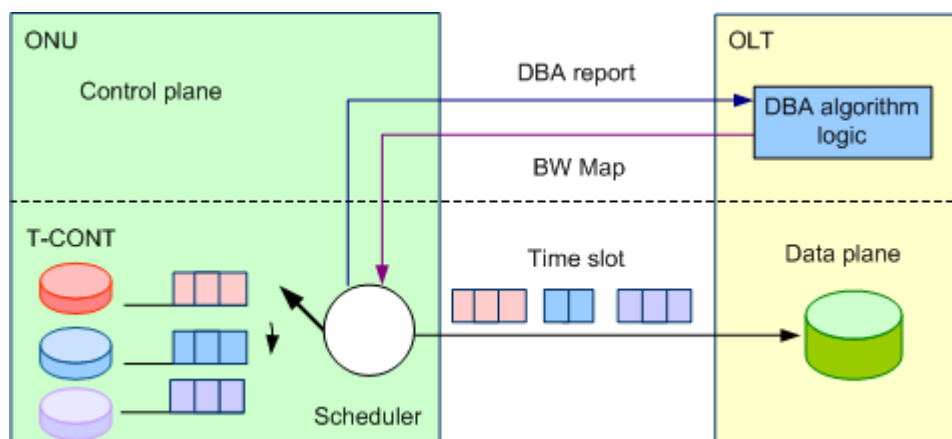
6.3 DBA

Working Principle

The OLT uses DBA to dynamically adjust the upstream bandwidth allocated to different ONUs to address the burst traffic on the ONUs, meeting the ONU upstream bandwidth requirements and improving the utilization of the PON upstream bandwidth.

Figure 6-5 shows the principles of DBA.

Figure 6-5 Principles of DBA



In the preceding figure,

- The DBA module in the OLT consistently collects DBA reports and uses the DBA algorithm to calculate the upstream bandwidth allocated to each ONU.
- The OLT sends the calculated result to each ONU using a bandwidth (BW) map.
- Each ONU transmits burst upstream data using permitted timeslots defined in the BW map.

Highlights and Applications

- Based on ONUs' burst upstream service traffic, the OLT dynamically allocates an upstream bandwidth to each ONU in real time, improving upstream bandwidth utilization on PON ports.
- More users are supported on a PON port.
- Higher service bandwidths with burst requirements are supported than those before DBA is applied.

6.4 FEC

Context

Forward error correction (FEC) is mainly used for improving transmission quality of a line.

No ideal digital channel is available in practice. As a result, bit errors and jitter occur when digital signals are being transmitted over any transmission medium, deteriorating transmission quality on lines.

To resolve the problem, error correction mechanism is introduced.

- The mechanism can check and correct errors after data is transmitted to the peer end, such as FEC.
- The mechanism can check errors after data is transmitted to the peer end but not correct errors.

Highlight and Application

- Does not require retransmission and provides a high real-time performance
- Requires an additional bandwidth (Users must balance the transmission quality and bandwidth.)
- Checks and corrects errors after data is transmitted to the peer end, but does not apply to services for which retransmission is enabled
- Applies to data transmission on the network that has a poor quality
- Applies to services that have a low requirement on delay (The delay is large if retransmission is configured for services.)

7 Security Technologies

[7.1 Line Encryption](#)

[7.2 ONU Authentication](#)

[7.3 Continuous-Mode ONU Detection](#)

7.1 Line Encryption

Context

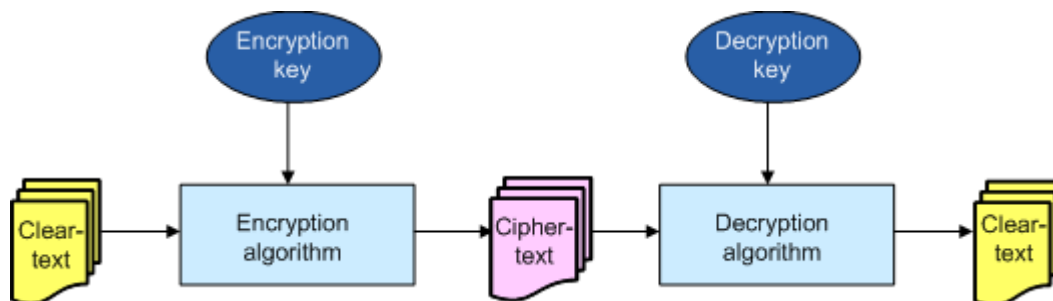
Line encryption technologies are required to eliminate the data theft risk.

The XG(S)-PON supports line encryption in the upstream and downstream directions to ensure two-way secure transmission of data messages.

Working Principle

Figure 7-1 shows line encryption technologies working principle.

Figure 7-1 Line encryption process



- The encryption algorithm to be used is the advanced encryption standard (AES).
- The XG(S)-PON systems use the AES-CTR encryption algorithm.

Highlight and Application

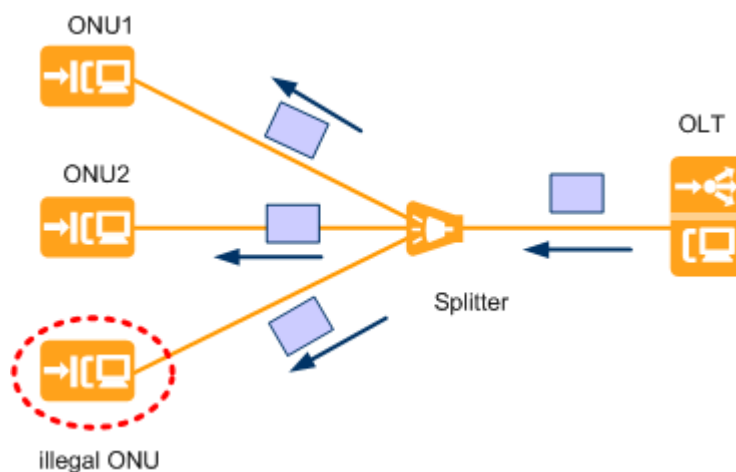
- The line encryption algorithms neither increase overhead nor decrease bandwidth usages.
- The line encryption algorithms will not prolong transmission delays.
- Enable line encryption if the usage scenarios promote high security requirements.

7.2 ONU Authentication

Context

In the PON system, downstream data is broadcast to all ONUs. As a result, downstream data destined for certain ONUs or all ONUs may be intercepted by illegal users.

Figure 7-2 Authentication process

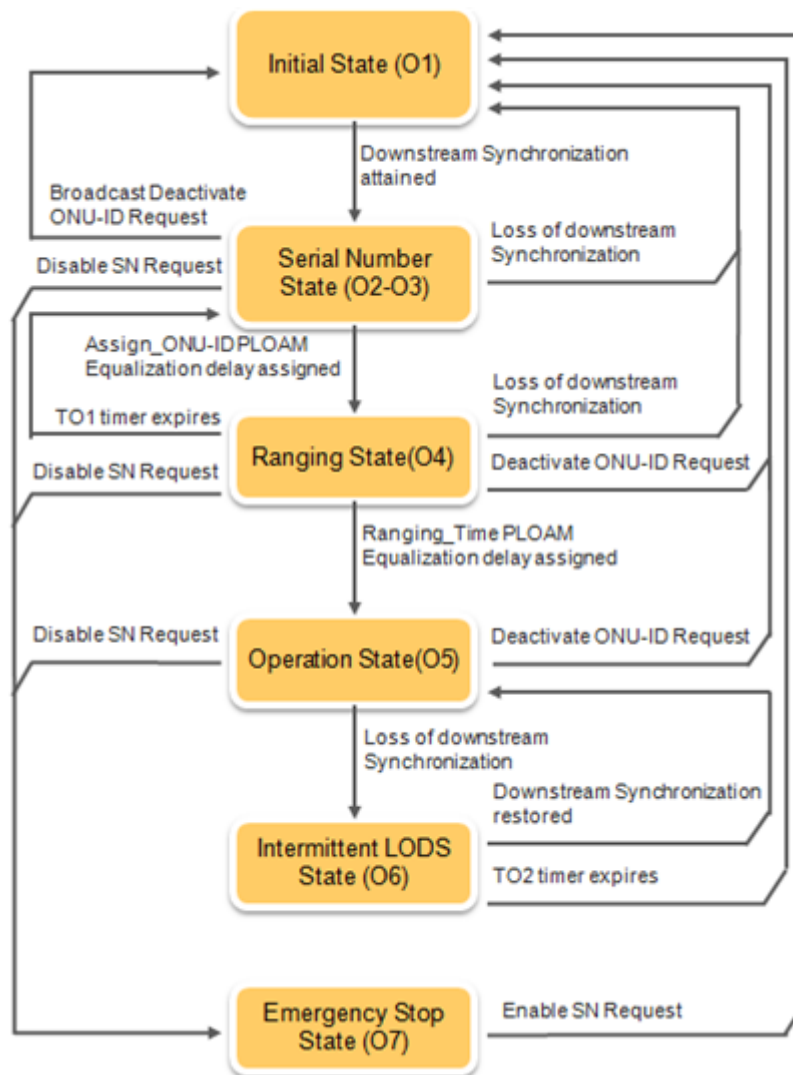


An optical line terminal (OLT) authenticates an optical network unit (ONU) based on the authentication information reported by the ONU and rejects unauthorized ONUs. Only authenticated ONUs can access a passive optical network (PON). This function enables carriers to manage and maintain devices on the PON network flexibly and conveniently.

Authentication Process

Figure 7-3 shows the authentication process:

Figure 7-3 Authentication Process



The authentication process includes six states:

- O1: Initial state.
- O2-3: Serial Number state.
- O4: Ranging state.
- O5: Operation state.
- O6: Intermittent LODS state.
- O7: Emergency Stop state.

Authentication Mode

The XG(S)-PON ONU supports the following authentication modes for the XG(S)-PON OLT:

- Password, Password+LOID
- SN, SN+LOID
- SN+Password
- LOID+CHECKCODE

Configuring the XG(S)-PON ONU Authentication Mode

On XG(S)-PON ONU, you can run the following commands to configure the XG(S)-PON ONU authentication mode:

- Run the **password** command to set the registration password of the current device that functions as a PON ONU.
- Run the **loid** command to set the ONU registers with the OLT in LOID or CHECKCODE authentication mode.
- Run the **display pon sn** command to query the SN of the ONU.

7.3 Continuous-Mode ONU Detection

Overview

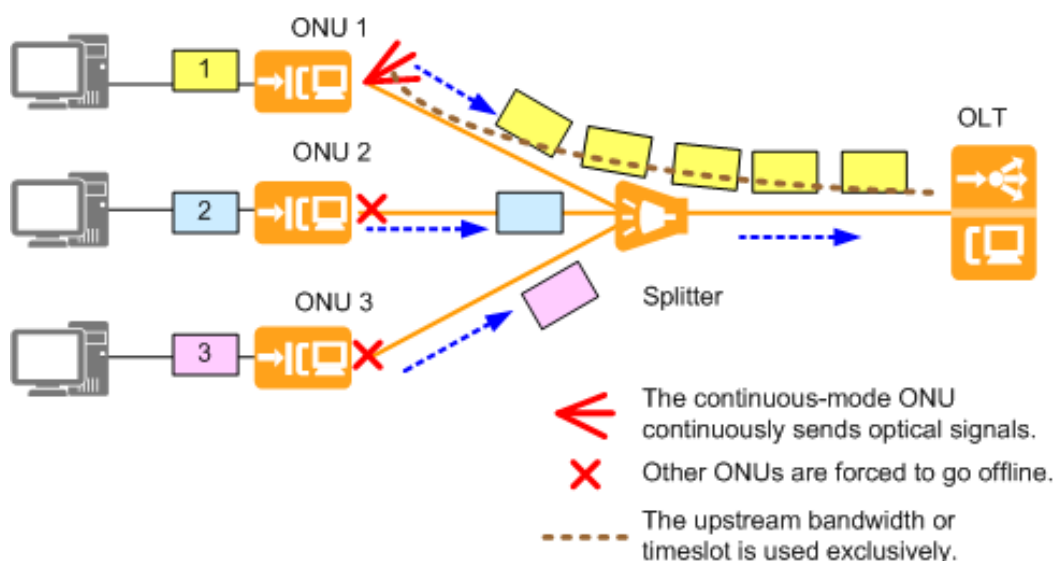
PON networks use the P2MP(point-to-multipoint) network architecture. They use time division multiple access (TDMA) in the upstream direction. ONUs must send optical signals upstream at the timeslots allocated by the OLT to prevent data conflict.

The ONUs sending optical signals upstream not at the timeslots allocated by the OLT are continuous-mode ONUs, also called rogue ONUs. A continuous-mode ONU continuously sends optical signals.

A continuous-mode ONU adversely affects the system as follows:

- If this ONU has been online, some or all ONUs connected to the same PON port go offline or frequently go offline and online.
- If this ONU has not been configured, other ONUs that have not been configured and connected to the same PON port will not be discovered by the OLT.

Figure 7-4 Continuous-mode ONU



Continuous-Mode ONU Detection

Continuous-mode ONU detection, also called rogue ONU detection, is used for detecting continuous-mode ONUs in the system and isolating them, ensuring proper system running. A continuous-mode ONU detection process involves three stages, checking, detection, and isolation.



The three stages are as follows:

- **Checking:** The OLT periodically checks whether a continuous-mode ONU connects to a PON port. This checking cannot locate the continuous-mode ONU.
The OLT opens an empty gate in the upstream direction to detect ONU optical signals in the upstream direction. If the OLT receives optical signals, it then goes to the detection stage to locate the ONU.
- **Detection:** The OLT locates the continuous-mode ONU.
The OLT issues a command to ONUs to instruct the optical modules of the ONUs to send optical signals upstream and checks whether optical signals can be received in the upstream direction. If other ONUs go offline after an ONU sends optical signals, this ONU is a continuous-mode ONU. In a detection process, the OLT checks all ONUs connected to a PON port for detecting all continuous-mode ONUs.
- **Isolation:** The OLT issues a command to power off the continuous-mode ONU, preventing this ONU from adversely affecting other ONUs connected to the same PON port.
After an ONU is powered off by the OLT, the ONU cannot send optical signals upstream even after being reset or power recycled. This ONU can send optical signals upstream only after the OLT cancels the isolation.

NOTE

The OLT checks continuous-mode ONUs but does not detect or isolate them by default.

Limitations and Restrictions

- The OLT checks and analyzes the abnormality in the sending of upstream optical signal over a PON line, identifies and isolates rogue ONUs of only non-malicious users. This feature does not apply to the intentionally sabotaged ONU or sub-standard ONU.
- A continuous-mode ONU (rogue ONU) is required to parse and respond to downstream PLOAM messages.
- When detecting a continuous-mode ONU, the OLT can quickly locate the continuous-mode ONU only if this ONU supports Huawei proprietary messages in the upstream direction.

8 Evolution From GPON to XG(S)-PON

8.1 Network Evolution Overview

For the GPON network that has been deployed on the live network, XG(S)-PON can smoothly evolve from the GPON network to the XG(S)-PON network.

8.2 Evolution Solution - Using XG(S)-PON Combo

This solution introduction smooth evolution from the GPON network to the XG(S)-PON network by adding the XG(S)-PON Combo Service Board.

8.3 Evolution Solution - Using Flex-PON

8.1 Network Evolution Overview

For the GPON network that has been deployed on the live network, XG(S)-PON can smoothly evolve from the GPON network to the XG(S)-PON network.

Why Is Smooth Evolution Required?

The smooth evolution from the GPON network to the XG(S)-PON network is mainly due to the following reasons:

- With the development of services, the bandwidth requirement of users is gradually increasing. In the short term, only some users need to be upgraded to the XG(S)-PON network, and some users continue to use the GPON network.
- For a PON network that has been deployed on the live network of a carrier, it is costly to directly cut over the GPON network to the XG(S)-PON network. The evolution from GPON to XG(S)-PON must be completed through smooth evolution.

What are the conditions for smooth evolution from GPON to XG(S)-PON?

XG(S)-PON has the following features to support smooth evolution from a GPON network to a XG(S)-PON network:

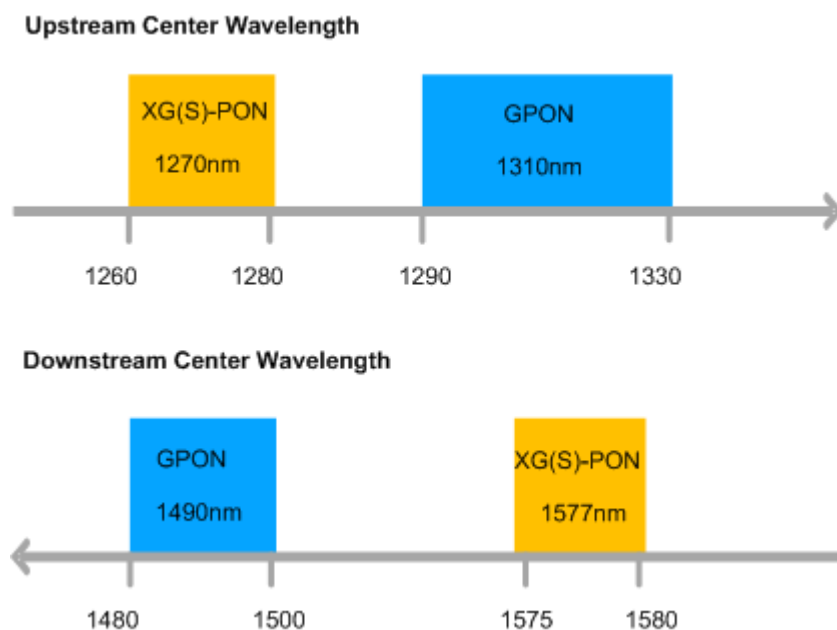
- The XG(S)-PON wavelength planning does not overlap the GPON wavelength planning. Therefore, the GPON and XG(S)-PON share the ODN network in the wavelength division multiplexing mode.
- The OLT platform supports coexistence of GPON service boards and XG(S)-PON service boards.

- XG(S)-PON and GPON have the same service provisioning and service deployment operations. They can share the NMS and service provisioning system.

No Wavelength Overlap Between GPON and XG(S)-PON

Figure 8-1 shows the wavelength distribution of GPON and XG(S)-PON.

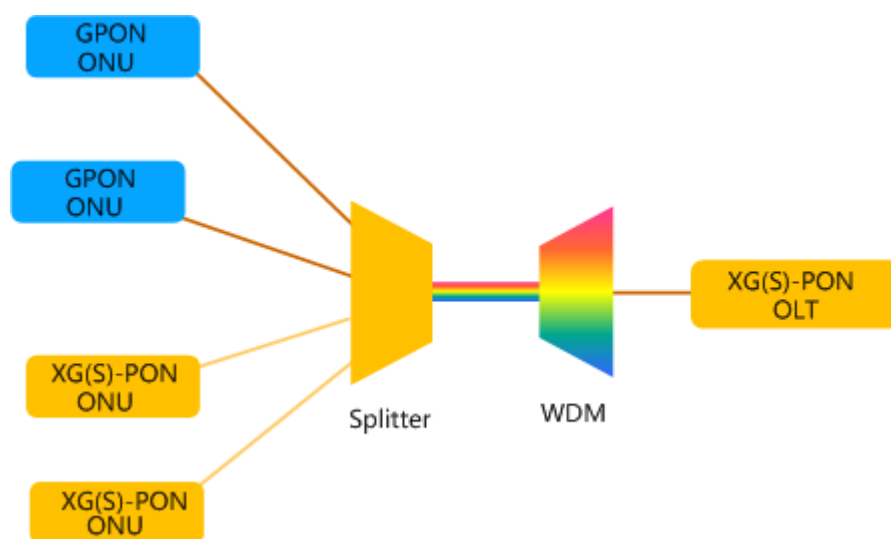
Figure 8-1 The Wavelength Distribution of GPON and XG(S)-PON



XG(S)-PON Can Co-exists with GPON in the Same ODN

Figure 8-2 shows the GPON and XG(S)-PON can coexist in the same ODN with wavelength division multiplexing (WDM) mode.

Figure 8-2 XG(S)-PON Can Co-exists with GPON in the Same ODN





WDM: Wavelength-Division Multiplexing

8.2 Evolution Solution - Using XG(S)-PON Combo

This solution introduces smooth evolution from the GPON network to the XG(S)-PON network by adding the XG(S)-PON Combo Service Board.

8.2.1 What Is XG(S)-PON Combo?

The PON Combo supports two PON technologies through a combo port. One PON Combo port supports multiple types of ONUs at the same time, implementing hybrid network construction of GPON and XG(S)-PON and smooth evolution from GPON to XG(S)-PON.

Huawei PON Combo provides two types: XG-PON Combo and XGS-PON Combo.

- XG-PON Combo:
 - XG-PON Combo means that GPON and XG-PON are integrated into one port through Combo.
 - The XG-PON Combo supports the access of GPON ONUs and XG-PON ONU.
- XGS-PON Combo:
 - XGS-PON Combo means that GPON and XGS-PON are integrated into one port through Combo.
 - The XGS-PON Combo supports GPON ONU, XG-PON ONU, and XGS-PON ONU.

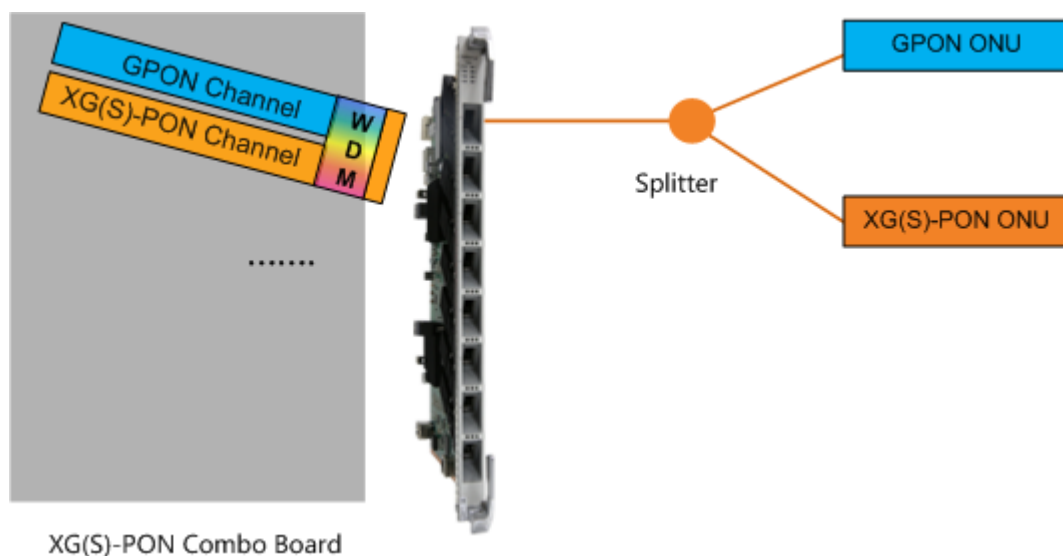


In this document, XG-PON Combo and XGS-PON Combo are short for XG(S)-PON Combo.

8.2.2 XG(S)-PON Combo Work Principle

Figure 8-3 shows the working principle of the XG(S)-PON combo service board.

Figure 8-3 Working Principle of the XG(S)-PON Combo Service Board



Working Principle:

- The XG(S)-PON combo board works with the XG(S)-PON combo optical module to implement a combo port working in GPON mode and XG(S)-PON mode at the same time.
- The XG(S)-PON combo optical module integrates the GPON optical module, XG(S)-PON optical module, and WDM multiplexer to share ODN resources without adding an external WDM multiplexer.
 - In the upstream direction: After the upstream signal of the ONU enters the XG(S)-PON combo port, the WDM determines whether the signal is a GPON signal or a XG(S)-PON signal according to the wavelength, and then sends the signal to the corresponding channel for processing.
 - In the downstream direction: After the downstream signal is sent from the OLT XG(S)-PON combo port, the GPON ONU and the XG(S)-PON ONU select the wavelength through the internal wavelength filter to receive the signal.

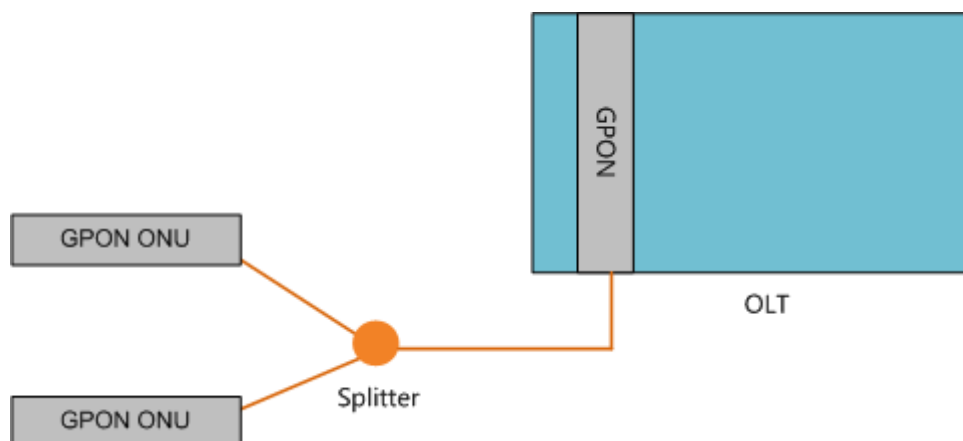
8.2.3 XG(S)-PON Combo Evolution Solution

This solution introduction smooth evolution from the GPON network to the XG(S)-PON network by adding the XG(S)-PON Combo Service Board.

Before Evolution

Figure 8-4 shows the GPON FTTx network, the OLT uses the GPON service board to connect to the GPON ONU before the evolution.

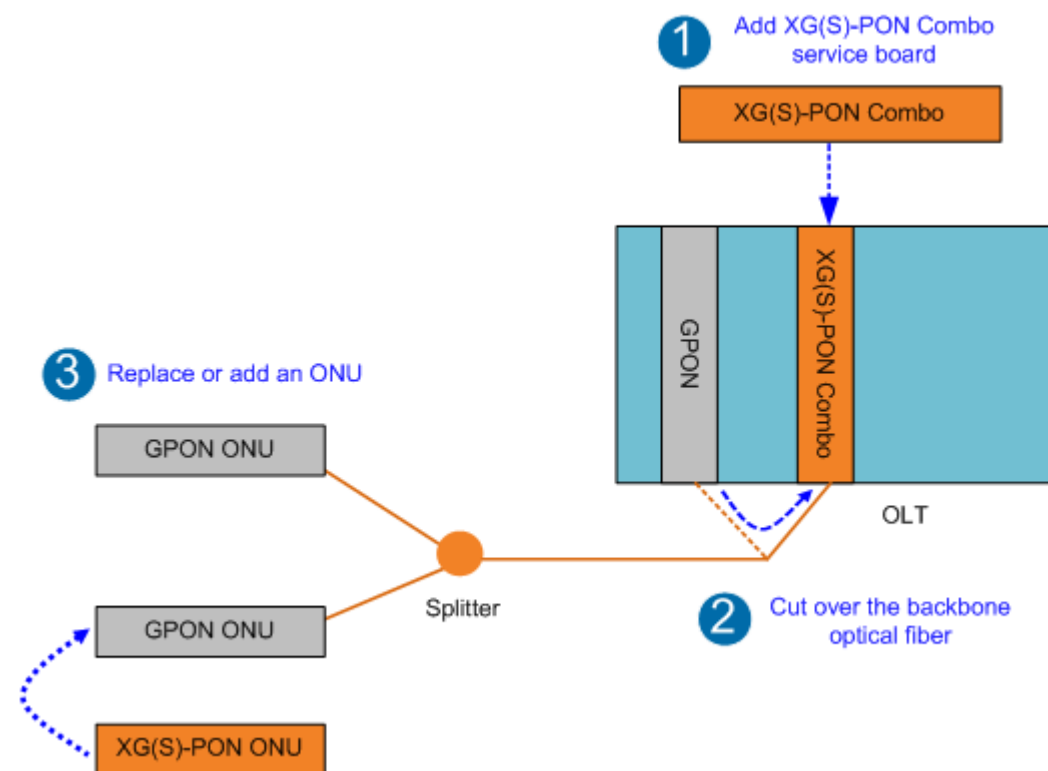
Figure 8-4 GPON FTTx Network



Evolution Solution

Figure 8-5 shows the smooth evolution from the GPON network to the XG(S)-PON network by adding adding the XG(S)-PON Combo Service Board.

Figure 8-5 Evolution Solution



NOTE

XG(S)-PON is short for XG-PON and XGS-PON.

Operation Procedure

1. Add XG(S)-PON Combo service board.

NOTE

- If the OLT slot on the live network supports only 10 Gbit/s switching capacity and cannot meet the forwarding requirements of XG(S)-PON service boards, replace the subrack.
- If the upstream port of the OLT supports only GE upstream bandwidth, it is recommended that you replace the upstream port with 10GE upstream bandwidth or even larger bandwidth to prevent the upstream port from becoming a bottleneck.

2. Migrate the backbone optical fiber of the GPON port to the XG(S)-PON combo port.
3. Add a XG(S)-PON ONU or replace a GPON ONU.

NOTE

- The XG-PON Combo optical module can be connected to GPON ONU and XG-PON ONU.
- The XGS-PON Combo optical module can be connected to GPON ONU, XG-PON ONU and XGS-PON ONU.

4. After the GPON ONU is replaced with the XG(S)-PON ONU, the evolution is complete.

8.3 Evolution Solution - Using Flex-PON

8.3.1 What Is Flex-PON?

Flex-PON is a flexible PON solution developed by Huawei for GPON and XG(S)-PON. It implements smooth network evolution through the integrated Flex-PON service board.

Multi-mode Integration

The ports of the Flex-PON service board can work in multiple modes , including:

- GPON
- XG-PON
- XGS-PON
- GPON&XG-PON Combo
- GPON&XGS-PON Combo

The port mode of the Flex-PON service board can be set as required. After the port mode is set, the corresponding ONU can be connected to the optical module that matches the port mode.

Smooth Evolution

The Flex-PON supports the evolution from the GPON network to the XG(S)-PON network.

- No board needs to be replaced. You only need to load the RTU (Right to Use, license) and replace the optical module to realize the evolution from GPON to XG(S)-PON.
- The OSS needs to be integrated only once. After the evolution from the GPON network to the XG(S)-PON network, no secondary integration is required.
- The ONT supports on-demand replacement.

Mapping between the Flex-PON port mode, RTU type, optical module type, and ONU type

When formulating an evolution solution for the Flex-PON, ensure that the port mode is supported by the RTU, optical module, and ONU. The following table lists the mapping between the Flex-PON port mode and the RTU, optical module, and ONU type.

Table 8-1 Mapping Between the Port Mode and the RTU, Optical Module, and ONU

Port Mode	RTU Type	Optical Module Type	ONU Type
GPON	No need	GPON	GPON ONU
XG-PON	XG(S)PON RTU	XG-PON	XG-PON ONU
XGS-PON	XG(S)PON RTU	XGS-PON	<ul style="list-style-type: none"> ● XG-PON ONU ● XGS-PON ONU
XG-PON Combo	XG(S)PON RTU	XG-PON Combo	<ul style="list-style-type: none"> ● GPON ONU ● XG-PON ONU

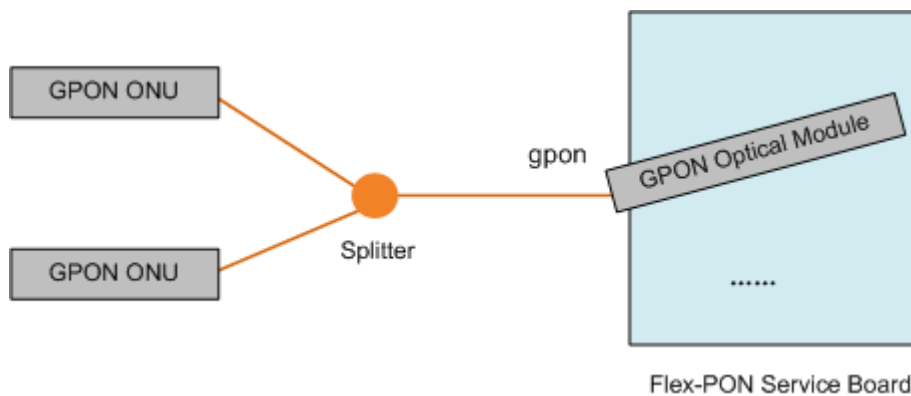
Port Mode	RTU Type	Optical Module Type	ONU Type
XGS-PON Combo	XG(S)PON RTU	XGS-PON Combo	<ul style="list-style-type: none"> ● GPON ONU ● XG-PON ONU ● XGS-PON ONU

8.3.2 Evolution Solution Overview

Before Evolution

Figure 1 shows the GPON FTTx network, the OLT uses the Flex-PON service board to connect to the GPON ONU before the evolution.

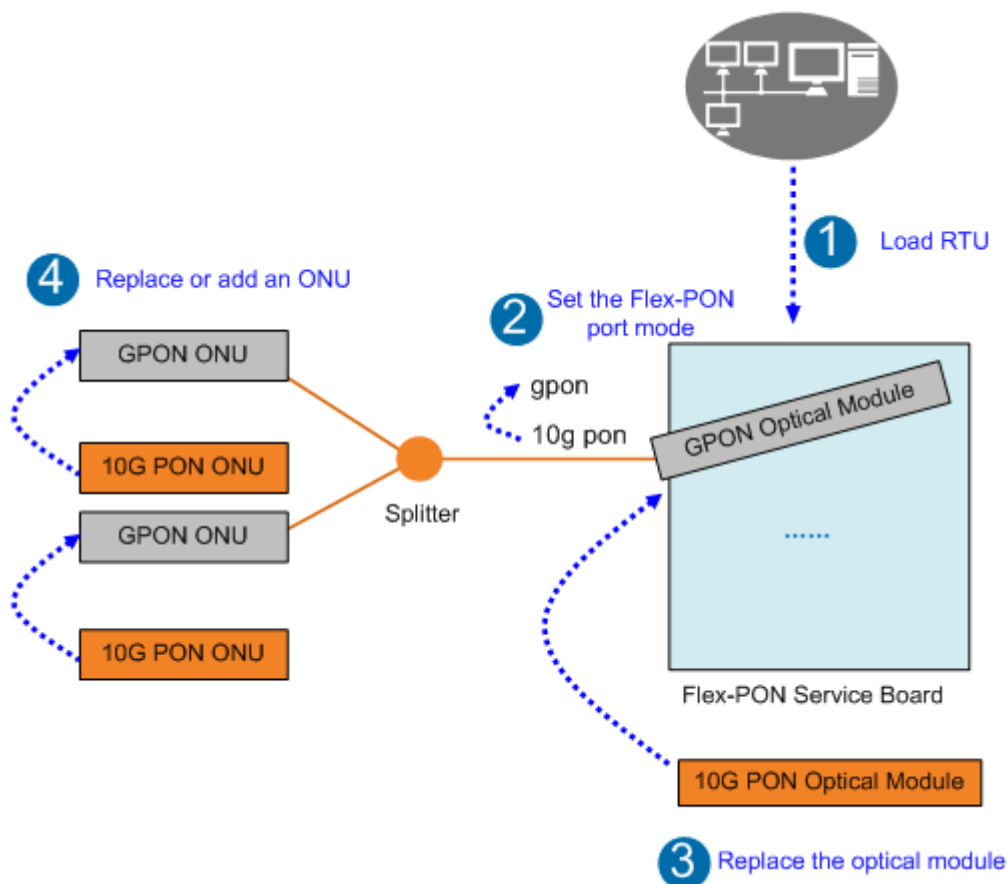
Figure 8-6 GPON FTTx Network



Evolution Solution

Figure 2 shows the smooth evolution from the GPON network to the XG(S)-PON network by Flex-PON solution.

Figure 8-7 Evolution Solution



The evolution solution must be completed in five steps:

1. Loading RTU;
2. Configuring the Flex-PON port mode;
3. Replace the optical module;
4. Replacing or adding an ONU;
5. Configuring Services;

Operation Procedure

1. Load the RTU. Use the NMS to remotely load the RTU to the Flex-PON port.

NOTICE

- The Flex-PON port can work normally only when the corresponding RTU is loaded (except for the GPON mode).
 - The RTU can be loaded only through the NMS, this service scenario cannot be performed without the NMS.
2. Set the Flex-PON port mode. On the OLT, run the `port flex-mode { all | portid } { gpon | xg-pon | xgs-pon | combo-pon { xg/g | xgs/g } [auto | wdm] }` command to set the port mode of the Flex-PON.

Parameter	Parameter Description
all	Sets the port mode of all ports on a flex-PON board.
<i>portid</i>	Set the port mode of a Flex-PON port.
gpon	Set the port mode of the Flex-PON port to GPON .
xg-pon	Set the port mode of the Flex-PON port to XG-PON .
xgs-pon	Set the port mode of the Flex-PON port to XGS-PON .
combo-pon	Set the port mode of the Flex-PON port to Combo-PON . In this case, you need to specify the Combo-PON type.
xg/g	Set the port mode of the Flex-PON port to XG-PON&GPON Combo-PON .
xgs/g	Set the port mode of the Flex-PON port to XGS-PON&GPON Combo-PON .
auto	Set the multiplexing mode of a combo-PON port to auto .
wdm	Set the multiplexing mode of a combo-PON port to WDM .

For example, set port 0 of the Flex-PON board to work in xgs/g combo mode and set the multiplexing mode to WDM.

```
huawei(config-if-gpon-0/1)#port flex-mode
{ all<K>|portid<U><0,15> }:0
{ combo-pon<K>|gpon<K>|xg-pon<K>|xgs-pon<K> }:combo-pon
{ xg/g<K>|xgs/g<K> }:xgs/g
{ <cr>|auto<K>|wdm<K> }:wdm
```

3. Replace the GPON optical module with a Flex-PON optical module.

NOTICE

The optical module type must be the same as the port mode. Otherwise, the optical module cannot work properly.

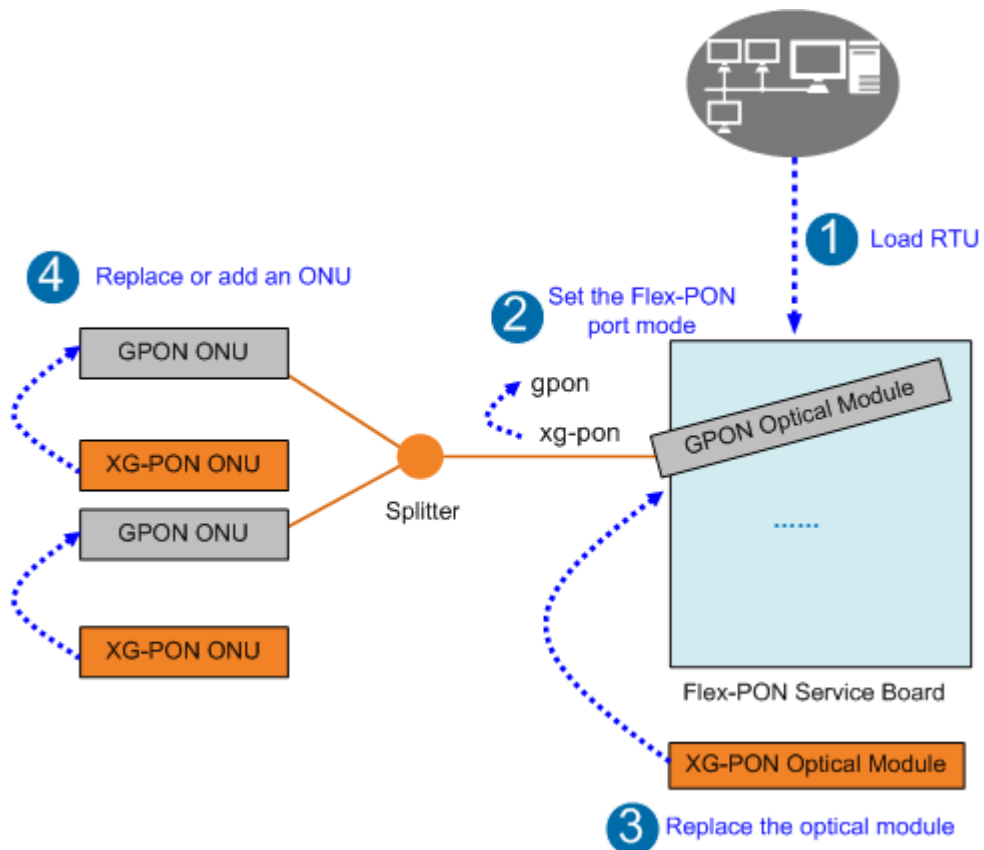
4. Add the XG(S)-PON ONU or replace the GPON ONU with the XG(S)-PON ONU.
5. Configure services. For details, see the [Flex-PON Configuration Guide](#).

8.3.3 GPON Evolution to XG-PON

Evolution Solution

Figure 1 shows the smooth evolution from the GPON network to the XG-PON network by Flex-PON solution.

Figure 8-8 GPON Evolution to XG-PON



Operation Procedure

1. Load the RTU. Use the NMS to remotely load the XG(S)PON RTU to the Flex-PON port.
2. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **gpon** to **xg-pon**.

For example, set port 0 of the Flex-PON board to the xg-pon mode.

```
huawei(config-if-gpon-0/1)#port flex-mode
{ all<K>|portid<U><0,15> } :0
{ combo-pon<K>|gpon<K>|xg-pon<K>|xgs-pon<K> } :xg-pon
```

NOTICE

If a GPON ONU already exists on the Flex-PON port, you need to delete the GPON ONU and then switch the mode. Otherwise, the switching fails.

3. Replace the GPON optical module with a XG-PON optical module.
4. Add the XG-PON ONU or replace the GPON ONU with the XG-PON ONU.

NOTE

The XG-PON optical module can be connected to only the XG-PON ONU.

5. Configure services. For details, see the [Flex-PON Configuration Guide](#).
6. The evolution is complete.

Reference Information

After the XG-PON FTTx network evolution is complete, if you want to return to the GPON FTTx network, perform the following steps:

1. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **xg-pon** to **gpon**.

NOTICE

If a XG-PON ONU already exists on the Flex-PON port, you need to delete the XG-PON ONU and then switch the mode. Otherwise, the switching fails.

-
2. Replace the XG-PON optical module with a GPON optical module.
 3. Replace the XG-PON ONU with the GPON ONU.

NOTE

The GPON optical module can be connected to only the GPON ONU.

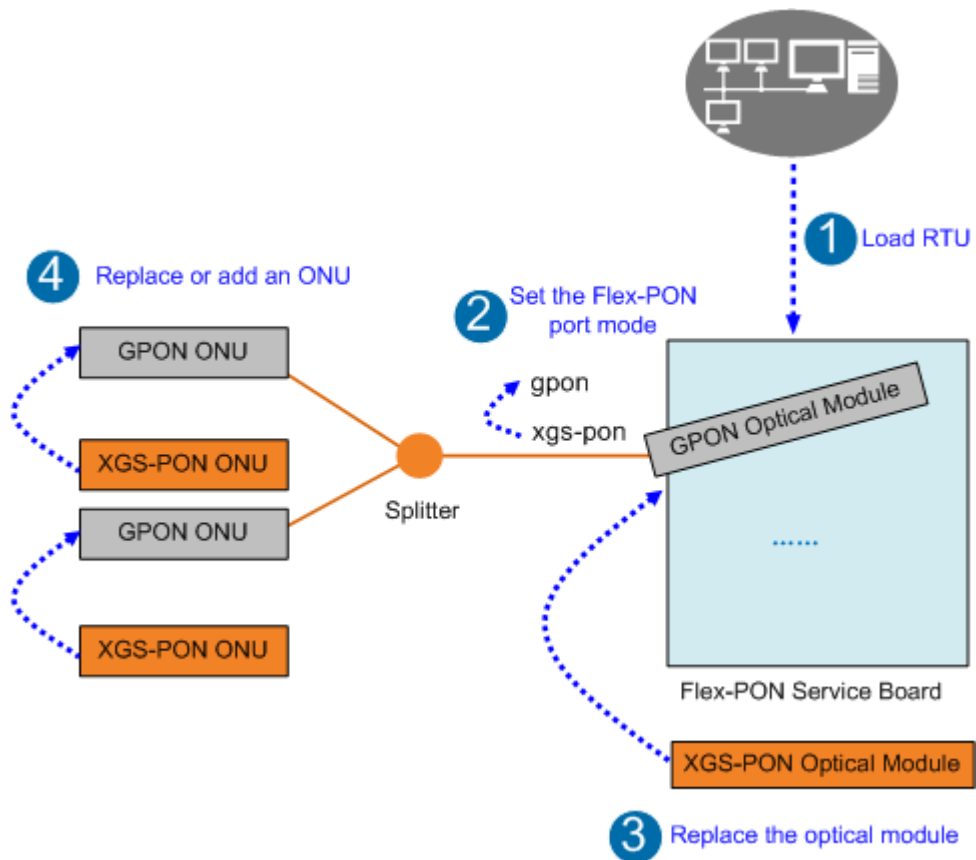
4. Configure services. For details, see the [Flex-PON Configuration Guide](#).
5. The evolution is complete.

8.3.4 GPON Evolution to XGS-PON

Evolution Solution

[Figure 1](#) shows the smooth evolution from the GPON network to the XGS-PON network by Flex-PON solution.

Figure 8-9 GPON Evolution to XGS-PON



Operation Procedure

1. Load the RTU. Use the NMS to remotely load the XG(S)PON RTU to the Flex-PON port.
2. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **gpon** to **xgs-pon**.

For example, set port 0 of the Flex-PON board to the xgs-pon mode.

```
huawei(config-if-gpon-0/1)#port flex-mode
{ all<K>|portid<U><0,15> } :0
{ combo-pon<K>|gpon<K>|xg-pon<K>|xgs-pon<K> } :xgs-pon
```

NOTICE

If a GPON ONU already exists on the Flex-PON port, you need to delete the GPON ONU and then switch the mode. Otherwise, the switching fails.

3. Replace the GPON optical module with a XGS-PON optical module.
4. Add the XGS-PON ONU or replace the GPON ONU with the XGS-PON ONU.

NOTE

The XGS-PON optical module can be connected to XG-PON ONU and XGS-PON ONU.

5. Configure services. For details, see the [Flex-PON Configuration Guide](#).
6. The evolution is complete.

Reference Information

After the XGS-PON FTTx network evolution is complete, if you want to return to the GPON FTTx network, perform the following steps:

1. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **xgs-pon** to **gpon**.

NOTICE

If a XGS-PON ONU already exists on the Flex-PON port, you need to delete the XGS-PON ONU and then switch the mode. Otherwise, the switching fails.

-
2. Replace the XGS-PON optical module with a GPON optical module.
 3. Replace the XGS-PON ONU with the GPON ONU.

NOTE

The GPON optical module can be connected to only the GPON ONU.

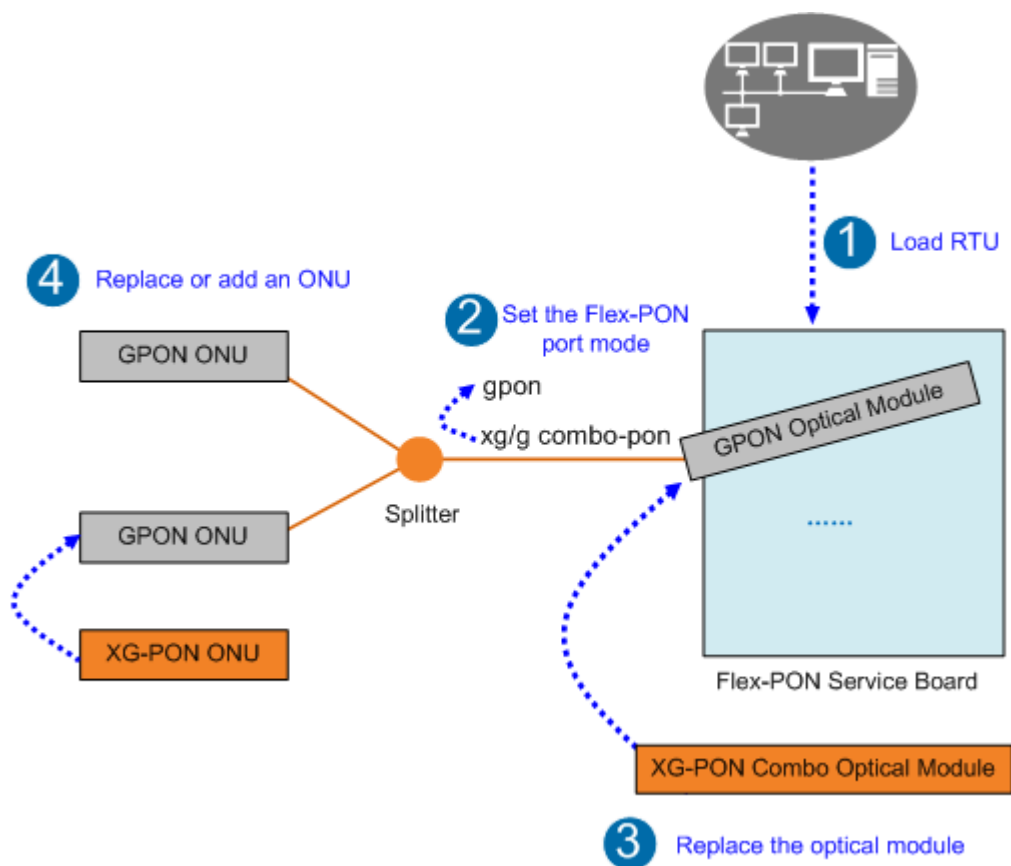
4. Configure services. For details, see the [Flex-PON Configuration Guide](#).
5. The evolution is complete.

8.3.5 GPON Evolution to XG-PON Combo

Evolution Solution

[Figure 1](#) shows the smooth evolution from the GPON network to the XG-PON Combo network by Flex-PON solution.

Figure 8-10 GPON Evolution to XG-PON Combo



Operation Procedure

1. Load the RTU. Use the NMS to remotely load the XG(S)PON RTU to the Flex-PON port.
2. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **gpon** to **xg/g combo-pon** and set the multiplexing mode to WDM.

```
huawei(config-if-gpon-0/1)#port flex-mode
{ all<K>|portid<U><0,15> } :0
{ combo-pon<K>|gpon<K>|xg-pon<K>|xgs-pon<K> } :combo-pon
{ xg/g<K>|xgs/g<K> } :xg/g
{ <cr>|auto<K>|wdm<K> } :wdm
```

NOTE

The XG-PON Combo supports the GPON ONU type. Therefore, you do not need to delete the GPON ONU when switching the port mode.

3. Replace the GPON optical module with a XG-PON Combo optical module.

NOTICE

After the port mode is switched to XG-PON Combo mode, the GPON optical module can continue to work and the GPON ONU can continue online. However, after the GPON optical module is removed and inserted, the GPON optical module cannot work. In this case, the XG-PON Combo optical module must be inserted.

4. Add the XG-PON ONU or replace the GPON ONU with the XG-PON ONU.

 **NOTE**

The XG-PON Combo optical module can be connected to GPON ONU and XG-PON ONU.

5. Configure services. For details, see the [Flex-PON Configuration Guide](#).
6. The evolution is complete.

Reference Information

After the XG-PON Combo FTTx network evolution is complete, if you want to return to the GPON FTTx network, perform the following steps:

1. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **xg/g combo-pon** to **gpon**.

NOTICE

If a ONU already exists on the Flex-PON port, you need to delete the ONU and then switch the mode. Otherwise, the switching fails.

2. Replace the XG-PON Combo optical module with a GPON optical module.
3. Replace the XG-PON ONU with the GPON ONU.

 **NOTE**

The GPON optical module can be connected to only the GPON ONU.

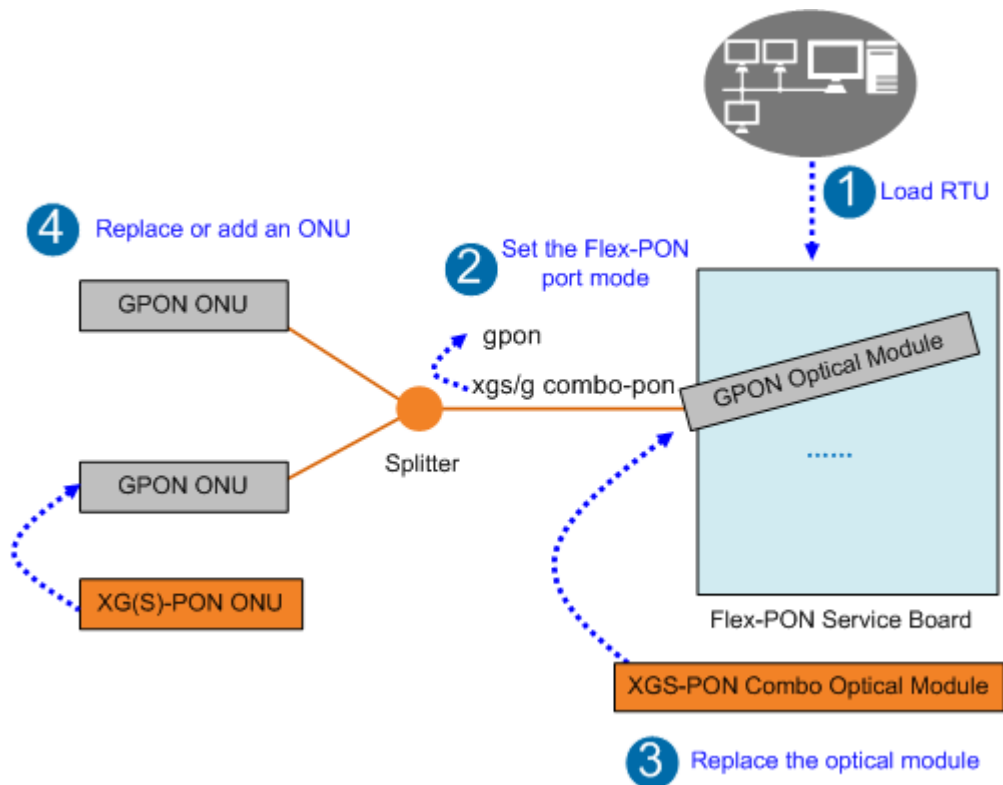
4. Configure services. For details, see the [Flex-PON Configuration Guide](#).
5. The evolution is complete.

8.3.6 GPON Evolution to XGS-PON Combo

Evolution Solution

Figure 1 shows the smooth evolution from the GPON network to the XGS-PON Combo network by Flex-PON solution.

Figure 8-11 GPON Evolution to XGS-PON Combo



NOTE

XG(S)-PON is short for XG-PON and XGS-PON.

Operation Procedure

1. Load the RTU. Use the NMS to remotely load the XG(S)PON RTU to the Flex-PON port.
2. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **gpon** to **xgs/g combo-pon** and set the multiplexing mode to WDM.

```

huawei(config-if-gpon-0/1)#port flex-mode
{ all<K>|portid<U><0,15> }:0
{ combo-pon<K>|gpon<K>|xg-pon<K>|xgs-pon<K> } :combo-pon
{ xg/g<K>|xgs/g<K> } :xgs/g
{ <cr>|auto<K>|wdm<K> } :wdm
    
```

NOTE

The XGS-PON Combo supports the GPON ONU type. Therefore, you do not need to delete the GPON ONU when switching the port mode.

3. Replace the GPON optical module with a XGS-PON Combo optical module.

NOTICE

After the port mode is switched to XGS-PON Combo mode, the GPON optical module can continue to work and the GPON ONU can continue online. However, after the GPON optical module is removed and inserted, the GPON optical module cannot work. In this case, the XGS-PON Combo optical module must be inserted.

4. Add the XG(S)-PON ONU or replace the GPON ONU with the XG(S)-PON ONU.

 **NOTE**

The XGS-PON Combo optical module can be connected to GPON ONU, XG-PON ONU and XGS-PON ONU.

5. Configure services. For details, see the [Flex-PON Configuration Guide](#).
6. The evolution is complete.

Reference Information

After the XGS-PON Combo FTTx network evolution is complete, if you want to return to the GPON FTTx network, perform the following steps:

1. Set the Flex-PON port mode. On the OLT, set the Flex-PON port mode from **xgs/g combo-pon** to **gpon**.

NOTICE

If a ONU already exists on the Flex-PON port, you need to delete the ONU and then switch the mode. Otherwise, the switching fails.

2. Replace the XGS-PON Combo optical module with a GPON optical module.
3. Replace the XG(S)-PON ONU with the GPON ONU.

 **NOTE**

The GPON optical module can be connected to only the GPON ONU.

4. Configure services. For details, see the [Flex-PON Configuration Guide](#).
5. The evolution is complete.

9 Configuration Guide

[9.1 Configuring a Service Board](#)

This section describes how to configure a 10G PON service board.

[9.2 Configuring the Port Attributes](#)

[9.3 XG\(S\)-PON Combo Configuration Guide](#)

[9.4 Flex-PON Configuration Guide](#)

9.1 Configuring a Service Board

This section describes how to configure a 10G PON service board.

Adding a Board

You can add a 10G PON service board using either of the following methods:

- Manually inserting a board: When 10G PON boards have been configured in the subrack, manually insert a required board.
- Adding a board offline: When a 10G PON service board needs to be pre-configured, add a 10G PON service board offline.

NOTE

- In global config mode, run the **board add** *frameid/slotidboard-type* command to add a 10G PON service board.
- After a board is successfully added offline, the board status is **Failed**. However, you can still configure or query data on the board.
- After a user manually inserts a board (the board type must be the same as that of the board added offline), the board status changes to **Normal**. Data configured for the board takes effect immediately after the configuration.

Configuring the Working Mode of a Board

The working mode of a service board (some specific service boards) can be set according to the actual application scenario.

Commands related to the working mode of a service board are as follows:

- Run the **gpon board workmode** command to configure the working mode of a service board.
- Run the **display gpon board workmode** command to query the working mode of a service board.

9.2 Configuring the Port Attributes

Automatic Discovery of an ONU

The OLT system adds an ONU using either of the following methods:

- Adding an ONU offline: Before installing an ONU, manually add an ONU to the OLT and configure the ONU. After the ONU goes online, the OLT authenticates the ONU and issues configurations to the ONU.
- Adding an ONU online: After an ONU is installed, the OLT discovers the online ONU and adds and configures it.

The automatic discovery of an ONU applies when an ONU is added online. In this scenario, the installation time of an ONU is uncertain because the OLT periodically searches for online ONUs.

- The automatic discovery of an ONU connecting to OLT PON ports is disabled by default.
- Run the **port ont-auto-find** command to enable the automatic discovery of an ONU.
- Run the **display ont autofind** command to query the automatic discovery of an ONU.

Laser

Run a command to enable or disable a laser for a PON port.

- The laser for a PON port is enabled by default.
- Run the **shutdown** command to disable a laser.
- Run the **undo shutdown** command to enable a laser.

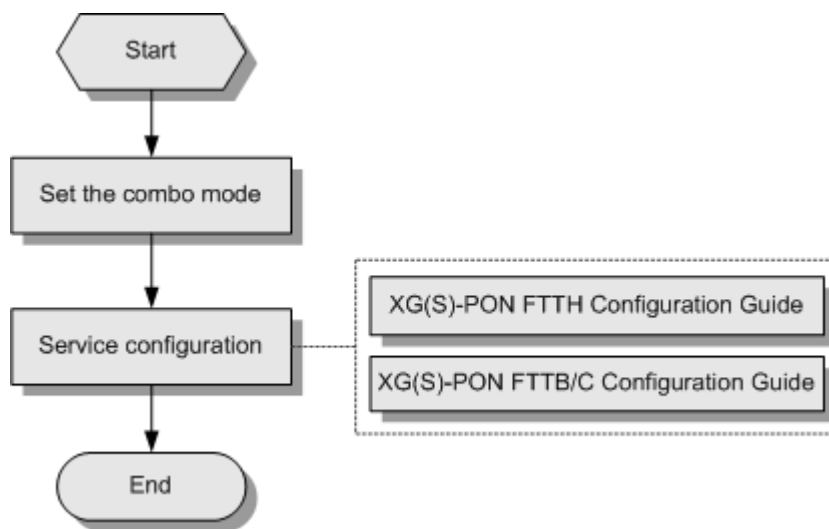
NOTE

After a laser is disabled, all services carried on the port with the laser are interrupted. Exercise caution when disabling a laser.

9.3 XG(S)-PON Combo Configuration Guide

Figure 1 shows the process of configuring the XG(S)-PON Combo service. After the XG(S)-PON Combo mode is configured, you can configure the service according to the configuration cases in the corresponding scenario.

Figure 9-1 XG(S)-PON Combo Service Configuration Process



Configuration Procedure

1. Set the combo mode of a XG(S)-PON Combo port.

On the OLT, run the **port combo-mode** { **all** | *portid* } { **auto** | **wdm** } command to set the combo mode of a XG(S)-PON Combo port.

NOTE

- **auto**: sets the combo mode of a XG(S)-PON Combo PON port to **auto**.
- **wdm**: sets the combo mode of a XG(S)-PON Combo PON port to **wdm**.
- The XG(S)-PON Combo port mode must be the same as that of the XG(S)-PON Combo optical module.

For example, set the combo port 0/1/0 to the auto mode.

```

huawei(config-if-gpon-0/3)#port combo-mode
{ all<K>|portid<U><0,15> } :
0
{ auto<K>|wdm<K> } :auto
  
```

2. XG(S)-PON Combo Service Configuration.

NOTE

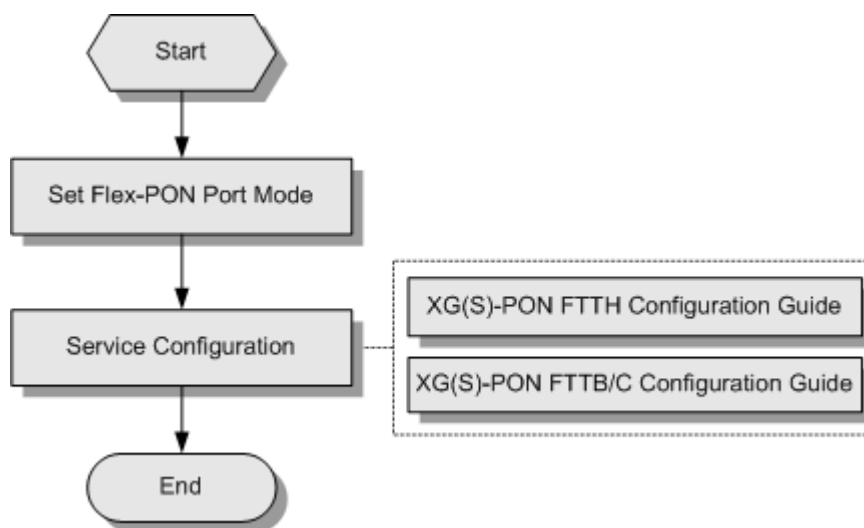
After the GPON is switched to the XG(S)-PON, pay attention to the following points:

- If the GPON ONU is not replaced after the evolution, the GPON ONU configuration remains unchanged.
- If GPON ONU is replaced with XG-PON ONU or XGS-PON ONU after the evolution, delete GPON ONU and configure XG-PON ONU or XGS-PON ONU.
- For an XG(S)-PON FTTH network, configure services according to the XG(S)-PON FTTH Configuration Guide.
 - For carrier customers, visit: [XG\(S\)-PON FTTH Configuration Guide](#)
 - For enterprise customers, visit: [XG\(S\)-PON FTTH Configuration Guide](#)
- For the XG(S)-PON FTTB/C networking, configure services according to the XG(S)-PON FTTB/C Configuration Guide.
 - For carrier customers, visit: [XG\(S\)-PON FTTB/C Configuration Guide](#)
 - For enterprise customers, visit: [XG\(S\)-PON FTTB/C Configuration Guide](#)

9.4 Flex-PON Configuration Guide

Figure 1 shows the flowchart for configuring the Flex-PON service. After setting the Flex-PON port mode, you can configure services according to the configuration cases in the corresponding scenario.

Figure 9-2 Flowchart for configuring the Flex-PON service



Configuration Procedure

Step 1 Set the port mode of the Flex-PON.

On the OLT, run the **port flex-mode** command to set the port mode of the Flex-PON.

NOTE

The configured Flex-PON port mode must be the same as the optical module type. Otherwise, the cannot work properly.

For example, set port 0 of the Flex-PON board to work in xgs/g combo mode and set the multiplexing mode to WDM.

```
huawei(config-if-gpon-0/1)#port flex-mode
{ all<K>|portid<U><0,15> }:0
{ combo-pon<K>|gpon<K>|xg-pon<K>|xgs-pon<K> }:combo-pon
{ xg/g<K>|xgs/g<K> }:xgs/g
{ <cr>|auto<K>|wdm<K> }:wdm
```

Step 2 Service configuration.

NOTE

After the GPON is switched to the XG(S)-PON, pay attention to the following points:

- For the evolution from GPON to XG-PON Combo or XGS-PON Combo, if the GPON ONU is not replaced after the evolution, the GPON ONU configuration remains unchanged.
- For the evolution from GPON to XG-PON and XGS-PON, the XG-PON ONU or XGS-PON ONU needs to be configured because the GPON ONU is replaced with the XG-PON ONU or XGS-PON ONU after the evolution.
- For an XG(S)-PON FTTH network, configure services according to the XG(S)-PON FTTH Configuration Guide.

- For carrier customers, visit: [XG\(S\)-PON FTTH Configuration Guide](#)
- For enterprise customers, visit: [XG\(S\)-PON FTTH Configuration Guide](#)
- For the XG(S)-PON FTTB/C networking, configure services according to the XG(S)-PON FTTB/C Configuration Guide.
 - For carrier customers, visit: [XG\(S\)-PON FTTB/C Configuration Guide](#)
 - For enterprise customers, visit: [XG\(S\)-PON FTTB/C Configuration Guide](#)

---End

10 Reference Standards and Protocols

The following lists standards and protocols:

- ITU-T G.987: ITU-T Recommendation G.987 (2010), G.987 definitions, abbreviations and acronyms
- ITU-T G.987.1: ITU-T Recommendation G.987.1 (2009), 10 Gigabit-capable Passive Optical Network (XG-PON): General Requirements
- ITU-T G.987.2: ITU-T Recommendation G.987.2 (2009), 10 Gigabit-capable Passive Optical Network (XG-PON): Physical Media Dependent (PMD) layer specification
- ITU-T G.987.3: XG-PON TC Layer Specification
- ITU-T G.987.4: XG-PON Reach Extension Specification
- ITU-T G.988: ITU-T Recommendation G.988 (2010), ONU management and control interface specification (OMCI)
- ITU-T G.9807.1: ITU-T Recommendation G.9807.1 (2016), 10-Gigabit-capable symmetric passive optical network (XGS-PON)