GPON Fundamentals

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Objectives

- Upon completion of this course, you will be able to:

  - Describe GPON Network Architecture

  - Outline GPON Basic Concepts

  - Outline GPON Key Technologies

  - Outline GPON Applications
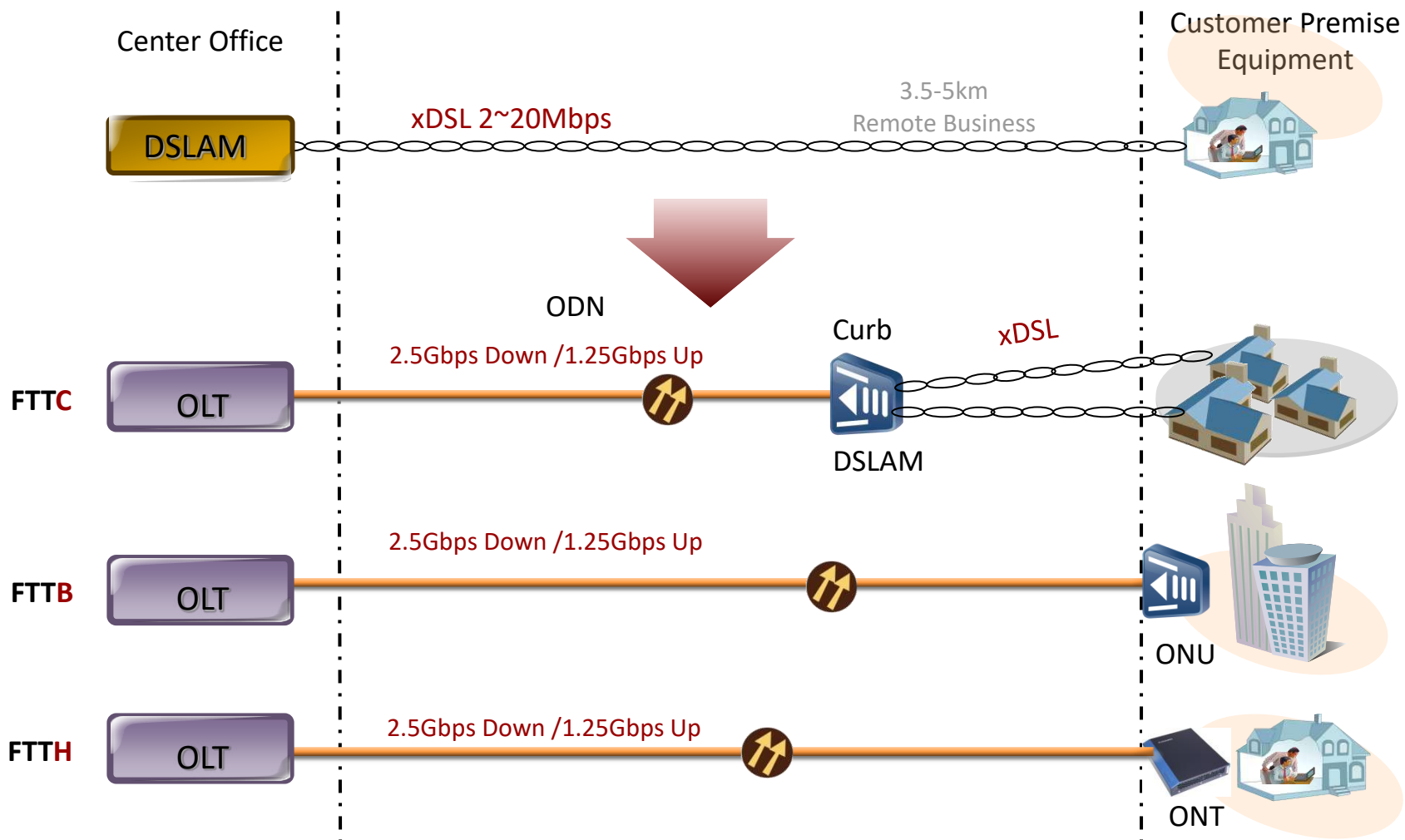
  - Outline 10G GPON Concepts and Technologies

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Contents

1. **Overview of Optical Access Network**

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What is Access Network?

- Definition:

  - An access network is that part of a telecommunications network which connects subscribers to their immediate service provider.

- Classification based on transmission media:

  - Wired

    - Twisted-pair/Coaxial-cable/Fiber

  - Wireless

    - Wi-Fi/WiMAX etc.
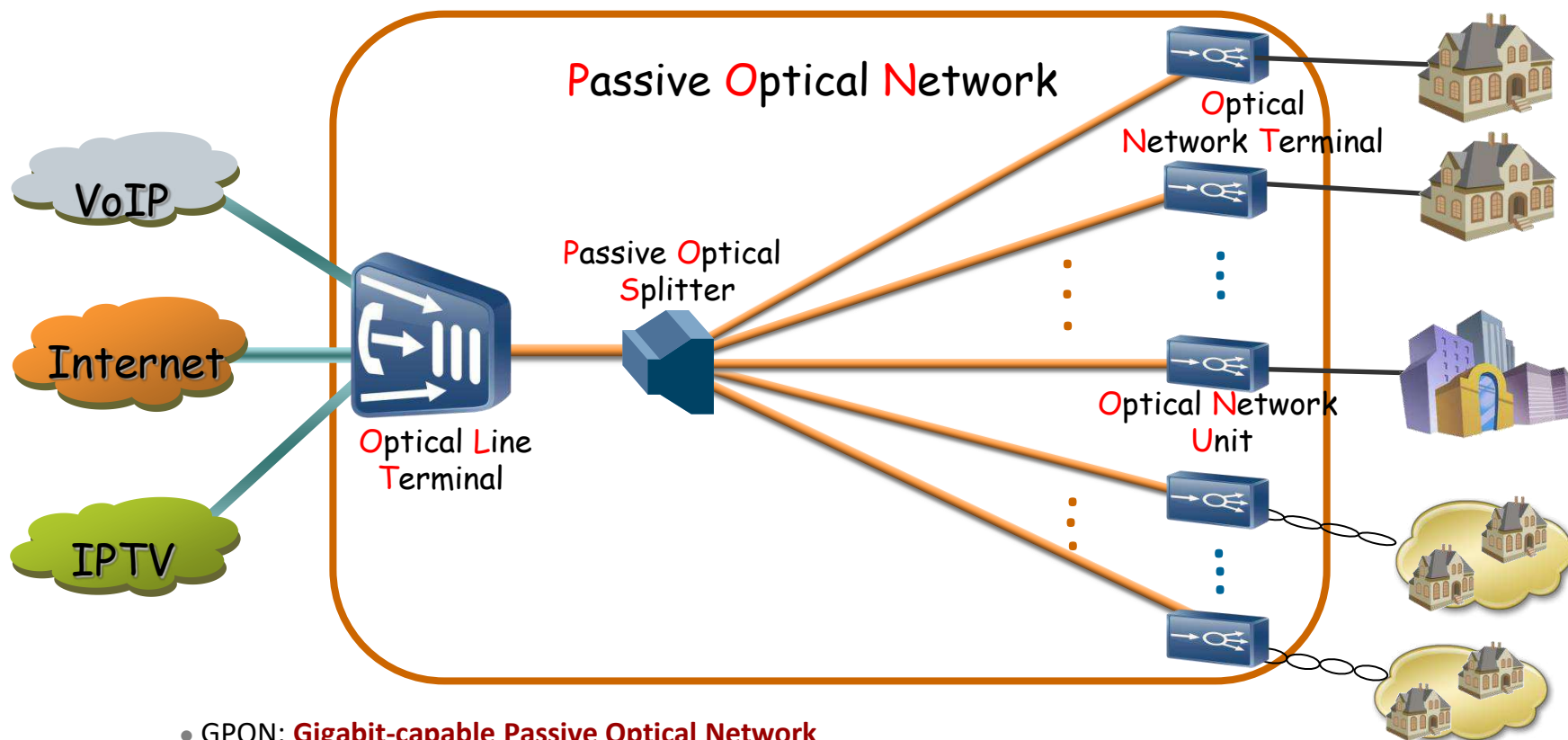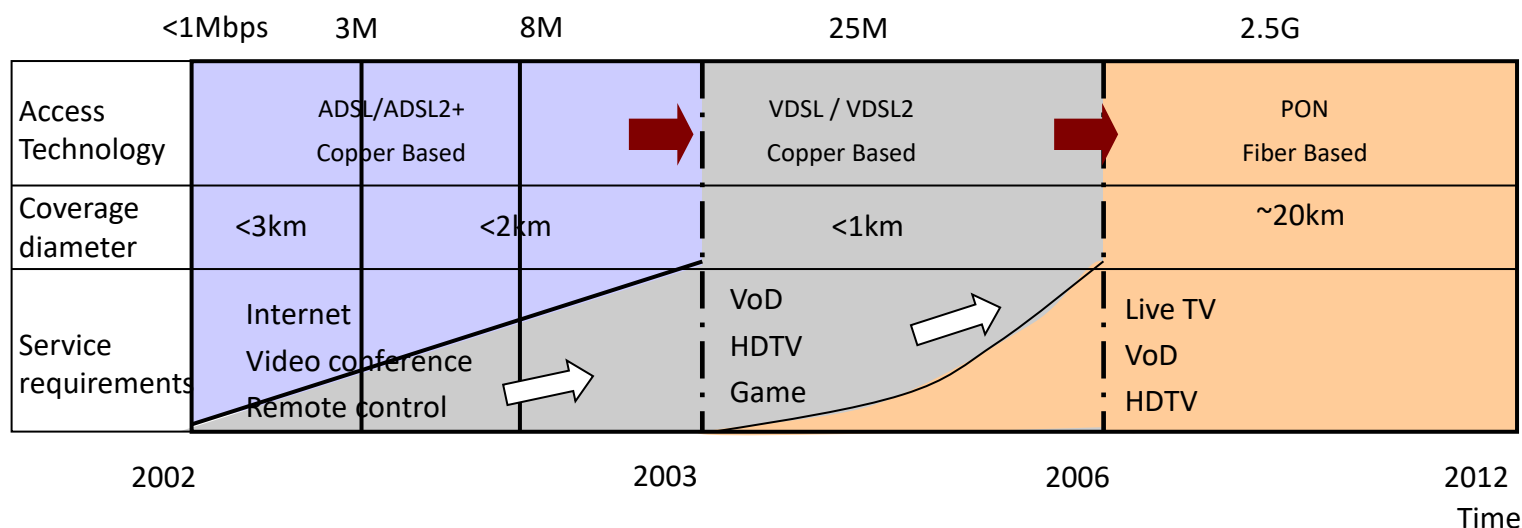
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Architecture of Optical Access Network

Center Office

Customer Premise Equipment

DSLAM

xDSL 2~20Mbps

3.5-5km
Remote Business

ODN

Curb

xDSL

FTTC   OLT   2.5Gbps Down /1.25Gbps Up

DSLAM

FTTB   OLT   2.5Gbps Down /1.25Gbps Up

ONU

FTTH   OLT   2.5Gbps Down /1.25Gbps Up

ONT

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What is GPON?

Passive Optical Network

Optical Network Terminal

Passive Optical Splitter

Optical Network Unit

Optical Line Terminal

VoIP

Internet

IPTV

- GPON: **Gigabit-capable Passive Optical Network**

- PON is short for Passive Optical Network ;

- GPON architecture: Passive optical network featuring one-to-multiple-point;

  ▫ Optical Line Terminal (OLT)   Optical Network Unit (ONU)   Optical Distribution Network (ODN).

Why GPON?

	<1Mbps 3M	8M	25M	2.5G
Access Technology	ADSL/ADSL2+ Copper Based		VDSL / VDSL2 Copper Based	PON Fiber Based
Coverage diameter	<3km <2km		<1km	~20km
Service requirements	Internet Video conference Remote control		VoD HDTV Game	Live TV VoD HDTV

2002   2003   2006   2012

Time

- GPON supports :

  - Triple-play service

    - HDTV: 10-20M/program;

    - Data: 10M;

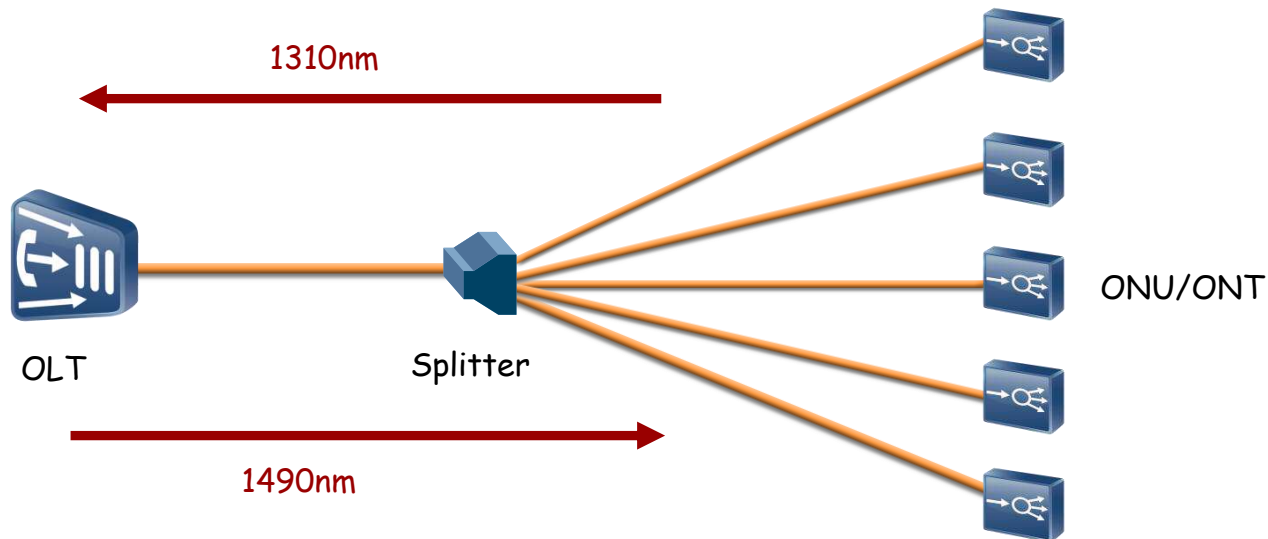   - Video Conference: 4.5M

    High-bandwidth up to 1.25Gbps/2.5Gbps
    Long-reach up to 20km

- GPON is the choice of large carriers in the international market.

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GPON Principle-Data Multiplexing

- GPON adopts Wavelength Division Multiplexing (WDM) technology, facilitating bi-direction communication over a single fiber.

1310nm

1490nm

OLT

Splitter

ONU/ONT

- To separate upstream/downstream signals of multiple users over a single fiber, GPON adopts two mechanisms:
    - In downstream direction, data packets are transmitted in a broadcast manner;
    - In upstream direction, data packets are transmitted in a TDMA manner

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GPON Principle-Downstream

Data for specified ONU
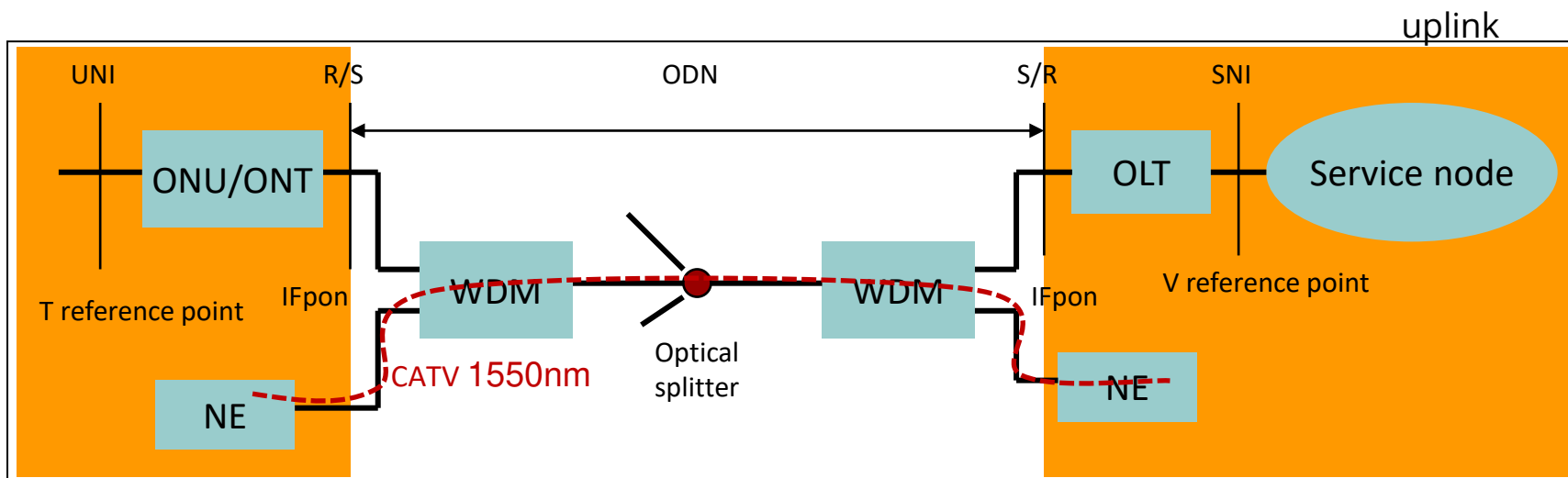
Data for specified ONU
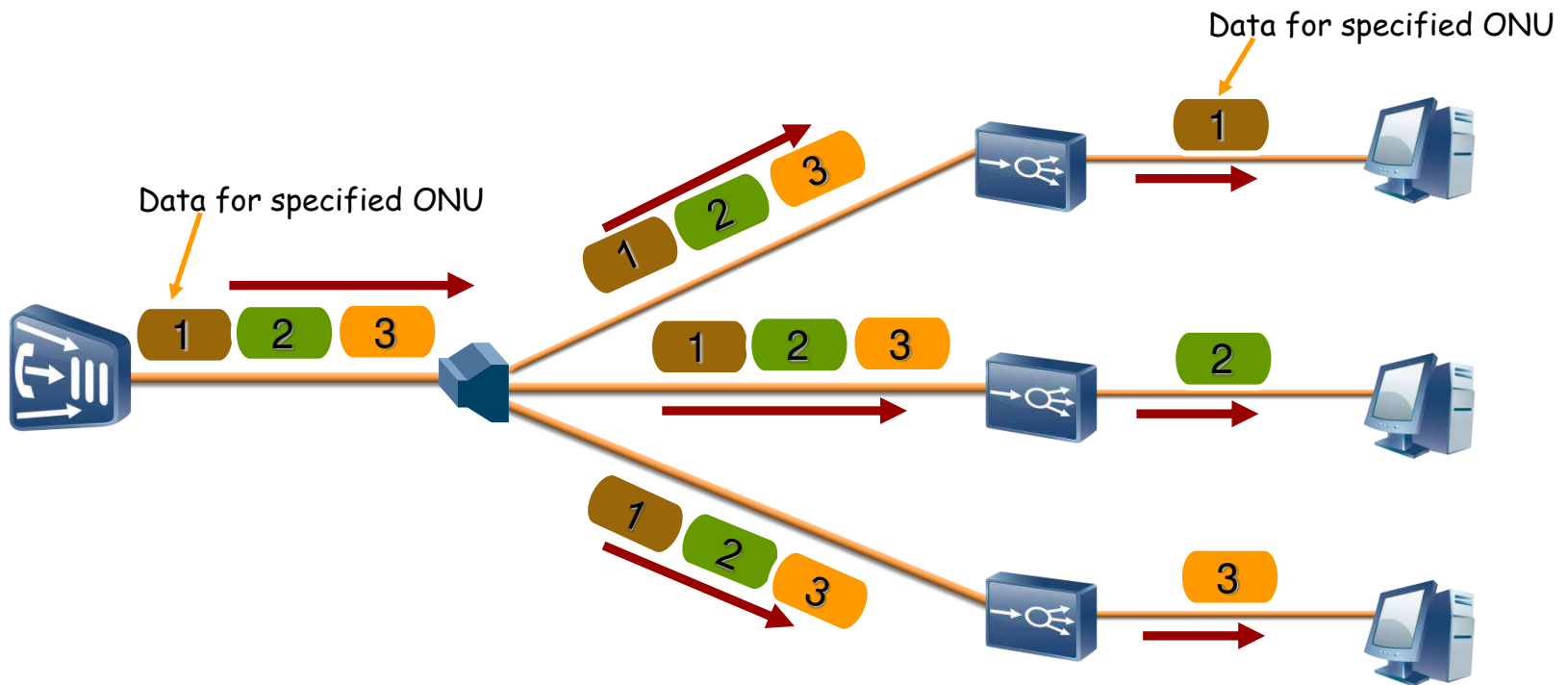
- Broadcast mode

GPON Principle-Upstream
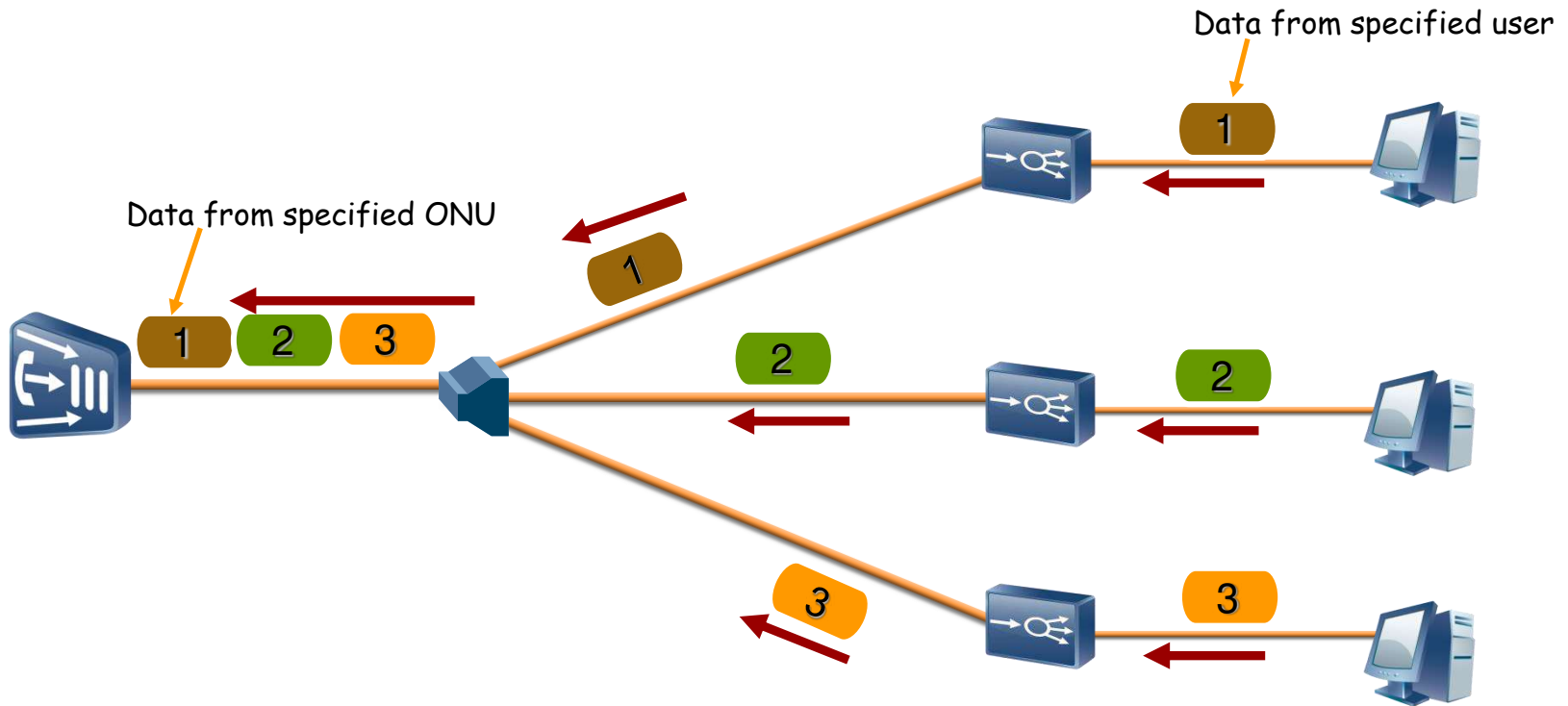
• TDMA (Time Division Multiplex Access) mode

GPON Network Model Reference

- OLT   Optical Line Terminal
- ONU   Optical Network Unit
- ONT   Optical Network Terminal
- ODN   Optical Distribution Network

- WDM   Wavelength Division Multiplex Module
- NE   Network Element
- SNI   Service Node Interface
- UNI   User Network Interface

Basic Performance Parameters

Upstream Rate(Gbps)	Downstream Rate(Gbps)
0.15552	1.24416
0.62208	1.24416
1.24416	1.24416
0.15552	2.48832
0.62208	2.48832
1.24416	**2.48832**
2.48832	2.48832

1.24416 Gbit/s up, 2.48832 Gbit/s down is the mainstream speed

Maximum logical reach	60 km
Maximum physical reach	20 km
Maximum differential fibre distance	20 km
Maximum Split ratio	1:128

The distance between nearest and farthest ONTs is 20 km

Attenuation and Power Budget

● Fiber attenuation relates to the fibre length

● The attenuation of fibre splicing point is

generally less than 0.2dB

● Other factors may cause attenuation, such

as fibre bending

> About 0.35 dB per km
> for 1310,1490nm

Table G.984.2 – Classes for optical path loss

	Class A	Class B	Class B +	Class C+
Minimum loss	5 dB	10 dB	13 dB	15 dB
Maximum loss	20 dB	25 dB	28 dB	30 dB
NOTE – The requirements of a particular class may be more stringent for one system type than for another, e.g. the class C attenuation range is inherently more stringent for TCM systems due to the use of a 1:2 splitter/combiner at each side of the ODN, each having a loss of about 3 dB.				

Questions

- PON system consists of __olt_____, ___odn___ and onu
- WDM is short for _wave devision multiplexing for comm between olt en onu
- The technology which GPON controls upstream data sending to avoid conflicts is called ___tdma_____for donwstream is broadcast___

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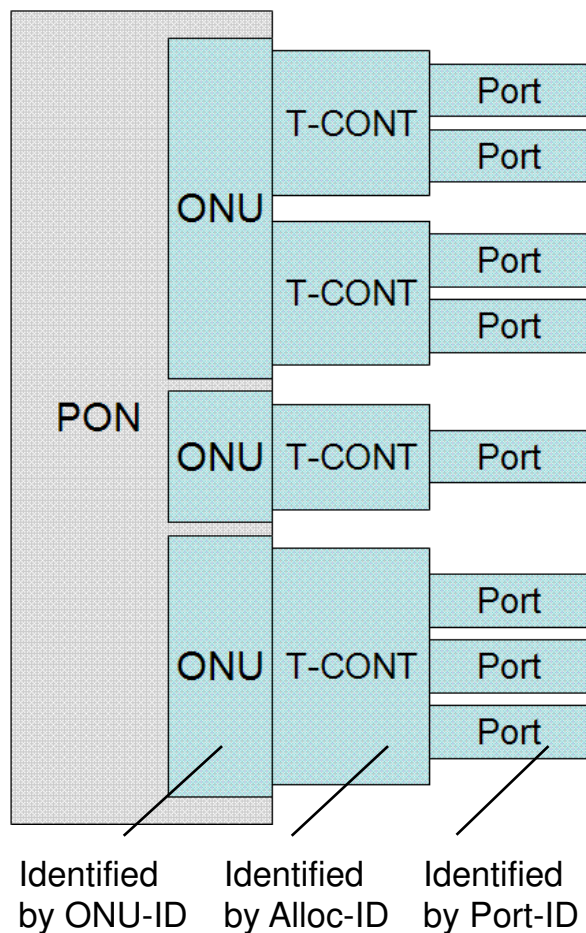**HUAWEI**

GPON Multiplexing Architecture - Upstream
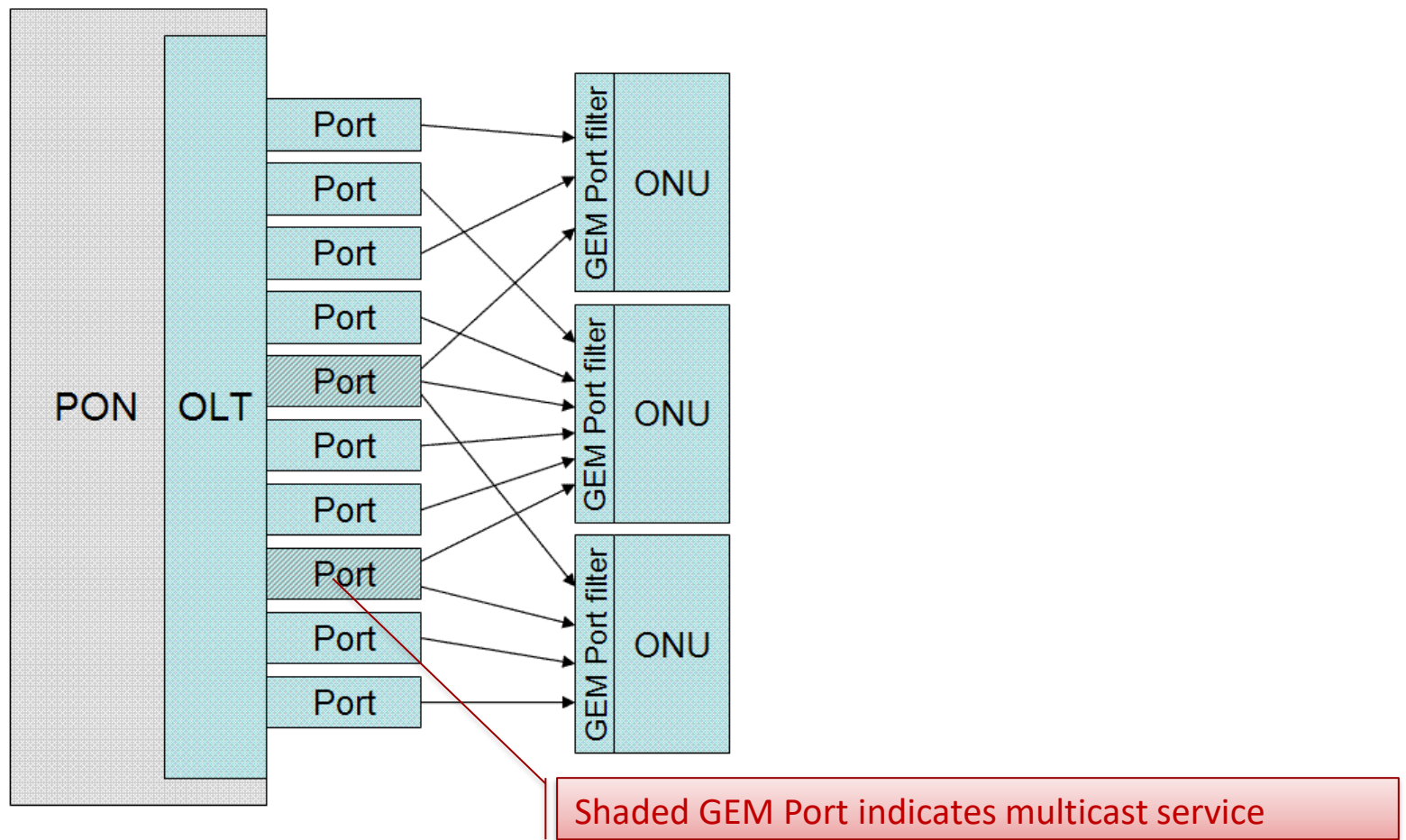

Figure 2 GPON service mapping relationship
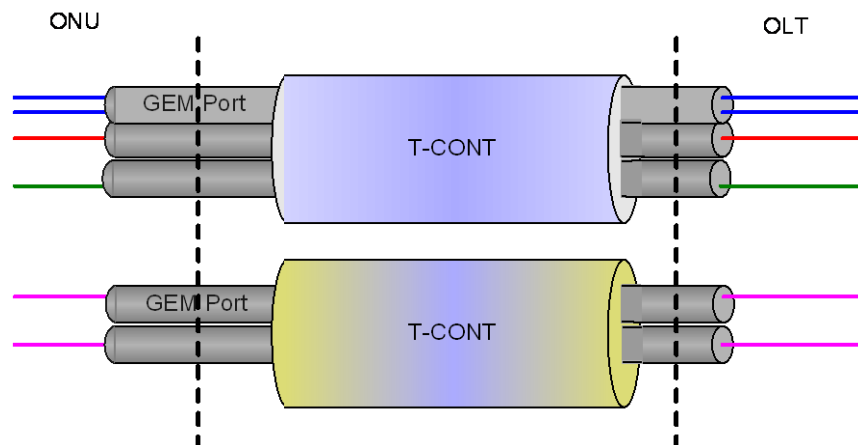
Figure 1 Principle of service multiplexing in the GPON system

GEM:GPON Encapsulation Mode
T-CONT:Transmission Container

GPON Multiplexing Architecture - Downstream
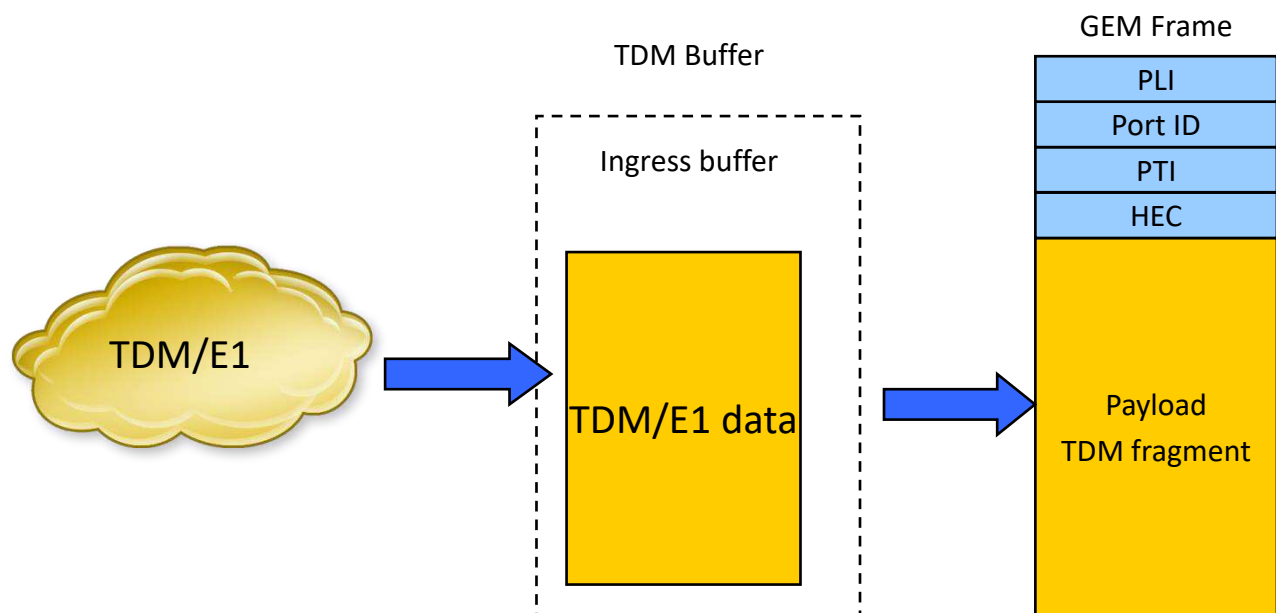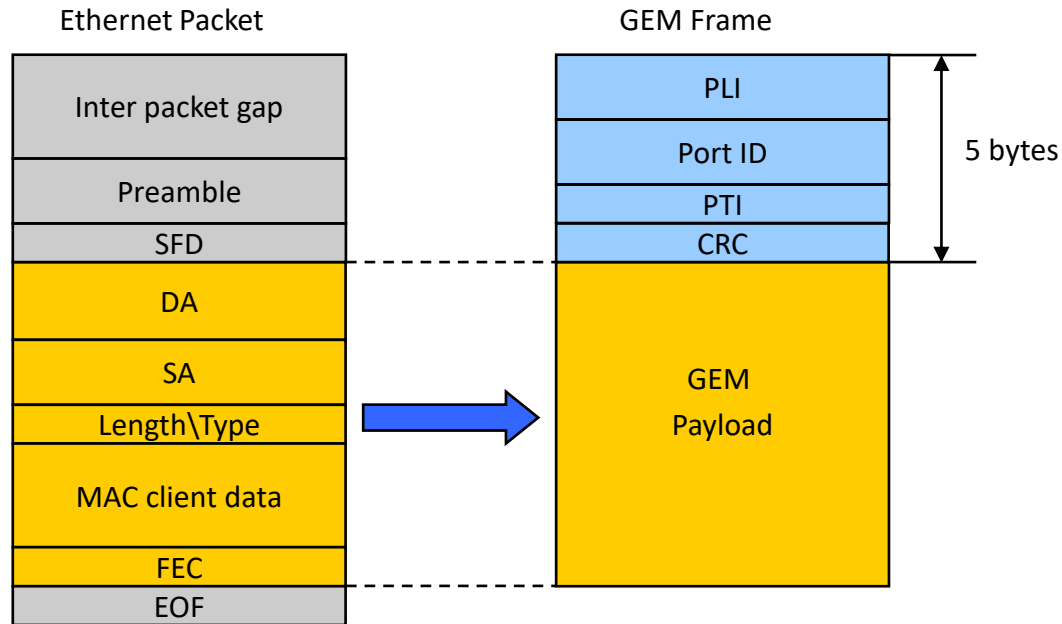

Shaded GEM Port indicates multicast service

GPON Frame Structure
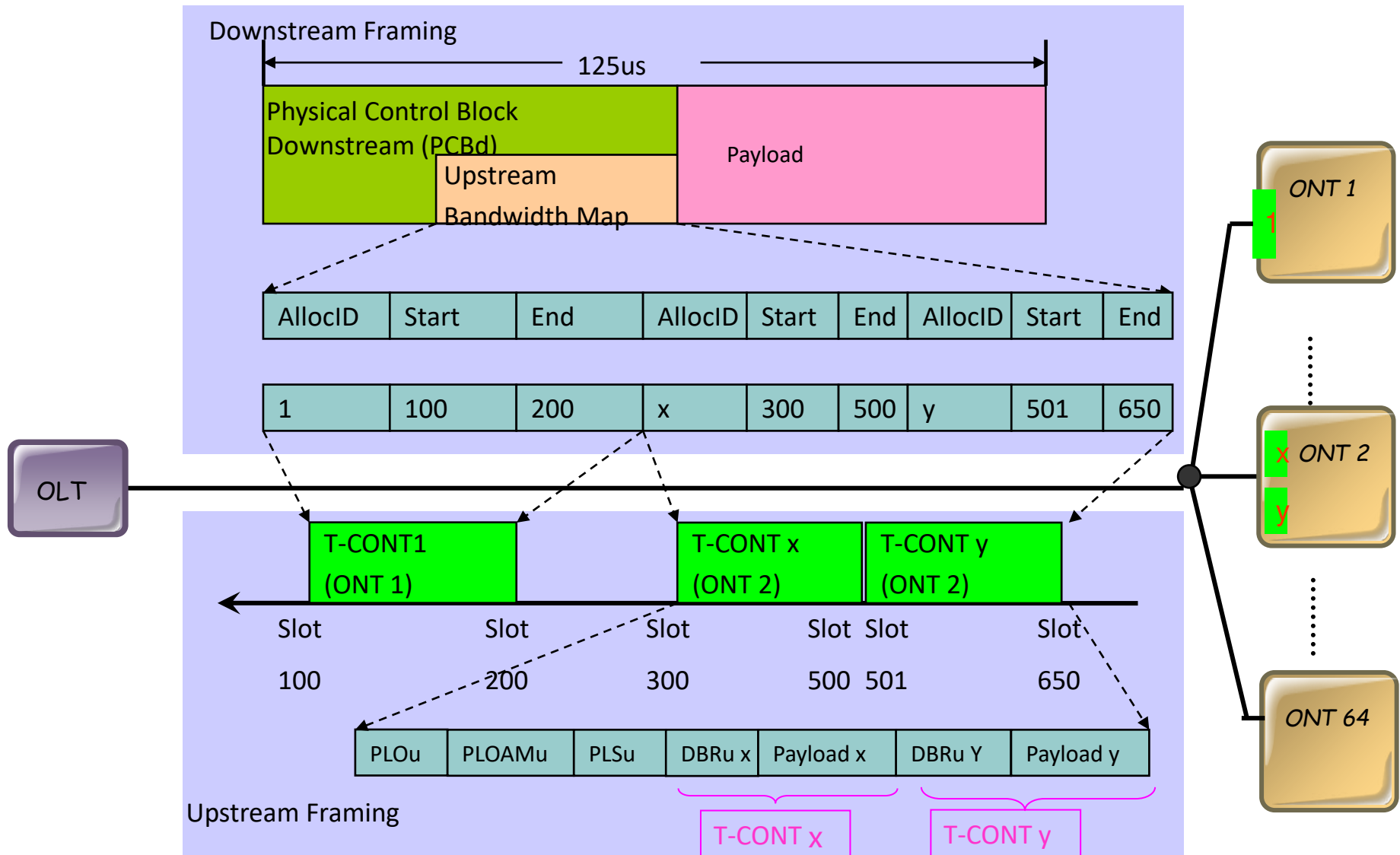
Mapping of TDM Service in GPON

TDM Buffer

GEM Frame

Ingress buffer

TDM/E1

TDM/E1 data

| PLI |
| Port ID |
| PTI |
| HEC |
| Payload TDM fragment |

- TDM frames are buffered and queued as they arrive, then TDM data is multiplexed in to fixed-length GEM frames for transmission.

- This scheme does not vary TDM services but transmit TDM services transparently.

- Featuring fixed length, GEM frames benefits the transmission of TDM services.

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Mapping of Ethernet Service in GPON

Ethernet Packet

GEM Frame

Ethernet Packet
Inter packet gap
Preamble
SFD
DA
SA
Length\Type
MAC client data
FEC
EOF

GEM Frame
PLI
Port ID
PTI
CRC
GEM Payload

5 bytes

●GPON system resolves Ethernet frames and then directly maps the data of frames into the GEM Payload.

● GEM frames automatically encapsulate header information.

● Mapping format is clear and it is easy for devices to support this mapping. It also boasts good compatibility.

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4. GPON Key Technologies

   4.1 DBA

   4.2 Encryption

DBA

- ● What is DBA?

  - ▫ DBA, Dynamic Bandwidth Assignment

- ● Why DBA?

  - ▫ It enhances the uplink bandwidth utilization of PON ports.

  - ▫ More users can be added on a PON port.

  - ▫ Users can enjoy higher-bandwidth services, especially those requiring comparatively greater change in terms of the bandwidth.

- ● DBA operation modes

  - ▫ SR-DBA: status report-DBA

  - ▫ NSR-DBA: non status report-DBA

SR-DBA Working Principle
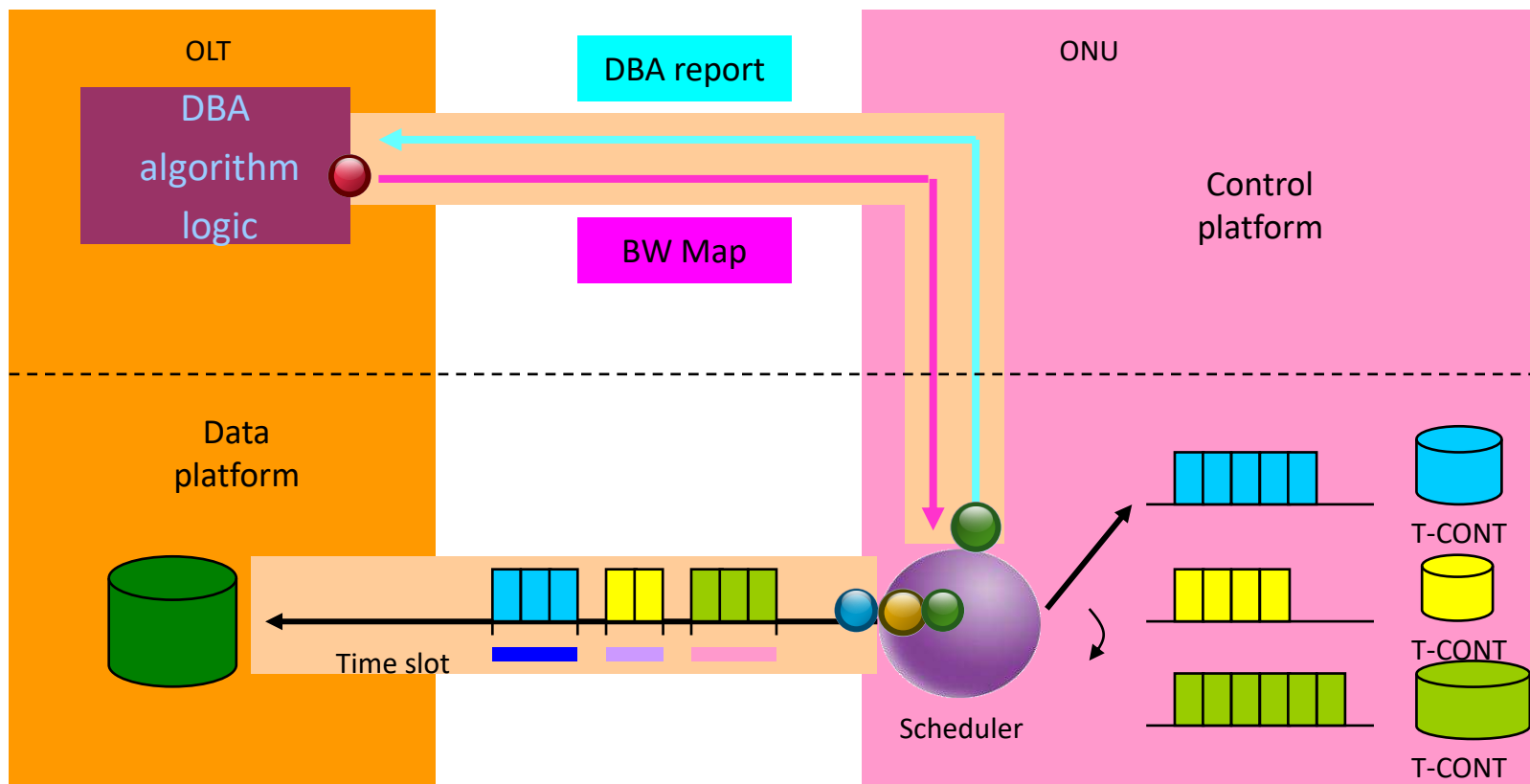
- DBA block in the OLT constantly collects information from DBA reports, and sends the algorithm result in the form of BW Map to ONUs .

- Based on the BW Map, each ONU sends upstream burst data on time slots specified to themselves and utilizes the upstream bandwidth.

SR-DBA Operation
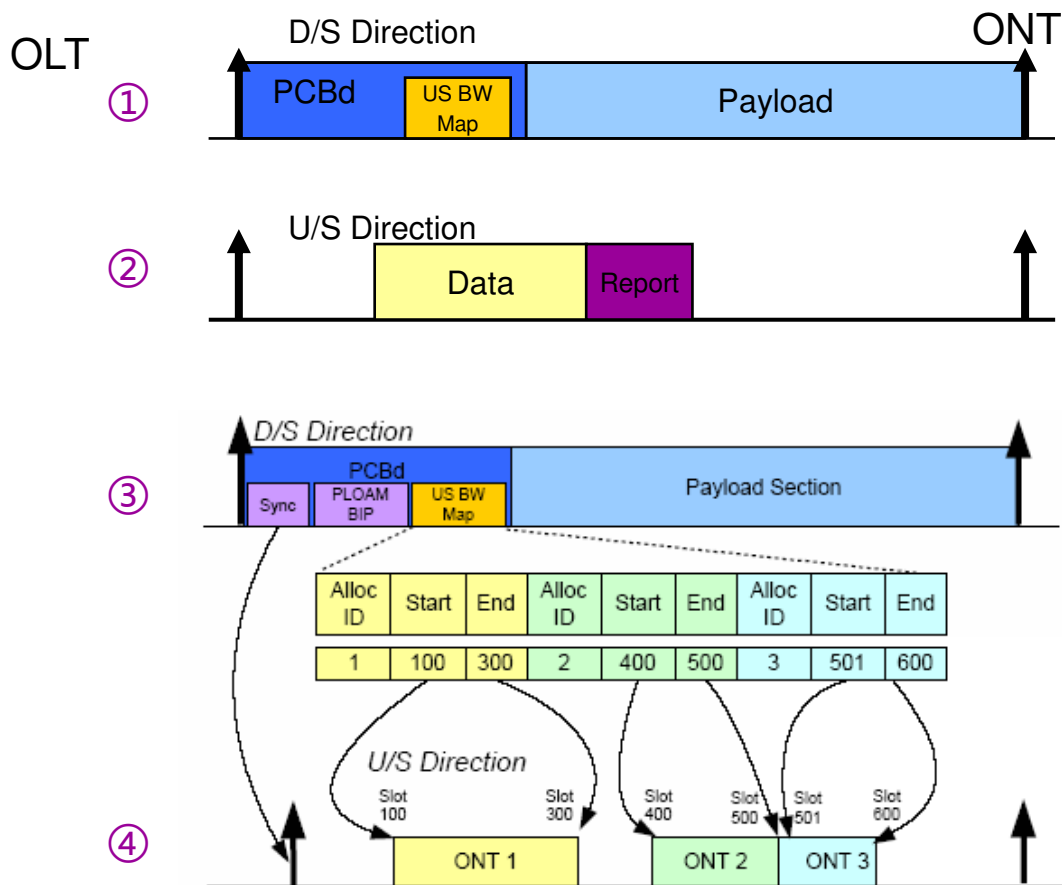
- Based on the algorithm result of last time, OLT delivers BW Map in the header of downstream frame.

- Based on the bandwidth allocation information, ONU sends the status report of data currently waiting in T-CONTs in the pecified time slots.

- OLT receives the status report from the ONU, pdates BW Map through DBA algorithm and hen delivers the new BW Map in the next rame.

- ONU receives the BW Map from the OLT and ends data in the specified time slots.

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T-CONT Bandwidth Terms

● Transmission Containers (T-CONTs): it dynamically receives grants delivered by OLT. T-CONTs are used for the management of upstream bandwidth allocation in the PON section of the Transmission Convergence layer. T-CONTs are primarily used to improve the upstream bandwidth utilization in the PON.

● T-CONT BW type falls into FB, AB, NAB, and BE.

● Five T-CONT types: Type1, Type2, Type3, Type4, and Type5.
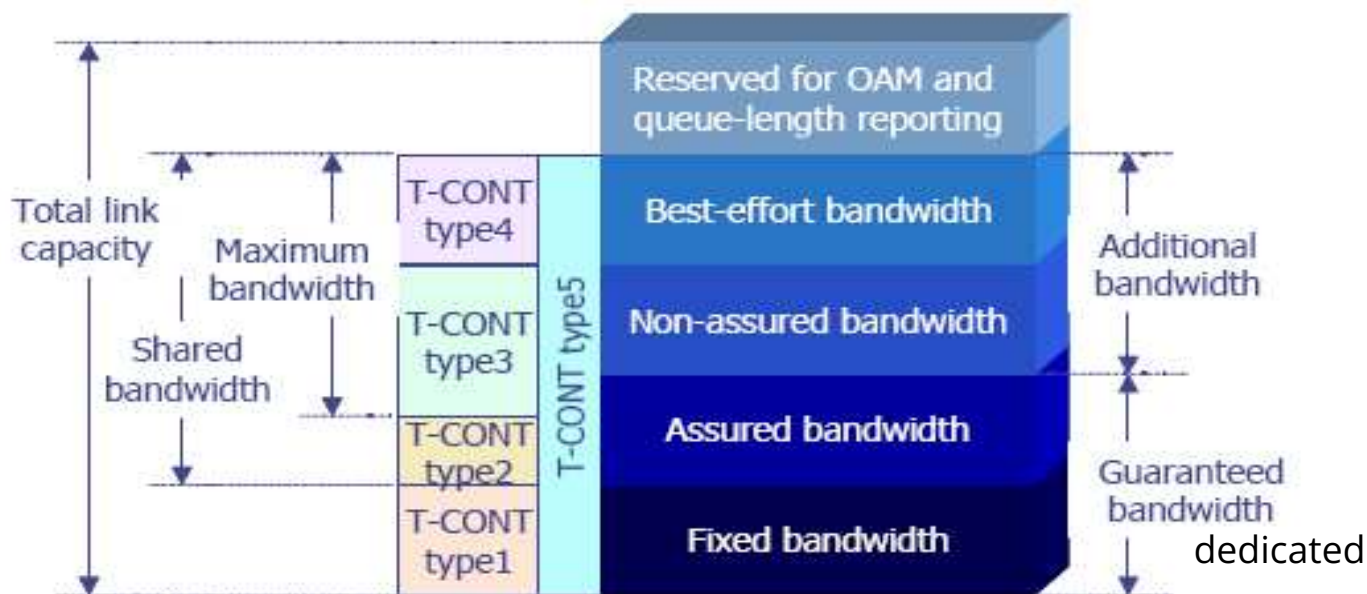
T-CONT Type and Bandwidth Type

Bandwidth Type	T-CONT Type				
	Type 1	Type 2	Type 3	Type 4	Type 5
Fixed Bandwidth	X	No	No	No	X
Assured Bandwidth	No	Y	Y	No	Y
Maximum Bandwidth	Z = X	Z = Y	Z > Y	Z	Z ≥ X + Y

- Type1 T-CONT is the fixed bandwidth type and mainly used for services sensitive to time delay and of higher priorities, such as voice services.

- Type2 and type3 T-CONT is the guaranteed bandwidth type and mainly used for video services and data services of higher priorities.

- Type4 is of the best-effort type and mainly used for data services (such as Internet and email), and services of lower priorities. These services do not require high bandwidth.

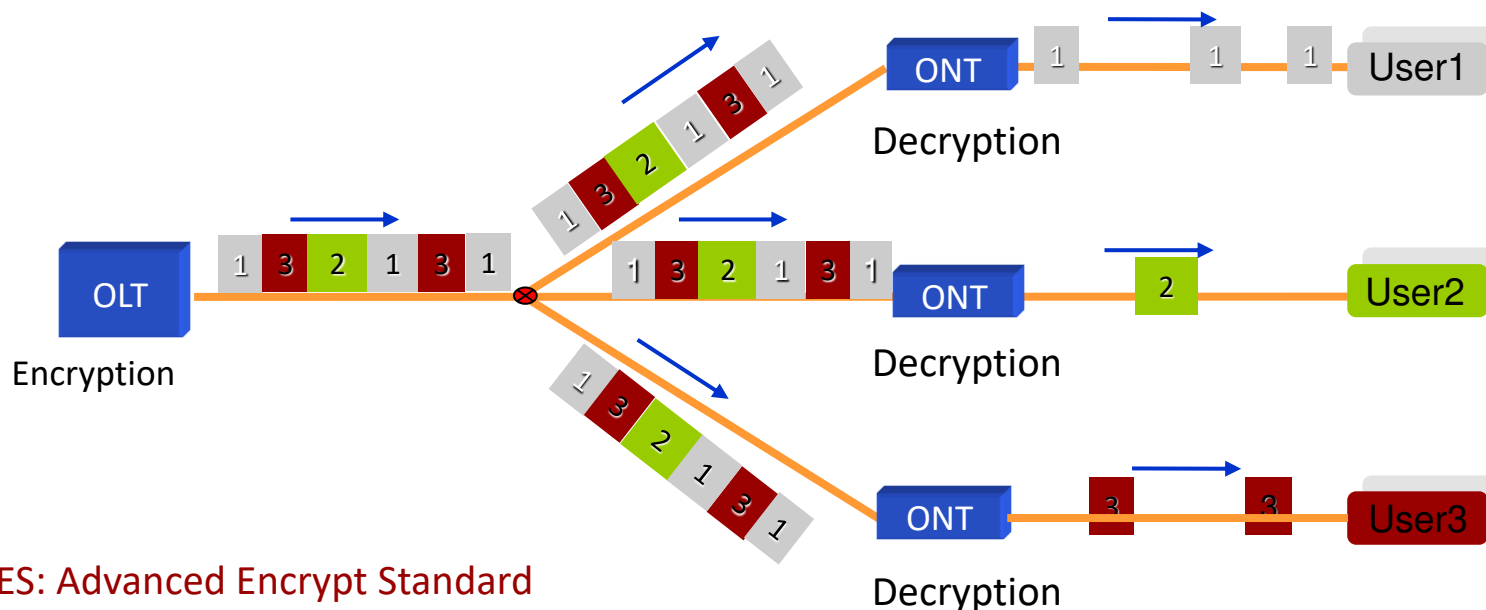- Type5 is of the mixed T-CONT type, involving all bandwidth types and bearing all services.

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4. GPON Key Technologies

4.1 DBA

4.2 Encryption

AES Encryption in GPON

AES: Advanced Encrypt Standard

A globally-used encryption algorithm

- OLT applies Advanced Encryption Standard (AES) 128 encryption.
- GPON supports encrypted transmission in downstream direction, such as AES128 encryption.
- In the case of GEM fragments, only the payload will be encrypted.
- GPON system initiates AES key exchange and switch-over periodically, improving the reliability of the line.

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GPON Terminal Authentication and Management

- GPON terminal authentication is a mechanism in which an OLT authenticates an ONU by the SN or password of the ONU and in this way denies access to unauthorized ONUs.

    - In the GPON system, only authenticated ONUs can access the system. Implementing authentication meets the carriers' requirements for flexible management and easy maintenance.

- GPON ONU main authentication:

    - SN authentication(mainly)

    - Password authentication(mainly),
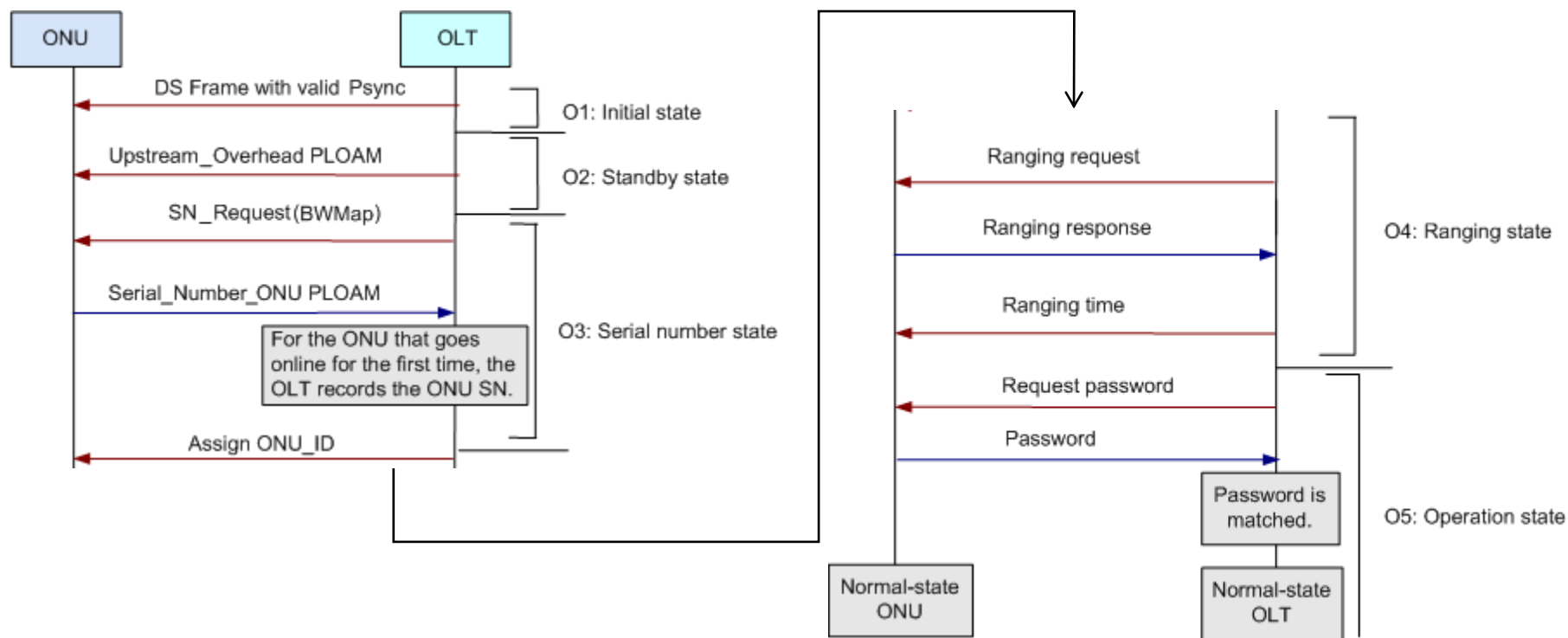
    - SN+Password authentication

SN authentication

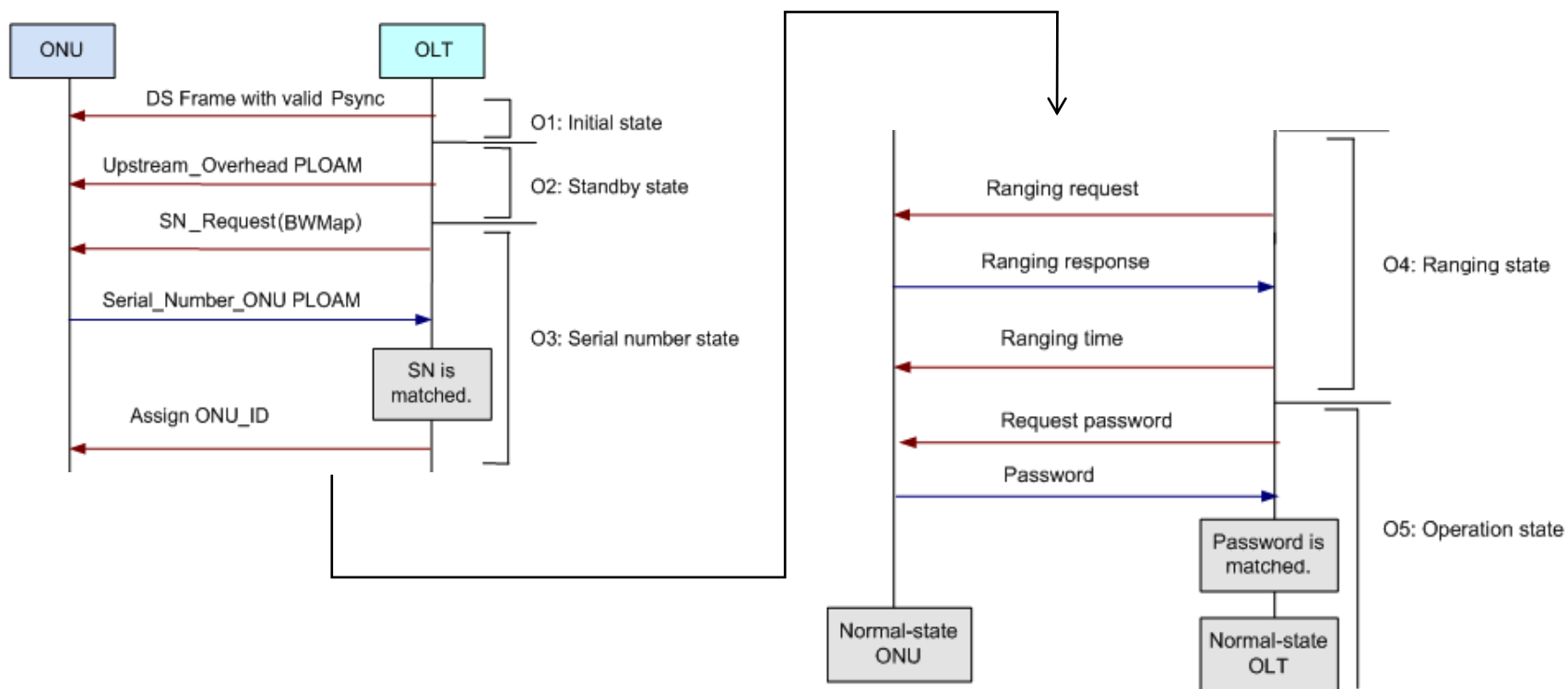- In SN authentication, the OLT matches only the ONU SN
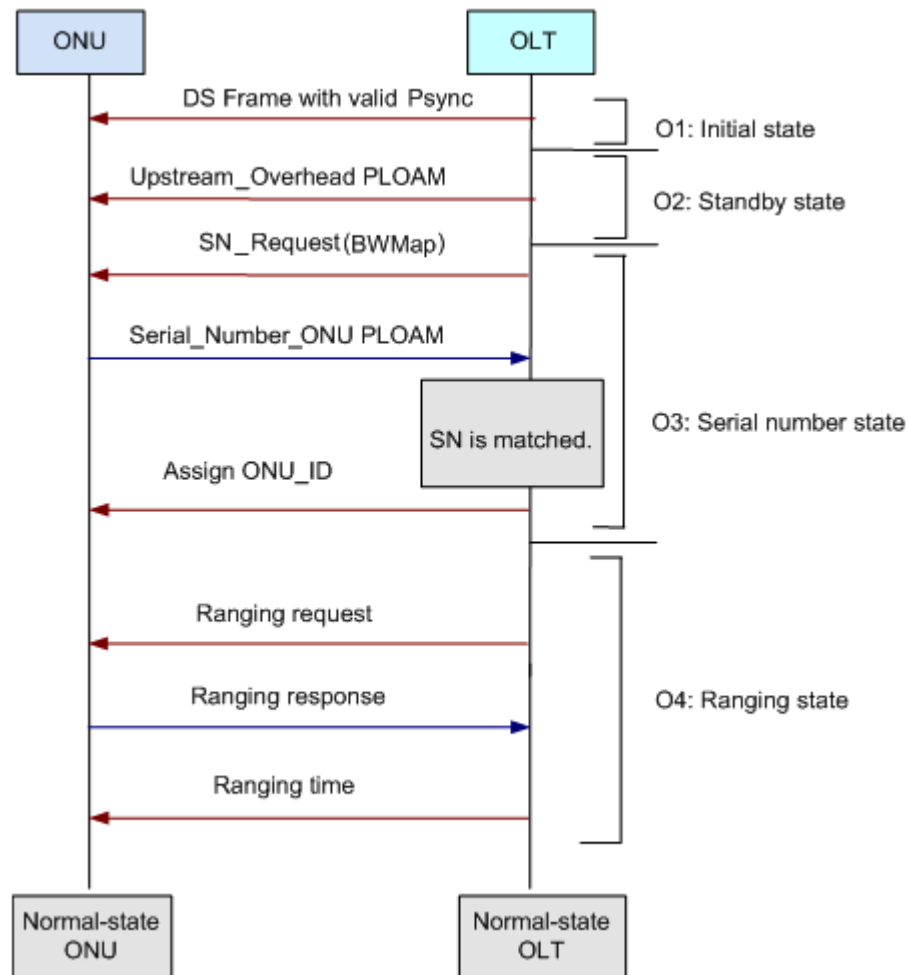
Password authentication

- In password authentication, the OLT matches the ONU password
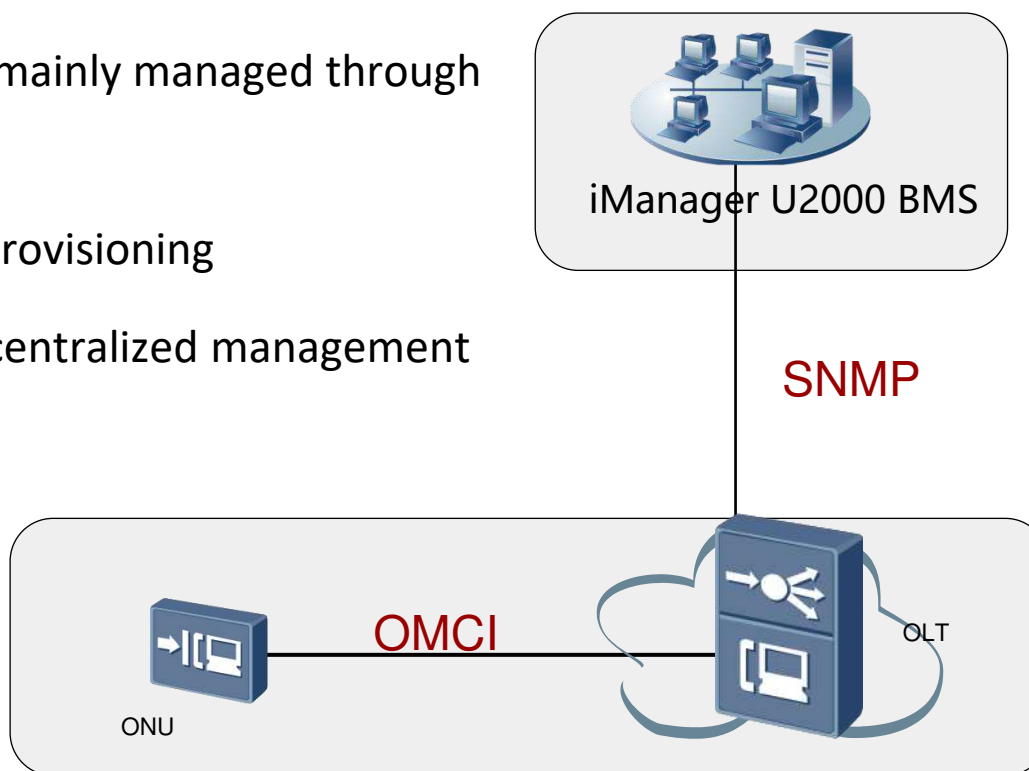
SN+Password authentication

- In SN+password authentication, the OLT matches both the ONU SN and password
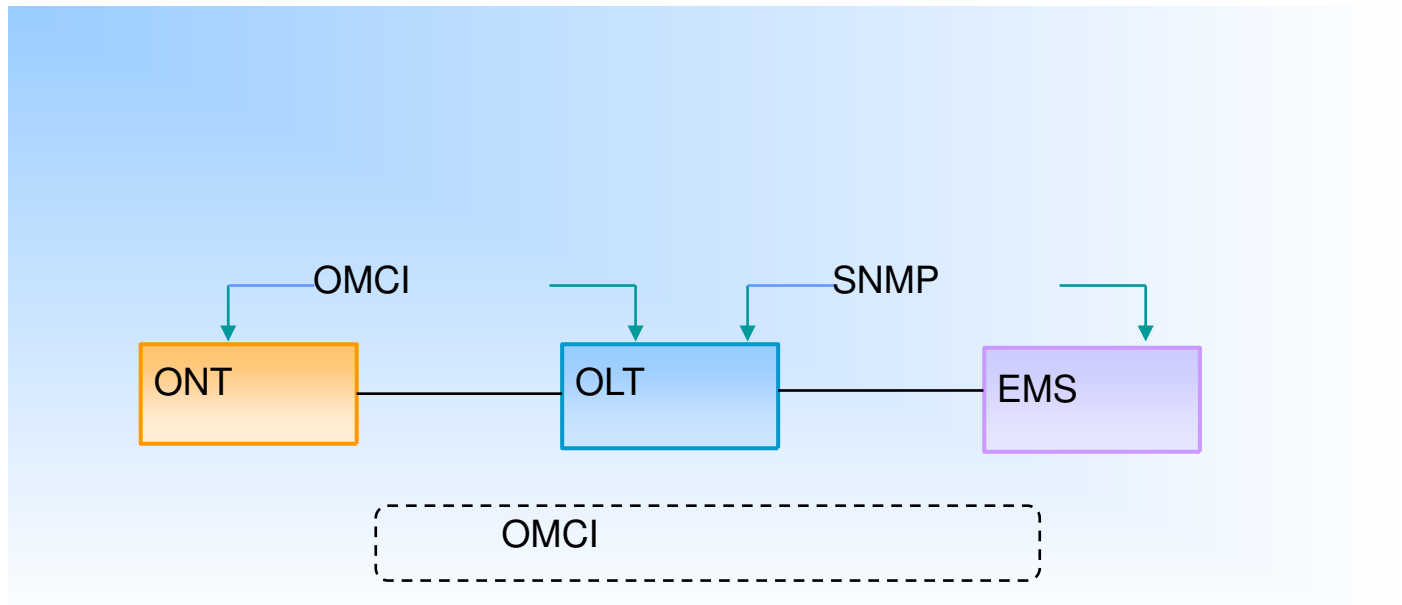
GPON Terminal Management

●GPON system are mainly managed through OMCI messages：

    ◻ONU service provisioning

    ◻ONU remote centralized management

iManager U2000 BMS
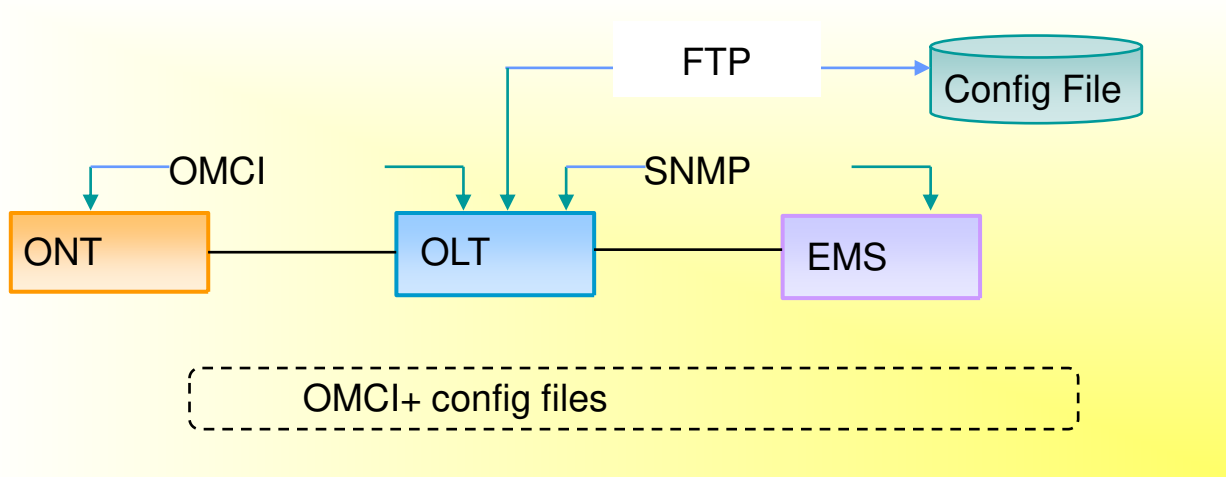
SNMP

OMCI

ONU

OLT

OMCI Mode

- Internet service/IPTV service configuration

    - delivery through OMCI

OMCI+config files Mode

- Internet service/IPTV service configuration

  - delivery through OMCI

- VOIP service configuration :

  - OLT download configuration files from the network management by FTP, then distributed it to ONT through OMCI channel

OMCI+SNMP Mode

- All the service configuration is issued to the ONT by EMS through SNMP method

- All the service of ONT is configured through CLI (command Line Interface)

  - Login the system through *telnet* method

  - The IP address of VLAN or METH port can be issued to ONT through OMCI method
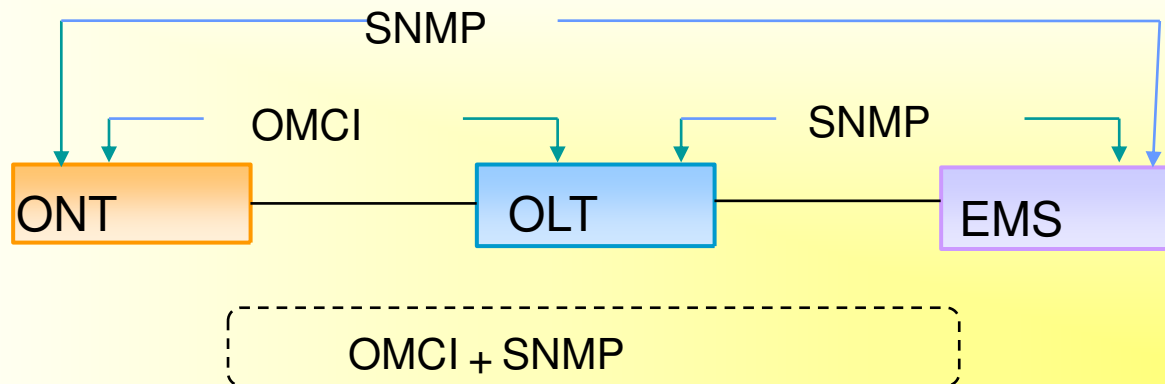
OMCI+TR069 Mode

- The OMCI still for the PON link layer configuration management, status performance management, fault management

- IP-based business (such as: Internet services, VoIP services, etc.) managed by ACS through TR-069
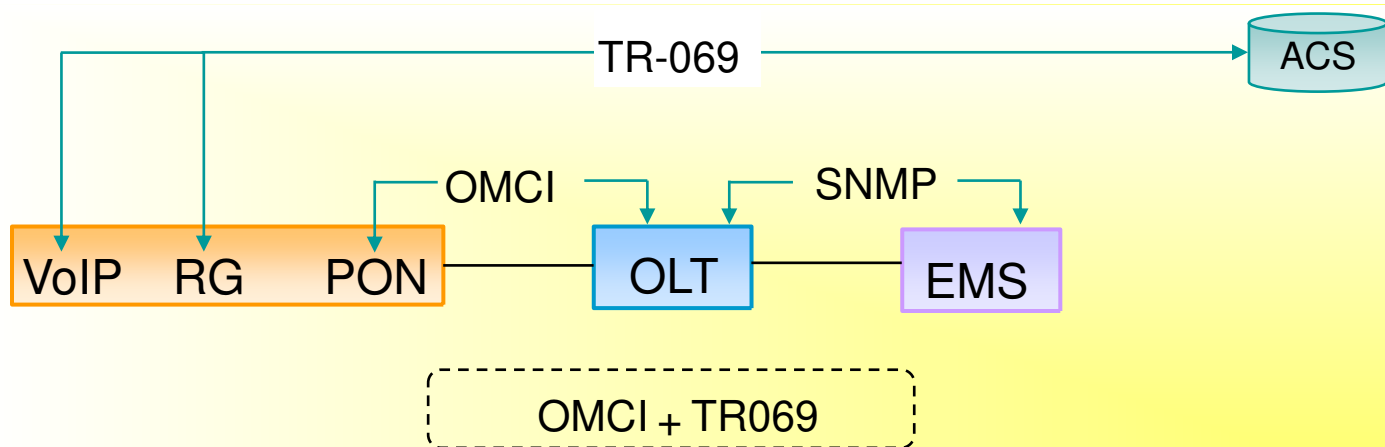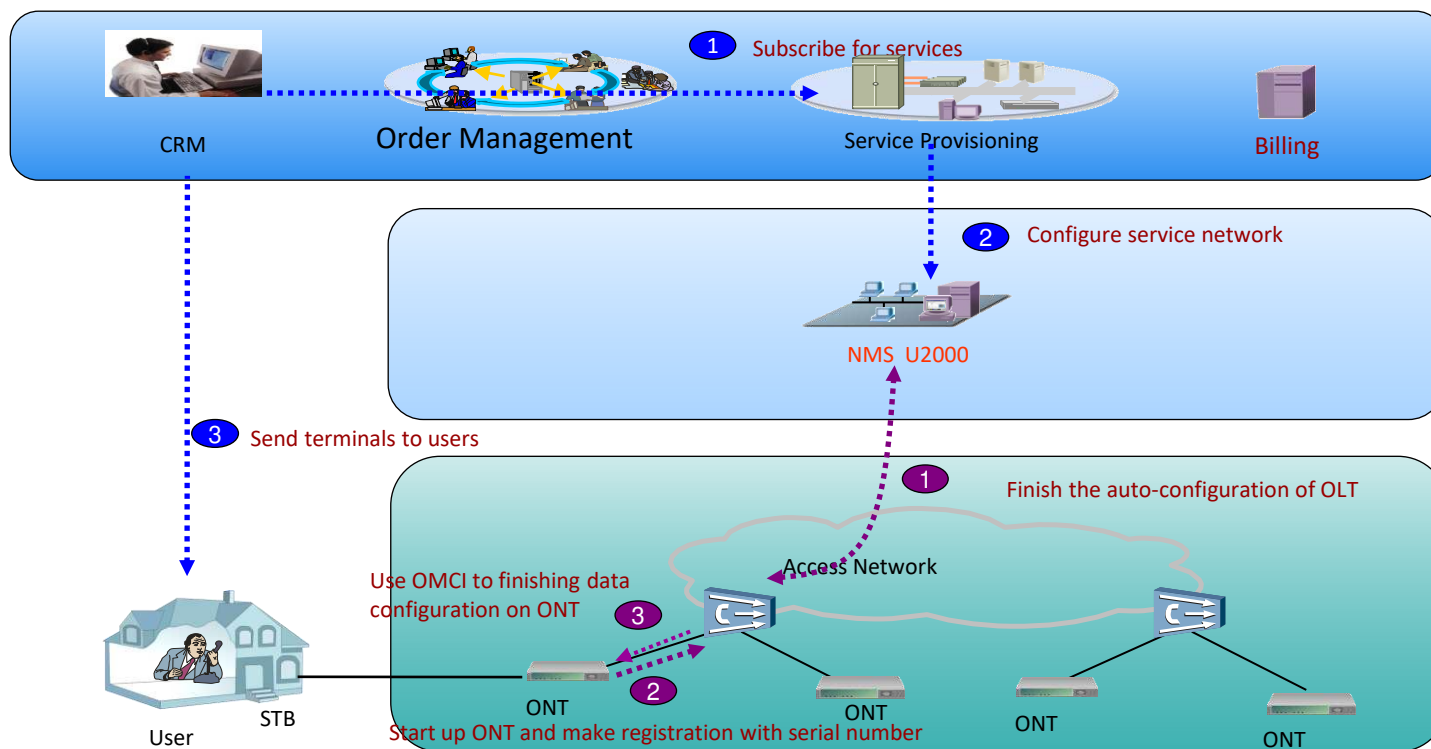
GPON Service Provisioning

Carriers' nightmare
Initial configurations (such as service system information configuration, data configuration) are required on terminals and then they can be put into use. To finish these configurations, it is not cost-effective to carriers.

Flexible Configuration plan of GPON

GPON supports zero configuration on terminals and plug-and-play of terminals, which is cost-effective.
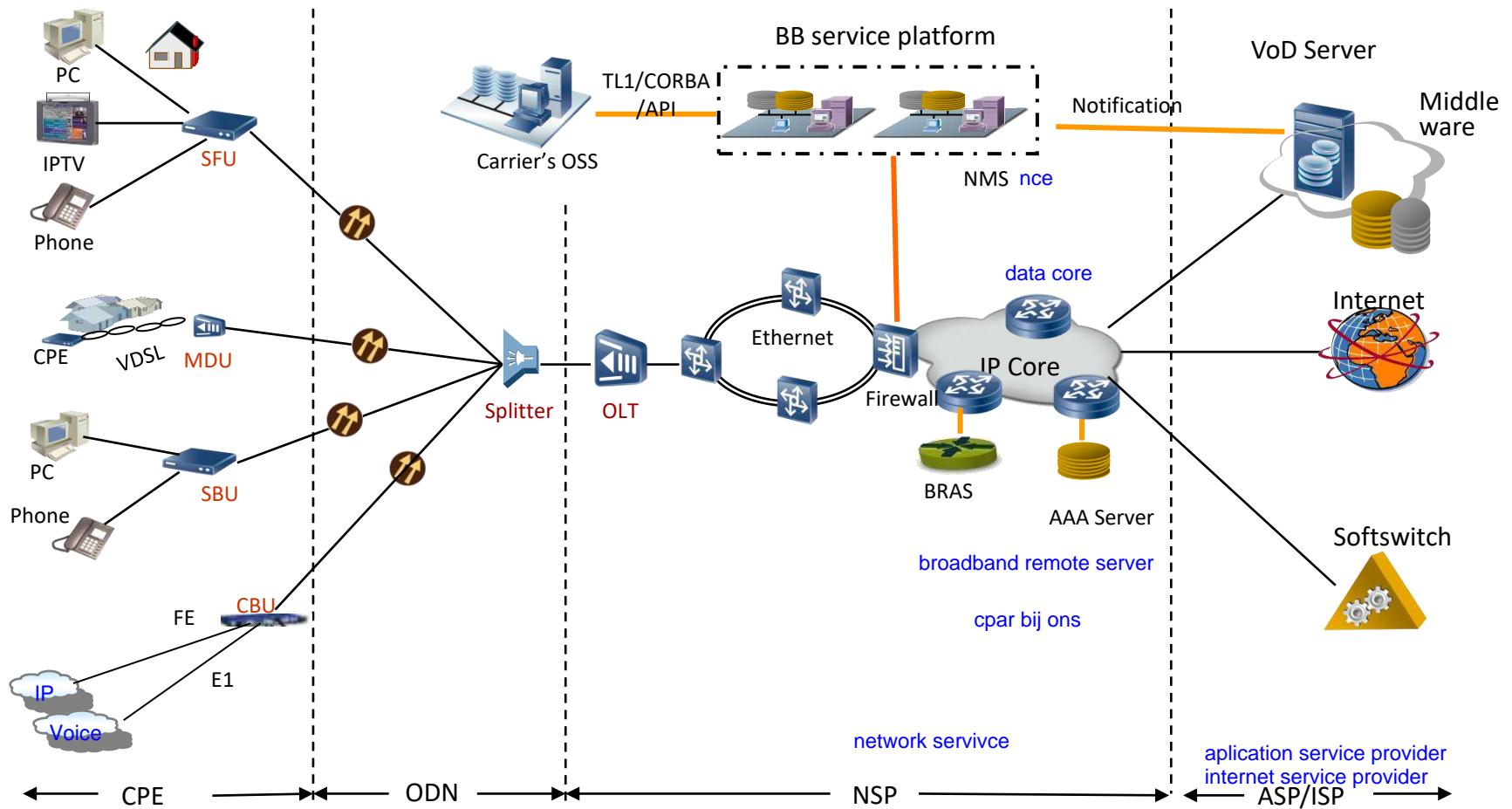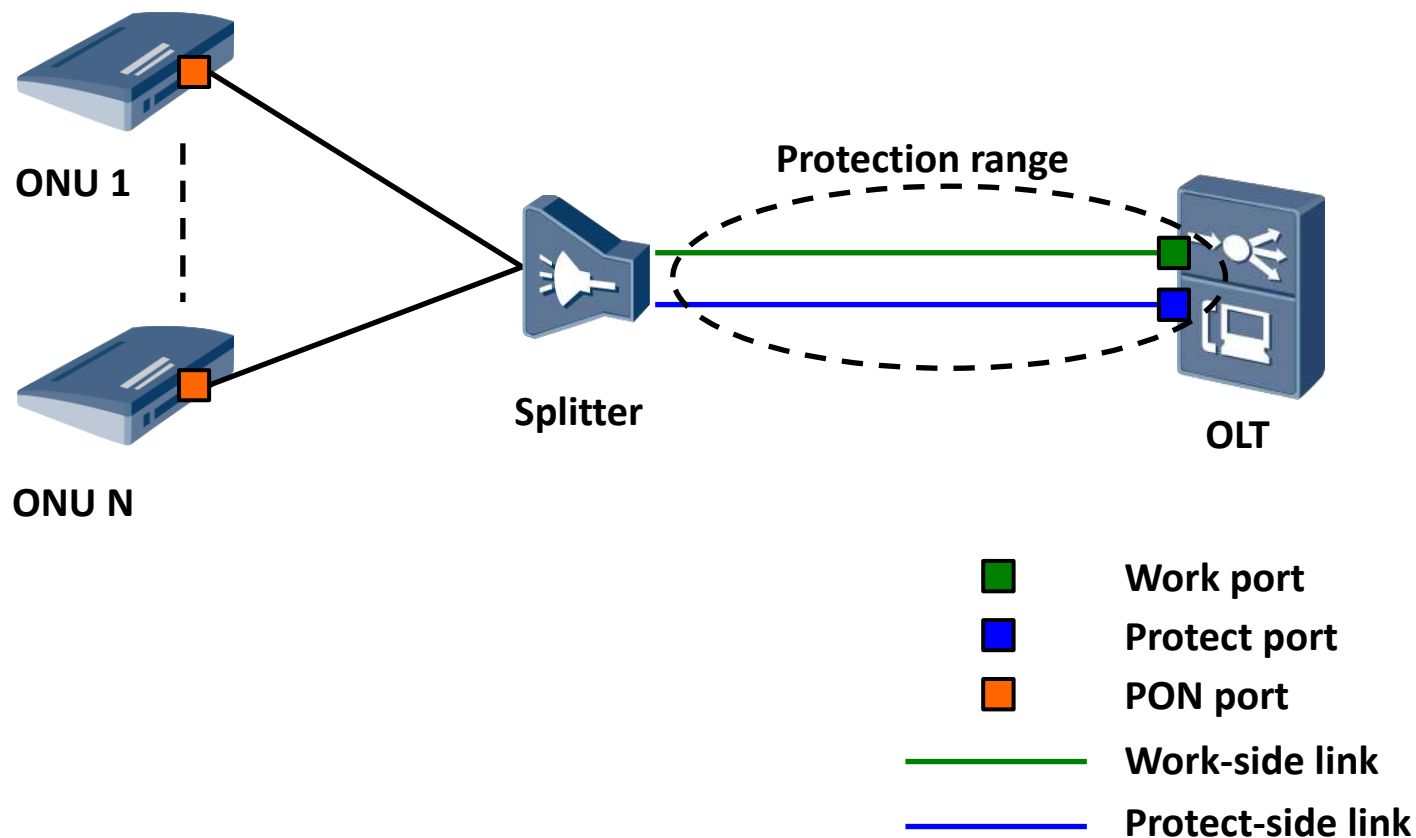
Application scenario

CRM

Order Management

1 Subscribe for services

Service Provisioning

Billing

2 Configure service network

NMS U2000

3 Send terminals to users

1 Finish the auto-configuration of OLT

Access Network

Use OMCI to finishing data configuration on ONT

3

User

STB

ONT

2

Start up ONT and make registration with serial number
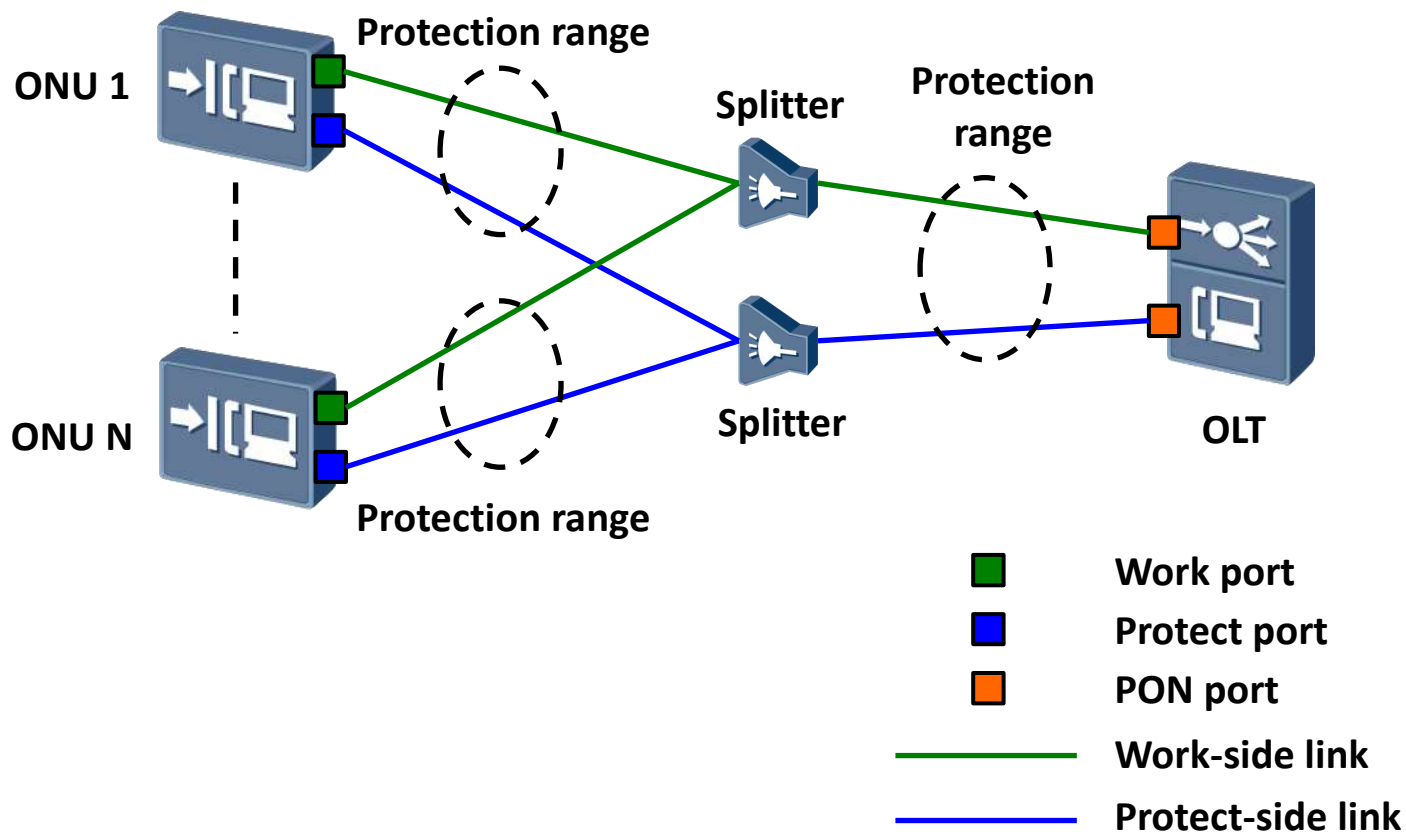
ONT

ONT

ONT

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Triple Play Solution in GPON

GPON Protection: Type B

GPON Protection: Type C Single Homing

GPON Protection: Type C Dual Homing
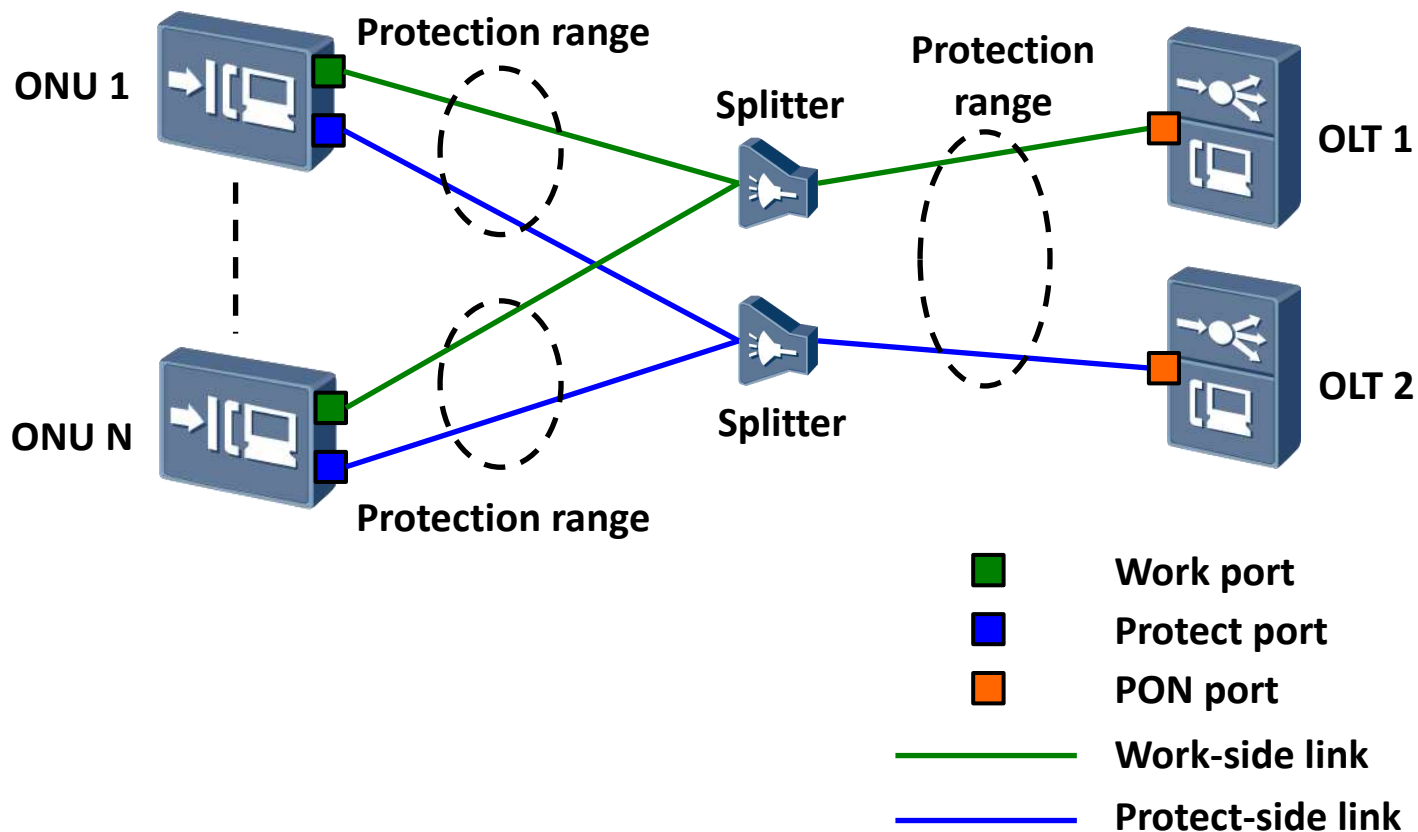
Contents
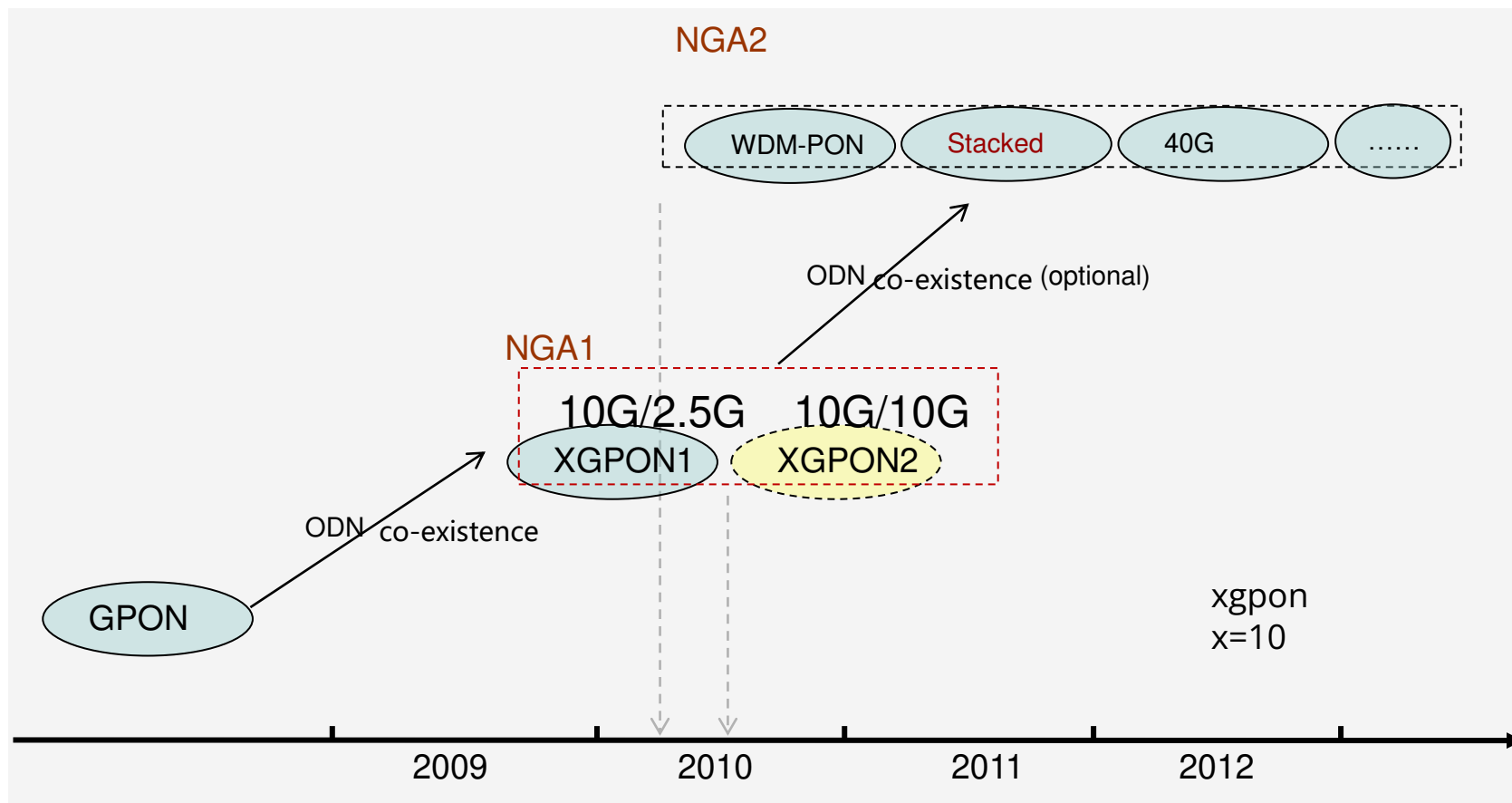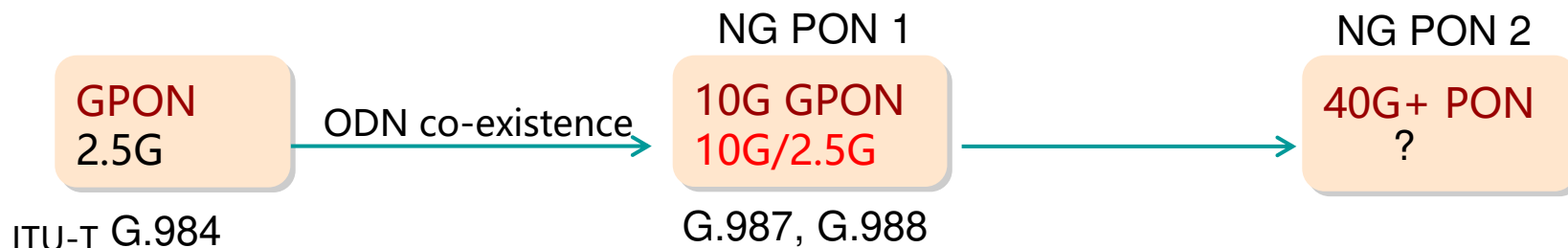
NG-PON Standards

next generation

NGA2

WDM-PON   Stacked   40G   ......

ODN co-existence (optional)

NGA1

10G/2.5G   10G/10G

XGPON1   XGPON2

ODN co-existence

GPON

xgpon
x=10

2009   2010   2011   2012

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10G GPON Standards

NG PON 1   NG PON 2

| GPON 2.5G | ODN co-existence → | 10G GPON 10G/2.5G | → | 40G+ PON ? |

ITU-T G.984   G.987, G.988

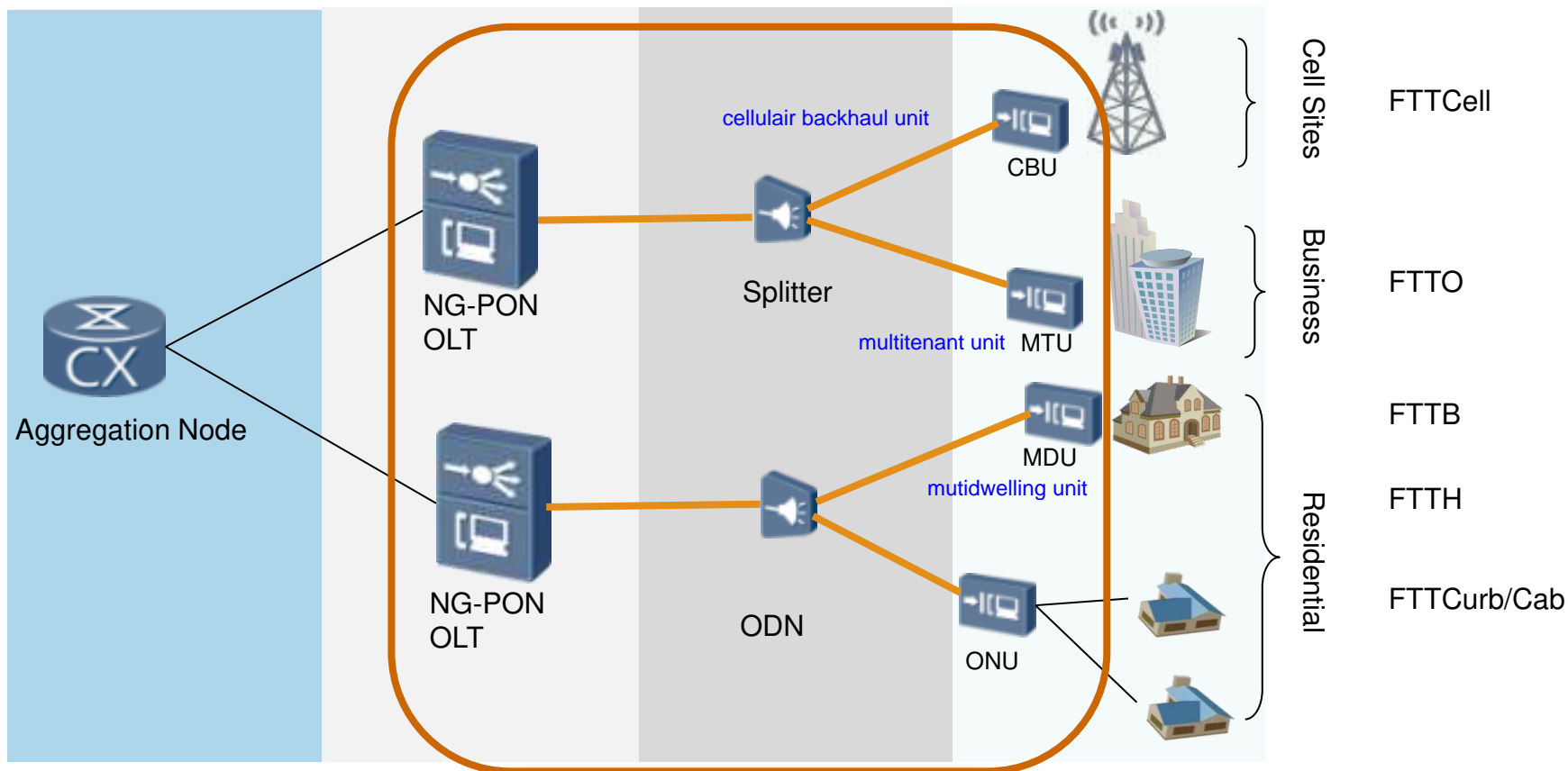- 10G GPON is the Technology Choice of NG PON 1

- 10G GPON is the upgrade version of GPON and inherits major technology features of GPON

  - with increase of bandwidth and improved service supporting capability

  - Bandwidth capability increased 4-fold and optical power budget up to 33/35dB

  - 10G GPON co-exists with GPON ODN

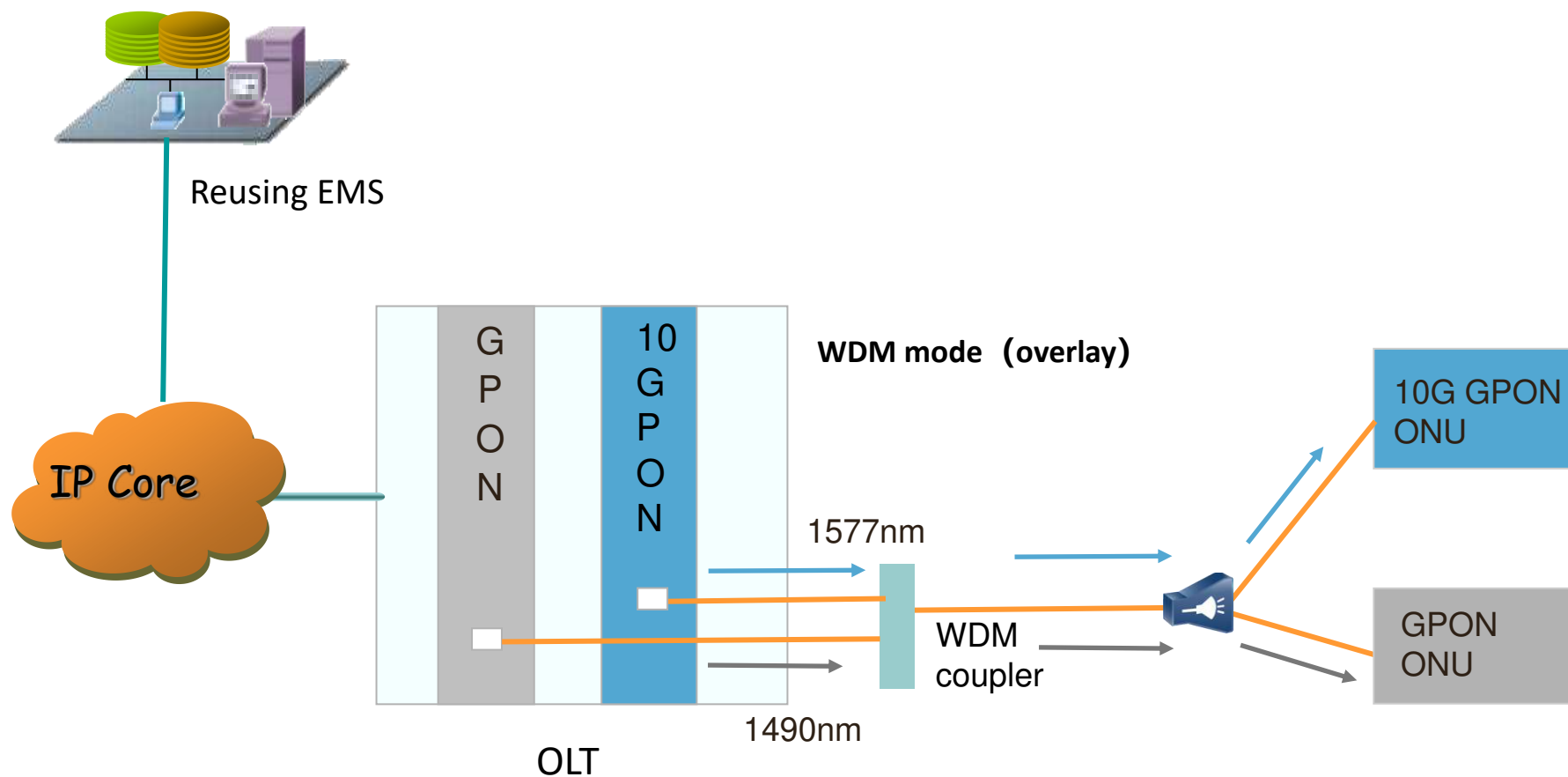 - Current equipment, EMS and OSS can be smoothly upgraded to 10G GPON

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10G GPON vs GPON

	10G GPON （G.987)	GPON （G.984)
Wave Length	DS 1575~1580nm US 1260~1280nm	DS 1480-1500nm US 1260-1360nm
Bandwidth	DS 9.95328Gbps US 2.48832Gbps	DS 2.48832Gbps US 1.24416Gbps/2.48832Gbps
Optical Power Budget	NGA1：29dB NGA2：31dB Extend：33 or 35dB	Class A: 5-20dB Class B: 10-25dB Class C: 15-30dB Class C+: 17-32dB
Max Logical Reach	100km	60km
Max Differencial Reach	40km	20km
Splitting Ratio	1:256	1:128
Frame Structure	XGEM	GEM
Authentication	bidirectional authentication on OLT and ONU	One-way authentication(OLT to ONU)
Number of TCONT support by each PON Port	MAX 2048	MAX 1024

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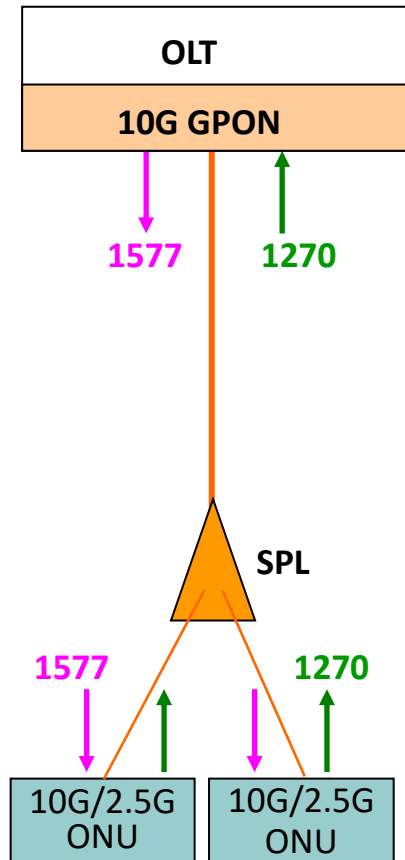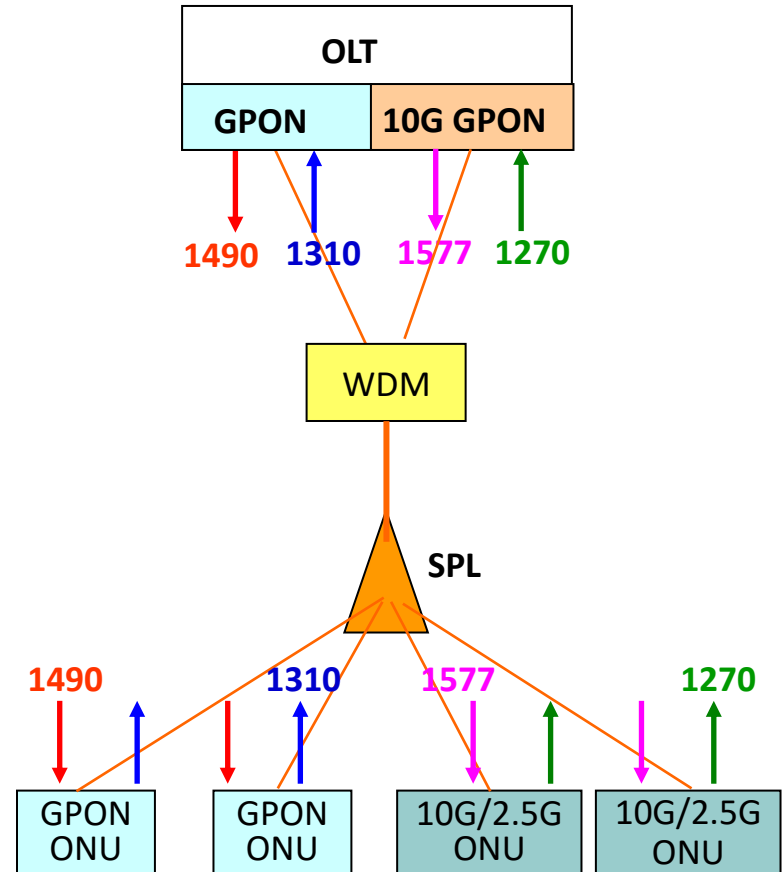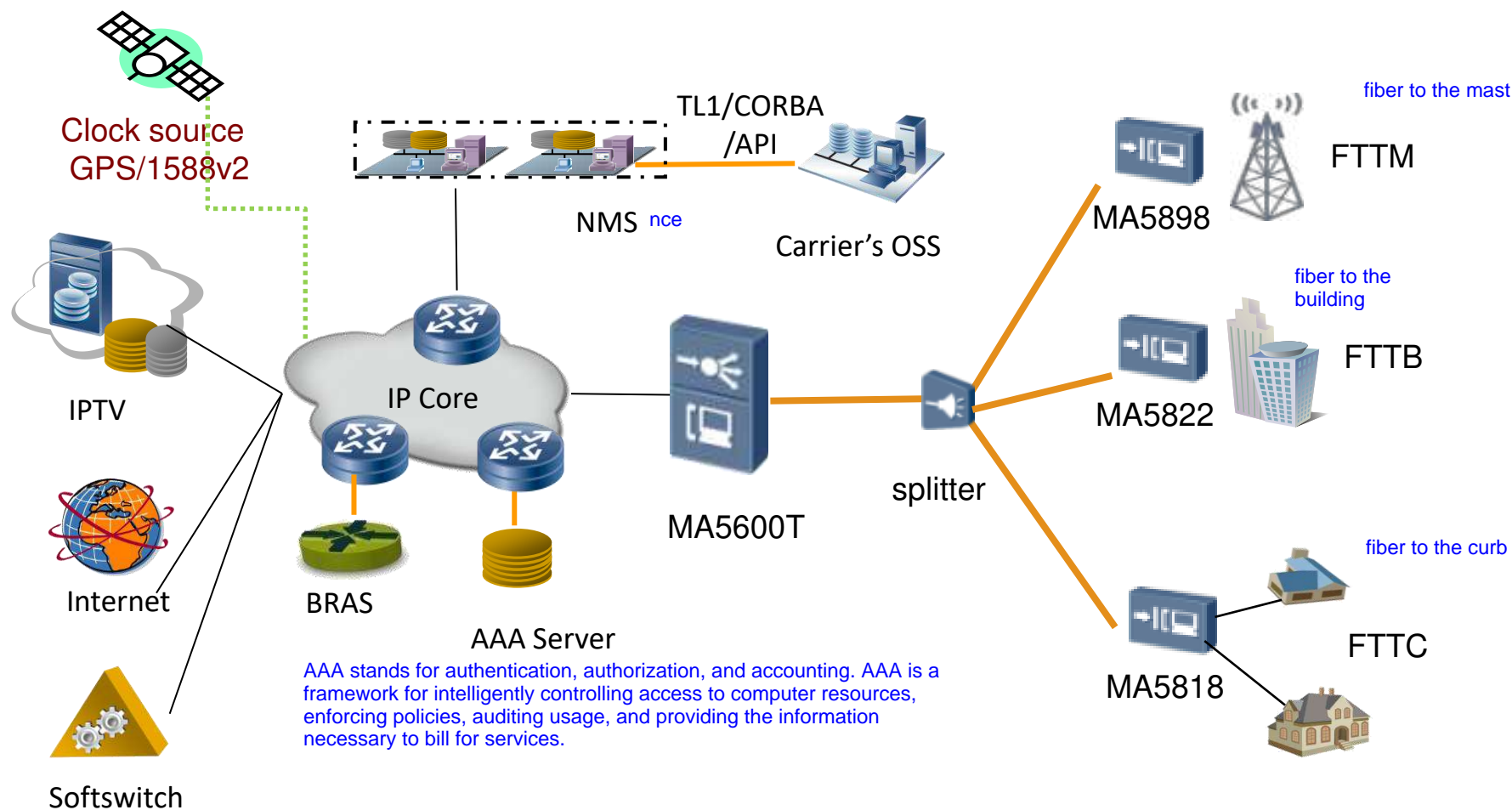# 10G GPON Network

GPON Migration to 10G PON

Reusing EMS

IP Core

OLT

G P O N

10 G P O N

WDM mode （overlay）

1577nm

WDM coupler

1490nm

10G GPON ONU

GPON ONU

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10G GPON Networking Mode

Independent mode

Mixed mode

10G GPON Network Application

Clock source GPS/1588v2

TL1/CORBA/API

NMS nce

Carrier's OSS

fiber to the mast

MA5898 — FTTM

fiber to the building

MA5822 — FTTB

fiber to the curb

MA5818 — FTTC

IPTV

Internet

Softswitch

IP Core

BRAS

AAA Server

MA5600T

splitter

AAA stands for authentication, authorization, and accounting. AAA is a framework for intelligently controlling access to computer resources, enforcing policies, auditing usage, and providing the information necessary to bill for services.

Summary

- In this presentation, we introduced GPON basic concepts, architecture and principles.

- We also discussed about GPON terminal authentication and management and GPON service provisioning.

- We introduced GPON network application and protection.

- At last, we introduced NG PON technologies briefly and 10G GPON network application.

Thank you

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