

PON

JUG

BANGKOK DATACOM CO., LTD.

WWW.BDC.CO.TH

Topic

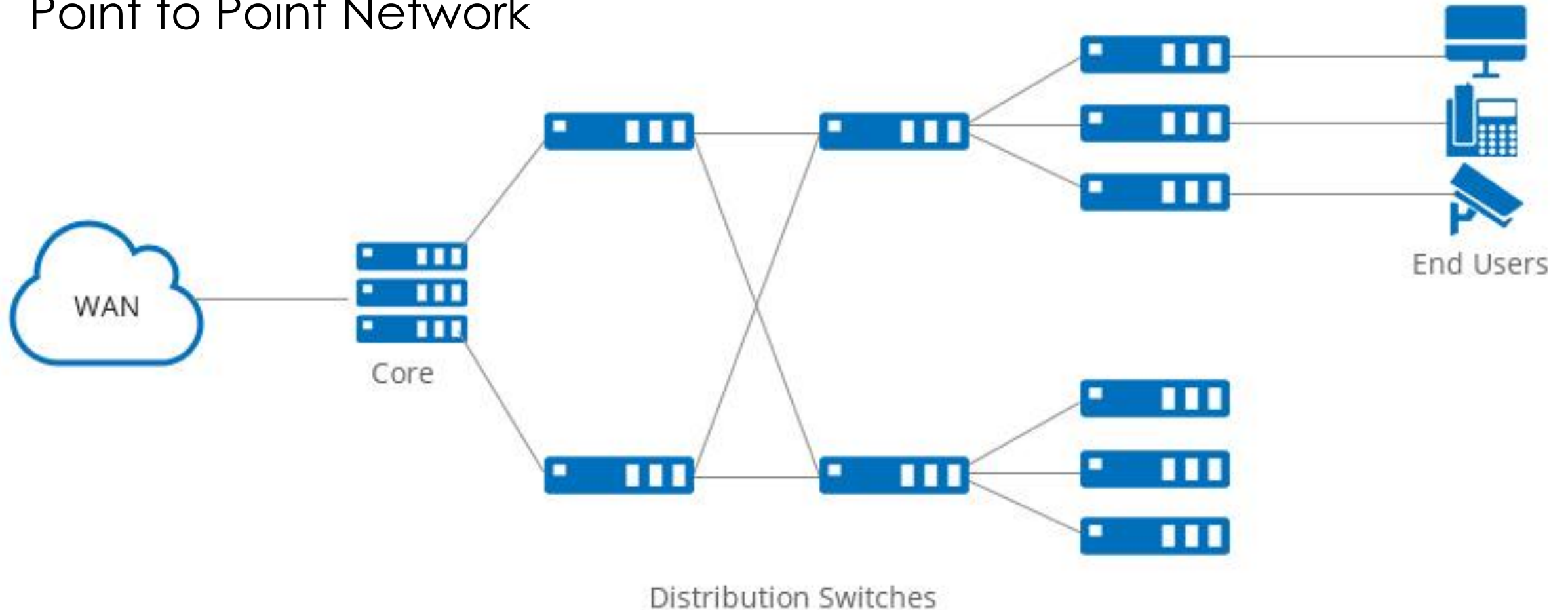
- ❑ **What is PON?**
- ❑ PON standards and Component
- ❑ Advantages of PON
- ❑ PON testing and maintenance
- ❑ Next Generation PON

What is PON?

- PON = Passive Optical Network
- AON = Active Optical Network

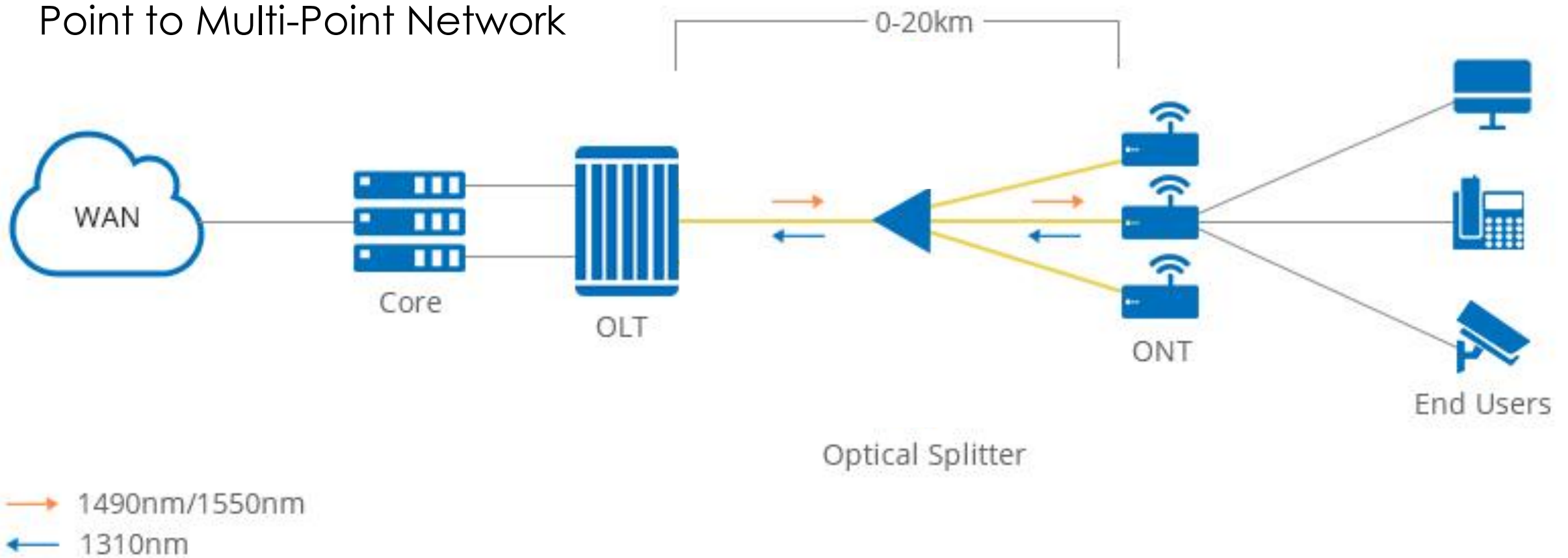
Active Optical Network

Point to Point Network



Passive Optical Network

Point to Multi-Point Network



ABC of PON

OLT = Optical Line Terminal

SPL = Optical splitter

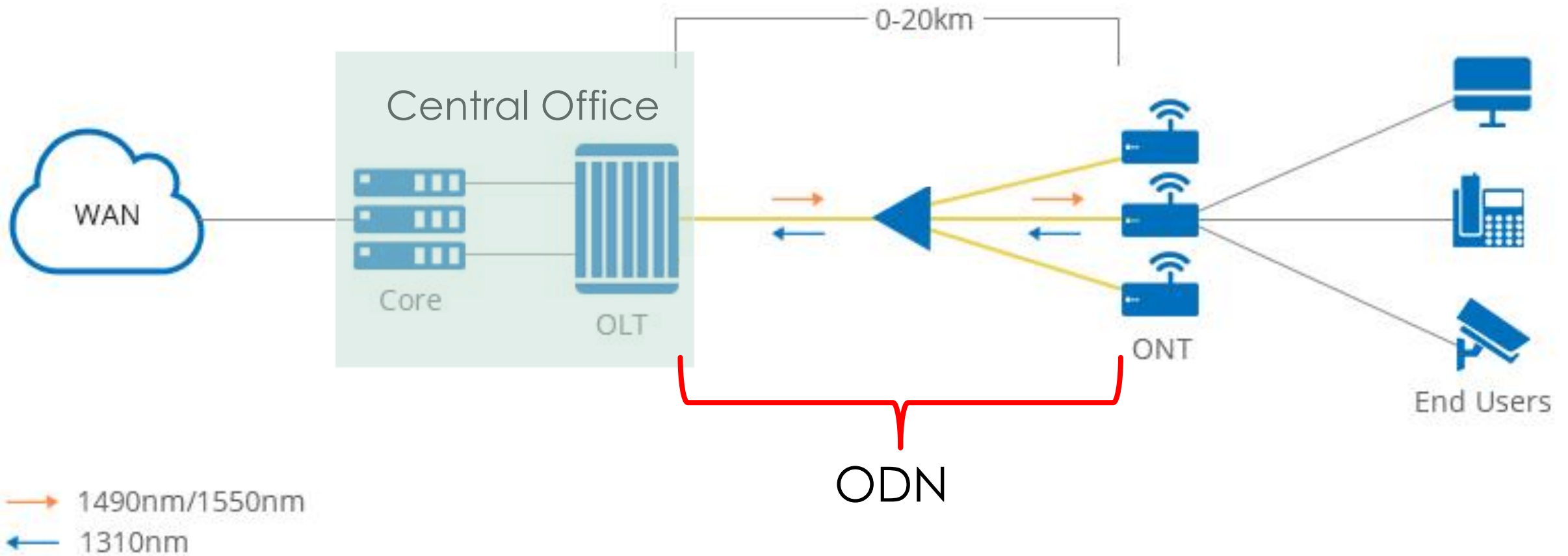
ONU = Optical network unit (IEEE term)

ONT = Optical network terminal (ITU-T Term)

CO = Central Office

ODN = Optical distribution network

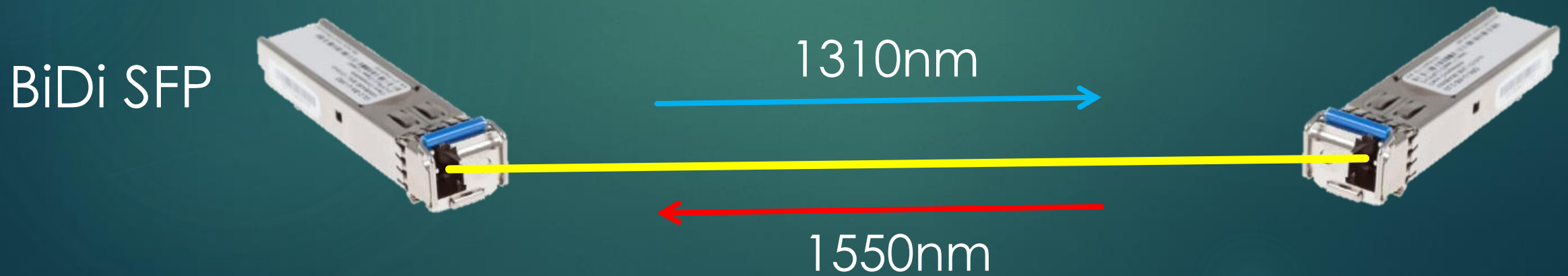
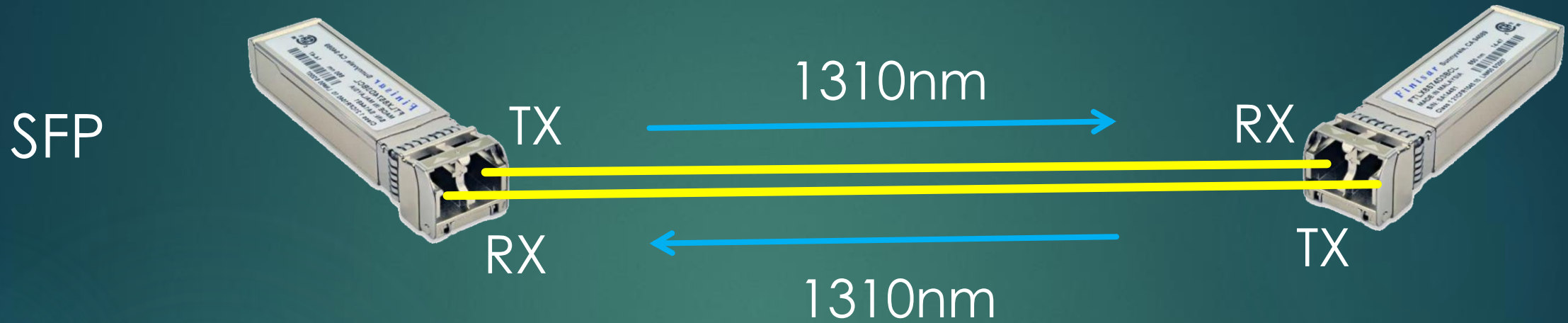
Passive Optical Network



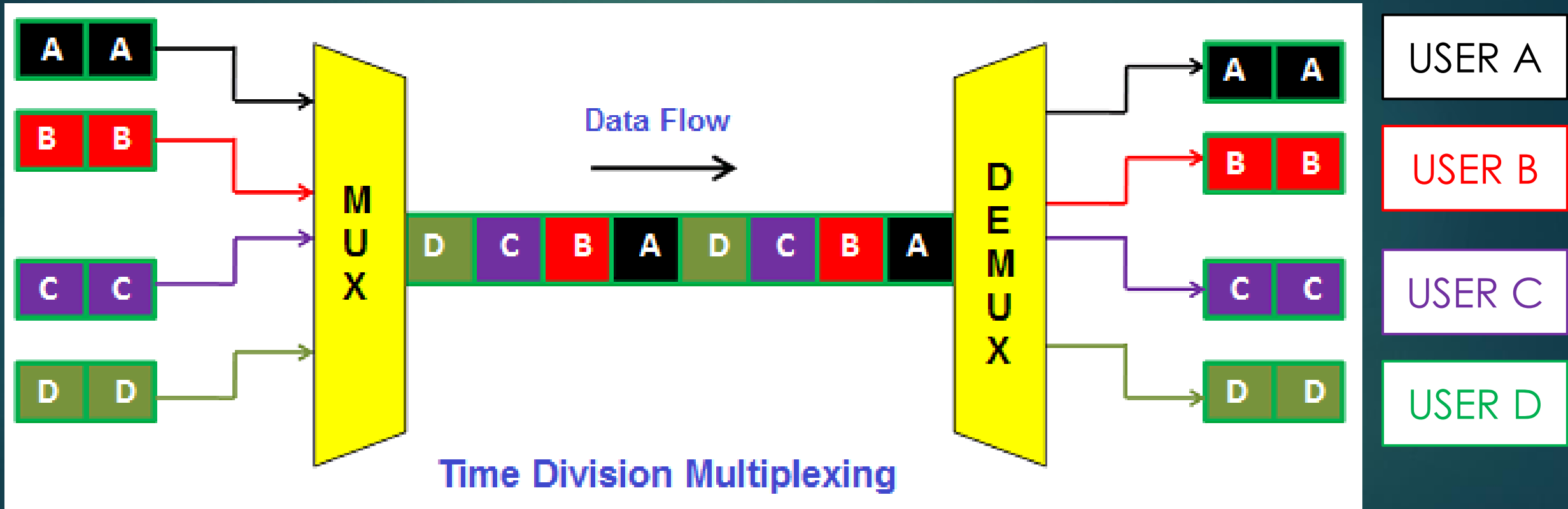
Technology using in PON

- ❑ WDM = Wavelength Division Multiplexing
- ❑ TDM = Time Division Multiplexing

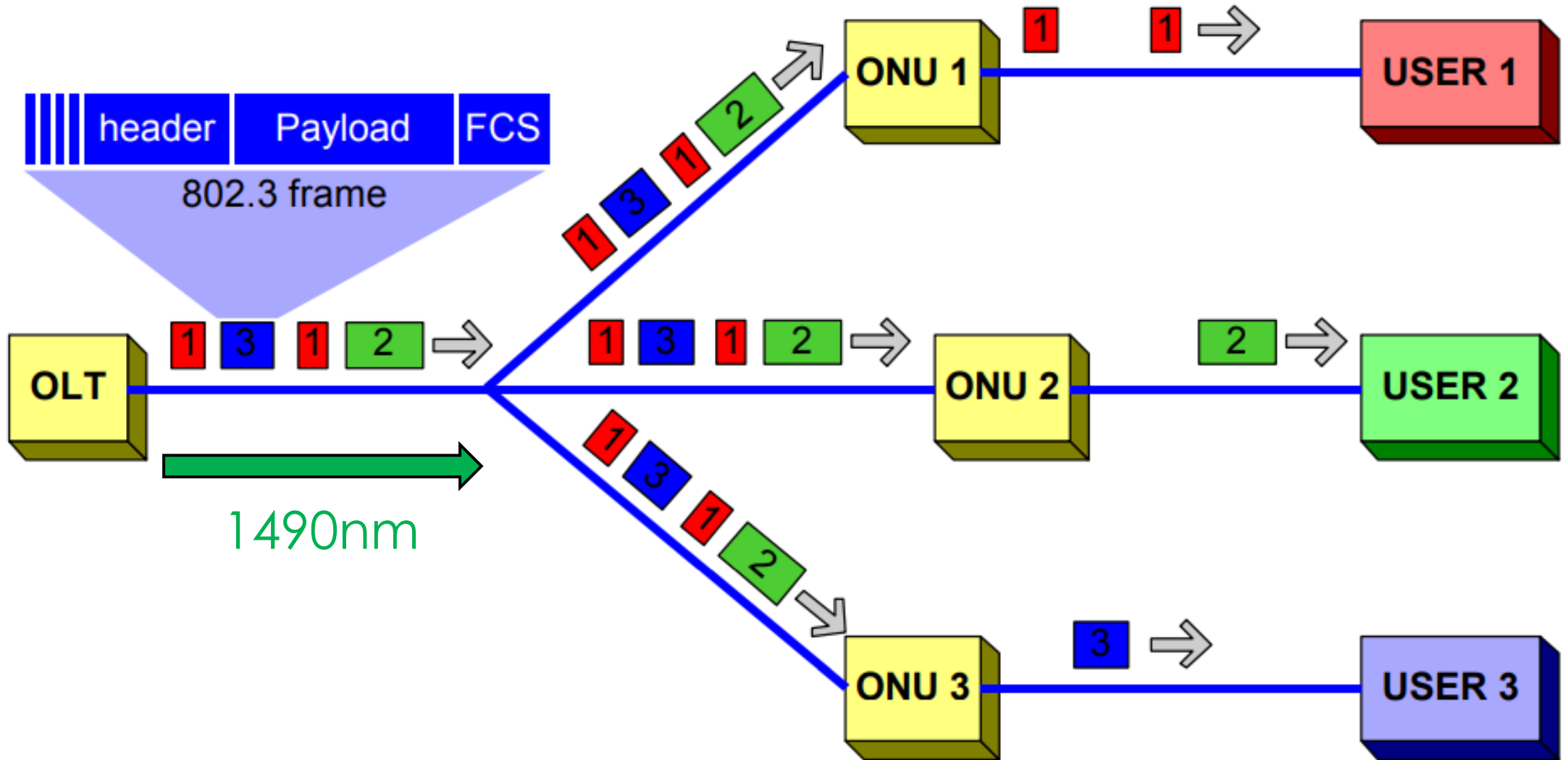
WDM technique



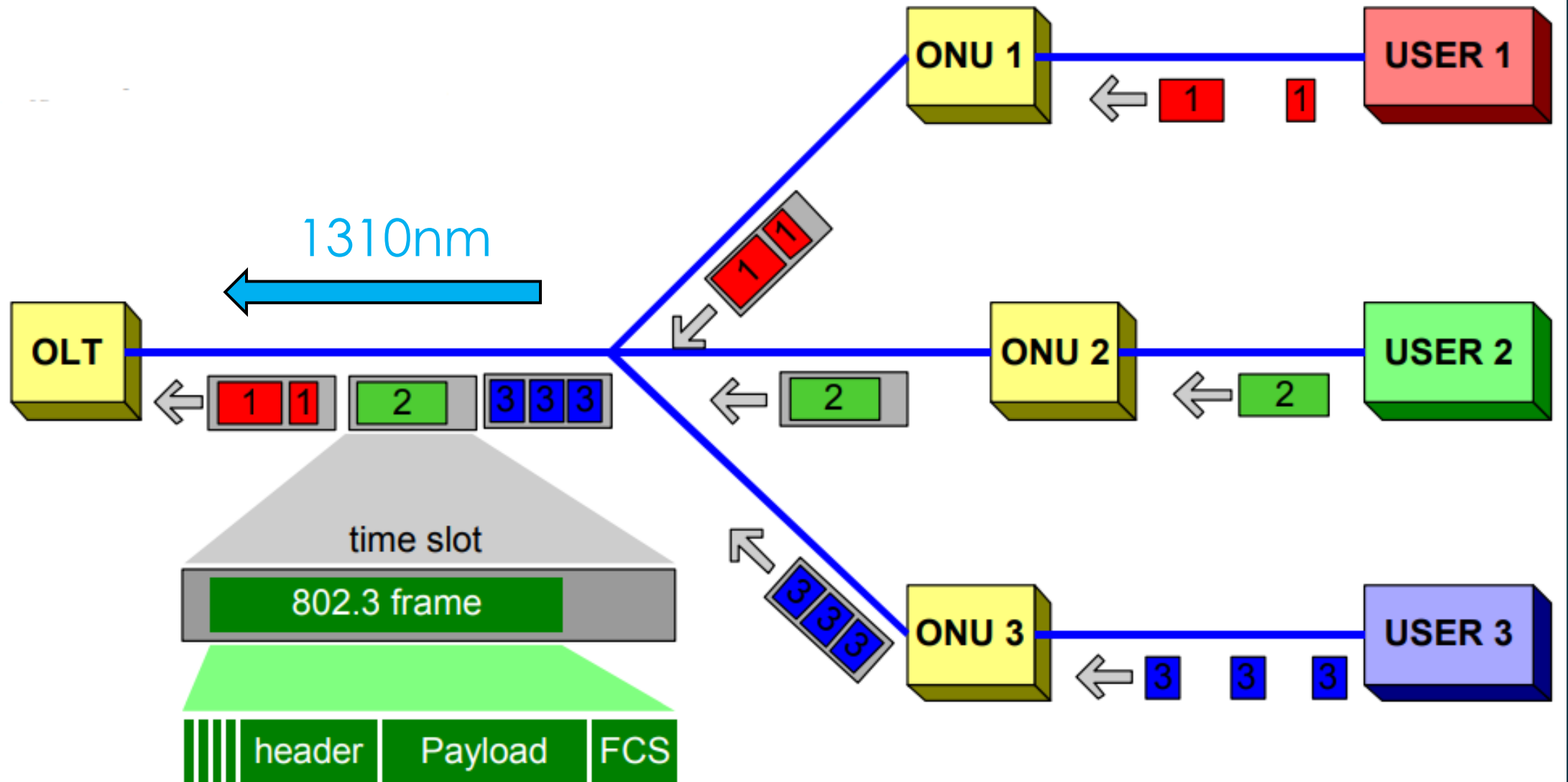
TDM technique



PON



PON



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PON Standardization & Organization

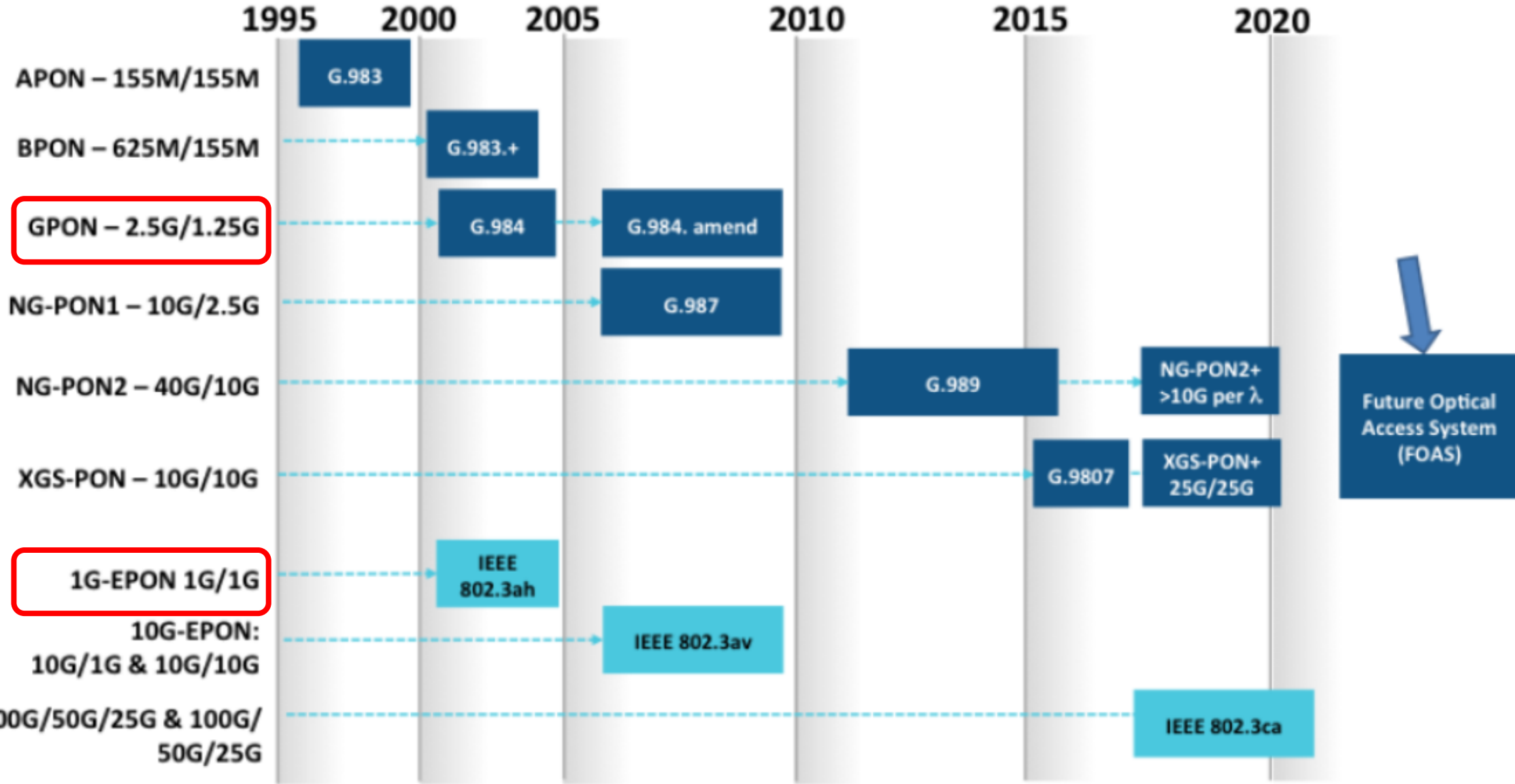
□ ITU-T : International Telecommunication Union
(Telecommunication Standardization)



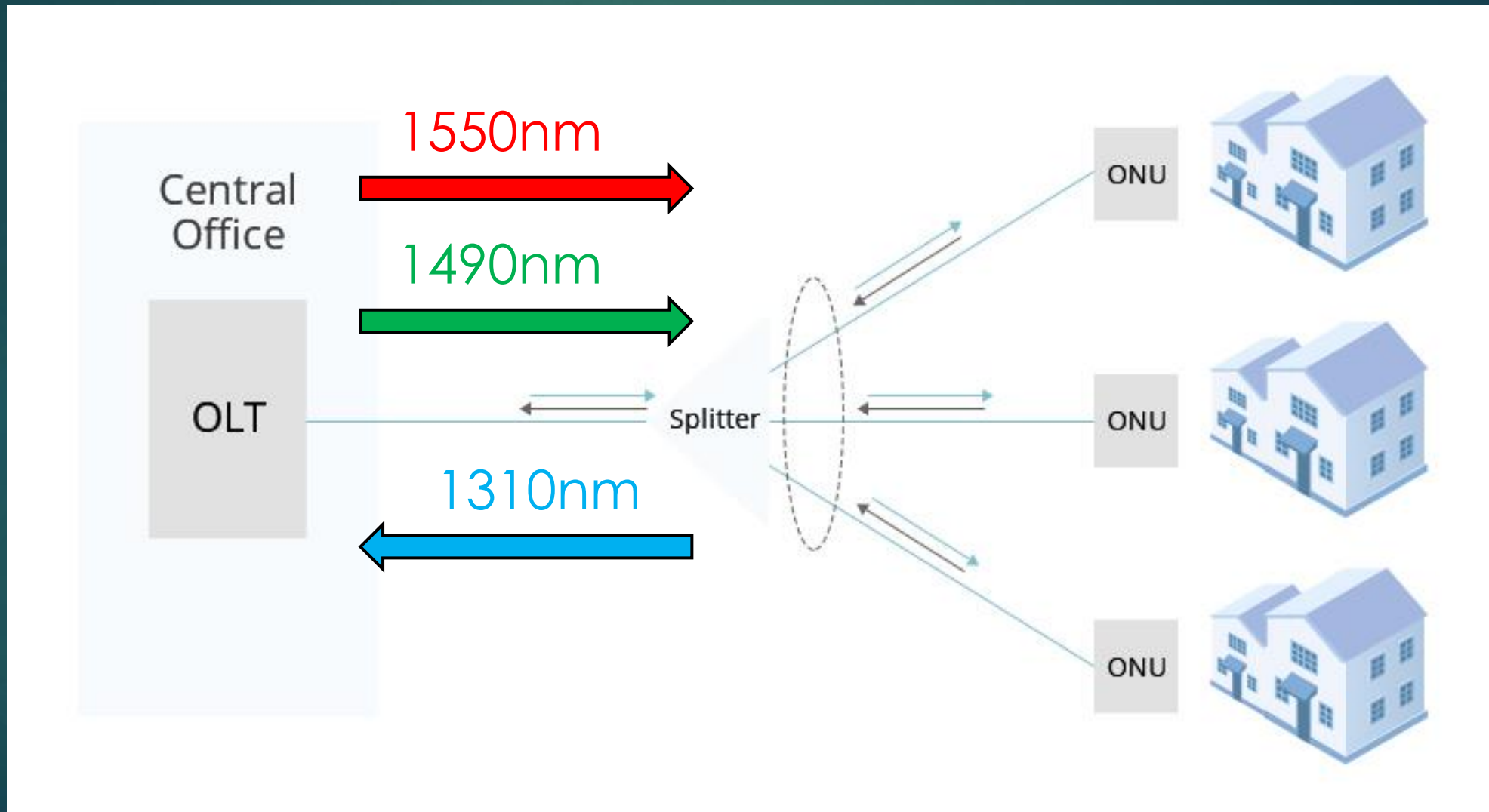
□ IEEE : Institute of Electrical and Electronic Engineers



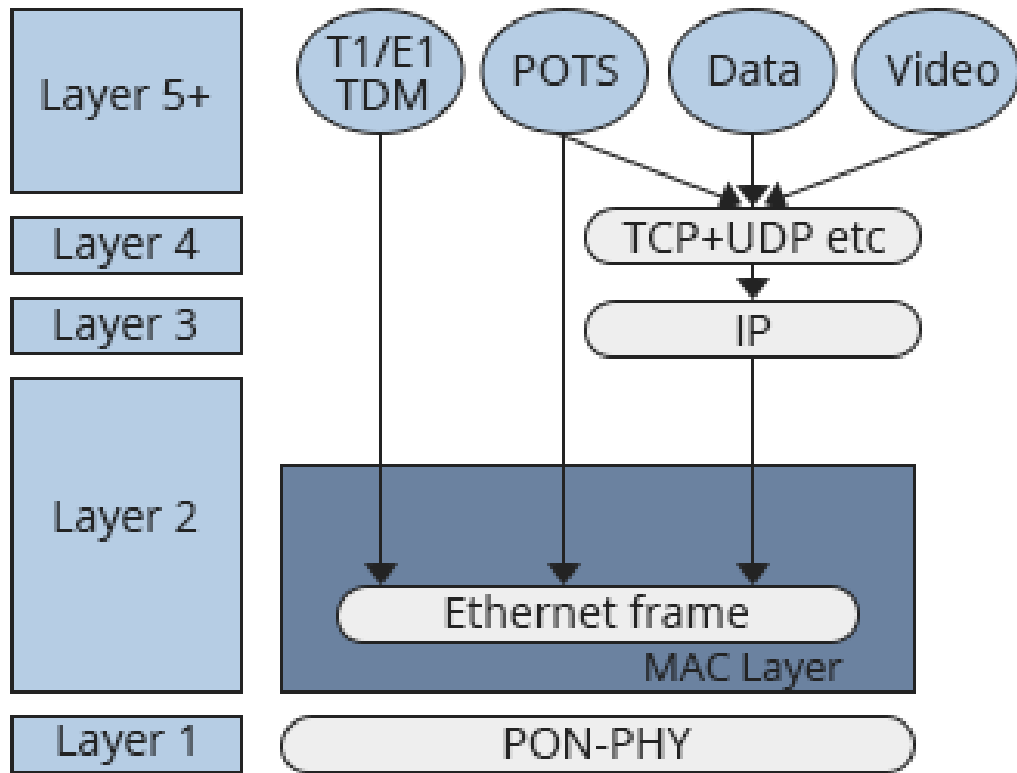
PON Standards



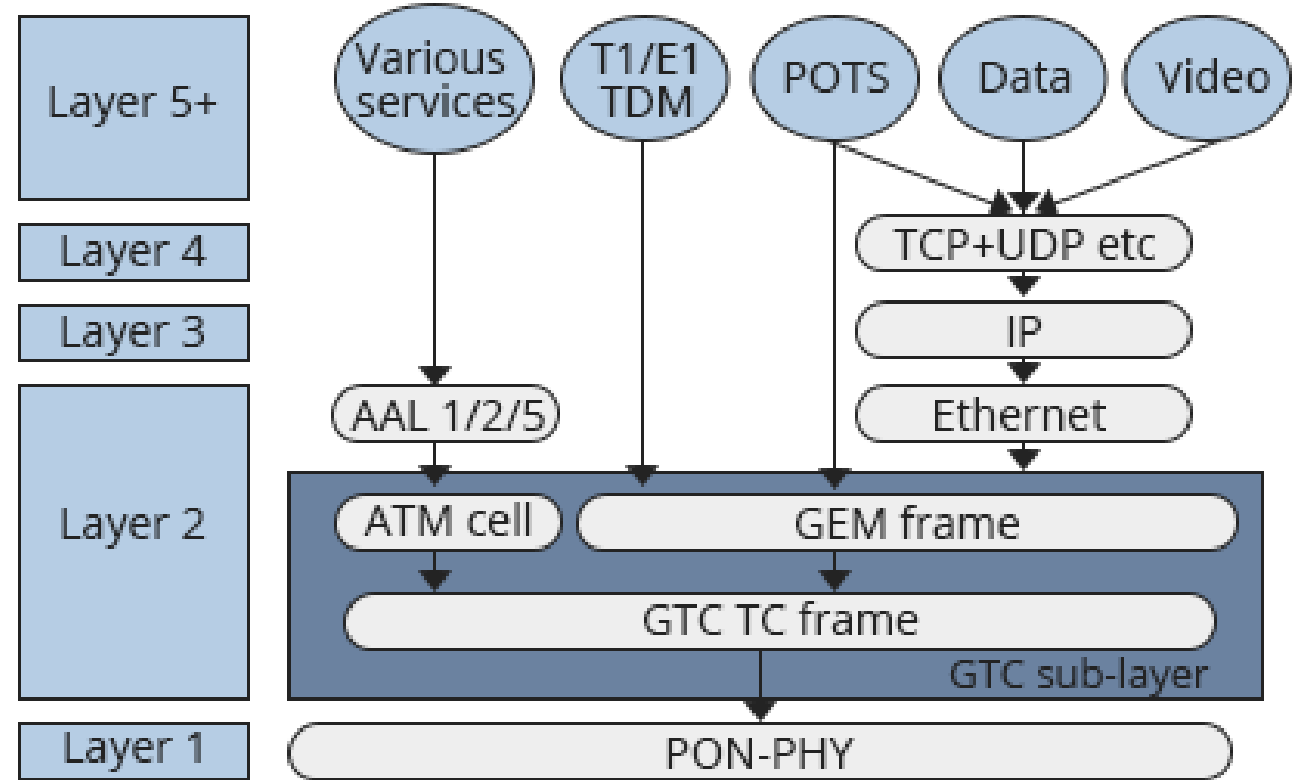
Fiber Optic Network in EPON & GPON



EPON & GPON Layering



EPON Layering



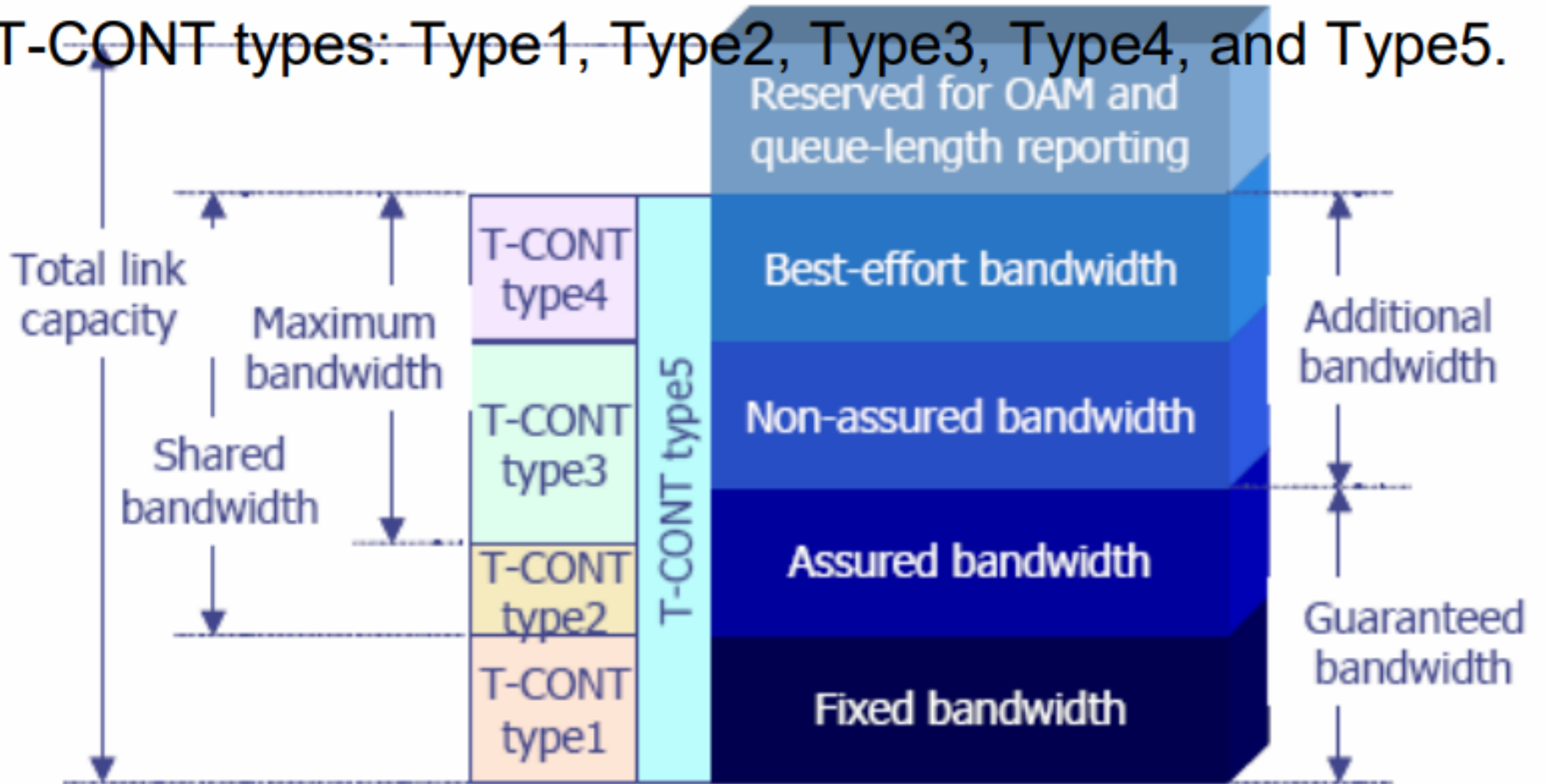
GPON Layering

EPON VS GPON

Item	EPON	GPON
Data Rate	Downstream = 1.244 Gbps Upstream = 1.244 Gbps	Downstream = 2.488 Gbps Upstream = 1.244 Gbps & 2.488 Gbps
Split ratio	1:32 1:64 with FEC	1:128
Encryption	Downstream & Upstream	Downstream only
QoS	No	Yes
Cost	1X	1.5X – 2X

GPON QoS

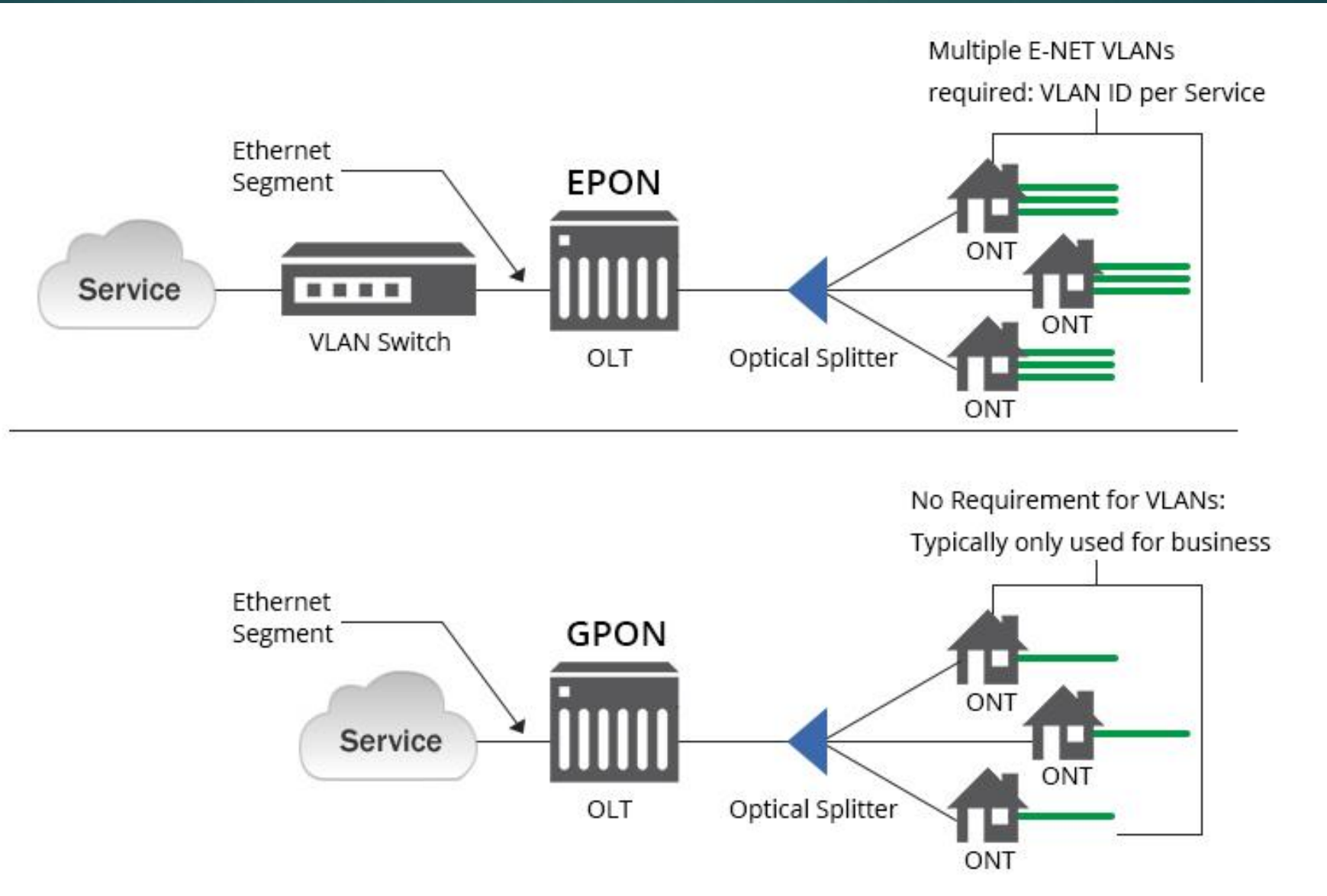
Five T-CONT types: Type1, Type2, Type3, Type4, and Type5.



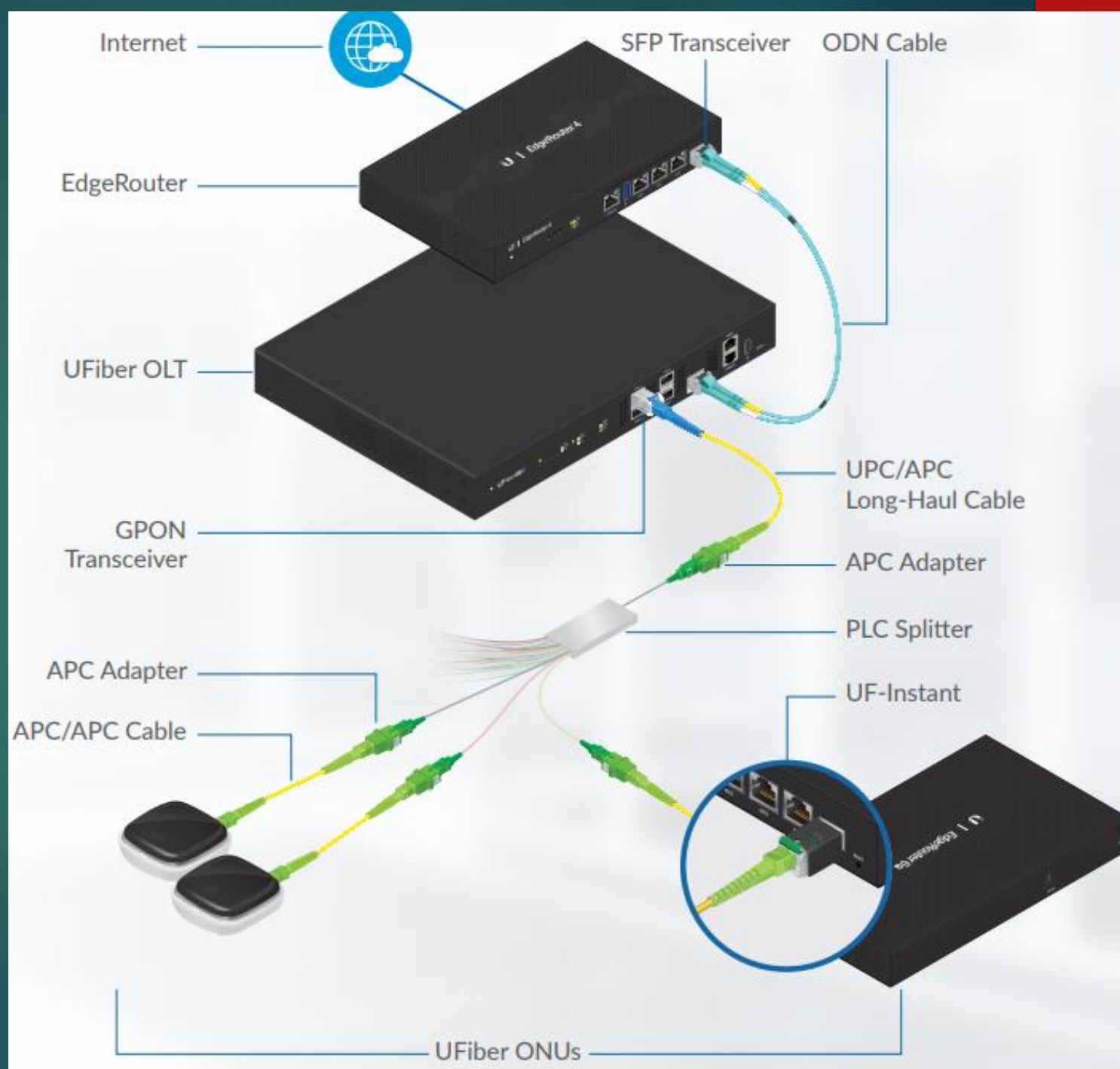
BW Type	Delay Sensitive	Applicable T-CONT types				
		Type 1	Type 2	Type 3	Type 4	Type 5
Fixed	Yes	X				X
Assured	No		X	X		X
Non-Assured	No			X		X
Best Effort	No				X	X

- Type1 T-CONT is of the fixed bandwidth type and mainly used for services sensitive to delay and services of higher priorities, such as voice services.
- Type2 and type3 T-CONT is of 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.

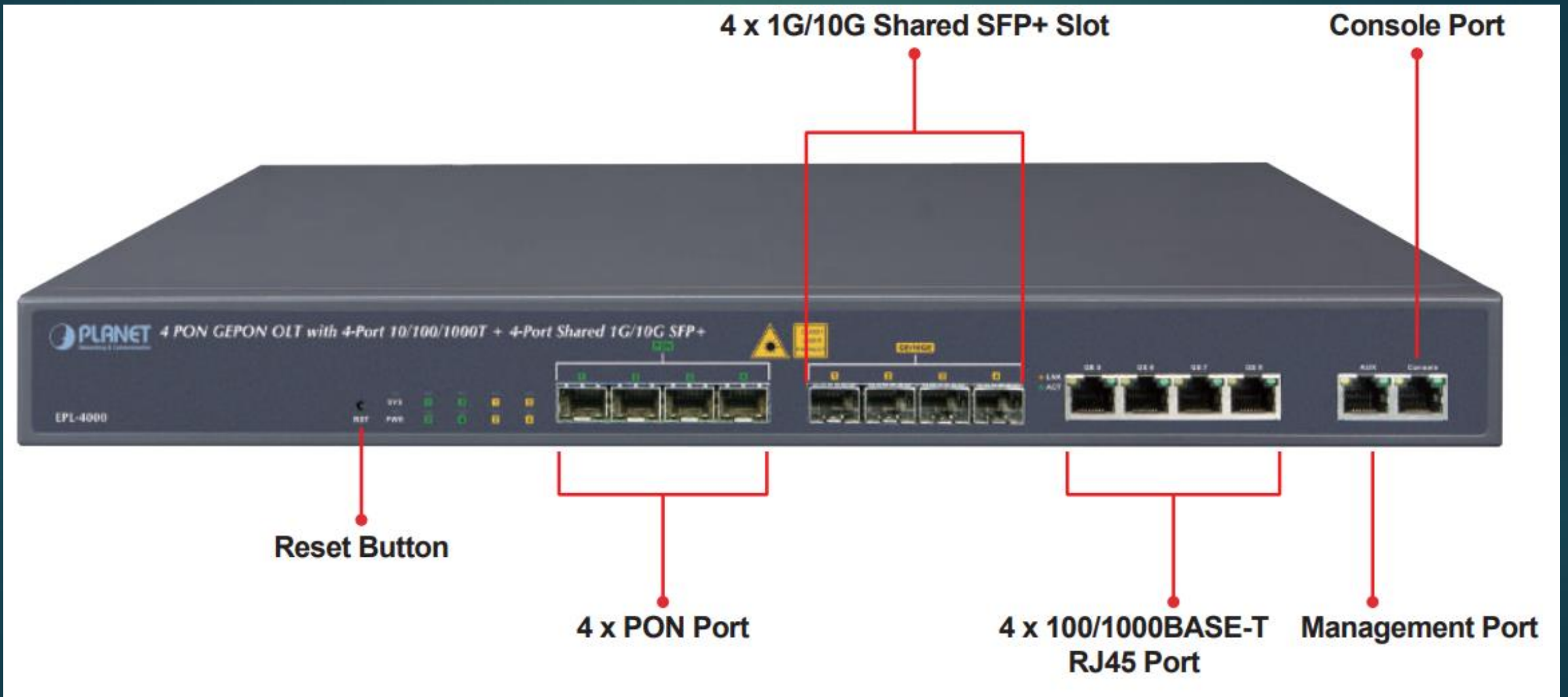
EPON VS GPON (QoS)



PON Component



OLT : Optical Line Terminal



GPON SFP

GPON C+ SFP Module In Stock

SKU: UF-GP-C+

[Summary](#)

The UFiber™ OLT's GPON SFP ports are designed for use with the UF-GP-C+ SFP module.



GPON C+ SFP Module

\$86

\$86



1



Add to Cart



GPON SFP

UF-GP-C+

Supported media	Single-mode fiber
Connector type	(1) SC/UPC
TX wavelength	1490 nm
RX wavelength	1310 nm
TX power range	3 to 7 dBm
RX power range	-30 to -12 dBm
Downstream data rate	2.5 Gbps
Upstream data rate	1.25 Gbps
Cable distance	20 km

UF-GP-B+

Supported media	Single-mode fiber
Connector type	(1) SC/UPC
TX wavelength	1490 nm
RX wavelength	1310 nm
TX power range	1.5 to 5 dBm
RX power range	-28 to -8 dBm
Downstream data rate	2.5 Gbps
Upstream data rate	1.25 Gbps
Cable distance	20 km

ITU-T G.984.2

**Table A.1 – B+ Optical power levels for the 2.4 Gbit/s downstream,
1.2 Gbit/s upstream system**

Items	Unit	Single fibre
OLT:		OLT
Mean launched power MIN	dBm	+1.5
Mean launched power MAX	dBm	+5
Minimum sensitivity	dBm	-28
Minimum overload	dBm	-8
Downstream optical penalty	dB	0.5
ONU:		ONU
Mean launched power MIN	dBm	+0.5
Mean launched power MAX	dBm	+5
Minimum sensitivity	dBm	-27
Minimum overload	dBm	-8
Upstream optical penalty	dB	0.5

Link Budget

	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.

Splitter

ratio

1:N

1:2

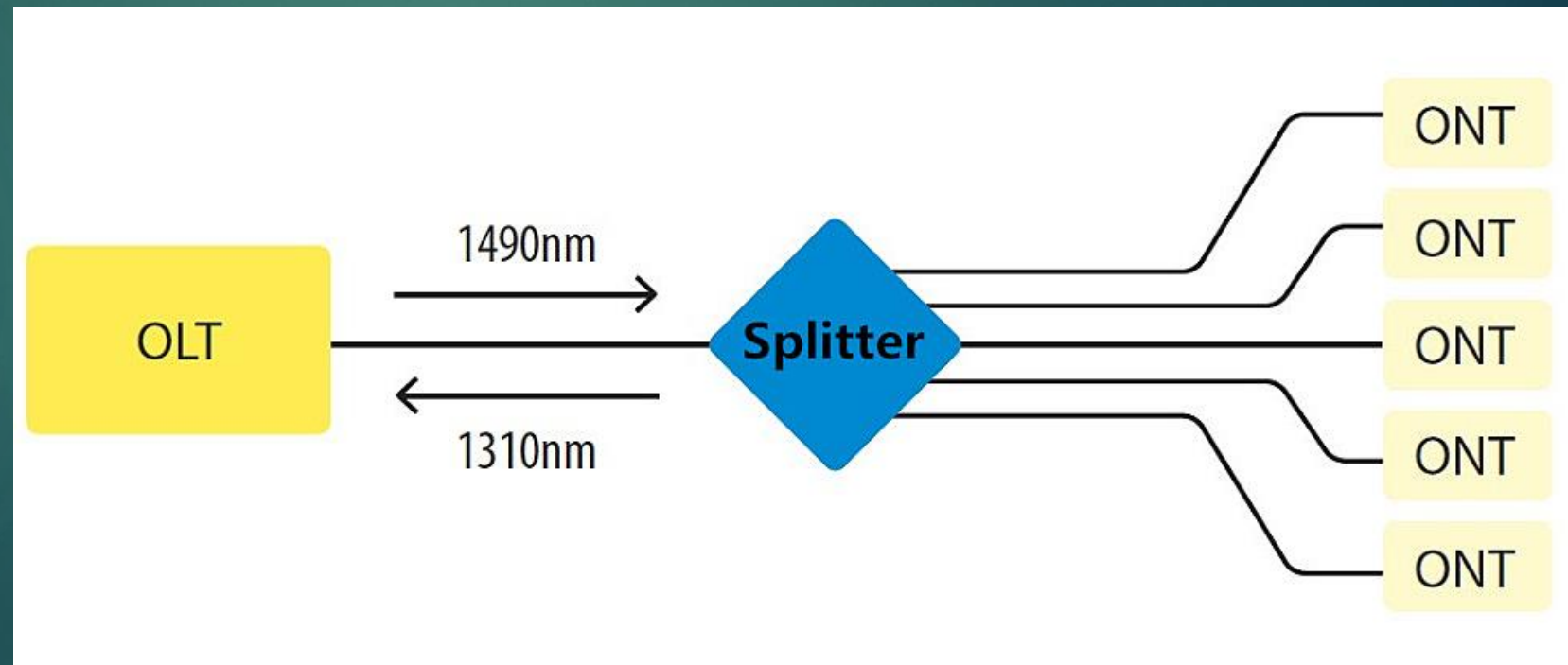
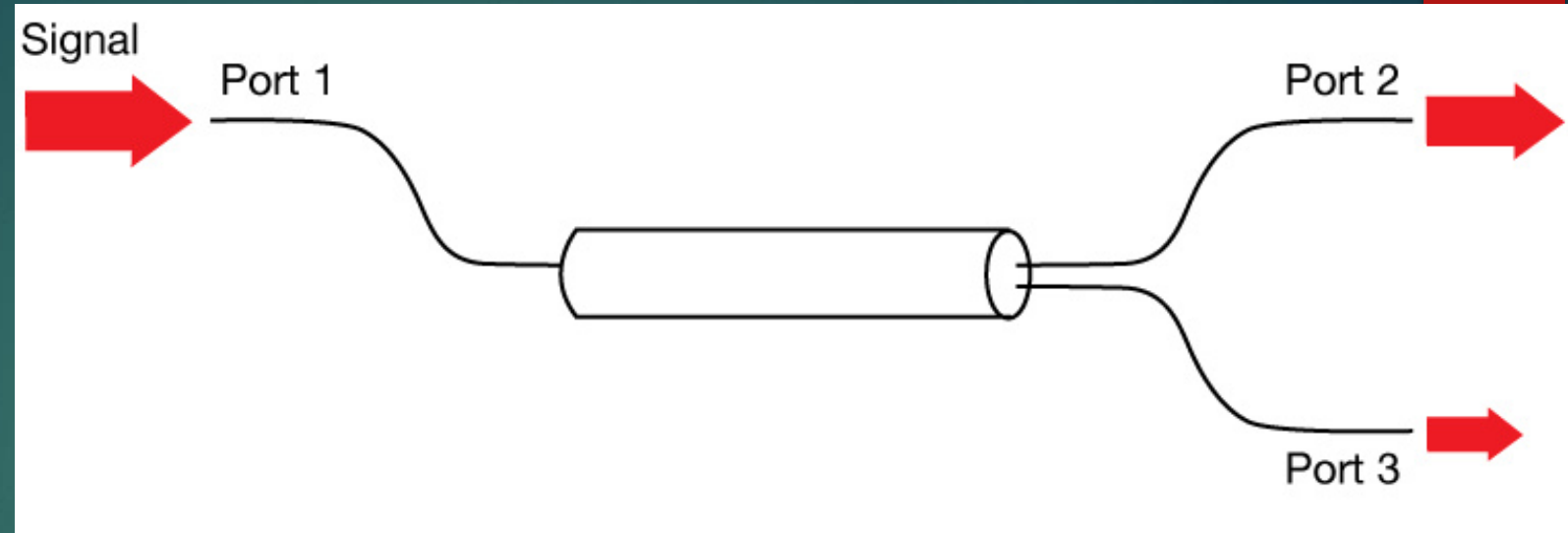
1:4

1:8

1:16

1:32

1:64

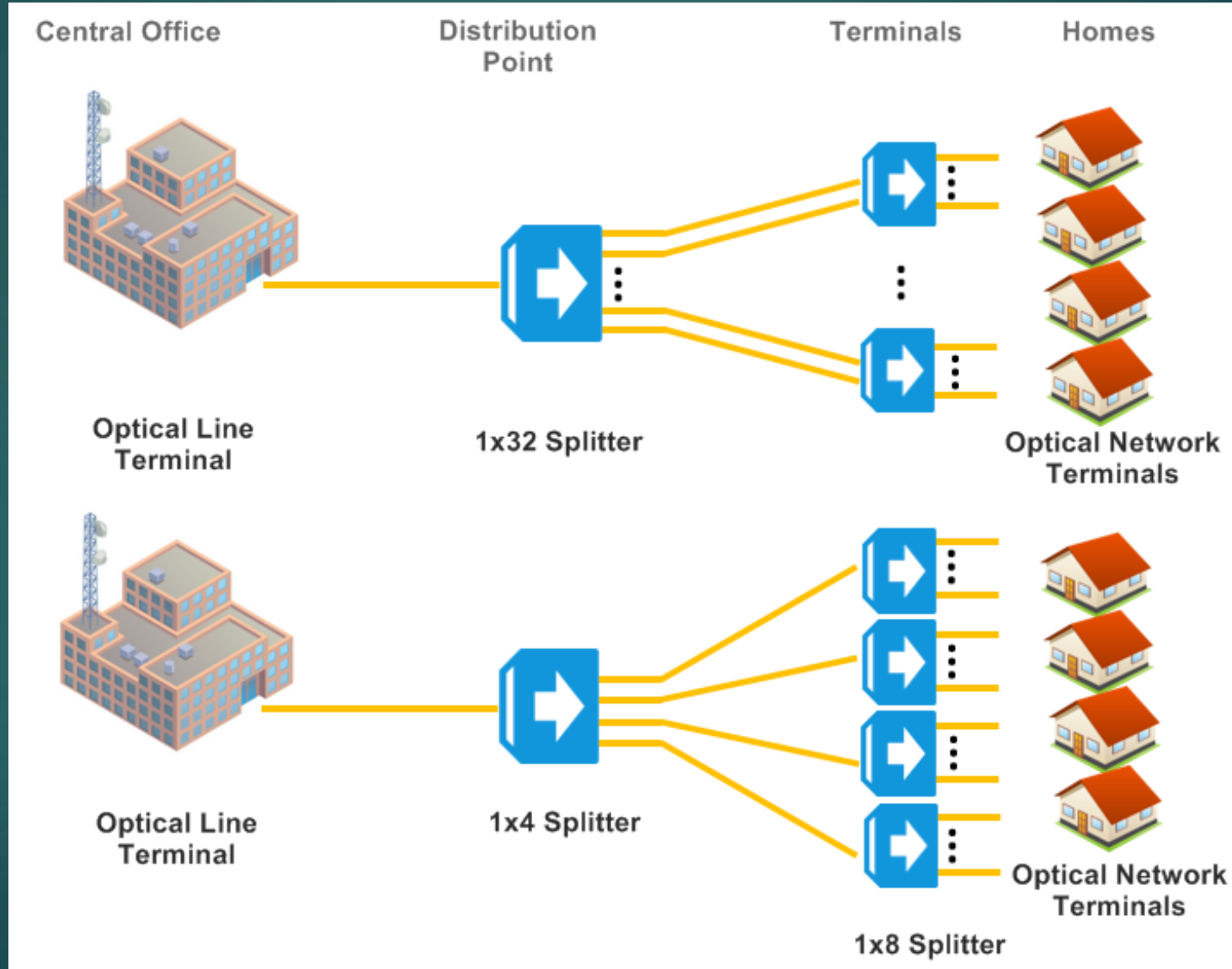


Splitter Loss

Splitter Ratio	Ideal Loss (dB)	Typical Loss (dB)
1:2	3	4
1:4	6	7
1:8	9	11
1:16	12	15
1:32	15	19
1:64	18	22

Loss	100%
- 0.1 dB	97%
- 0.2 dB	95%
- 0.5 dB	89%
- 1.0 dB	79%
- 2.0 dB	63%
- 3.0 dB	50%
- 6.0 dB	25%
- 9.0 dB	12.5%
-10.0 dB	10%
-20.0 dB	1%
-30.0 dB	0.1%

Centralized & Distributed Splitting

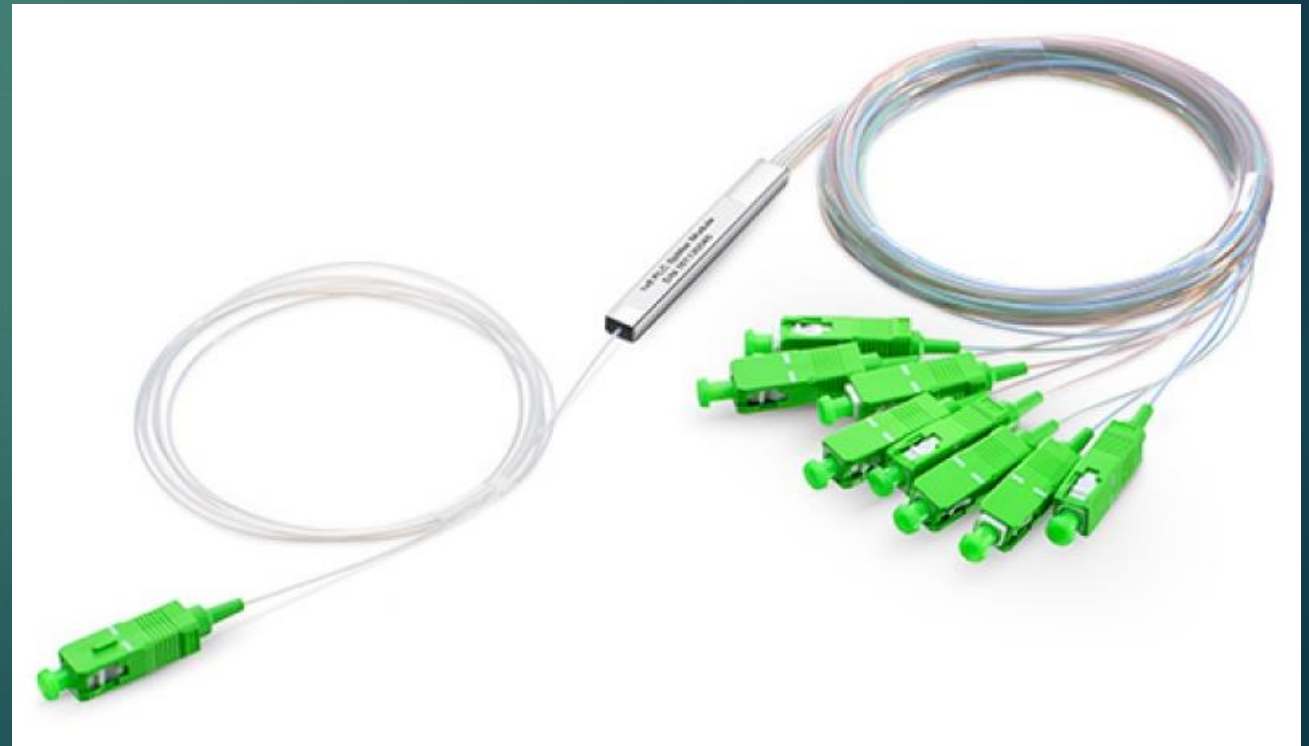


Splitter Type

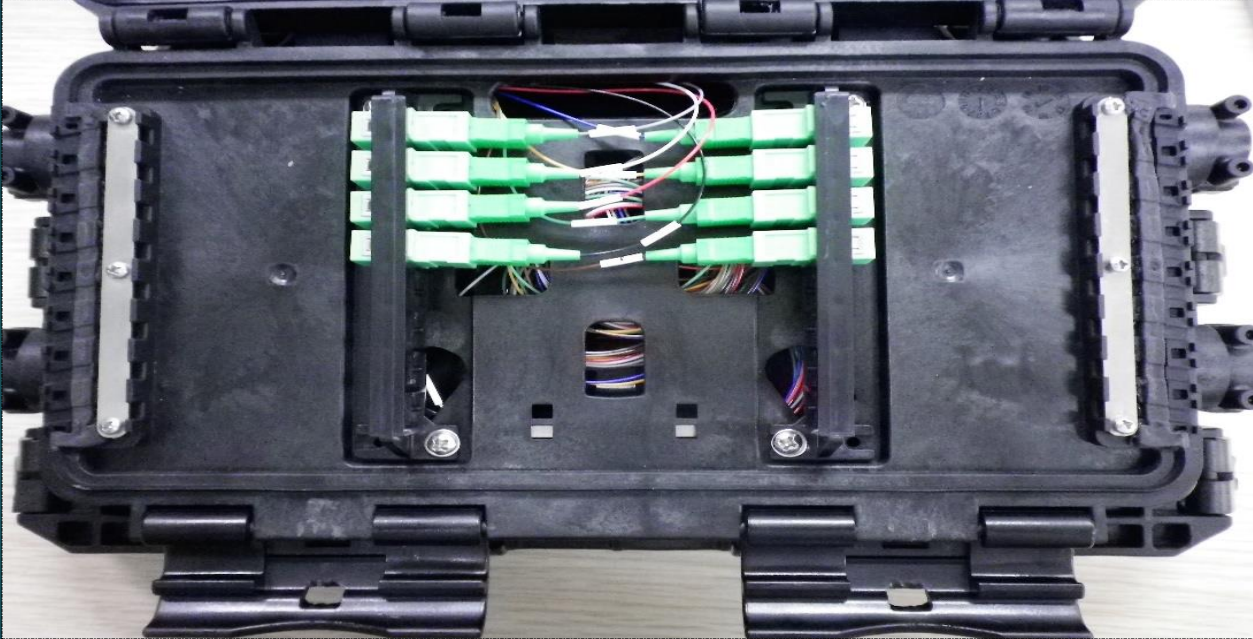


Bare Fiber Optical Splitter

Blockless Fiber Splitter



Fiber Optic Enclosure



Splitter Type

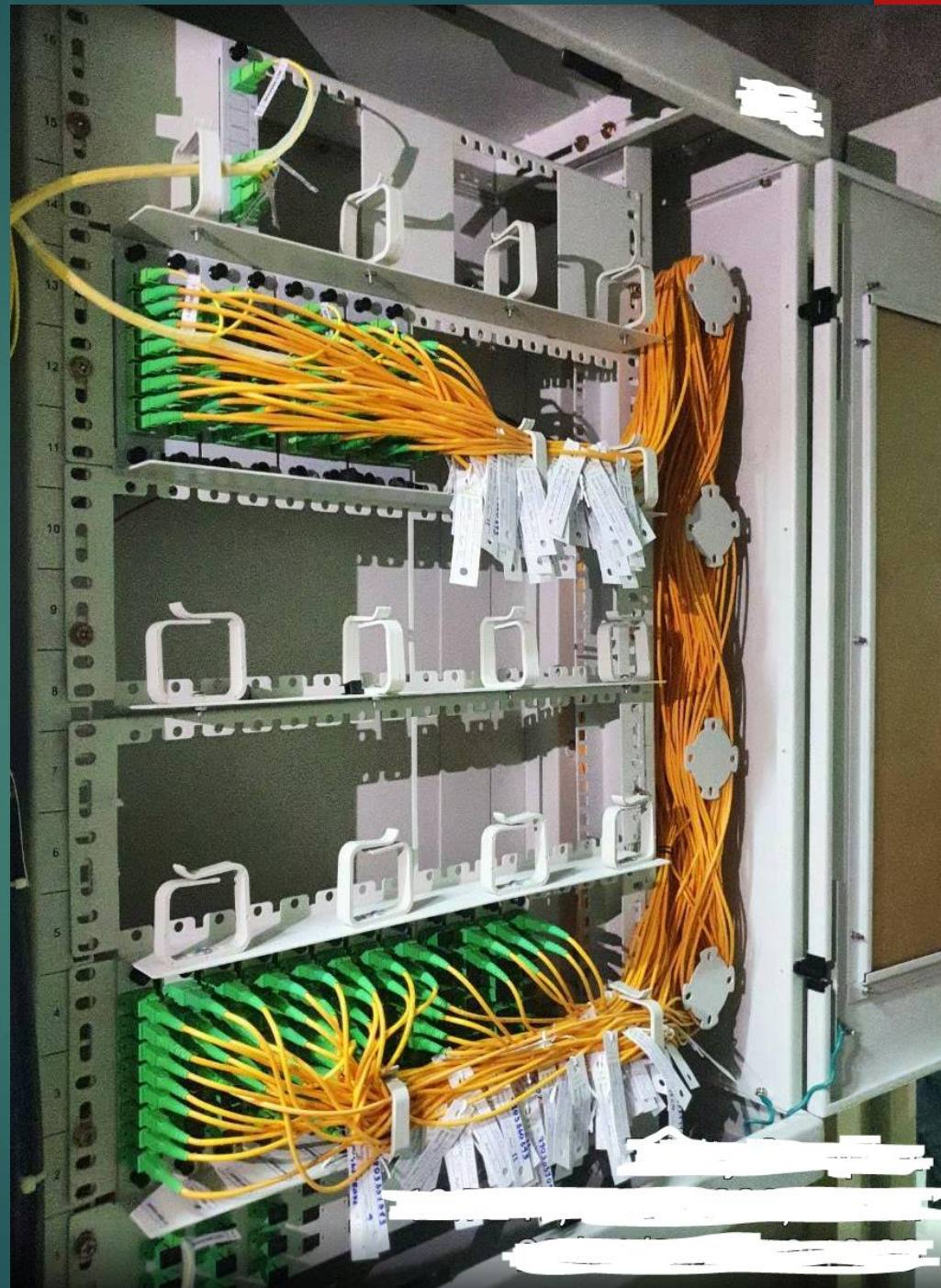
ABS Splitter



Splitter Type



LGX Splitter

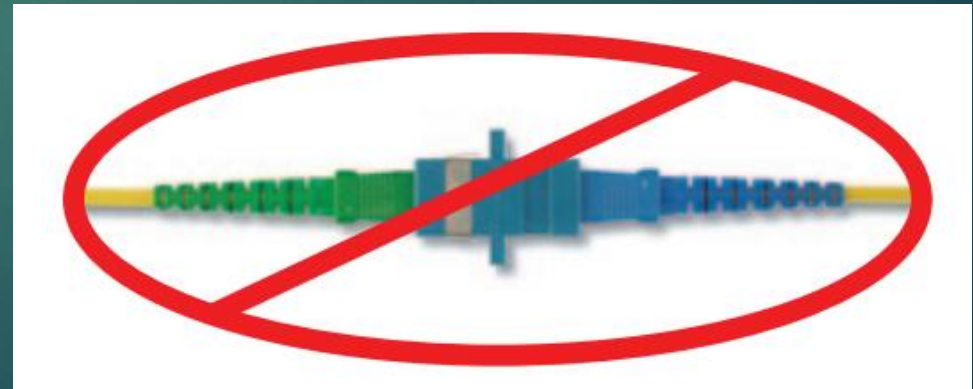
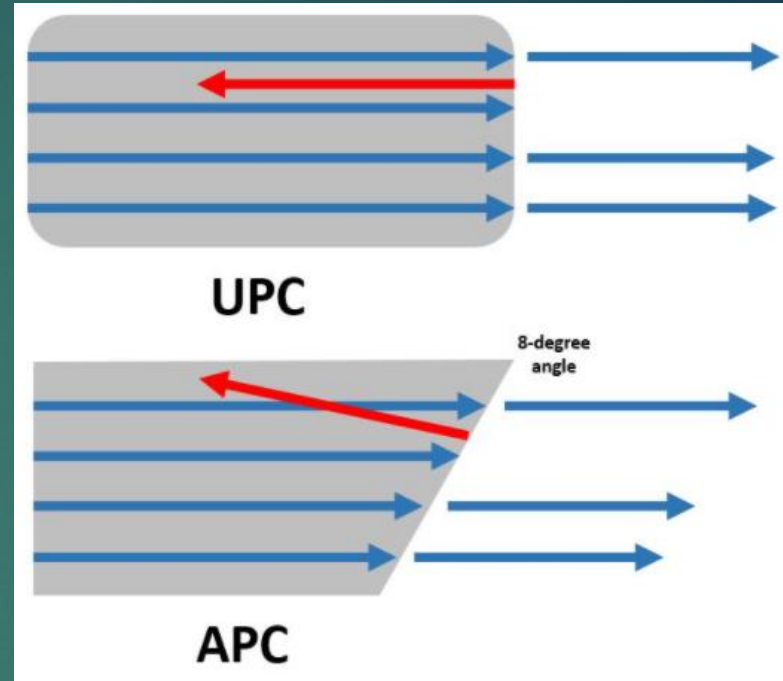
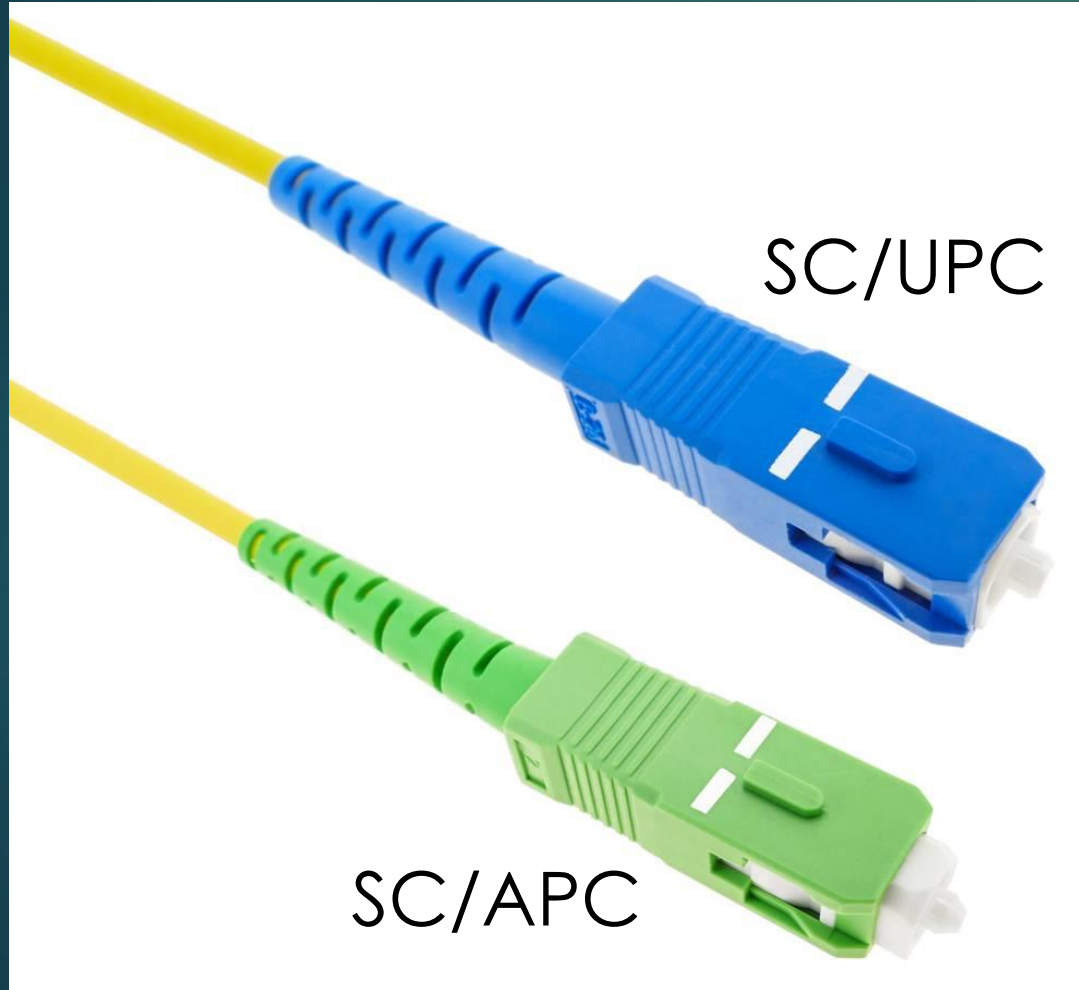


Splitter Type

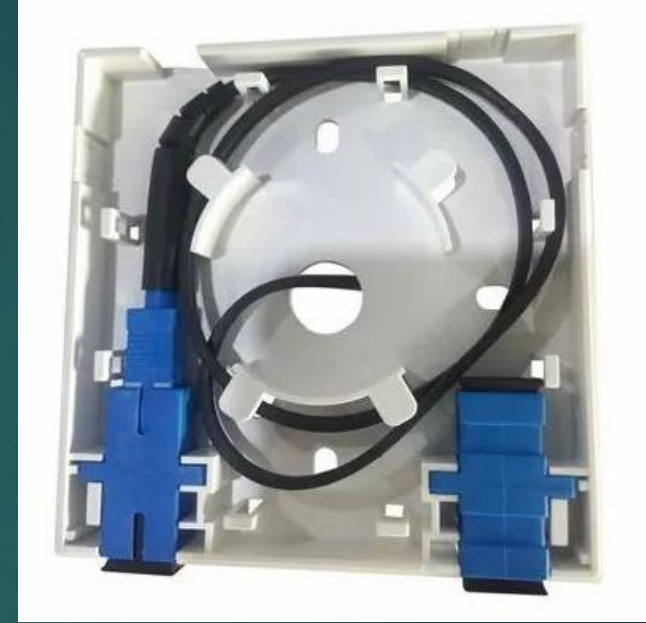
Rack Mount Splitter



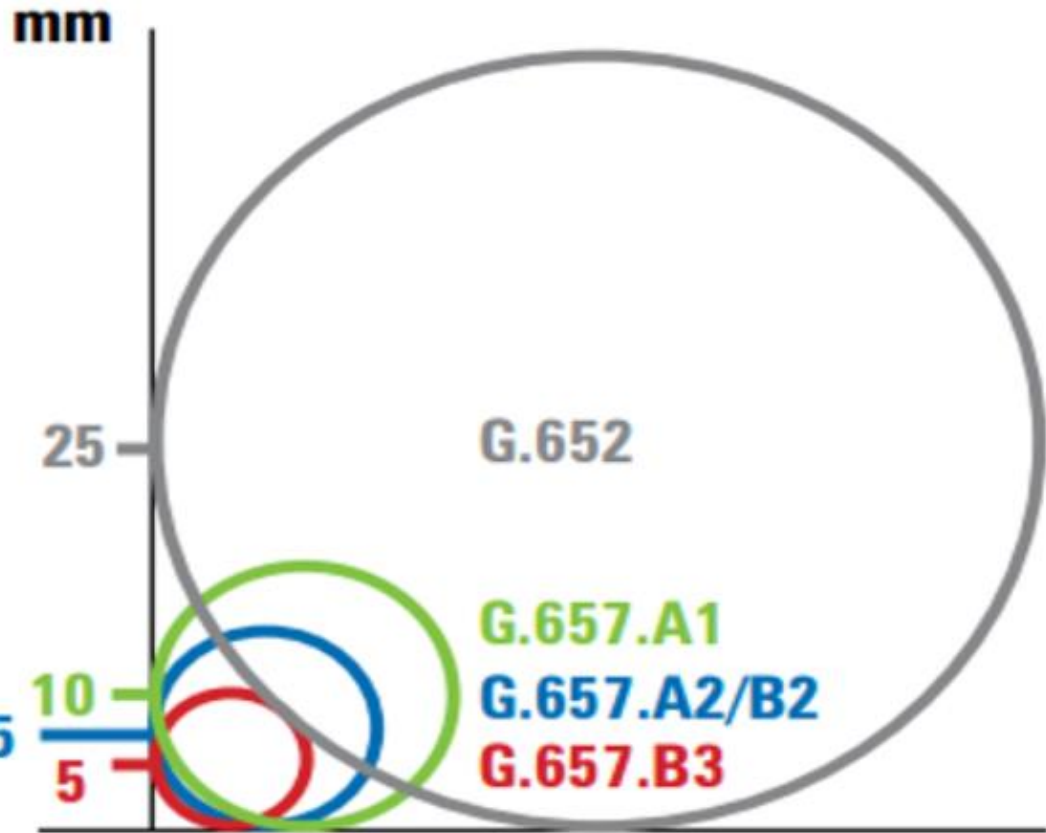
Fiber Connector



Fiber Optic Cable ITU-T G.657



Fiber Optic Cable ITU-T G.657



Bending Radius (mm)	Macrobending Loss (dB)	
	FTTH Cable (G.657A2)	Fiber Pigtail (G.652D)
10.0	0.02	0.18
7.5	0.06	1.6
5.0	0.37	8.13
3.8	0.65	15.61
2.5	1.71	-
1.5	6.68	-

ONU



Converter



WiFi Router



ONU Stick

TX : 1310nm
RX : 1490nm

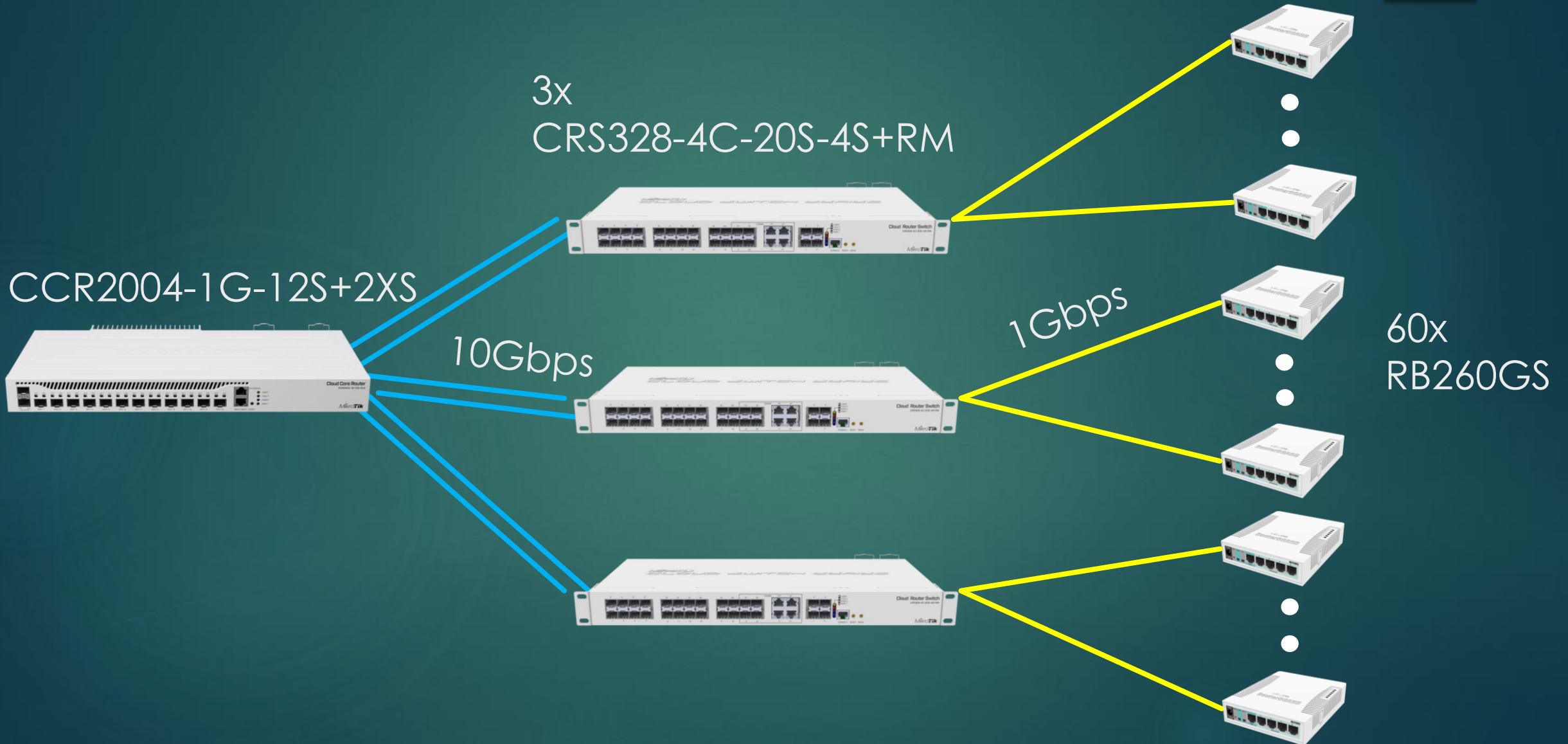
Topic

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- ❑ PON testing and maintenance
- ❑ Next Generation PON

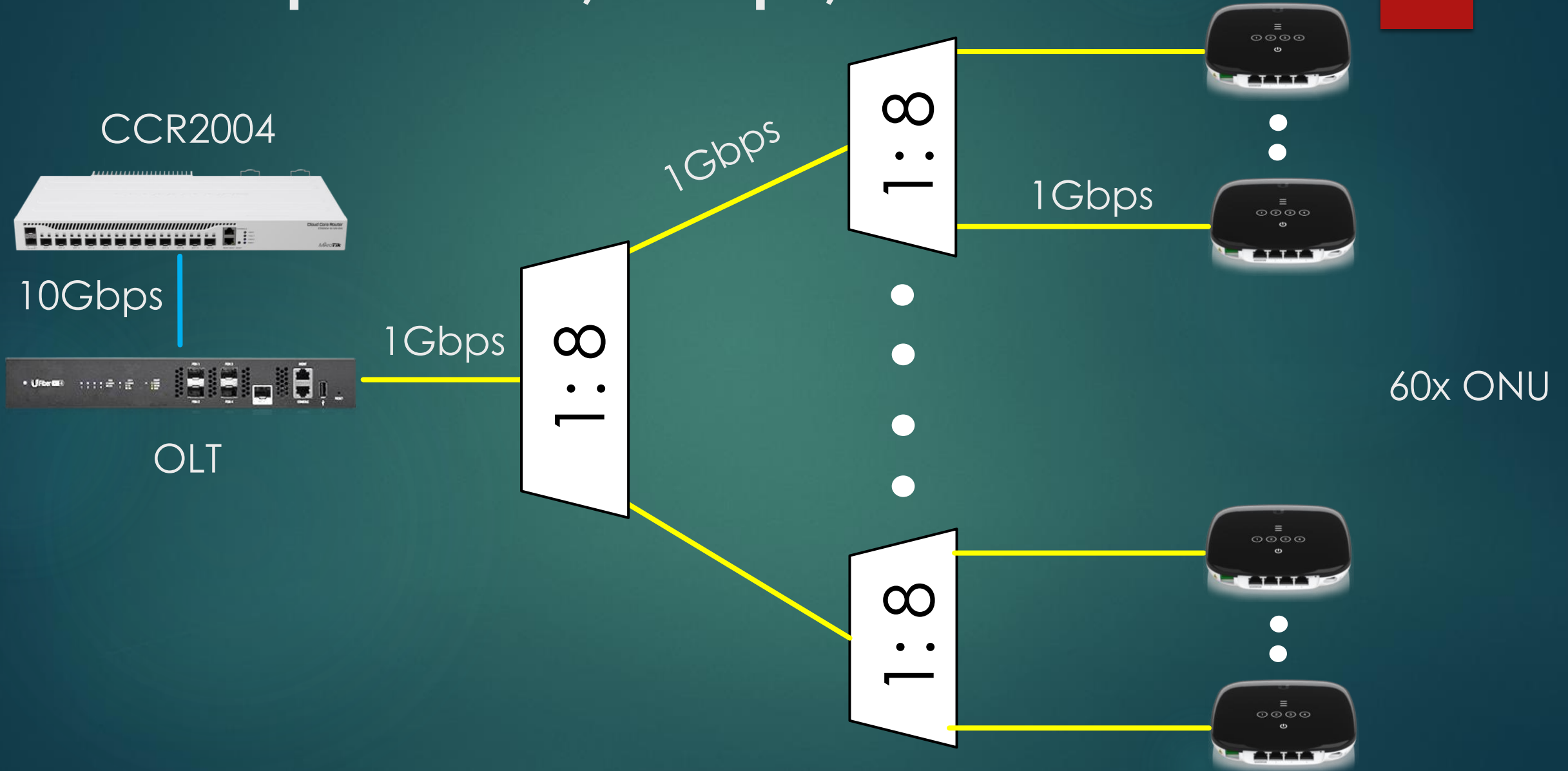
Advantage of PON

- ✓ Lower Budget
- ✓ Simplified Implement
- ✓ Convenient Maintenance
- ✓ Easier for Upgrade

Example : AON, 1Gbps, 60 Users



Example : PON, 1Gbps, 60 Users



Lower Budget

PON

Item	Quantity
Router	1
OLT	1
ONU	60
GPON SFP	1
Splitter 1:8	9
Fiber Optic	69

AON

Item	Quantity
Router	1
Distribution Switch	3
Access Switch	60
BiDi SFP+ 10G	12
BiDi SFP 1G	120
Fiber Optic	66

Limitations of PON

- × Shared bandwidth
- × More difficult to investigate problem
- × Potential Breakdown Risk
- × Distance Range 20km

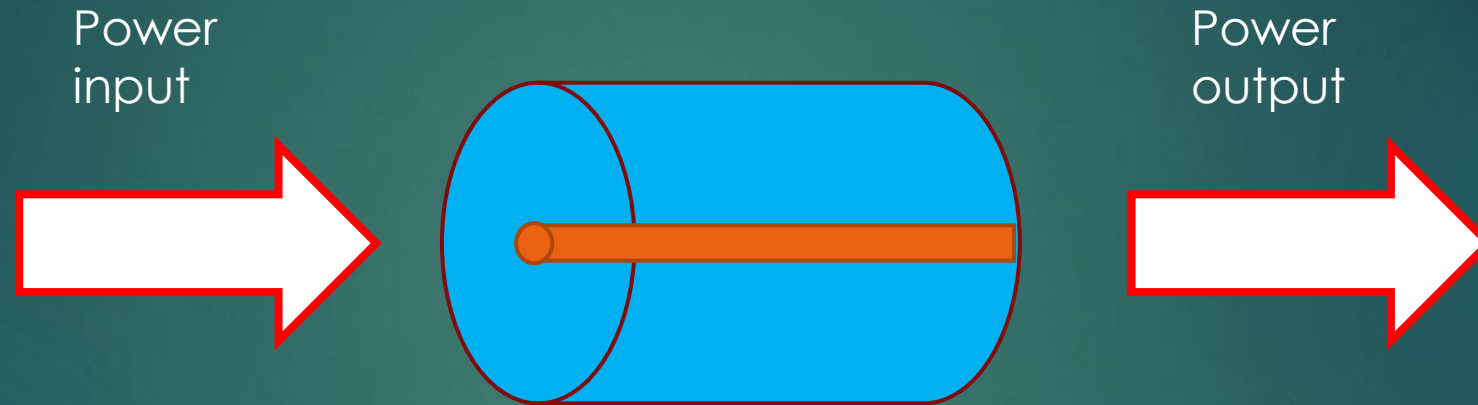
Topic

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PON Testing and Maintenance

- Optical Power Measurement
- Optical Return Loss Measurement
- OTDR Measurement

Optical Power Measurement



$$\text{Loss} = 10 \times \log (P_{\text{in}} / P_{\text{out}})$$

Absolute Optical Power (dBm)

Optical Power Meter

dBm = dB milliwatt



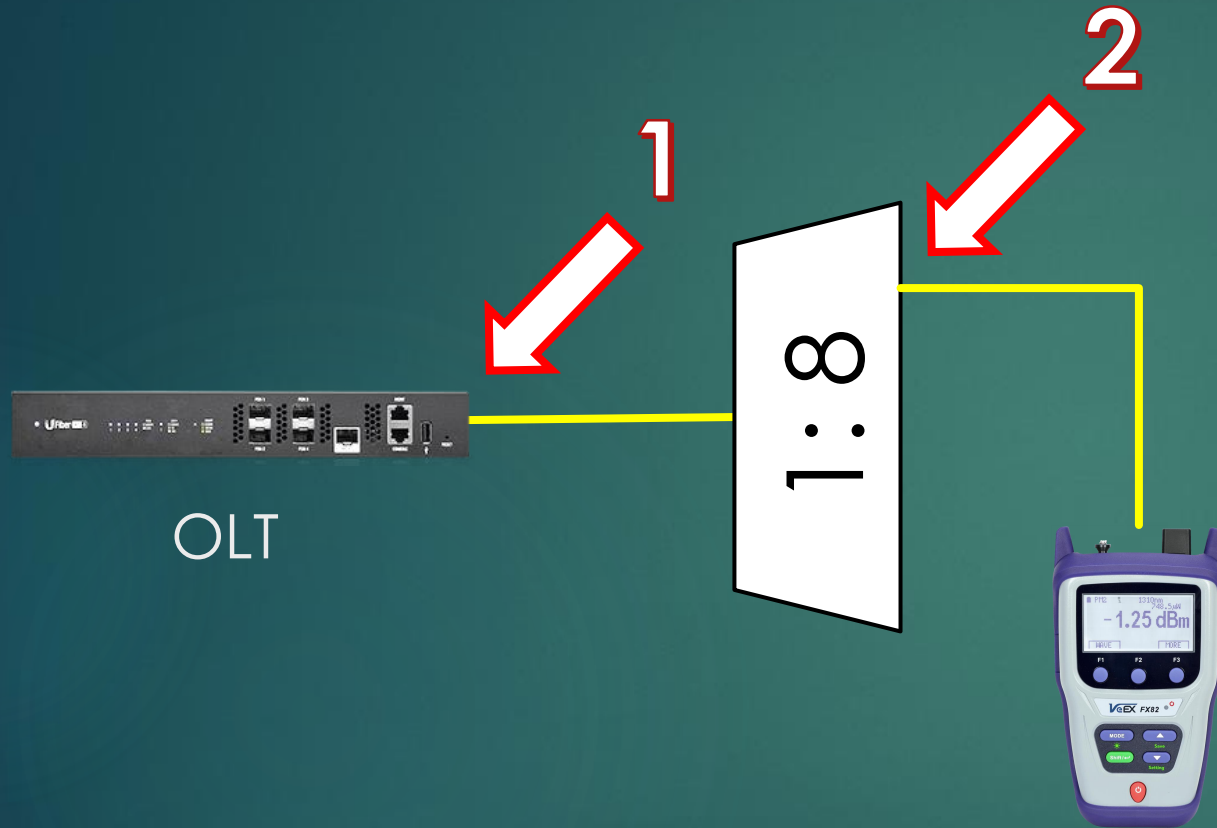
OLT

dBm	Milliwatts
0	1
+3	1.995
+6	3.981
+9	7.943
+10	10
+20	100
+30	1,000

dBm	Milliwatts
0	1
-3	0.501
-6	0.251
-9	0.126
-10	0.1
-20	0.01
-30	0.001



Relative Optical Power (dB)



OLT

Optical Power Meter

Wavelength 1490nm

1). OLT = 0 dBm

2). SPL = -10 dBm

Splitter Loss = 10 dB

Optical Power Meter

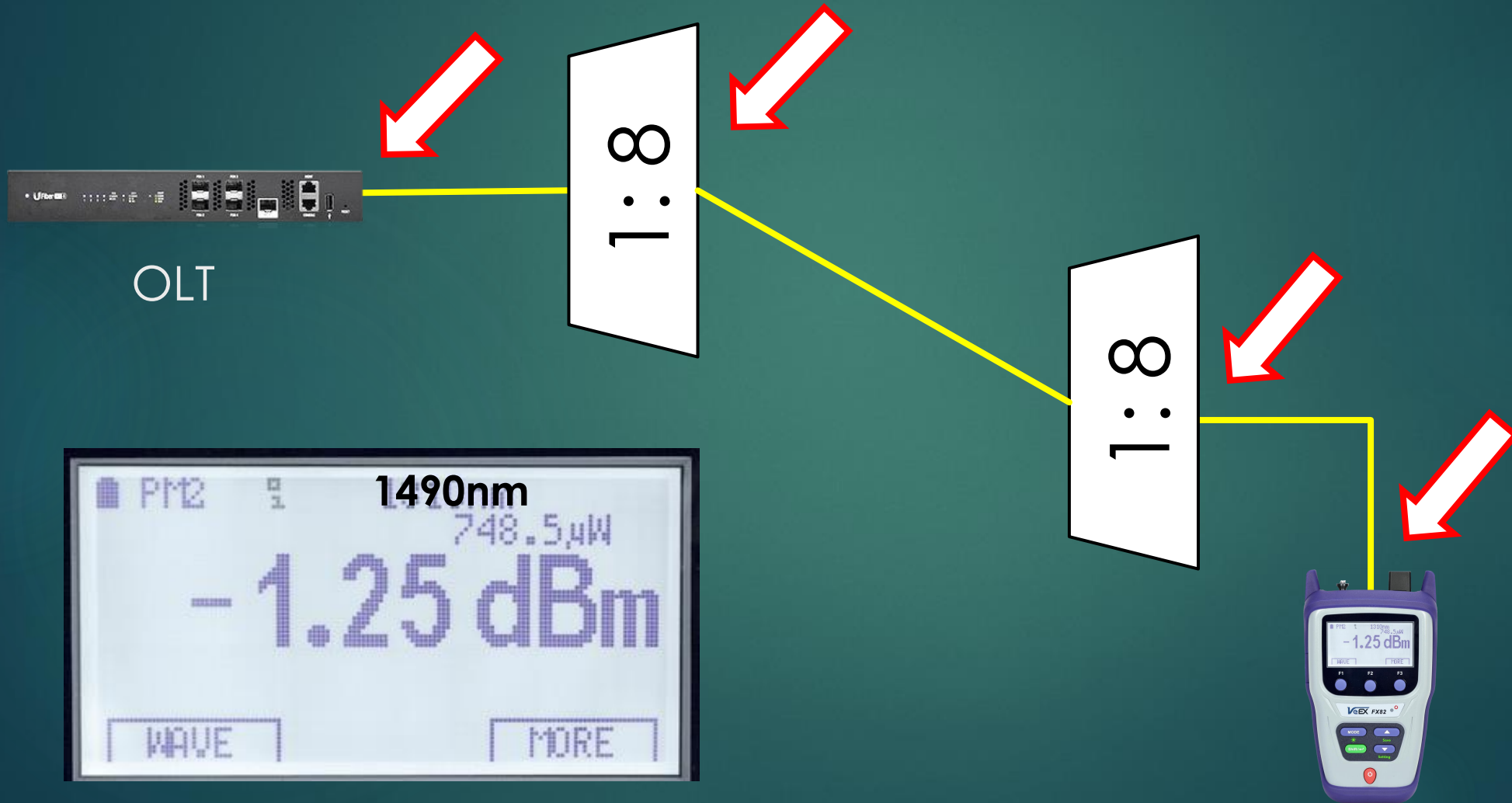


OPM



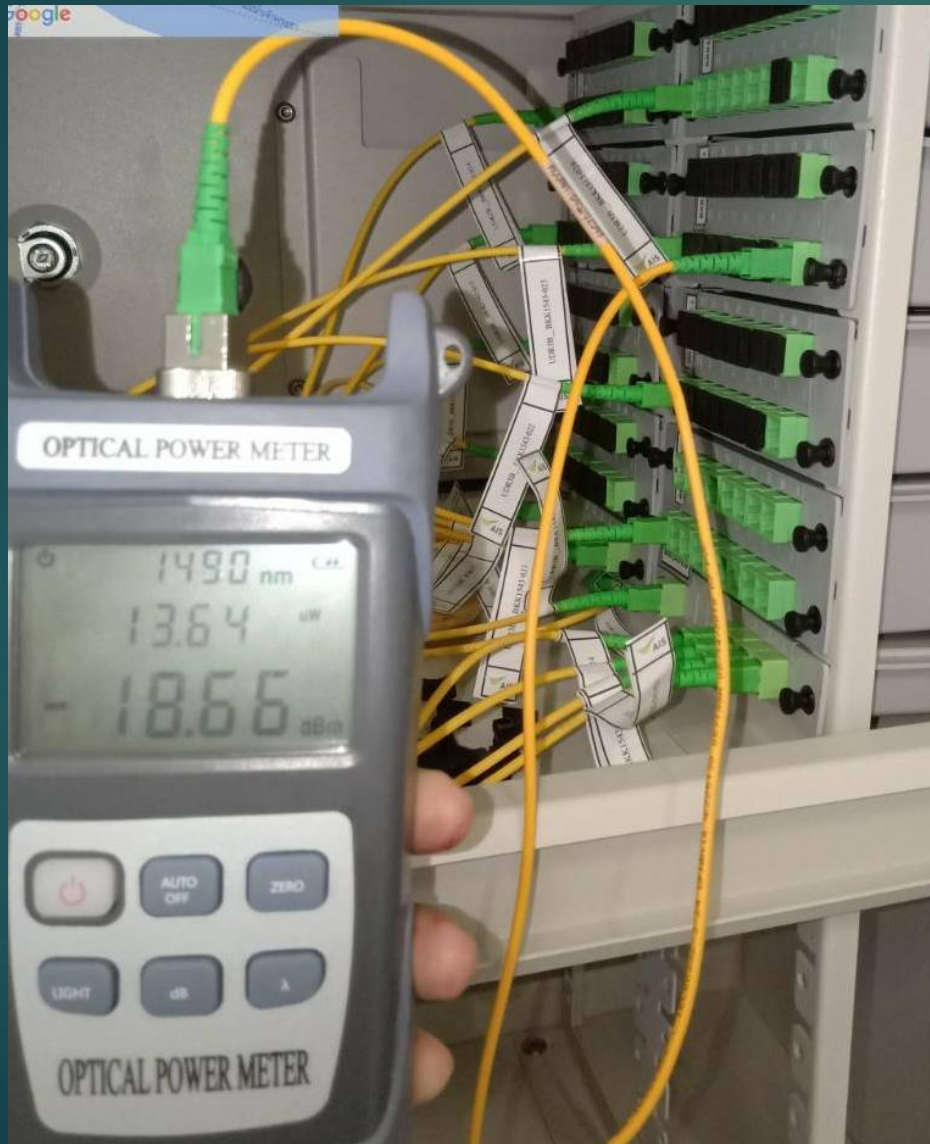
Wavelength : 850, 1300nm
1310, 1490, 1550nm
1625, 1650 nm

OPM measure only 1490nm DS



OLT
1st SPL
2nd SPL
ONU

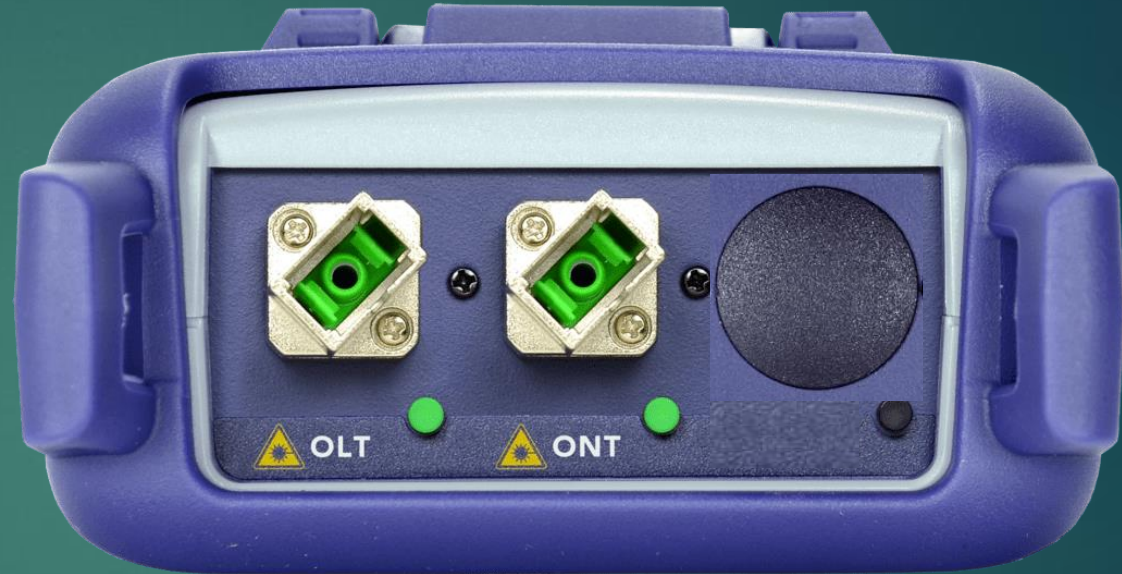
OPM measure only 1490nm DS



PON Power Meter

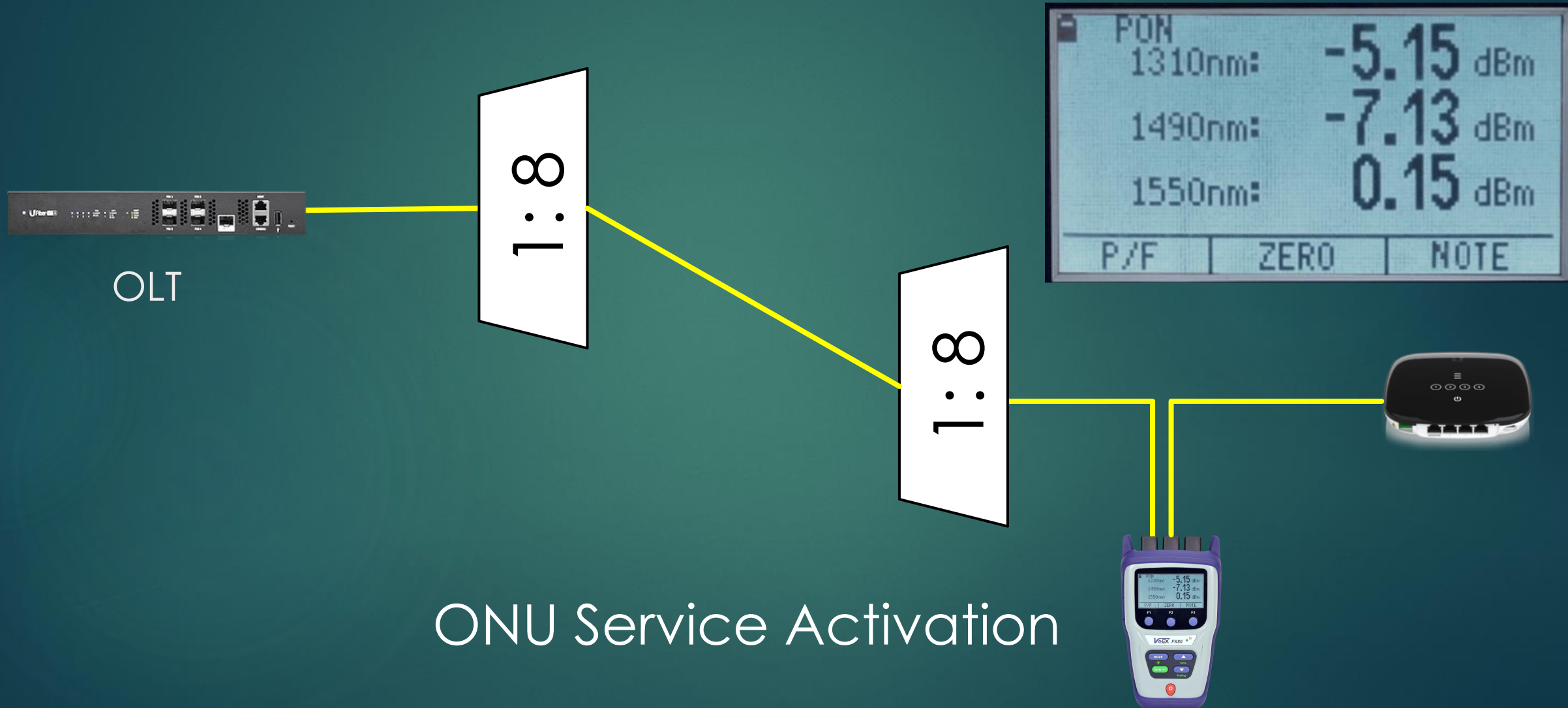


PON Power Meter

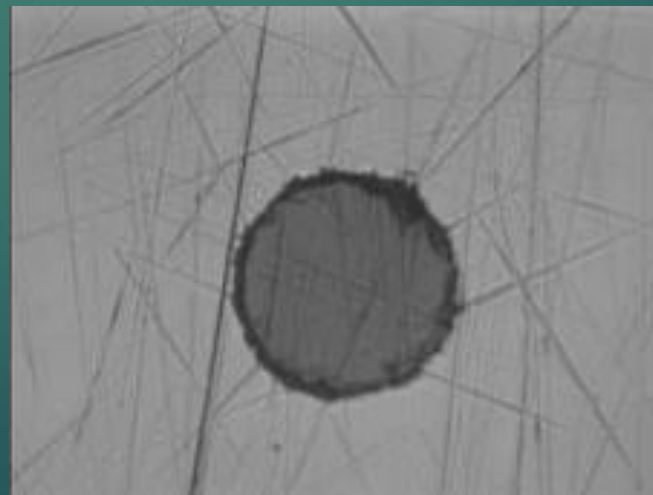
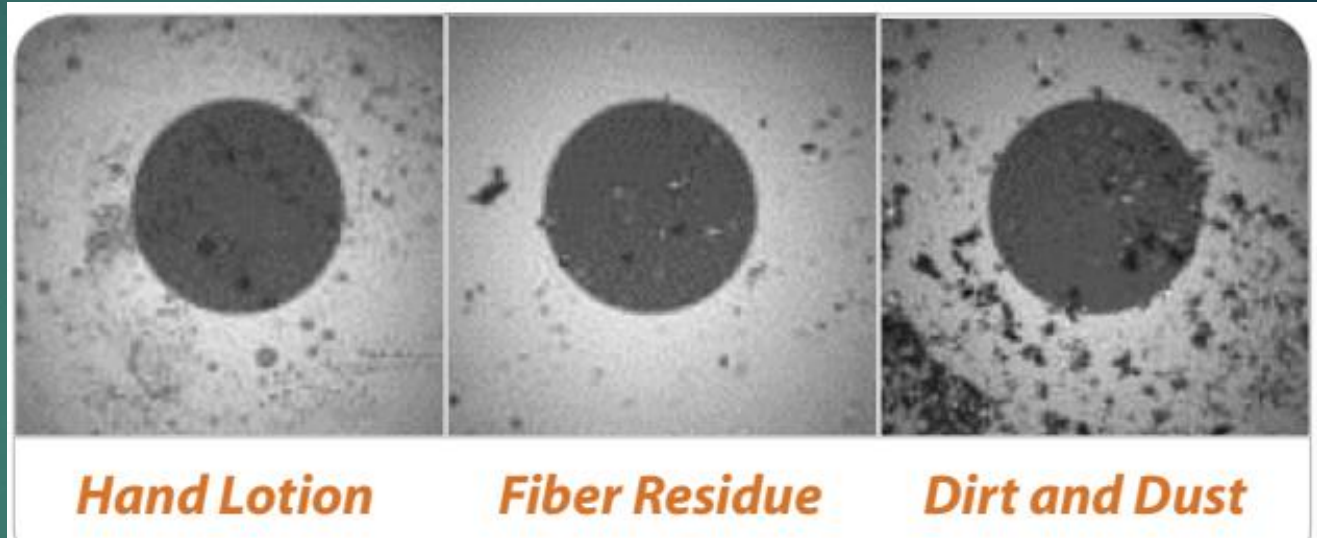
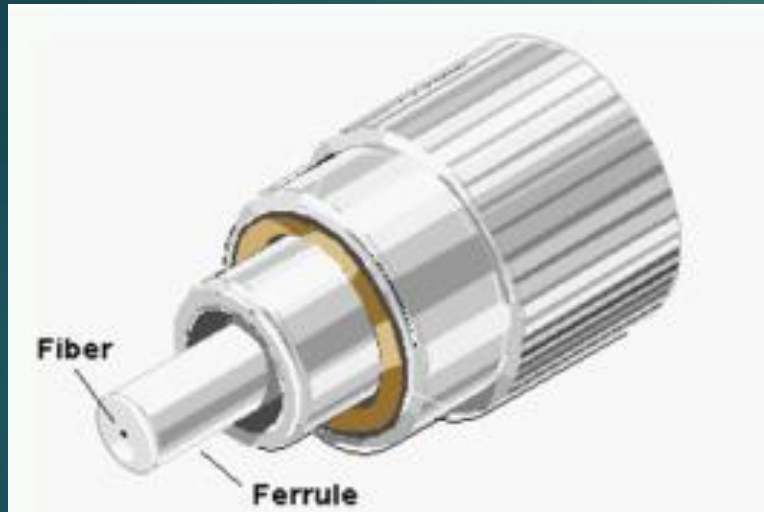


Wavelength : 1310, 1490, 1550nm

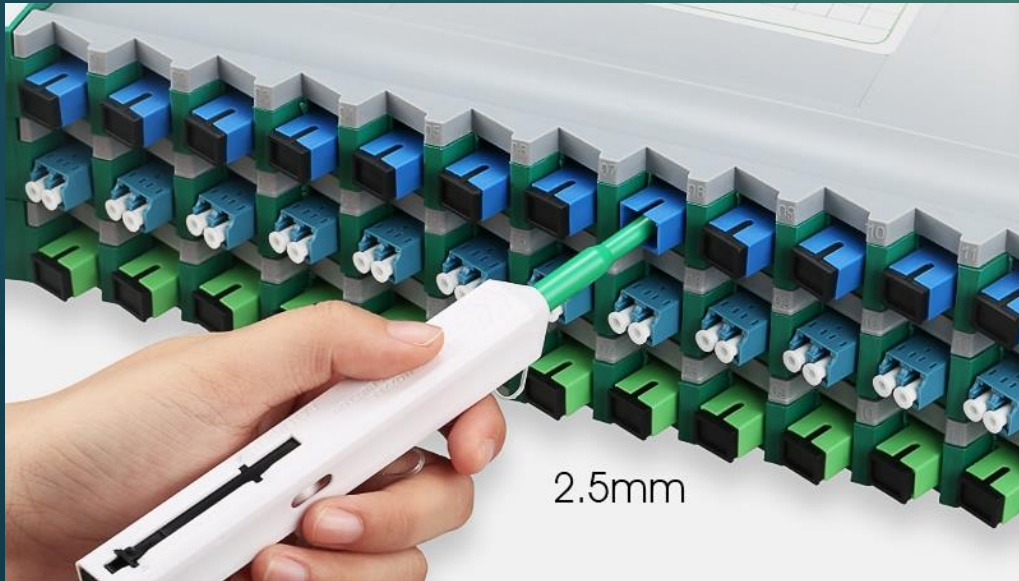
PON Power Meter measurement



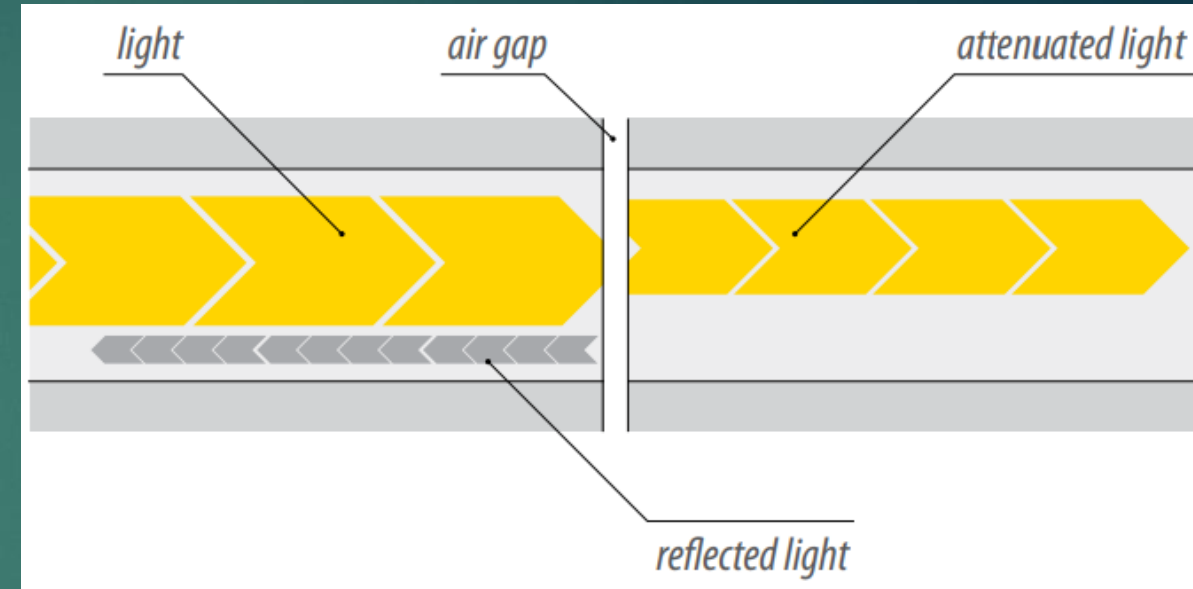
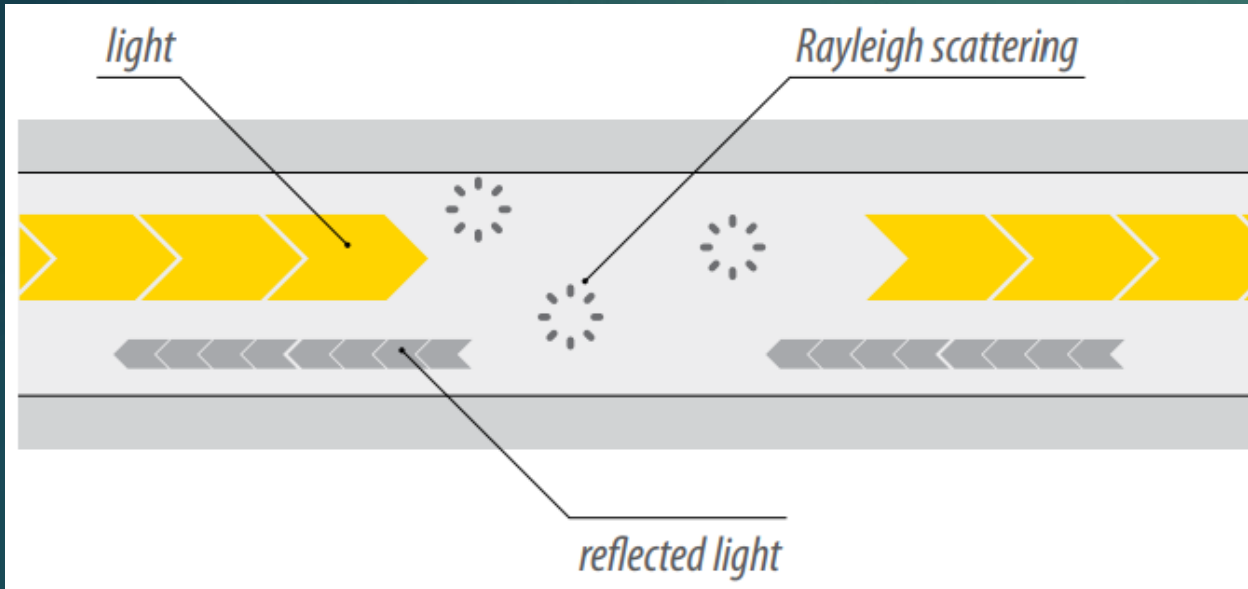
Connector Contamination



Connector Cleaning Tools



What is Optical Return Loss (ORL)?

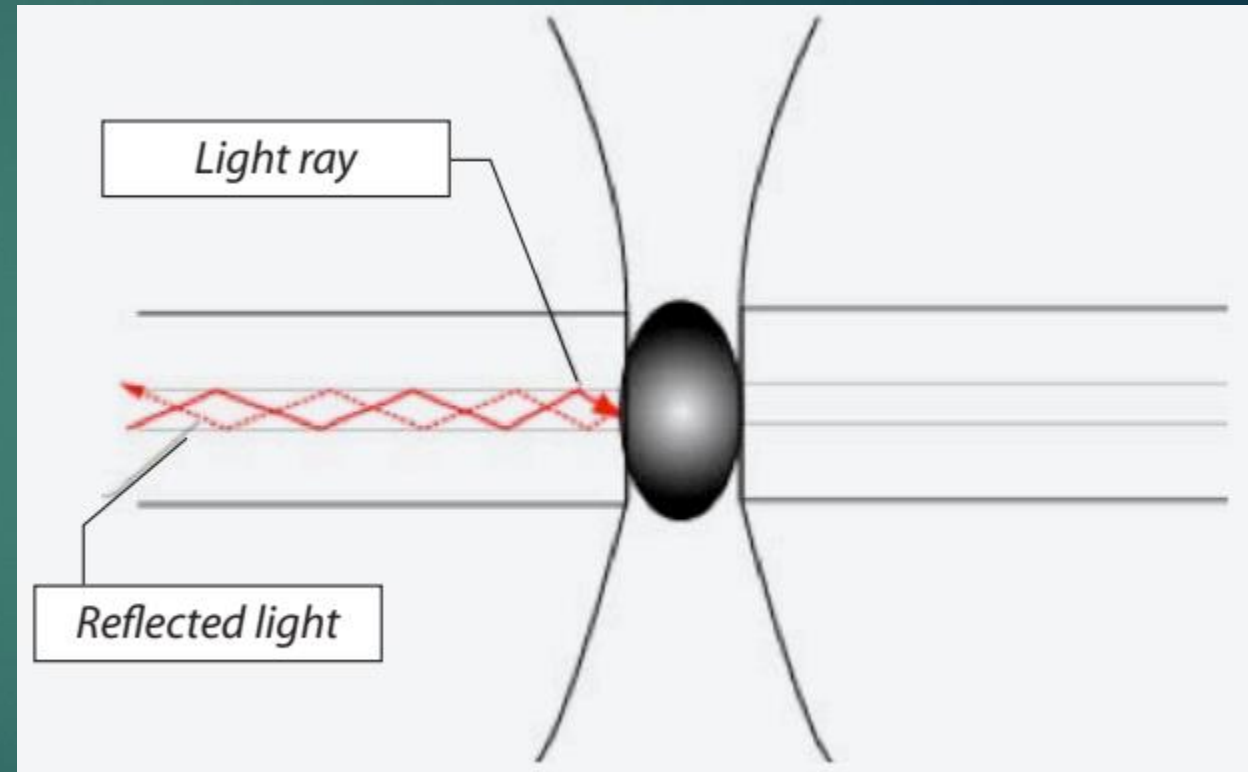
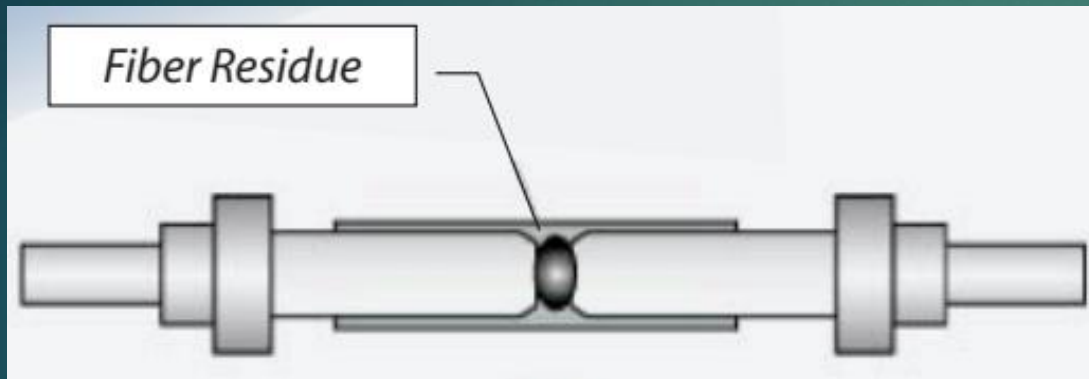


$$RL = 10 \log_{10} (PR/P_{in})$$

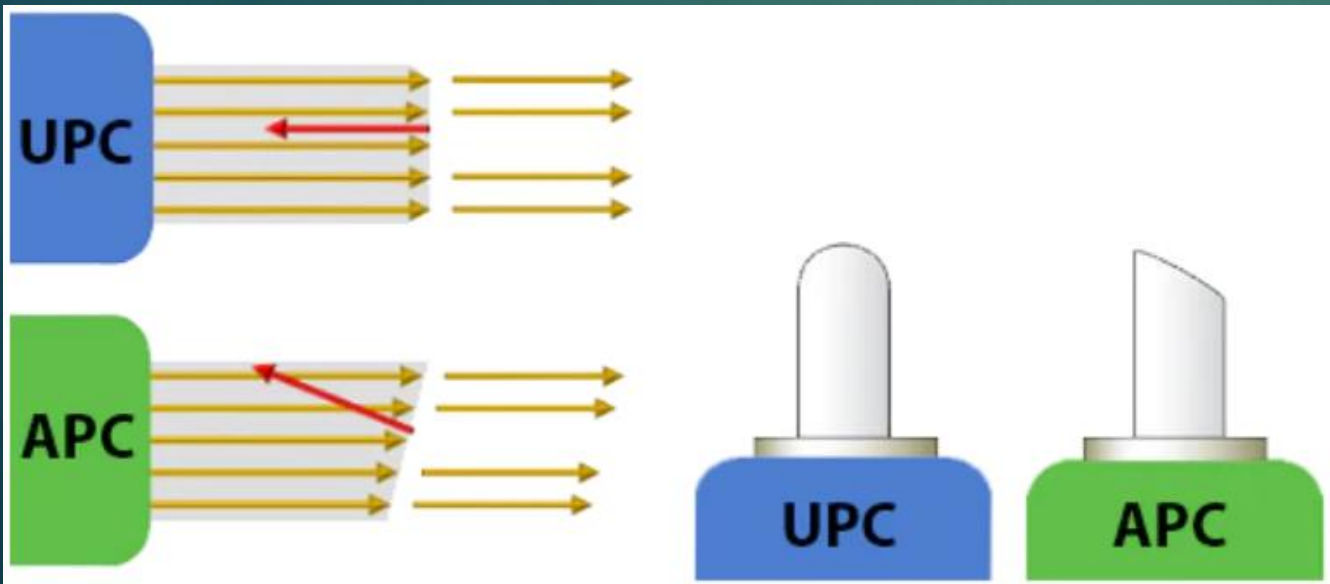
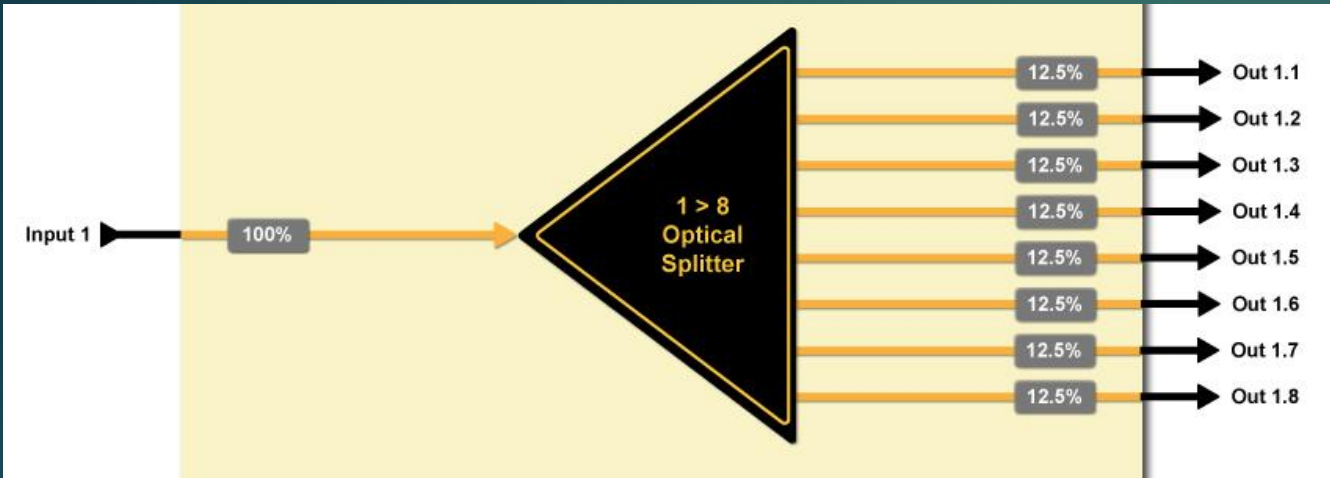
PR = reflected power

P_{in} = input power

What is Optical Return Loss (ORL)?



Why use APC connector in PON?



Connector Polish	Nominal Reflectance (dB)
FLAT	-20 dB
PC	-40 dB
UPC	-50 dB
APC	-60 dB or higher

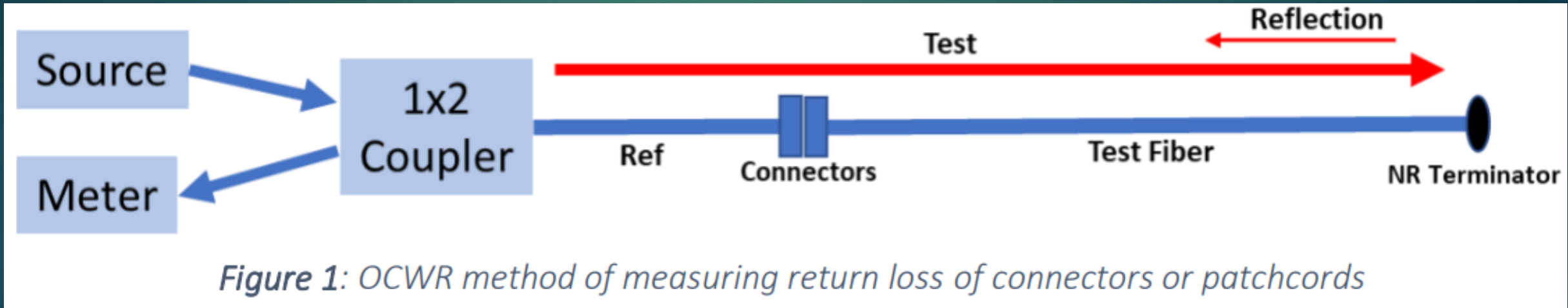
ORL Requirement in GPON

Table 2c – Optical interface parameters of 2 488 Mbit/s downstream direction

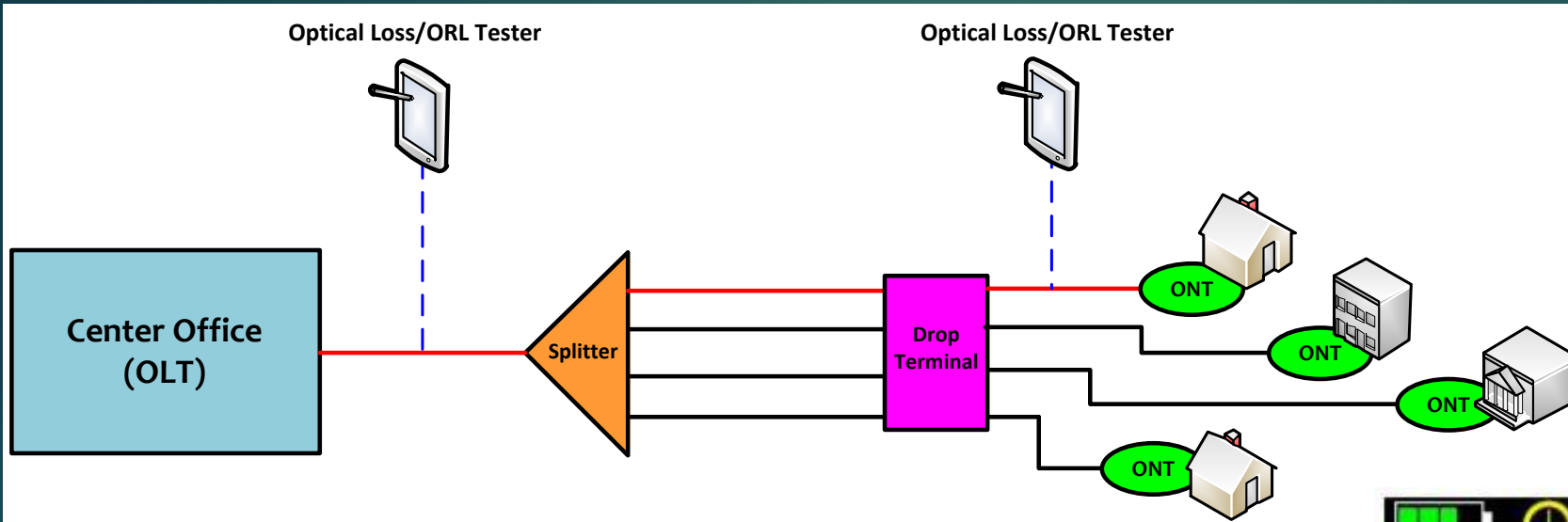
Items	Unit	Single fibre			Dual fibre		
OLT transmitter (optical interface O_{ld})							
Nominal bit rate	Mbit/s	2 488.32			2 488.32		
Operating wavelength	nm	1 480-1 500			1 260-1 360		
Line code	–	Scrambled NRZ			Scrambled NRZ		
Mask of the transmitter eye diagram	–	Figure 2			Figure 2		
Maximum reflectance of equipment, measured at transmitter wavelength	dB	NA			NA		
Minimum ORL of ODN at O _{lu} and O _{ld} (Notes 1 and 2)	dB	more than 32			more than 32		
ODN Class		A	B	C	A	B	C

How to measure ORL?

OCWR (Optical continuous wave reflectometer)



Bidirectional Loss Testing



2011-09-15 17:41

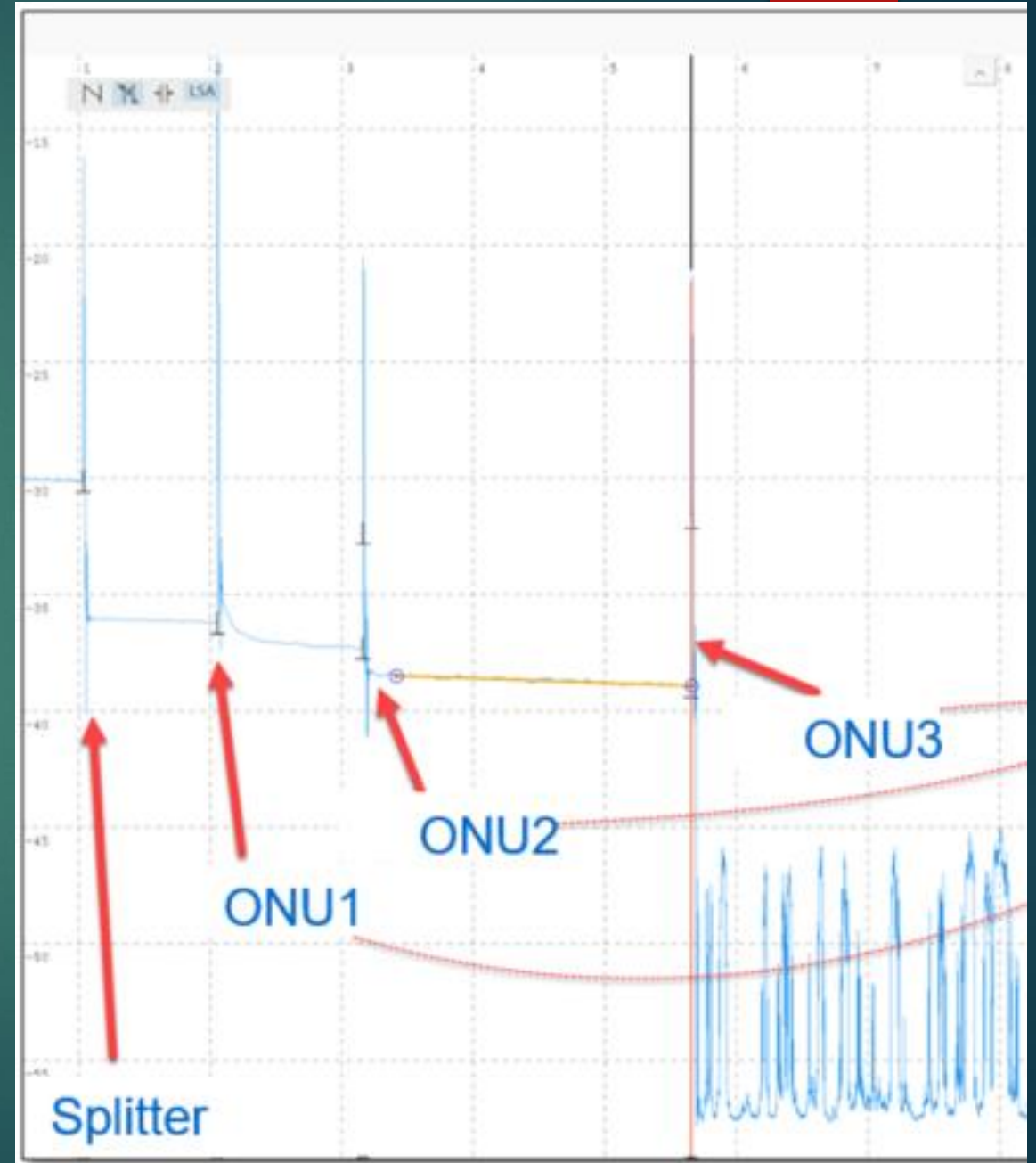
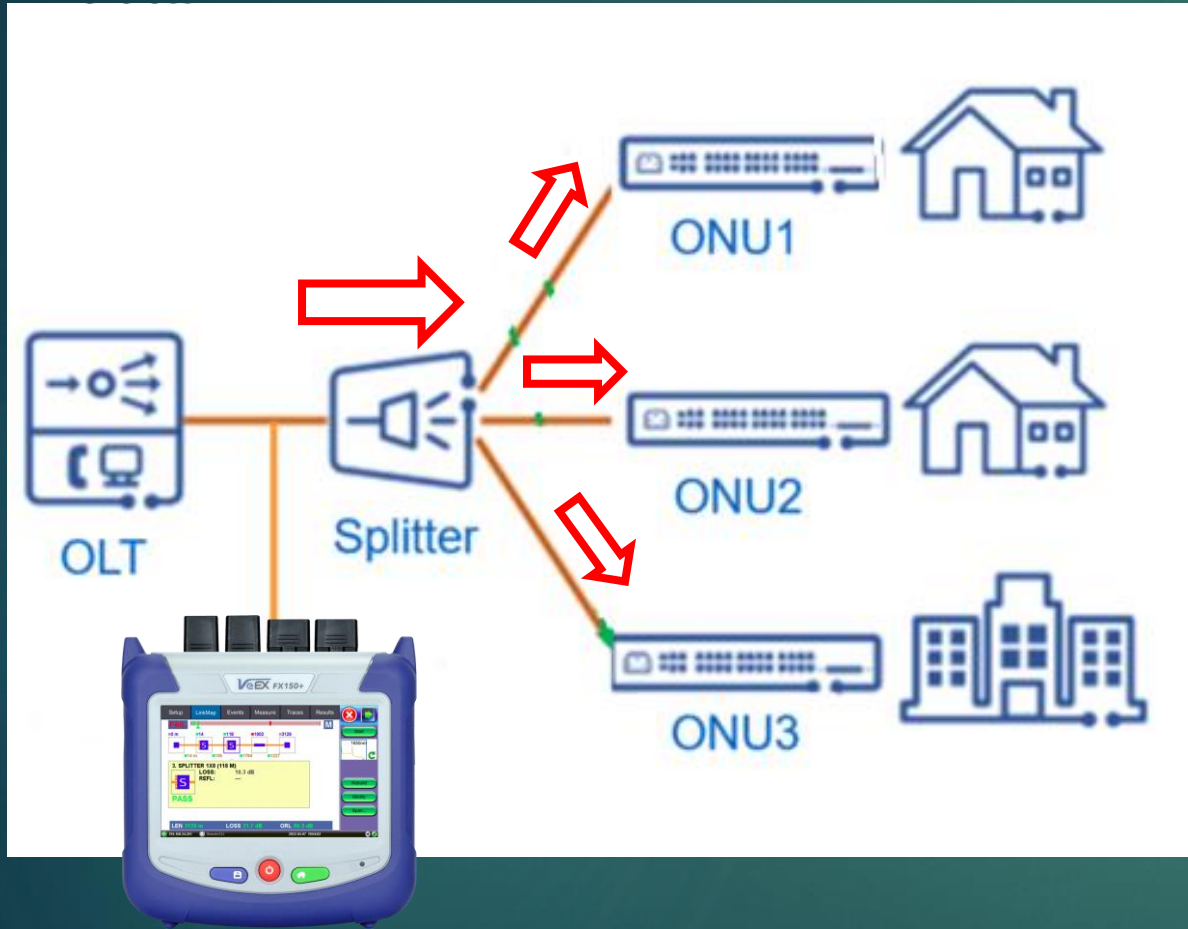
Save
▶ Start

	1310	1550
A→B (dB)	23.73	12.96
B→A (dB)	23.62	12.91
ORL-A (dB)	30.74	31.86
ORL-B (dB)	29.92	31.28

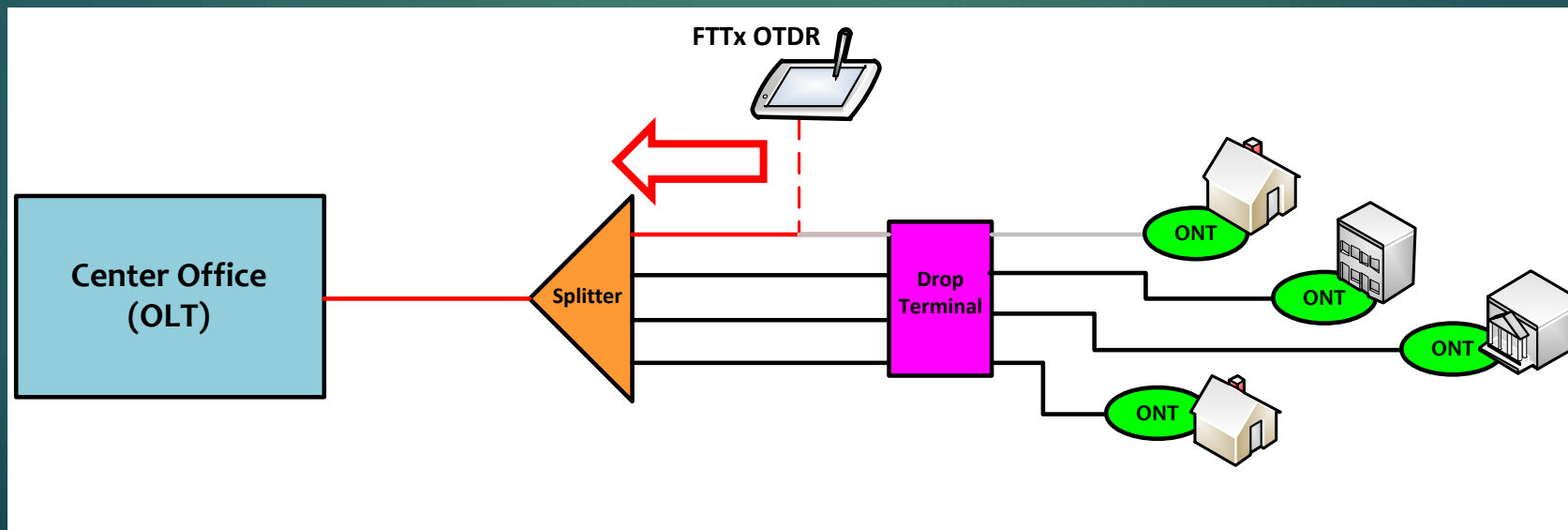
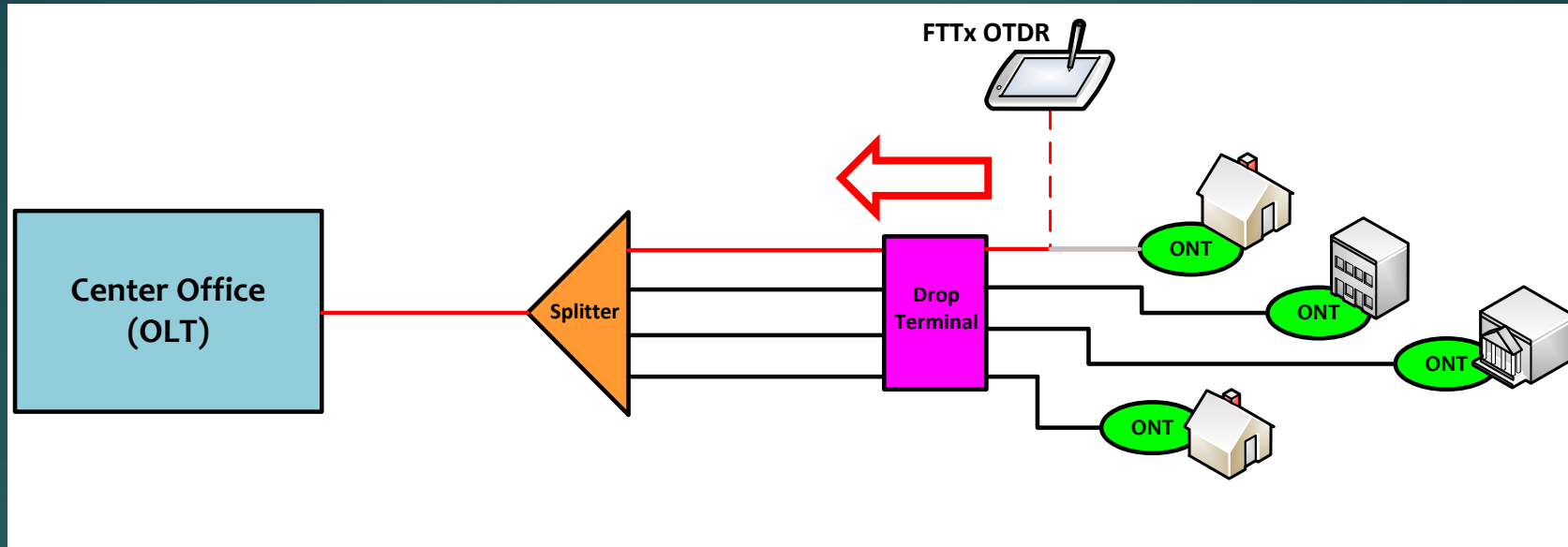
Loss Meter Length: 71.521km

Set ref. **BiDirTest** Save

OTDR Measurement



OTDR Measurement



OTDR Selection for PON

Out-of-service test

Wavelength : 1310/1550nm

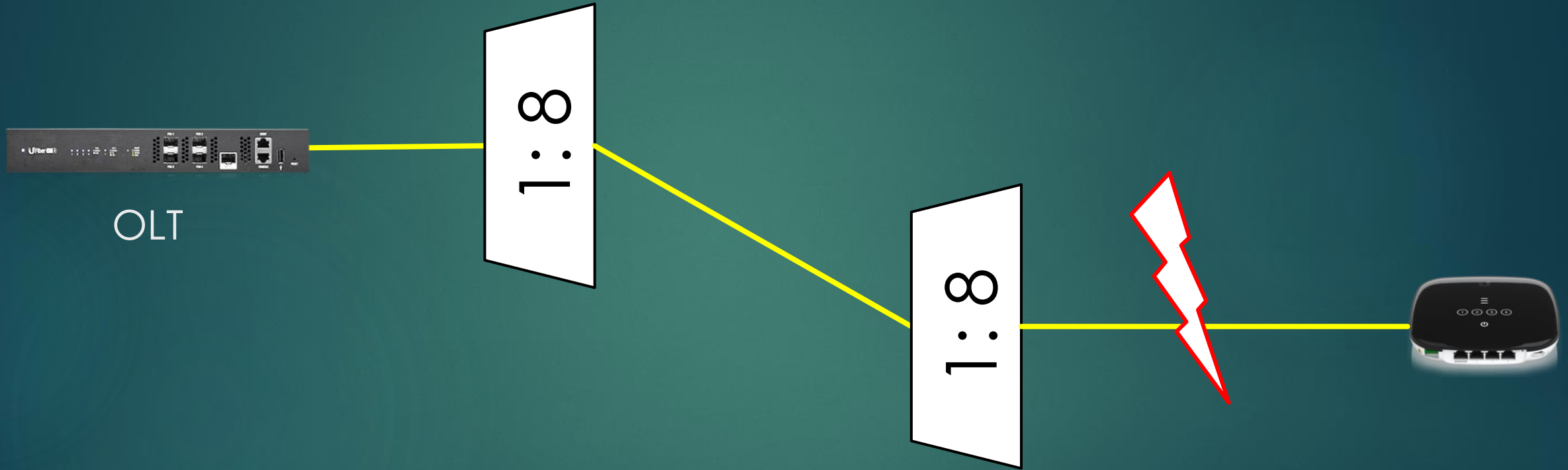
Dynamic Range ~ 22 dB

In-service test

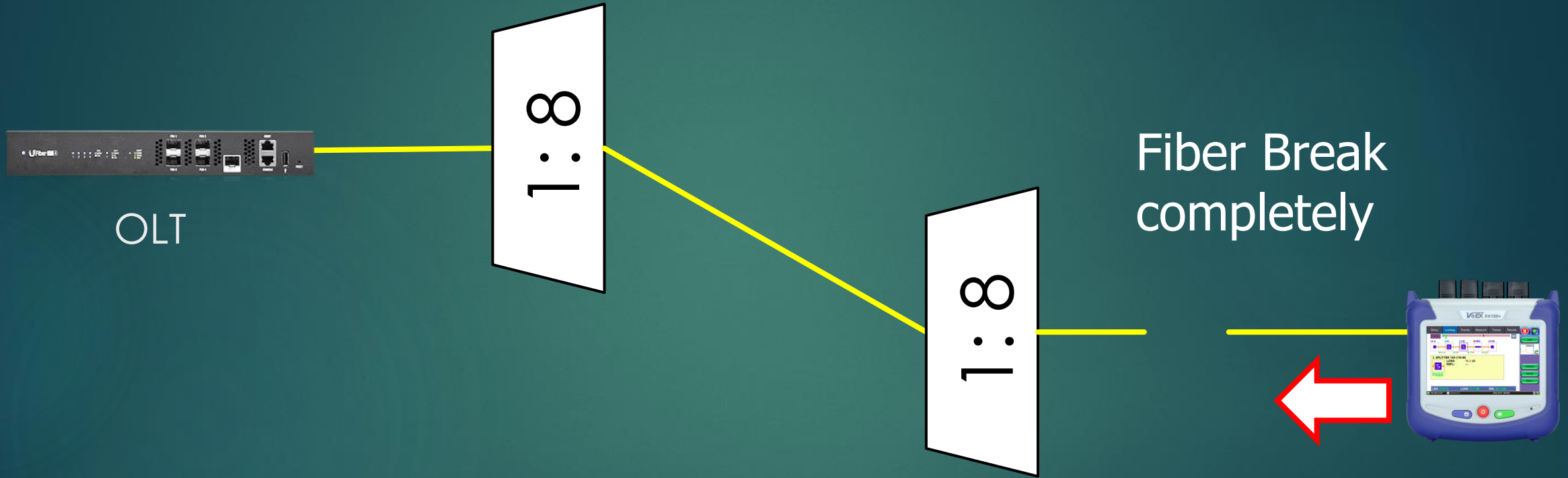
Wavelength : 1625nm or 1650nm (recommend)

Dynamic Range ~ 40 dB

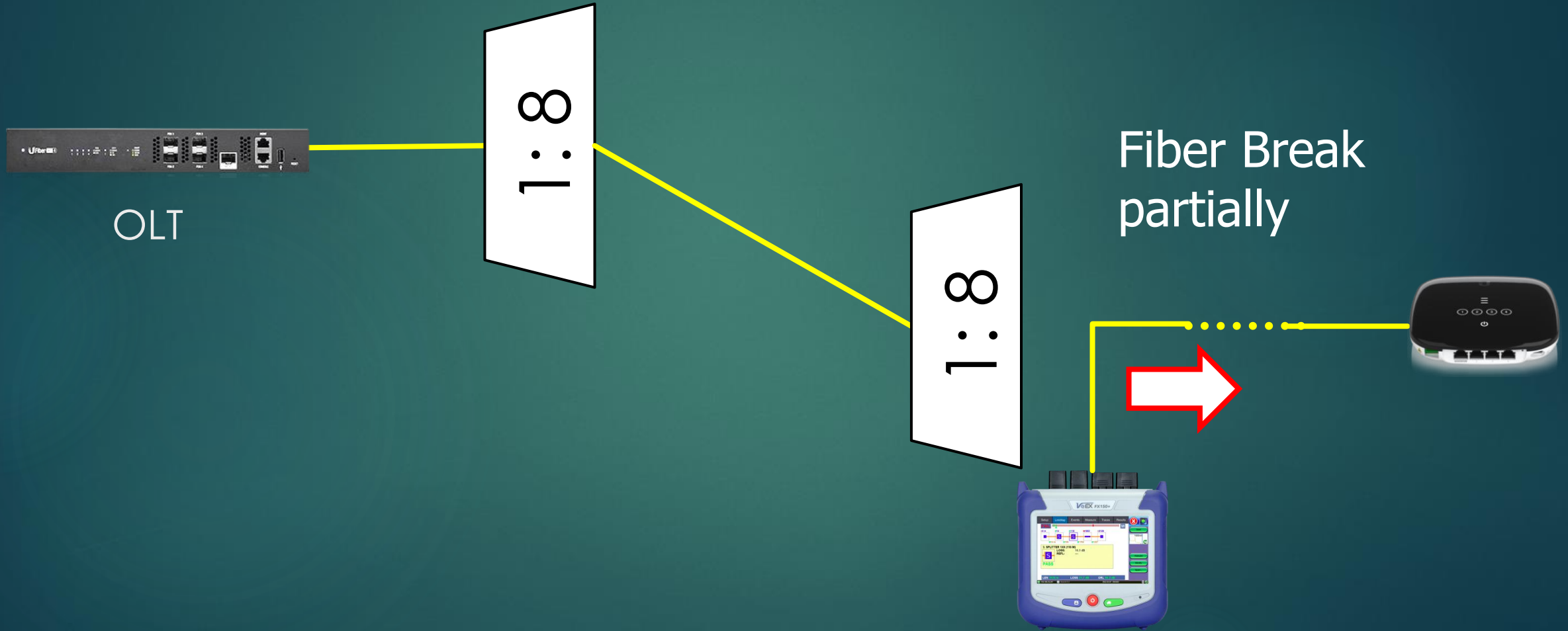
Out-of-Service test



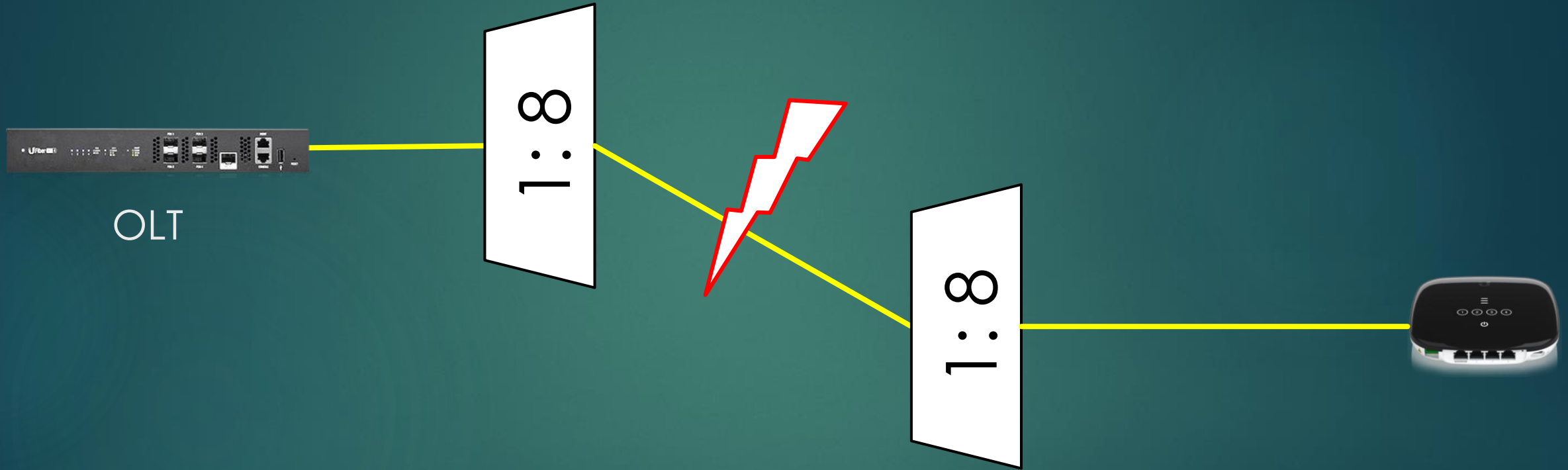
Out-of-Service test



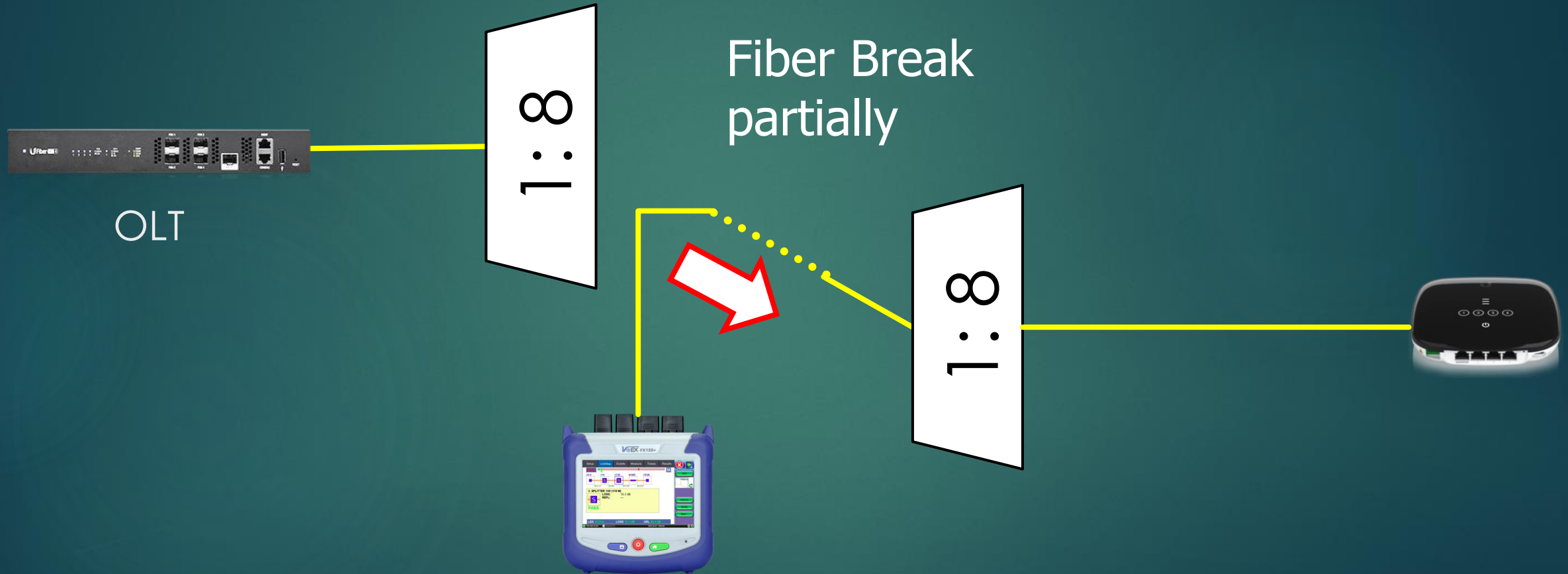
Out-of-Service test



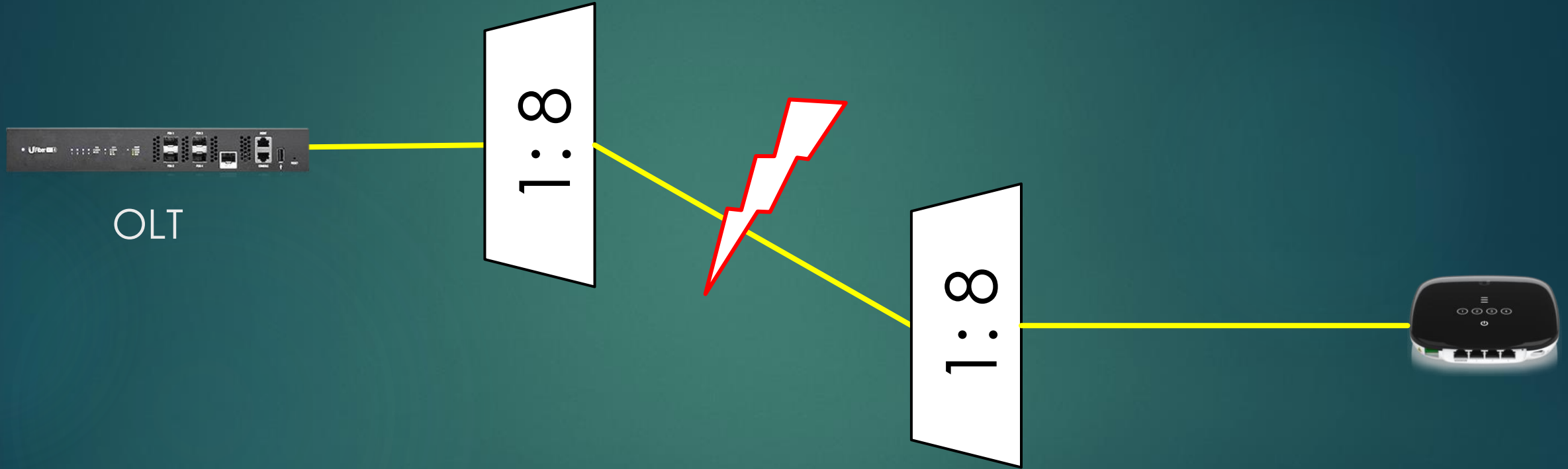
Out-of-Service test



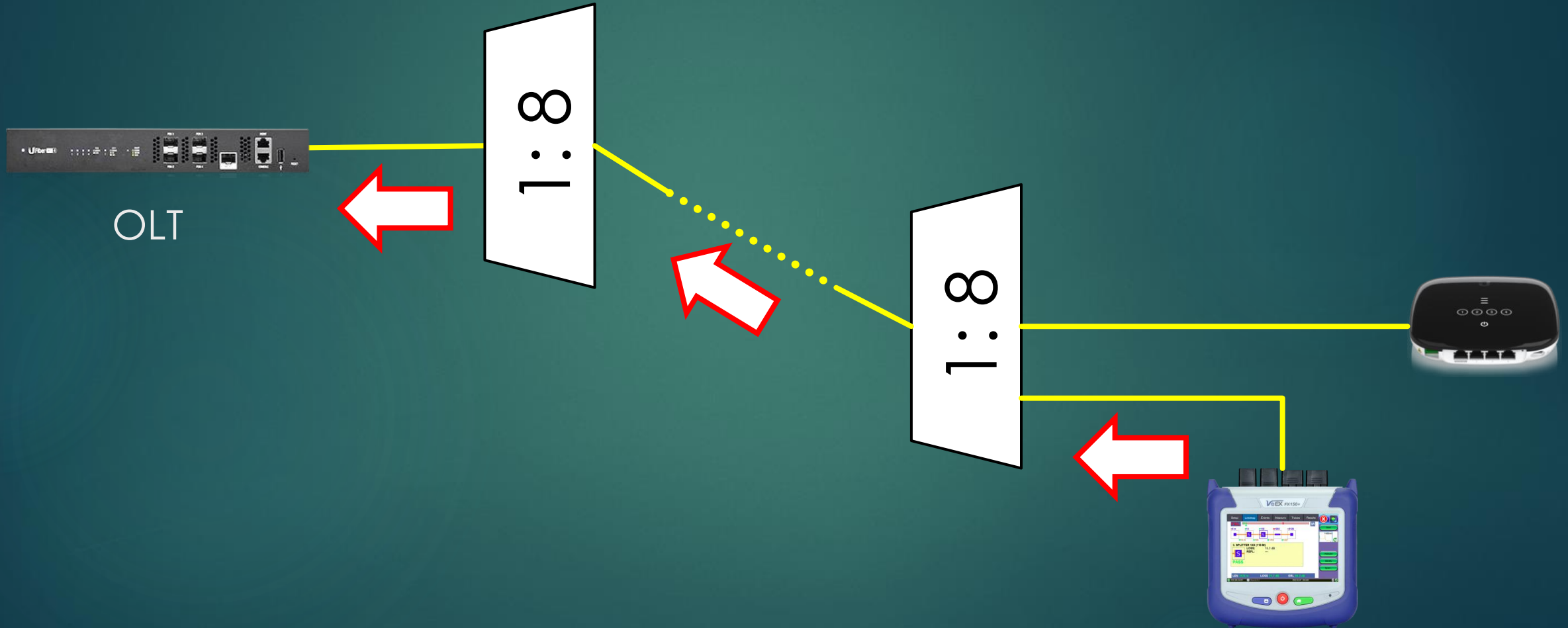
Out-of-Service test



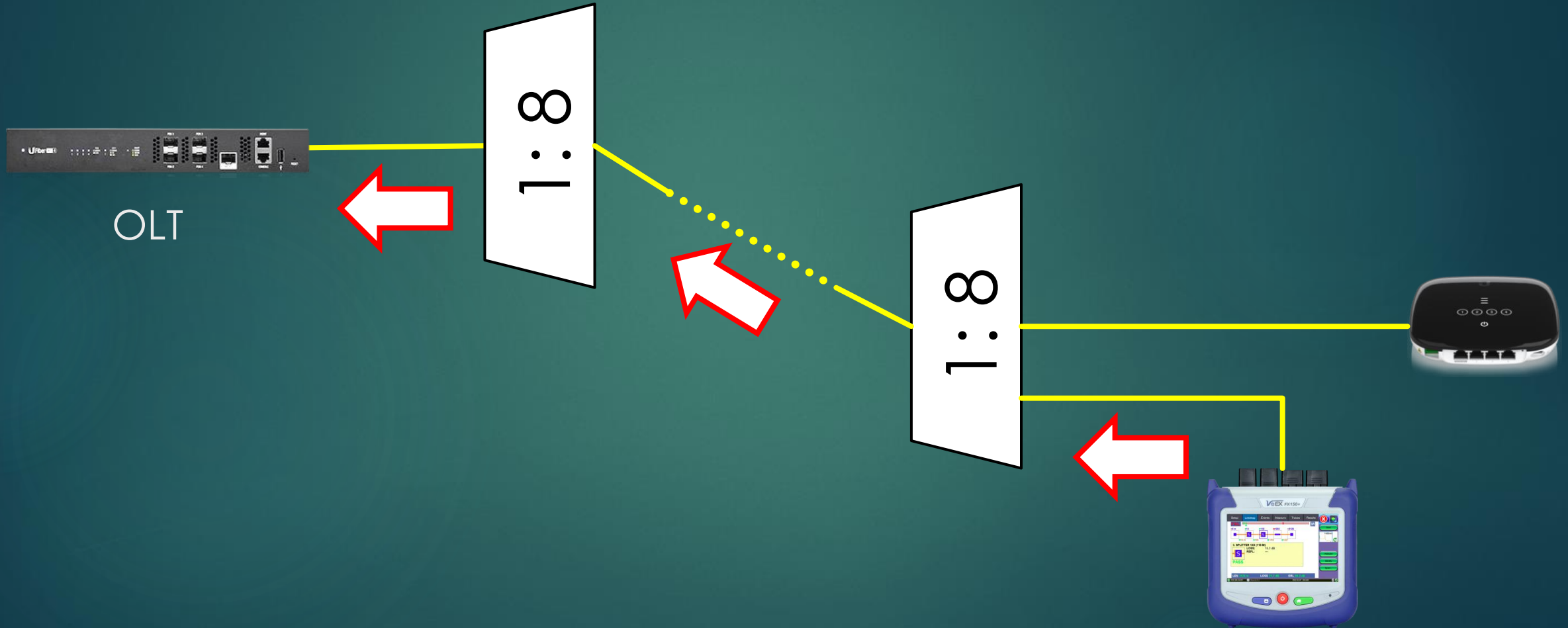
In-Service test



In-Service test



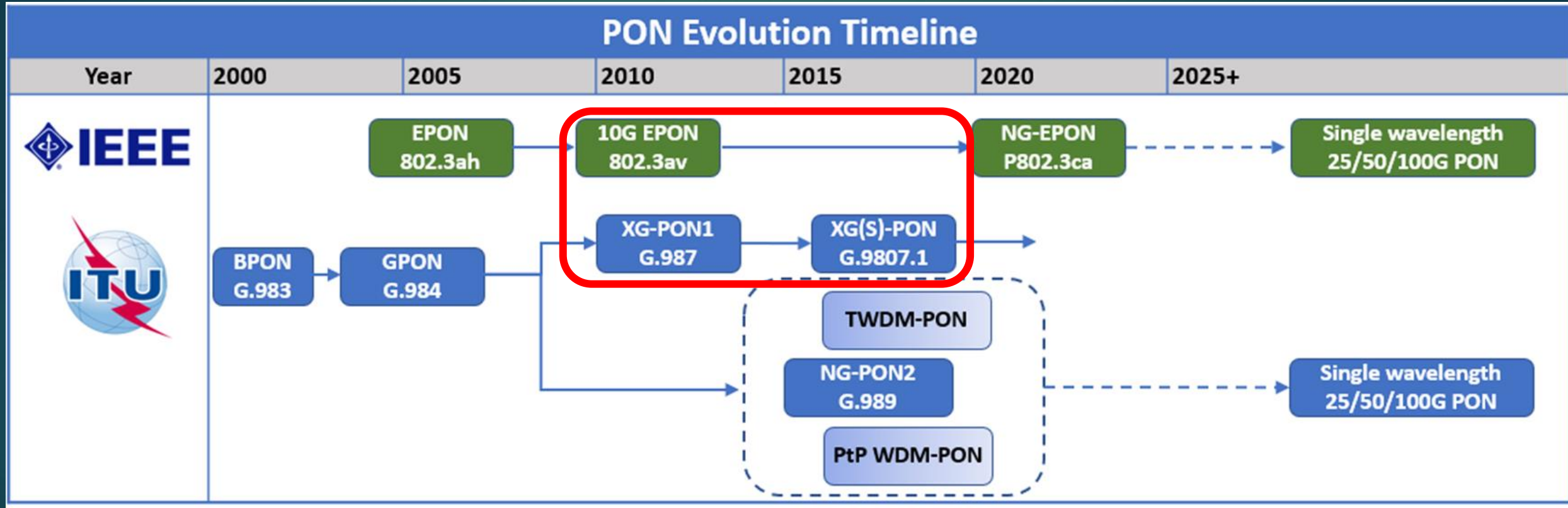
In-Service test



Topic

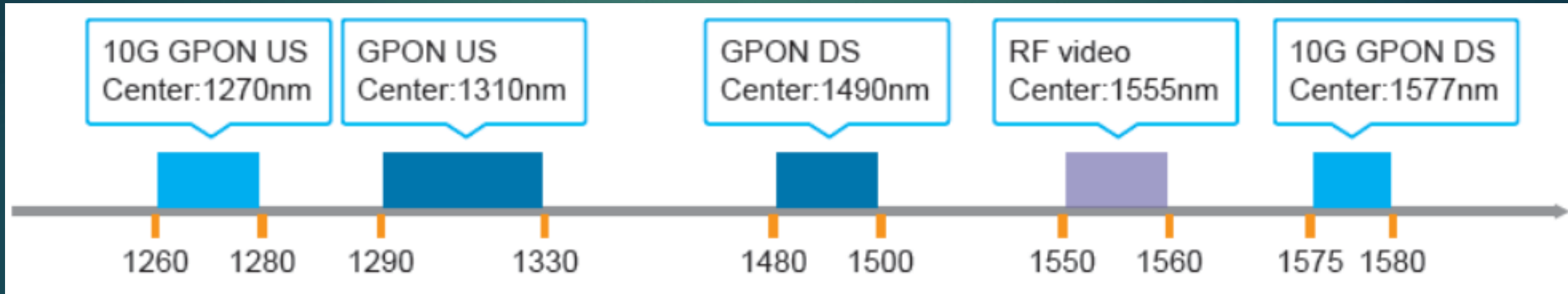
- ❑ What is PON?
- ❑ PON standards and Component
- ❑ Advantages of PON
- ❑ PON testing and maintenance
- ❑ **Next Generation PON**

Next Gen PON Standards



- 10G EPON (802.3av) : DS 10Gbps, US 2.5Gbps
- XG-PON (G.987) : DS 10Gbps, US 2.5Gbps
- XG(S)-PON (G.9807.1) : DS 10Gbps, US 10Gbps

Next Gen PON Wavelength



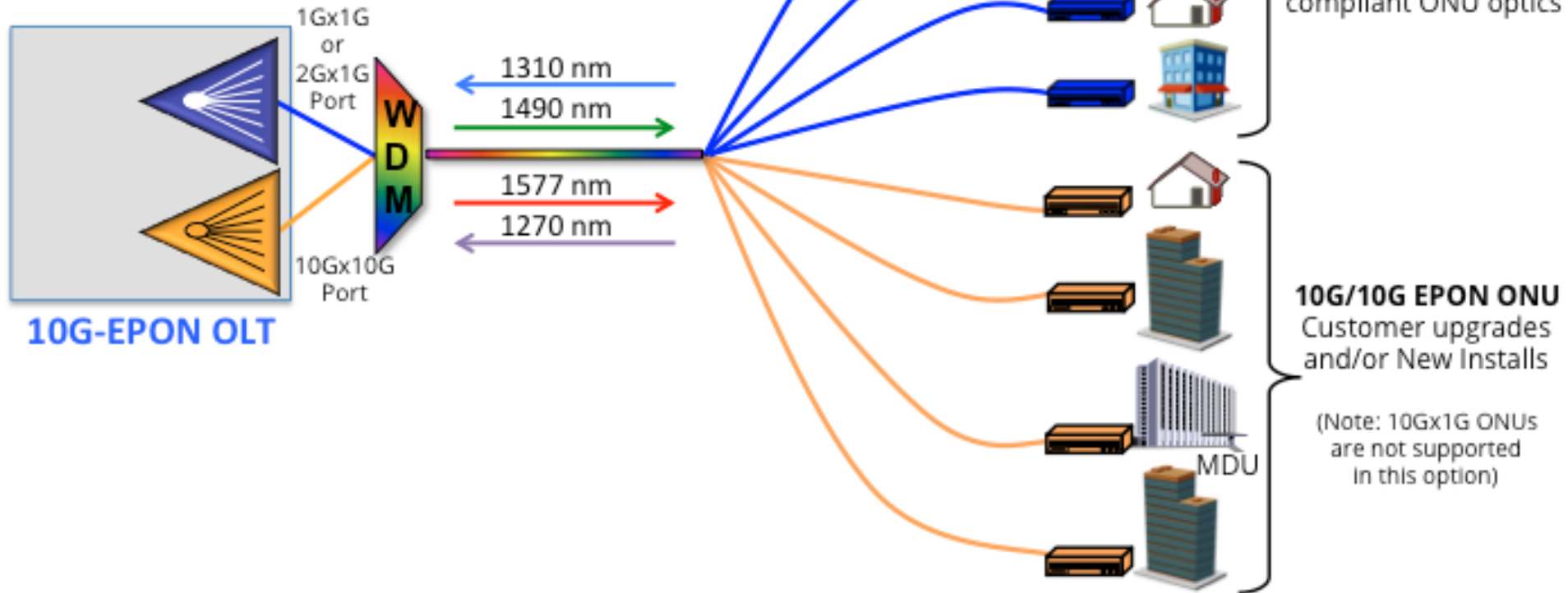
Next Gen PON Wavelength

Downstream Dual-rate WDM

1G DS 1490nm ± 10 "and" 10G DS 1577.5 ± 2.5

Upstream Dual-rate WDMA

1G US 1310nm ± 20 "and" 10G US 1270nm ± 10



2 OLT Ports Enabling 1G & 10G Downstream & 1G & 10G Upstream for 2 Types of ONUs

XGPON Power Meter



Q & A