NETWORK AND TELECOMMUNICATION

ACADEMIC BACKGROUNDS:

- 1987-1993 Georgia University of Technology (Former USSR) **Specialize: Radio Transmitting Device of Satellite Telecommunication Systems** (Master of Science).
- 1997-1998 Advanced course at the Saint–Petersburg State University of Technology in computer simulation of ground stations Modem for Sputnic communication (Russia).

PREVIOUS EMPLOYMENT:

- 2002-2018 The World Bank Cambodia (IT Analyst, Client Services).
- 1999 -2001 Worked as Systems Engineer at VIRTU International Limited.
- 1995 -1997 Worked as assistant manager in operation and technical department at CAMINTEL.
- 1993 – 1995 Worked as engineer in Operations and Technical Department in HUB-station (ex-UNTAC Networks) at Ministry of Post and Telecommunications of Cambodia.

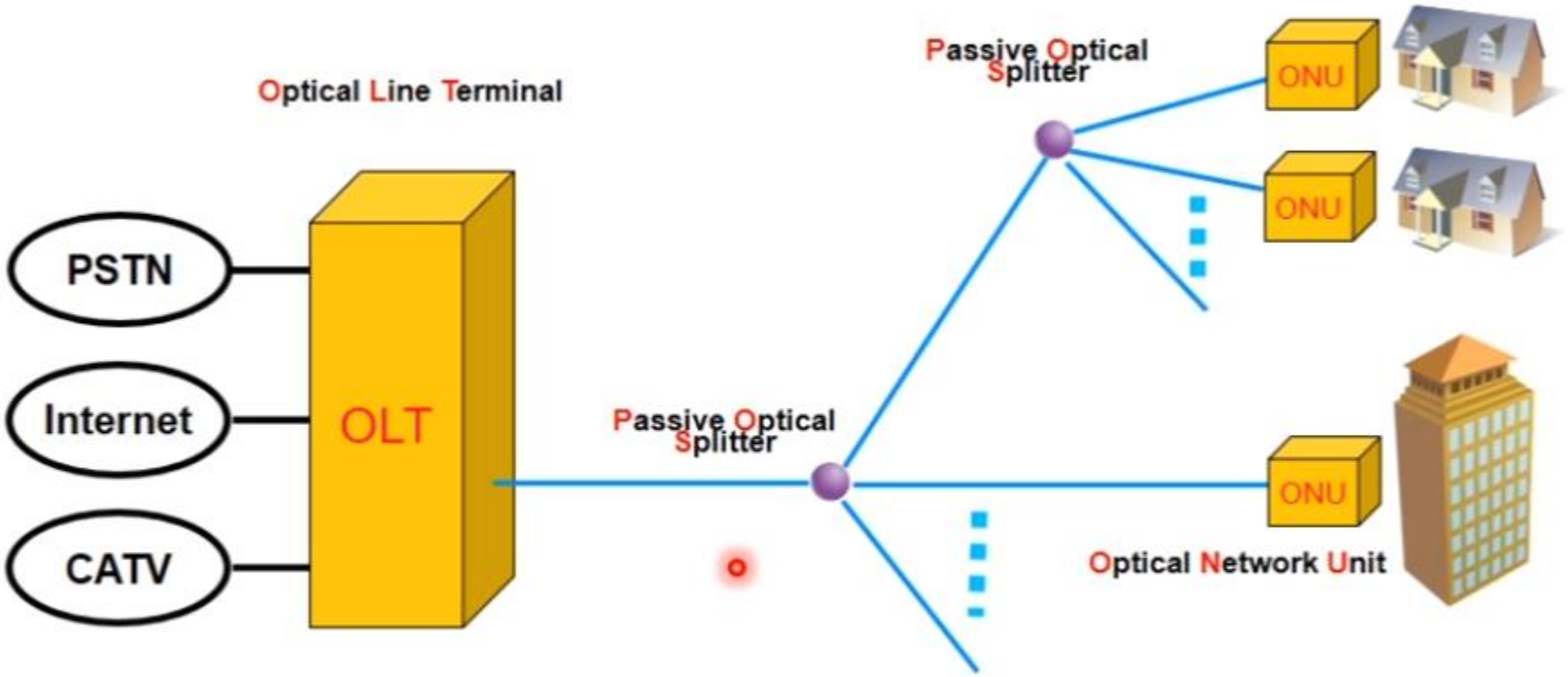
Teaching Experiences:

- 2000 Royal Academy of Cambodia (MSc.IT).
- 2002 Build Bright University (MSc.IT).
- 2019 National Polytechnic Institute of Cambodia (BSc.Telecom).
- 2020 Norton University (BSc.IT)
- 2023 Cambodia Academy of Digital Technology (BSc.Telecom).

Contents

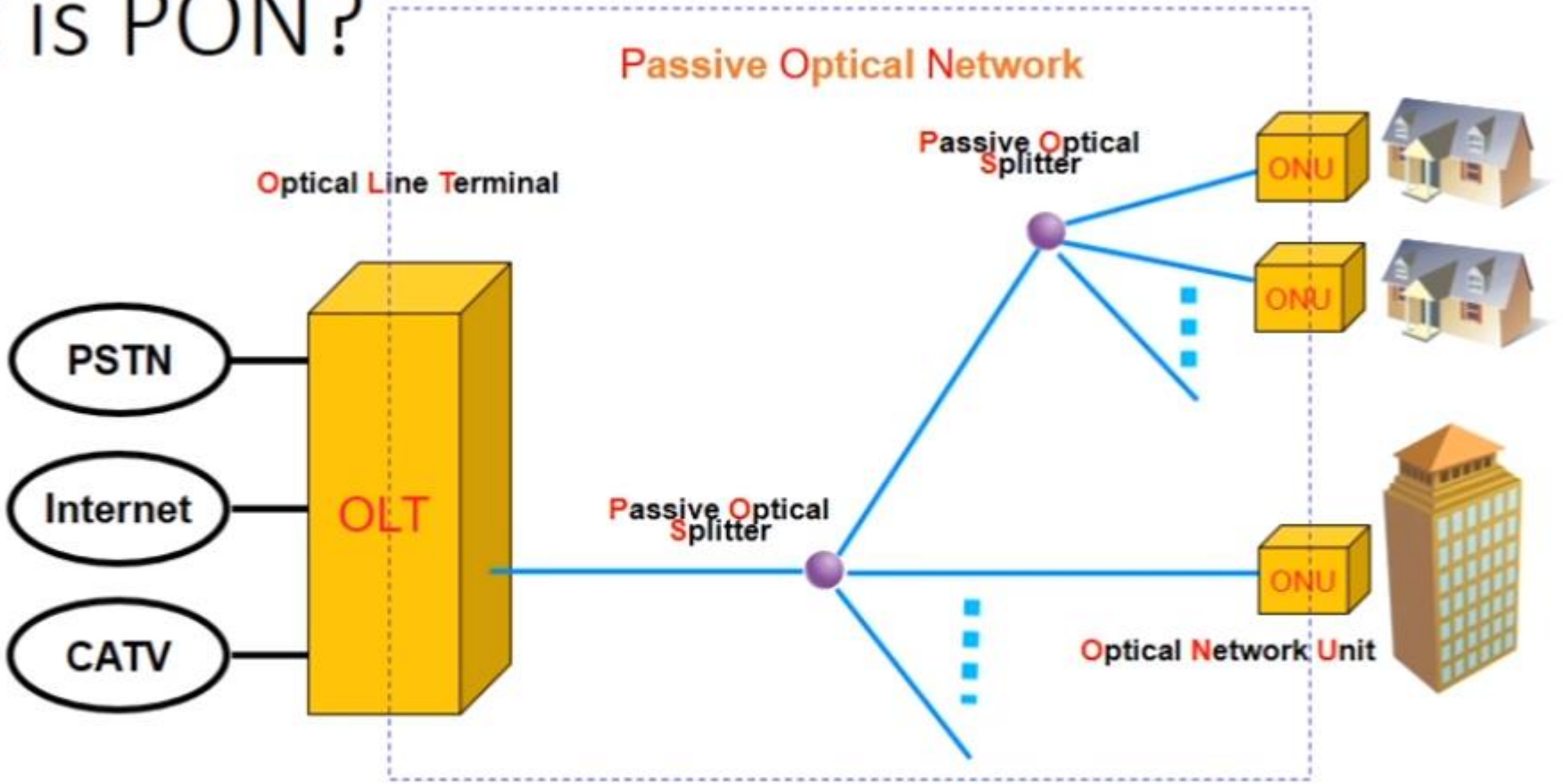
- Basic Concepts of PON
- Overview of Optical Access Network
- Analysis of GPON Standards
- GPON Key Technologies
- GPON Management
- Basic Services over GPON Network

What is PON?



- PON is a kind of passive optical network featuring one-to-multiple-point architecture;
- PON is short for Passive Optical Network ;
- PON consists of Optical Line Terminal (OLT), Optical Network Unit (ONU) and Passive Optical Splitter.

What is PON?



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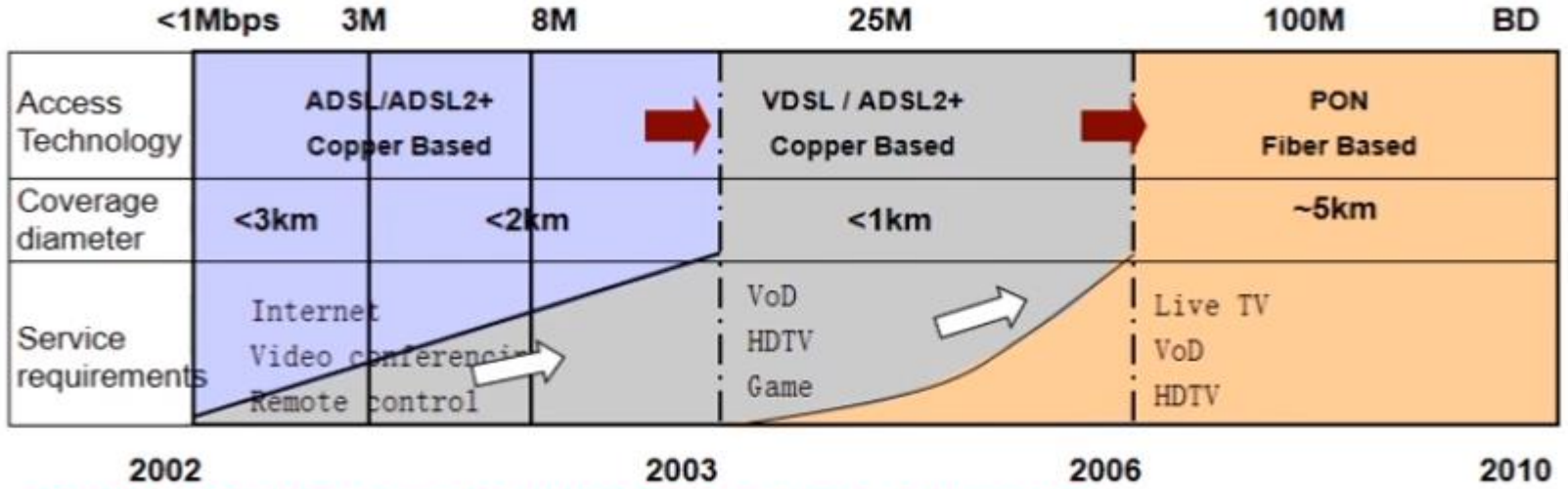
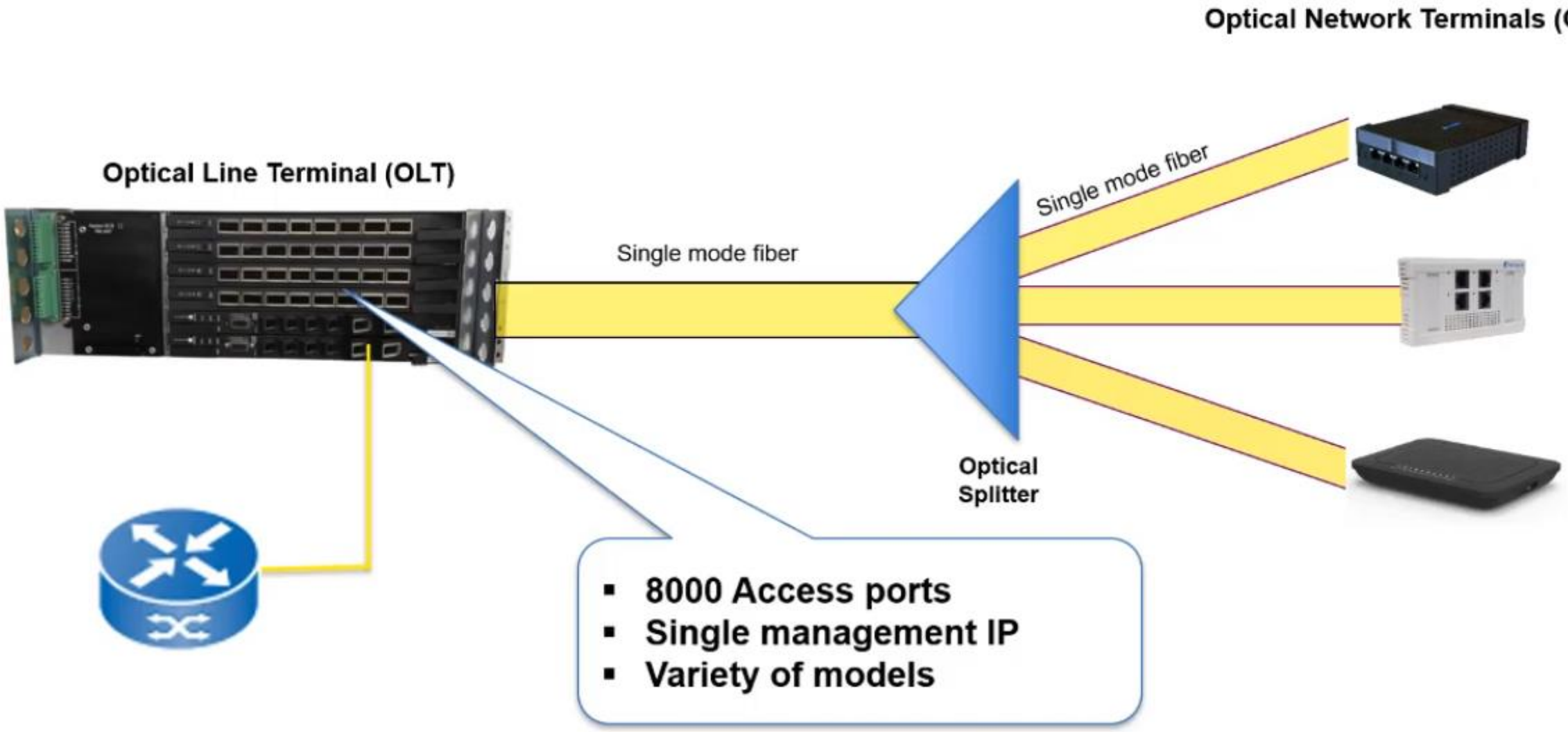
Why GPON?

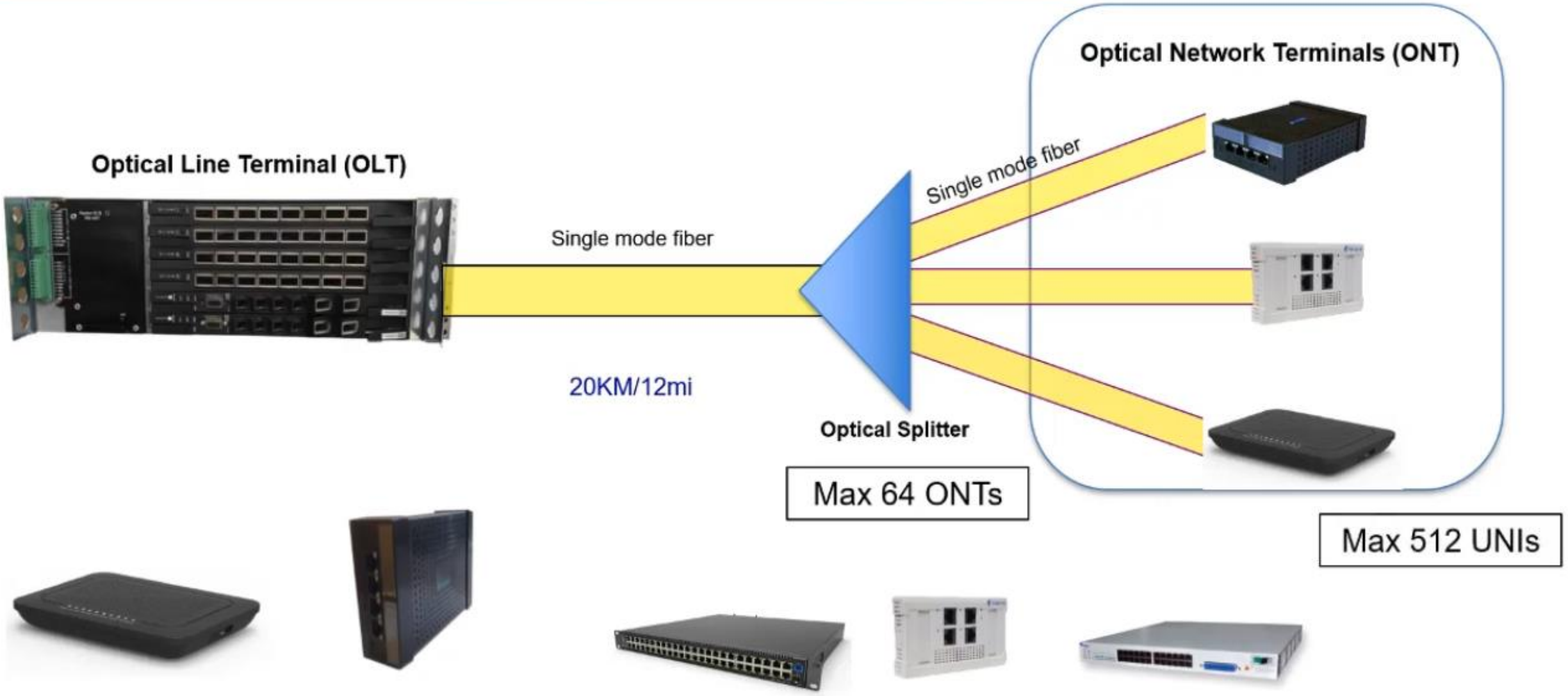


- GPON（Gigabit-capable Passive Optical Networks）
- GPON supports Triple—play service, providing competitive all-service solution.
- GPON supports high-bandwidth transmission to break down the bandwidth bottleneck of the access over twisted pair cables, so as to satisfy the requirements of high-bandwidth services, such as IPTV and live TV broadcasts.
- GPON supports the long-reach (up to 20 km) service coverage to overcome the obstacle of the access technology over twisted pair cables and reduce the network nodes.
- With complete standards and high technical requirements, GPON supports integrated services in a good way.
- GPON is the choice of large carriers in the international market.

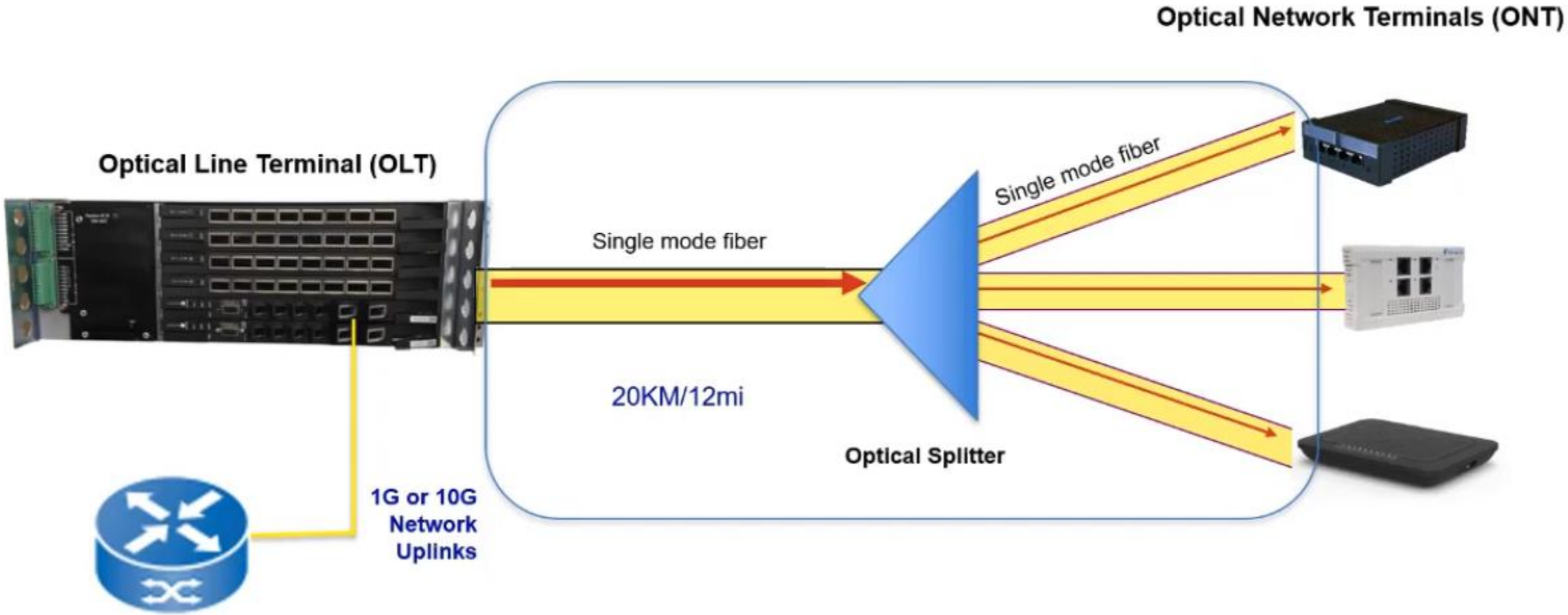
PON: *Optical Line Terminal (OLT)*



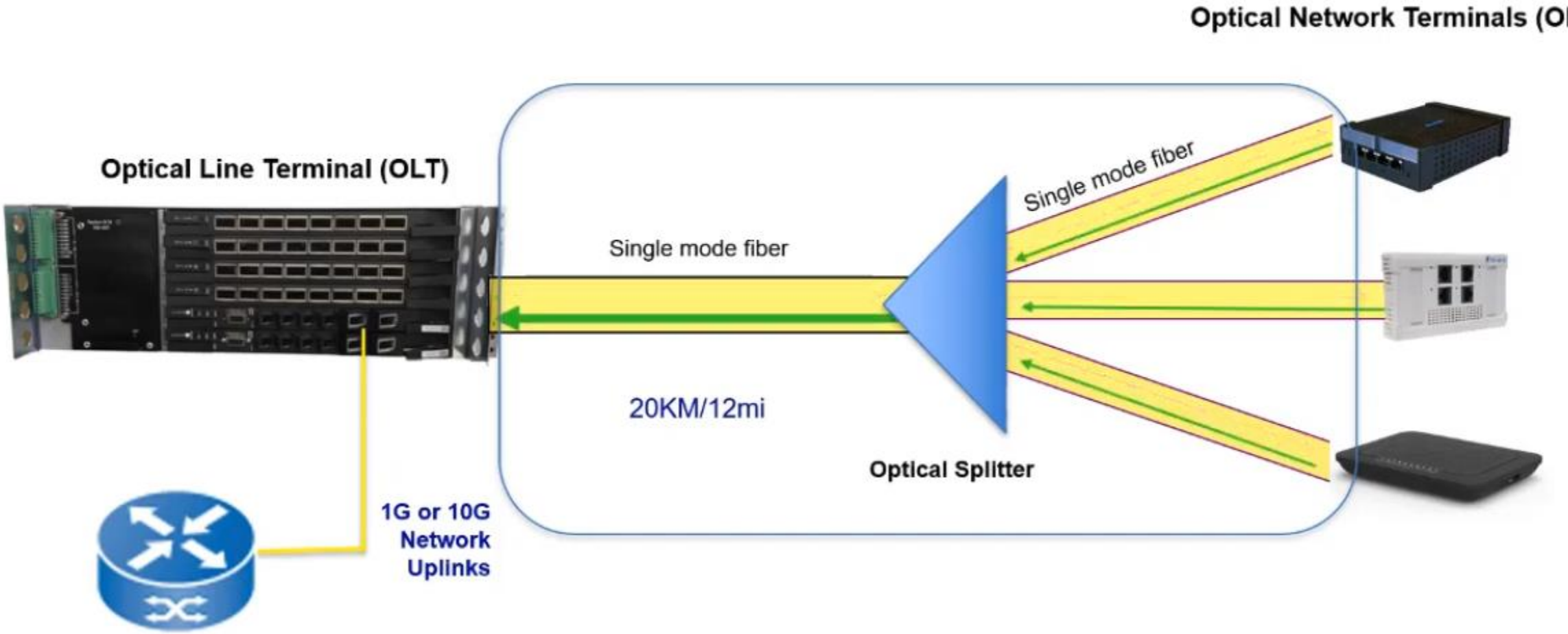
PON: Optical Network Terminals (ONTs)



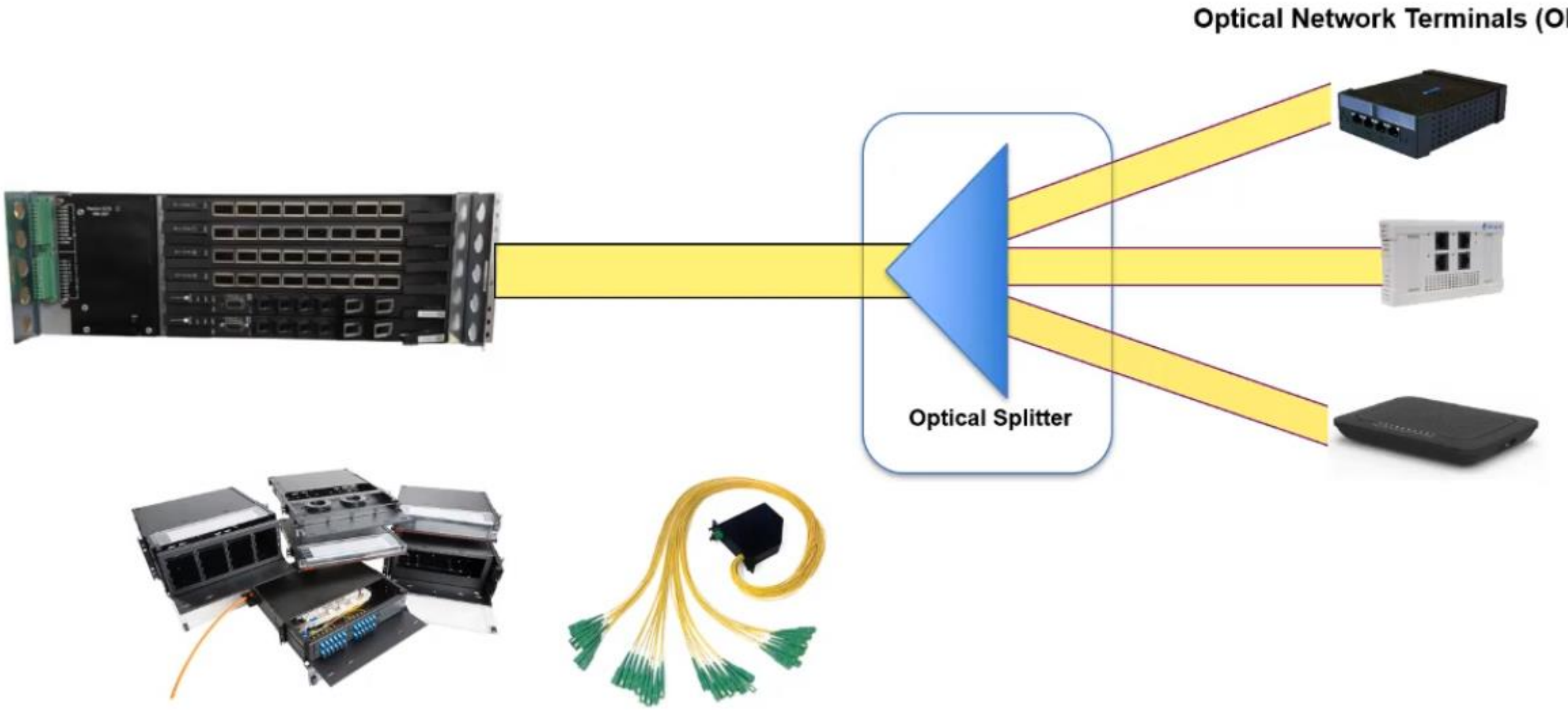
PON Components: The PON Interface



PON Components: The PON Interface



PON: *Optical Distribution Network Splitters*



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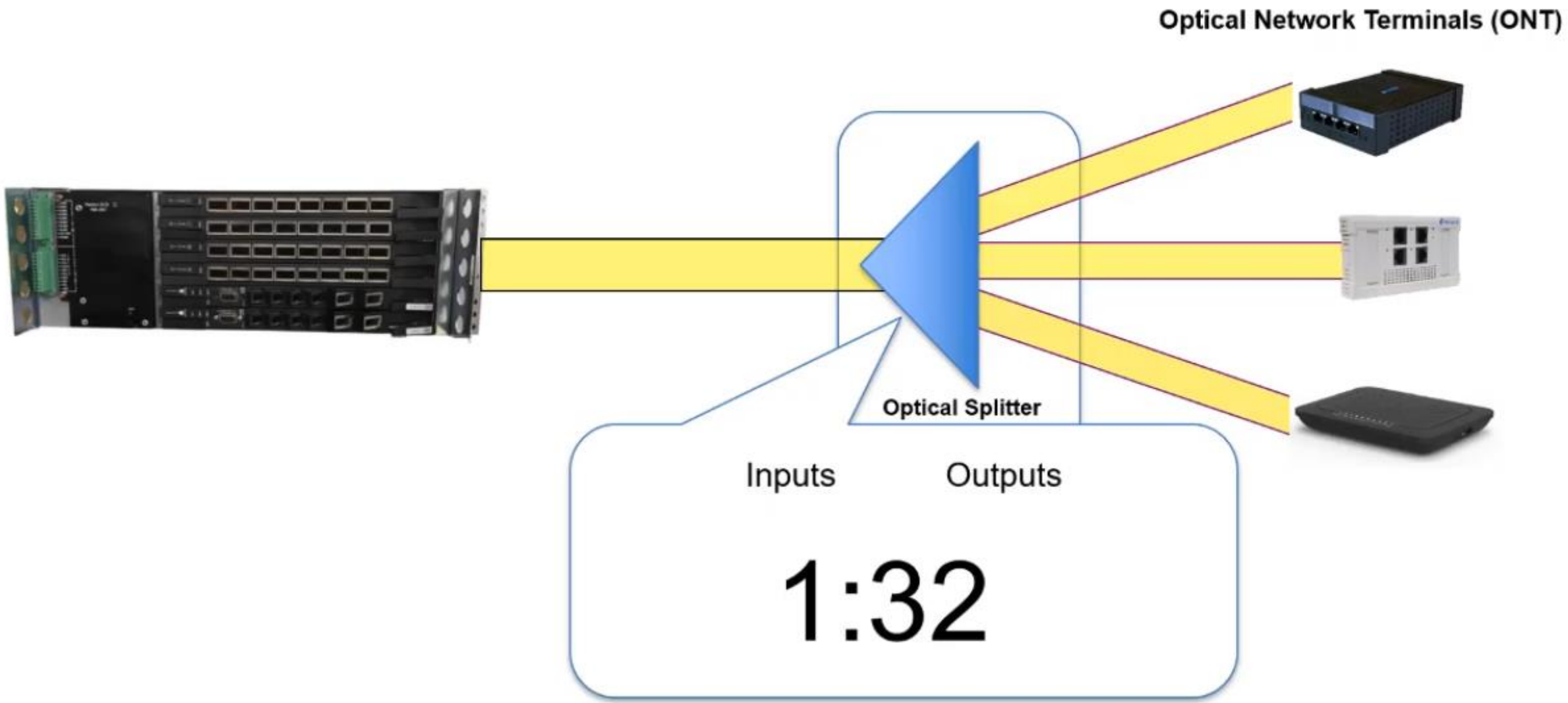

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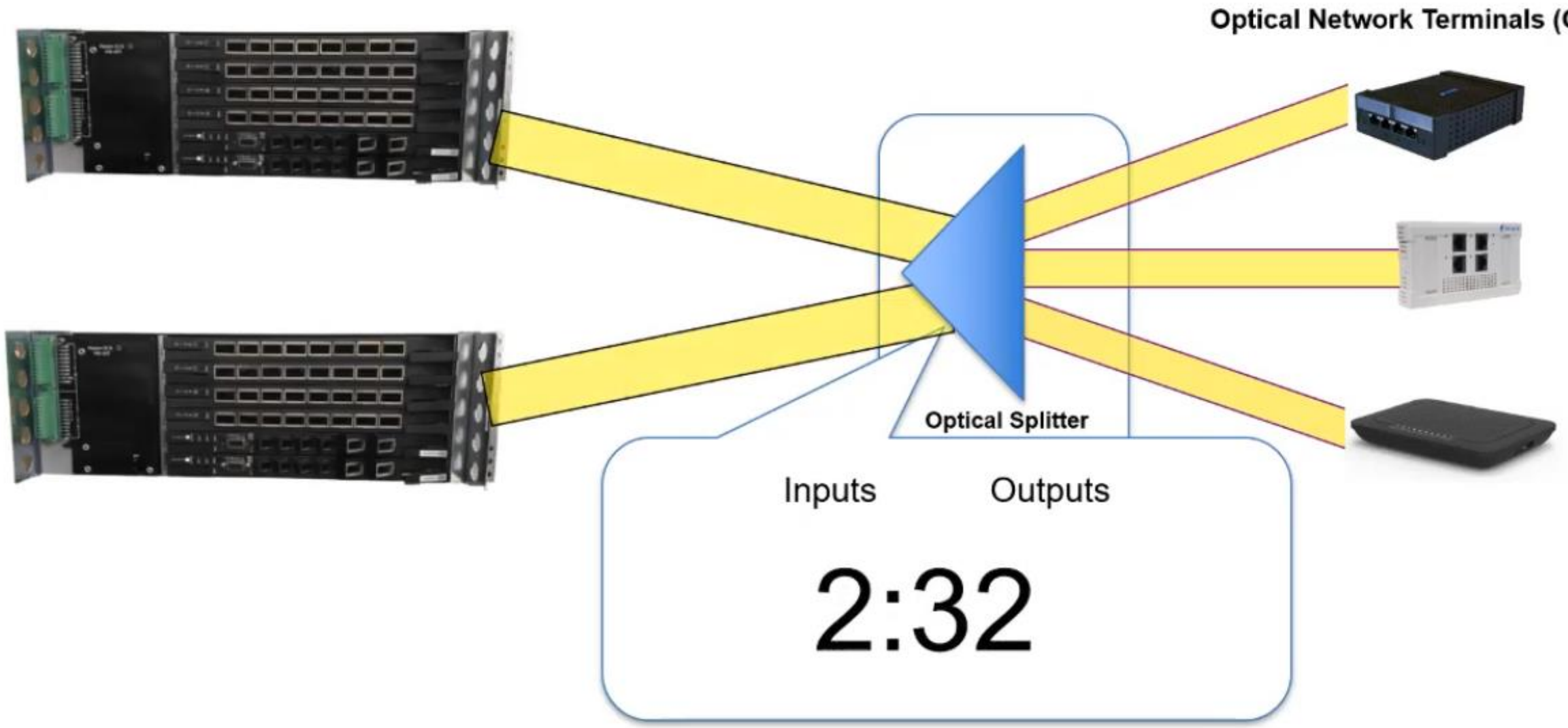
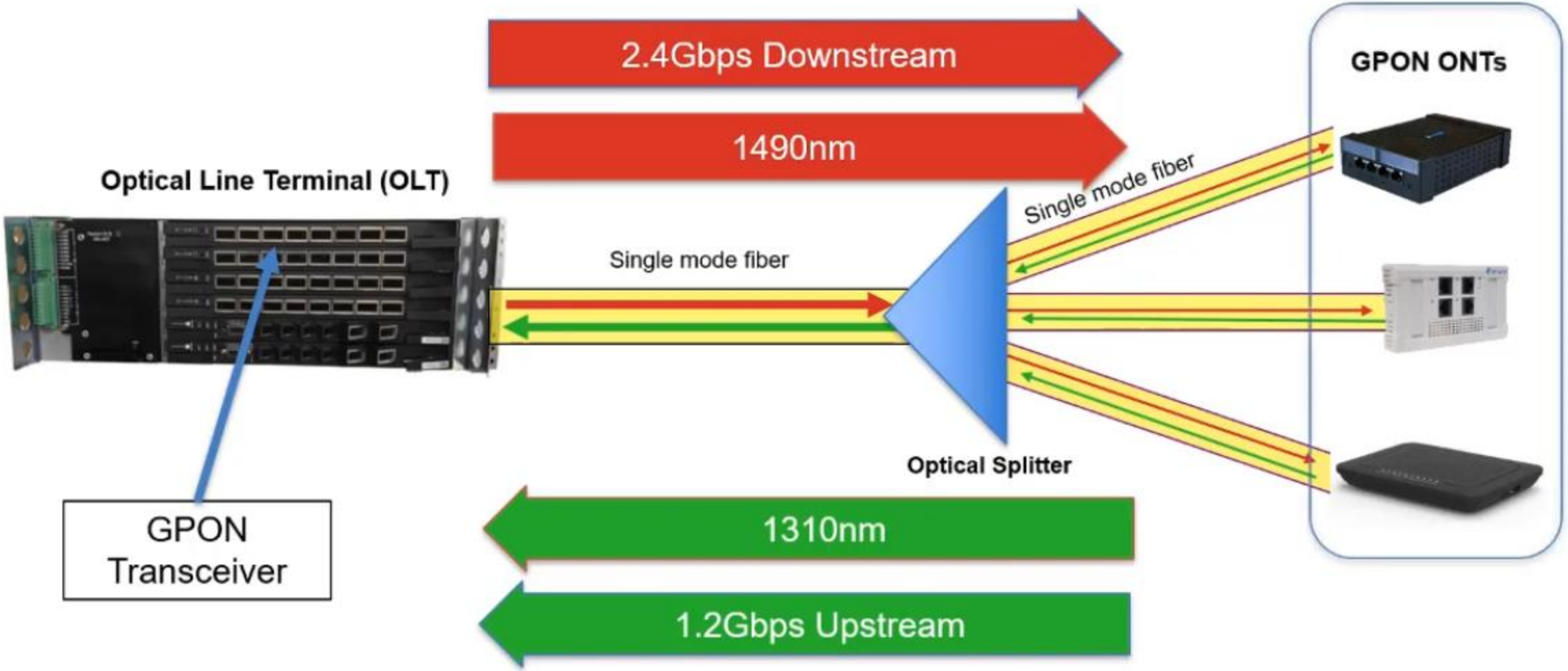


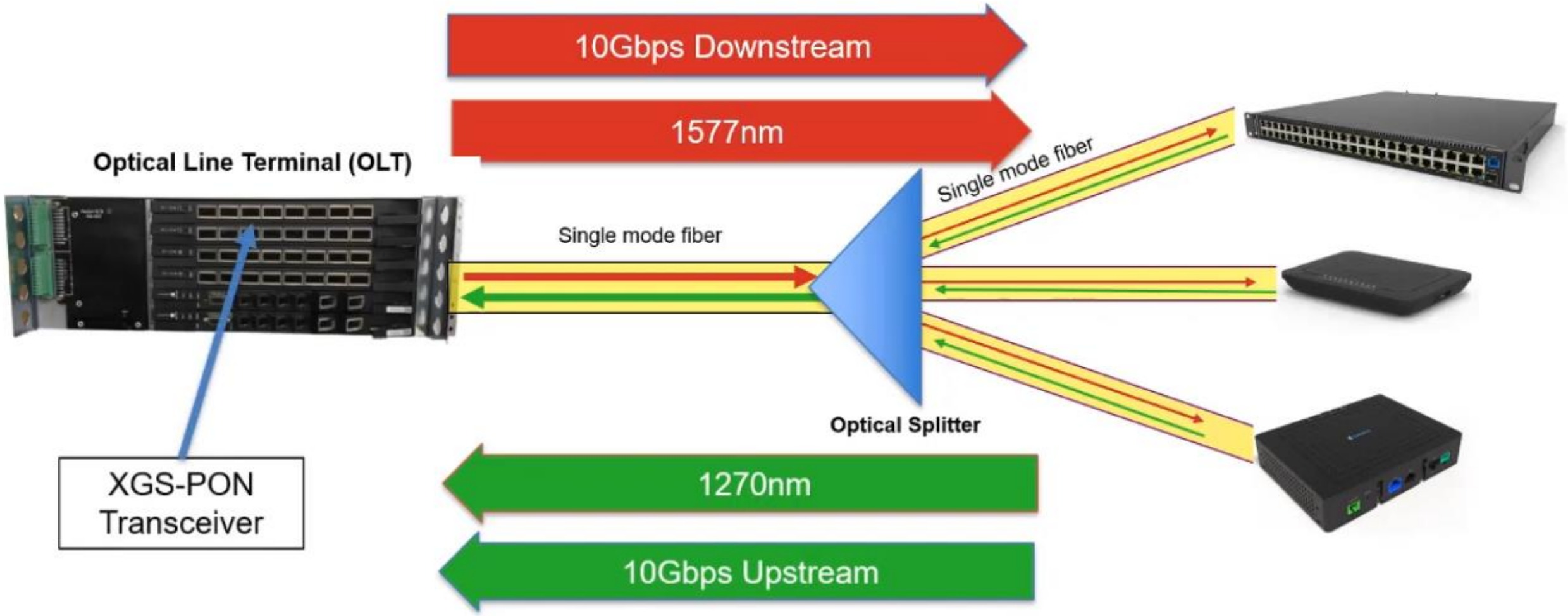
GPON Splitter

Split Ratios
1:2
1:4
1:8
1:16
1:32
1:64

PON Protocols: GPON



PON Protocols: XGS-PON



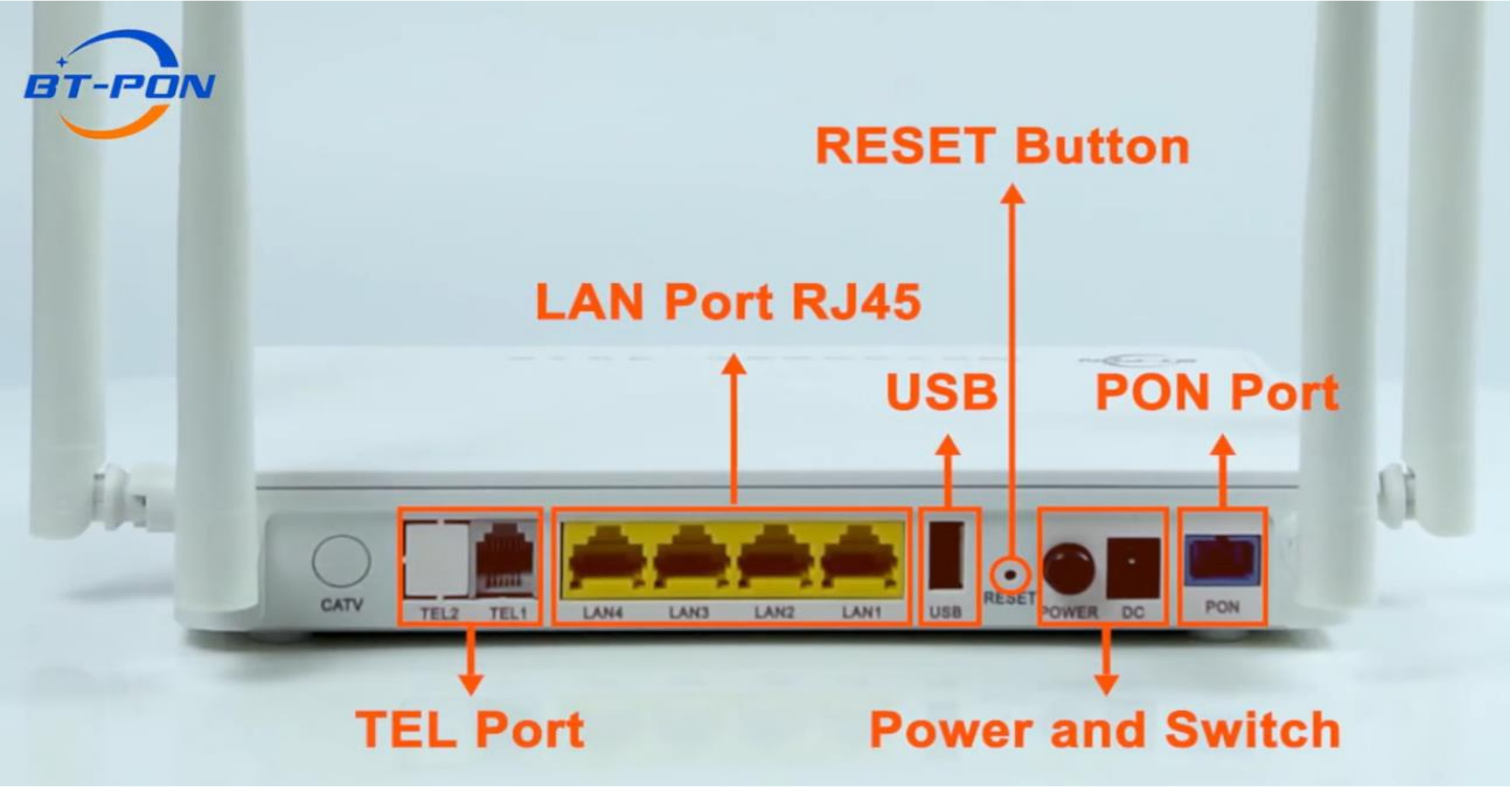

Losses
Min -13db
Max -29db
POWER
PON
LOS
LAN1
LAN2
LAN3
LAN4
TEL1
TEL2

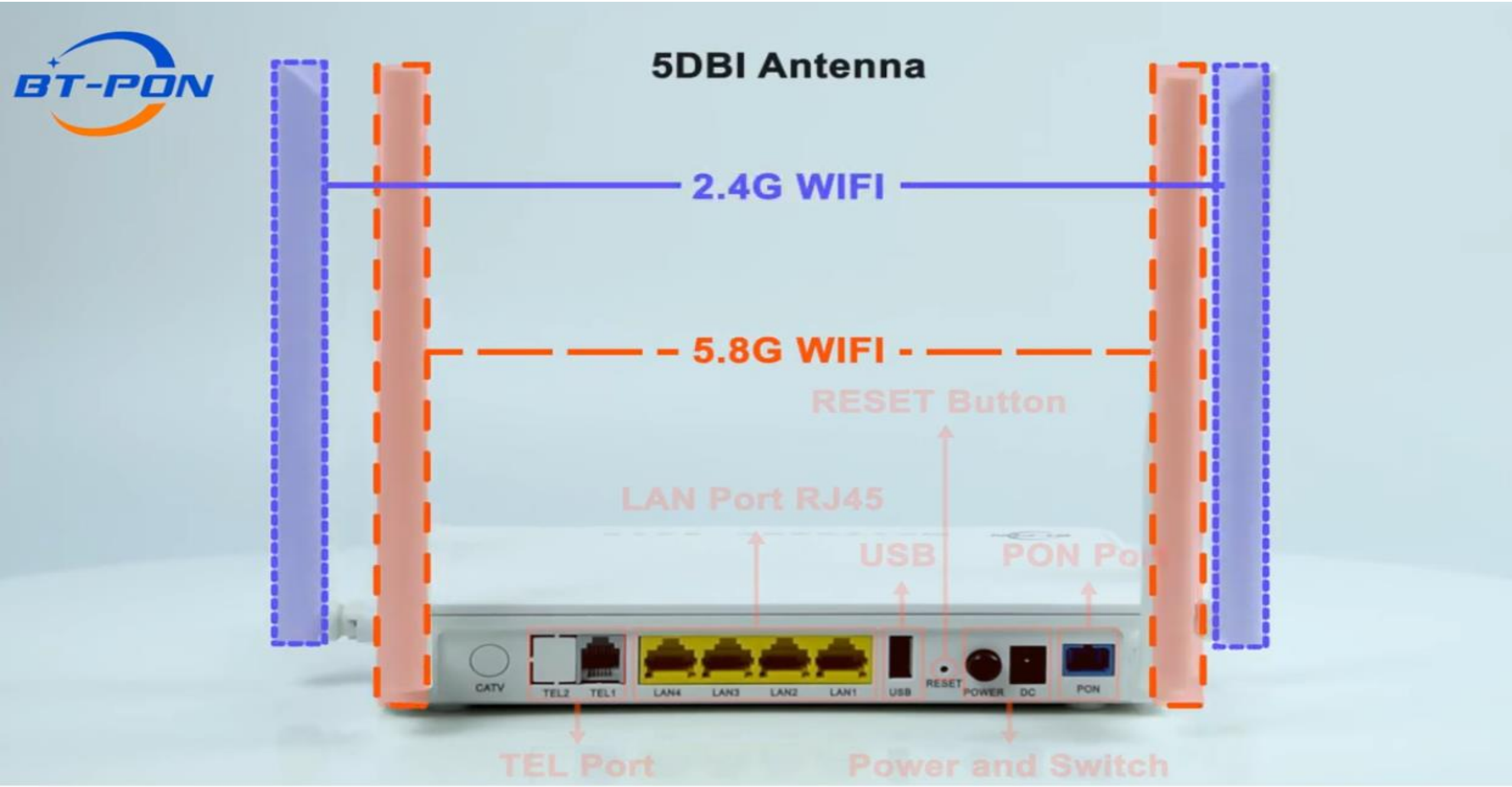
BT-PON

BT-PON BT-762XR

KEY FEATURES

- SUPPORT GPON AND EPON MODE
- COMPATIBLE WITH BT-PON, HUAWEI, ZTE AND FIBERHOME OLT
- SUPPORT DUAL BAND/ 2.4G/ 5G WIFI/ AC WIFI 1200 MBPS
- SUPPORT DHCP/ PPPOE/ STATIC IP BASED WAN CONNECTIONS
- SUPPORT IGMP SNOOPING
- FULLY COMPATIBLE WITH IEEE802.3AH STANDARDS


BT-PON
RESET Button
LAN Port RJ45
USB
PON Port
CATV
TEL2
TEL1
LAN4
LAN3
LAN2
LAN1
USB
RESET
POWER
DC
PON
TEL Port
Power and Switch

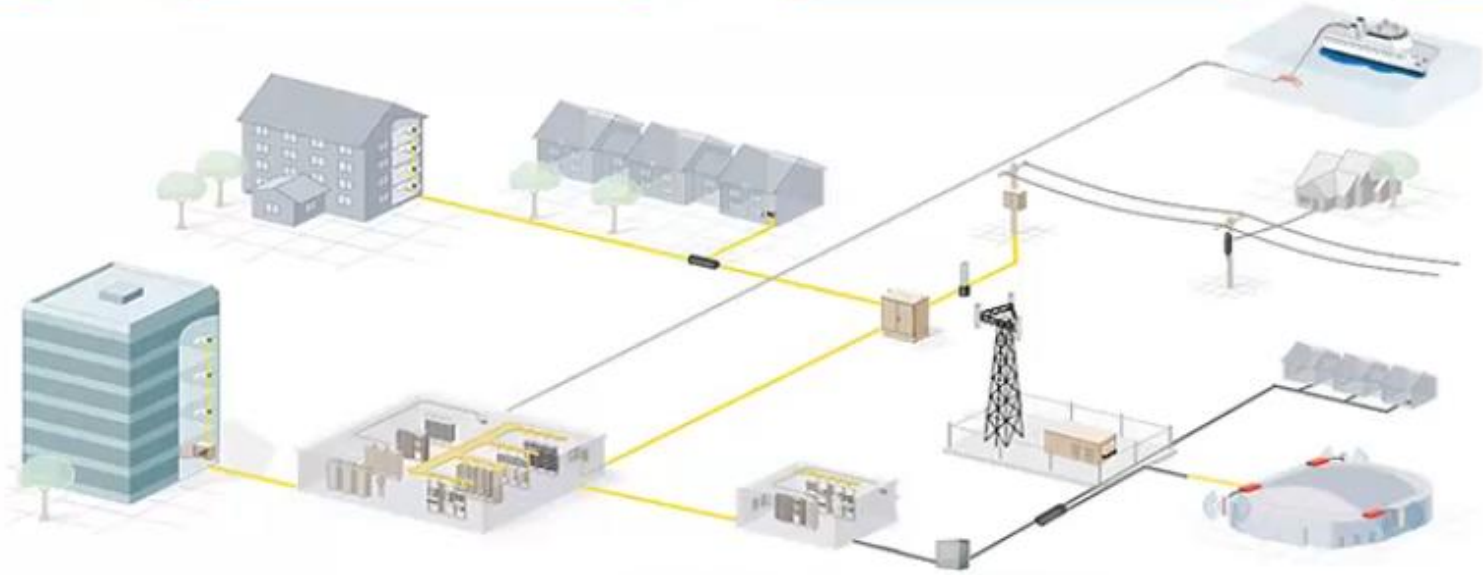

5DBI Antenna
2.4G WIFI
5.8G WIFI
RESET Button
LAN Port RJ45
USB
PON Port
CATV
TEL2
TEL1
LAN4
LAN3
LAN2
LAN1
USB
RESET
POWER
DC
PON
TEL Port
Power and Switch

Fiber to the Curb (FTTC)

Fiber to the Business (FTTB)

Fiber to the Home (FTTH)

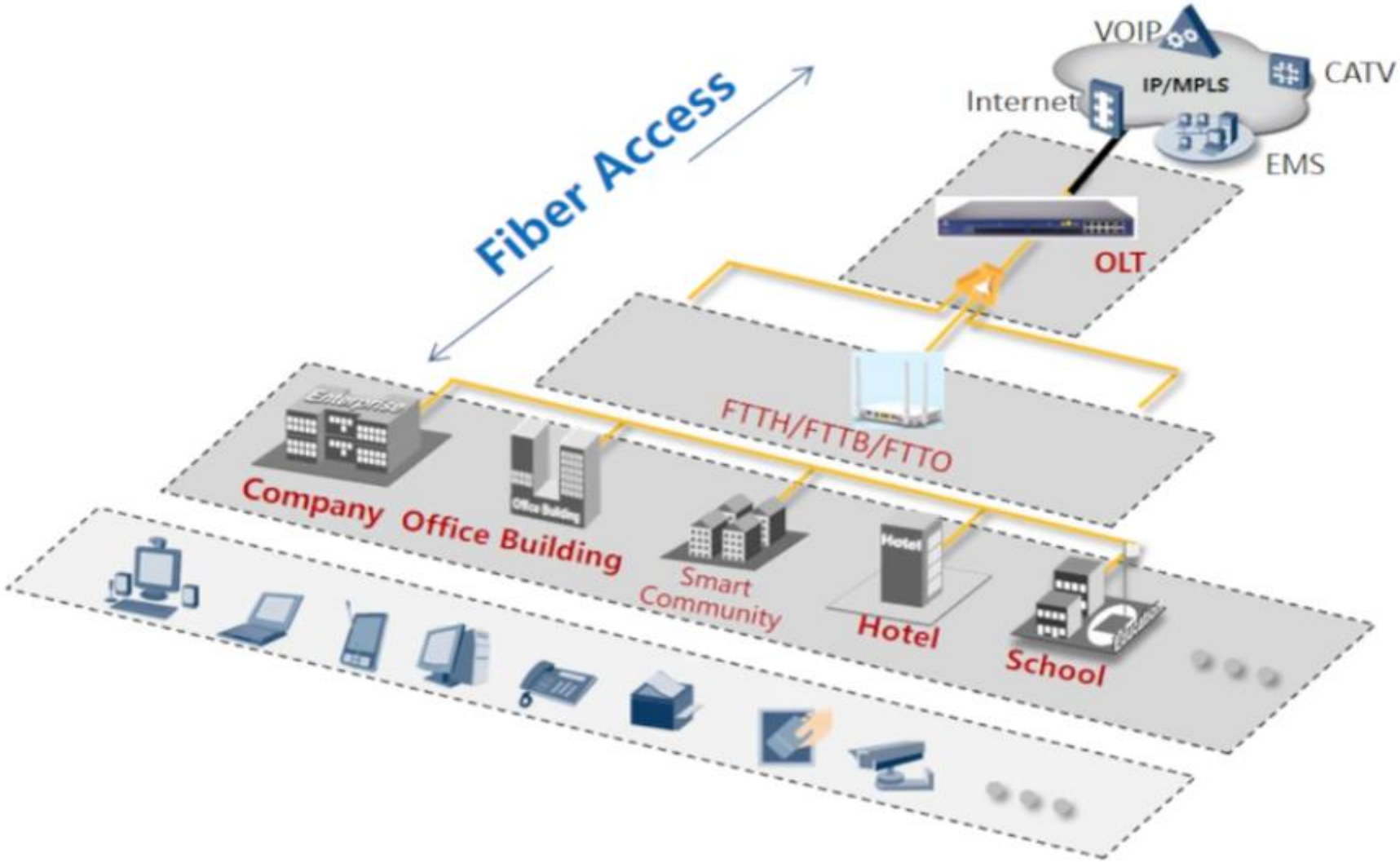
Fiber to the Building (FTTb)



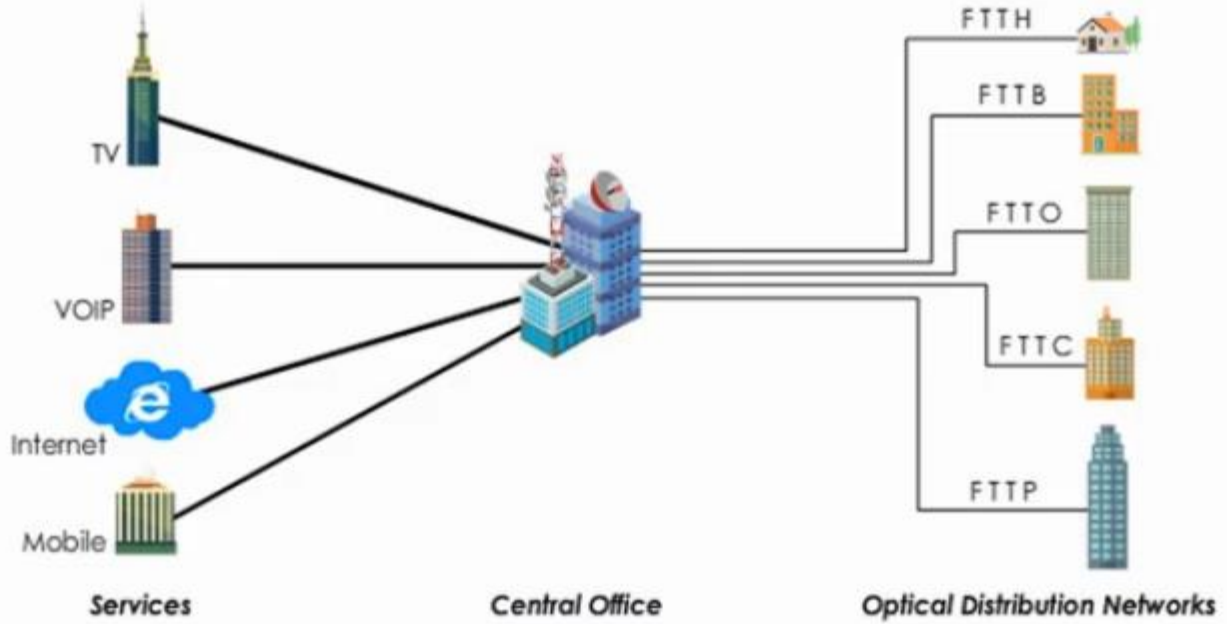
Fiber to the Premise (FTTP)

Fiber to the X (FFTx)

Fiber Access Solution

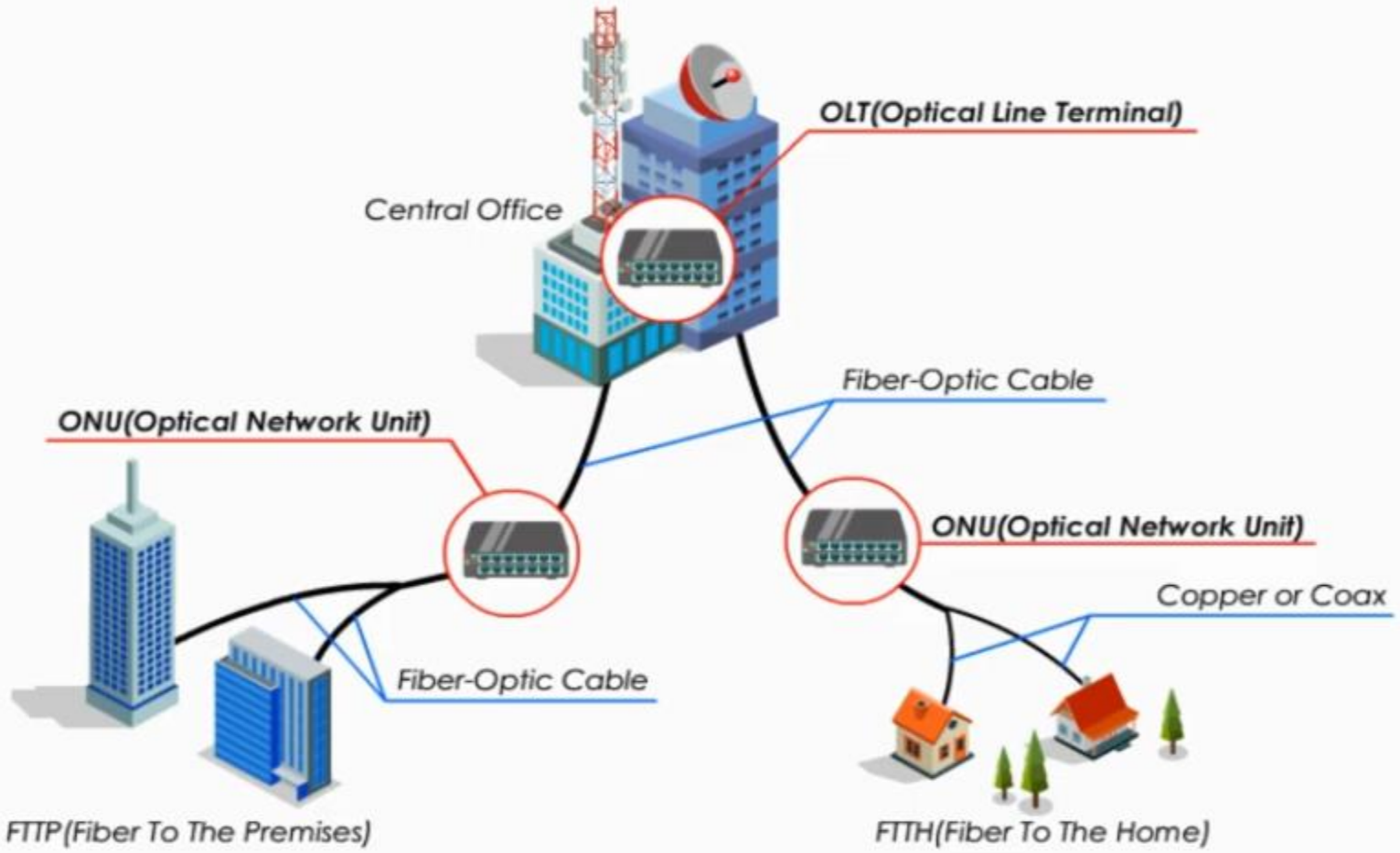


Fiber to the x(FTTX)



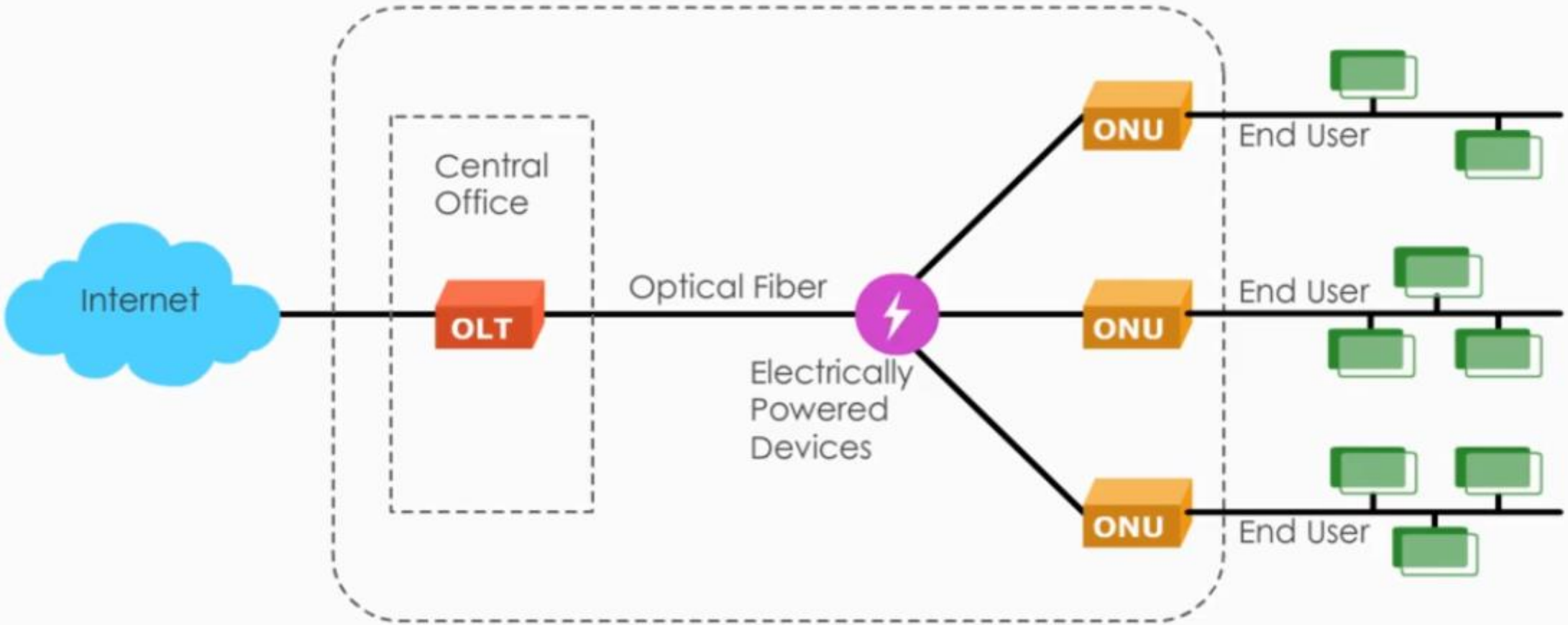
- A generic term of last-mile fiber-based broadband access networks and services
- Many different deployment methods and infrastructures, such as
  - Fiber to the Premises (FTTP), Fiber to the Home(FTTP), Fiber to the Building (FTTB), Fiber to the Office (FTTO), Fiber to the Cabinet (FTTC), and many others
- A key element to Next-generation access (NGA) in the local loop

Fiber to the x: FTTP vs FTTH



They use optical fiber to provide high-speed

Active Optical Network(AON)



However, AON is less popular than PON

Concepts

APON: ATM Passive Optical Networks

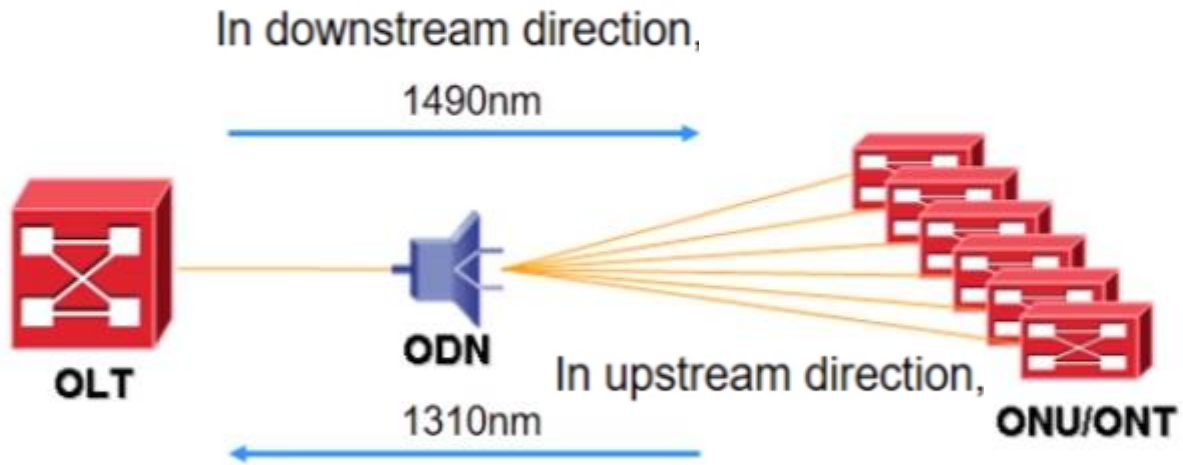
EPON: Ethernet Passive Optical Networks

GE-PON: Giga-bit Ethernet Passive Optical Networks

GPON: Gigabit-capable Passive Optical Networks

GPON Principle----Data Multiplexing

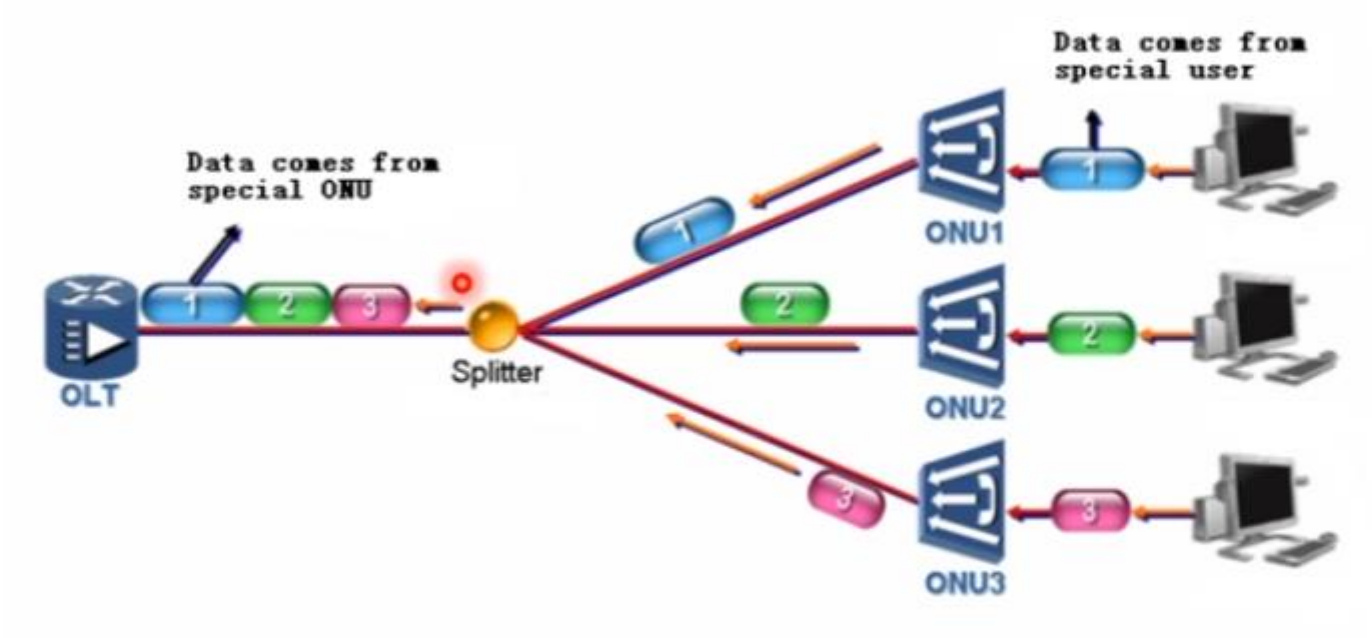
- GPON adopts Wavelength Division Multiplexing (WDM) technology, facilitating bi-direction communication over a single fiber.



To separate upstream/downstream signals of multiple users over a single fiber, GPON adopts two multiplexing mechanism:

- In downstream direction, data packets are transmitted in a broadcast manner;
- In upstream direction, data packets are transmitted in a TDMA manner.

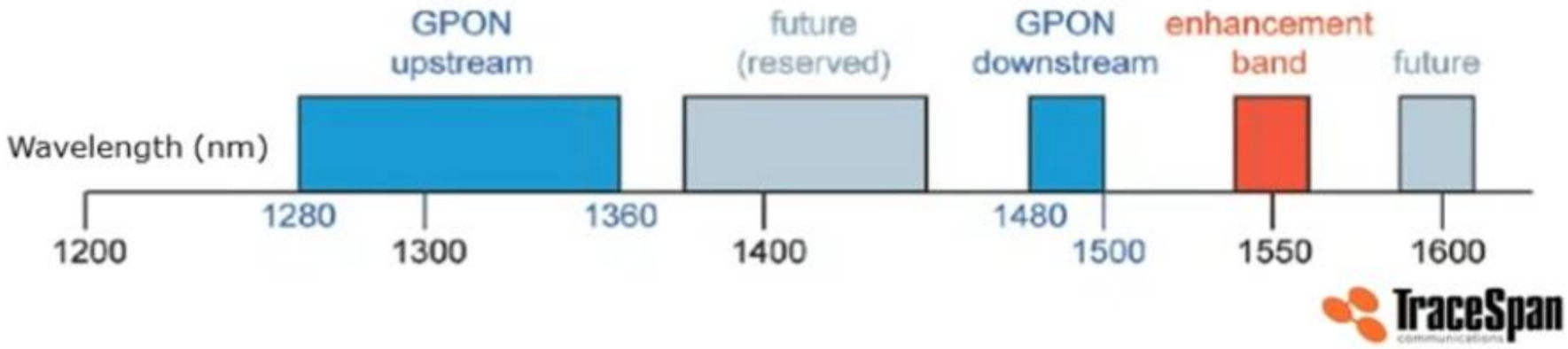
GPON Principle----Upstream Data



- TDMA mode

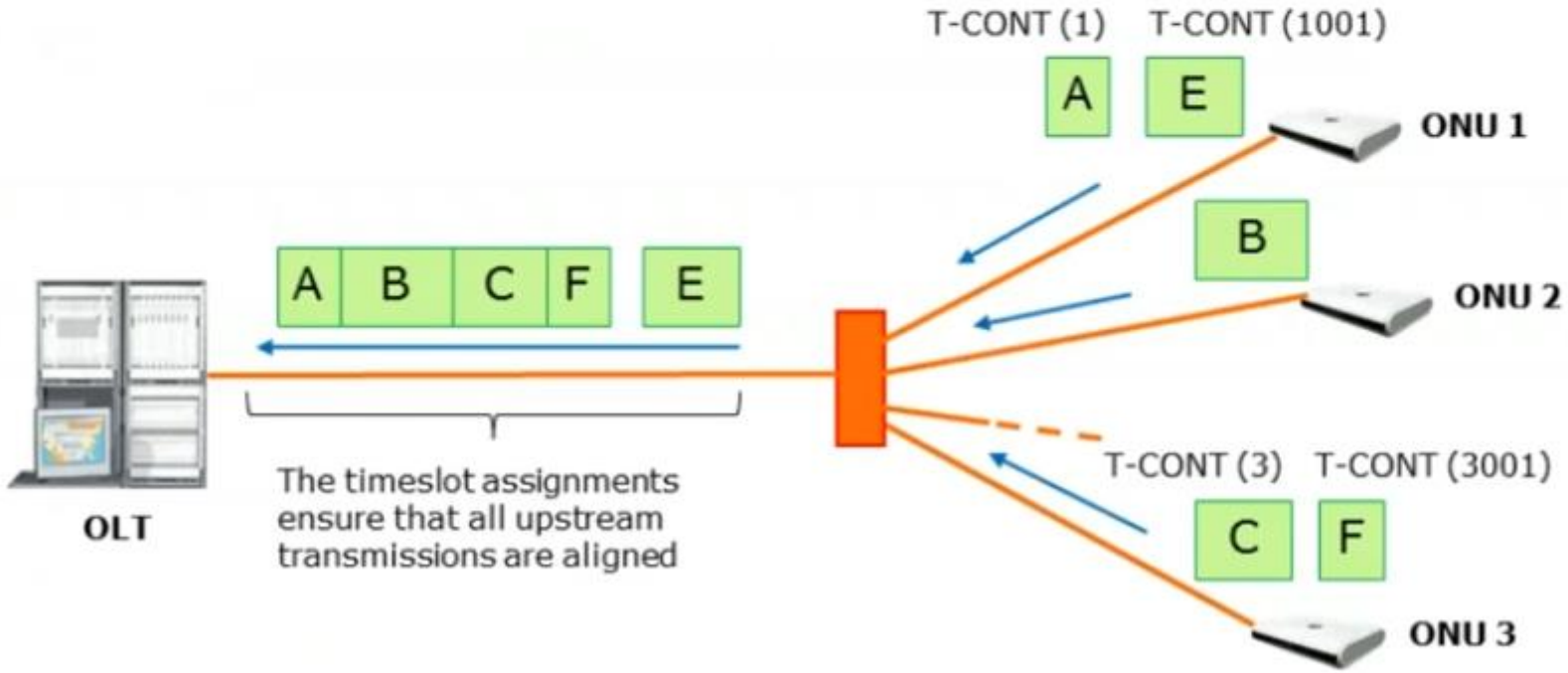
GPON

- A TDM/TDMA PON that meets full service access requirements
  - Support for asymmetric line rate operation. 2.488 Gbit/s D/S and 1.244 Gbit/s U/S rates
  - Downstream wavelength 1490 nm
  - Upstream wavelength 1310 nm
  - Option for "RF" Video overlay: wavelength 1550nm
  - Up to 128 ONUs per fiber tree but 32 or 64 is more typical.
  - 28 dB optical budget to support 20km reach and 1:32 split ratio
- First standards published in 2003-2004 by ITU-T, current standards are from 2014

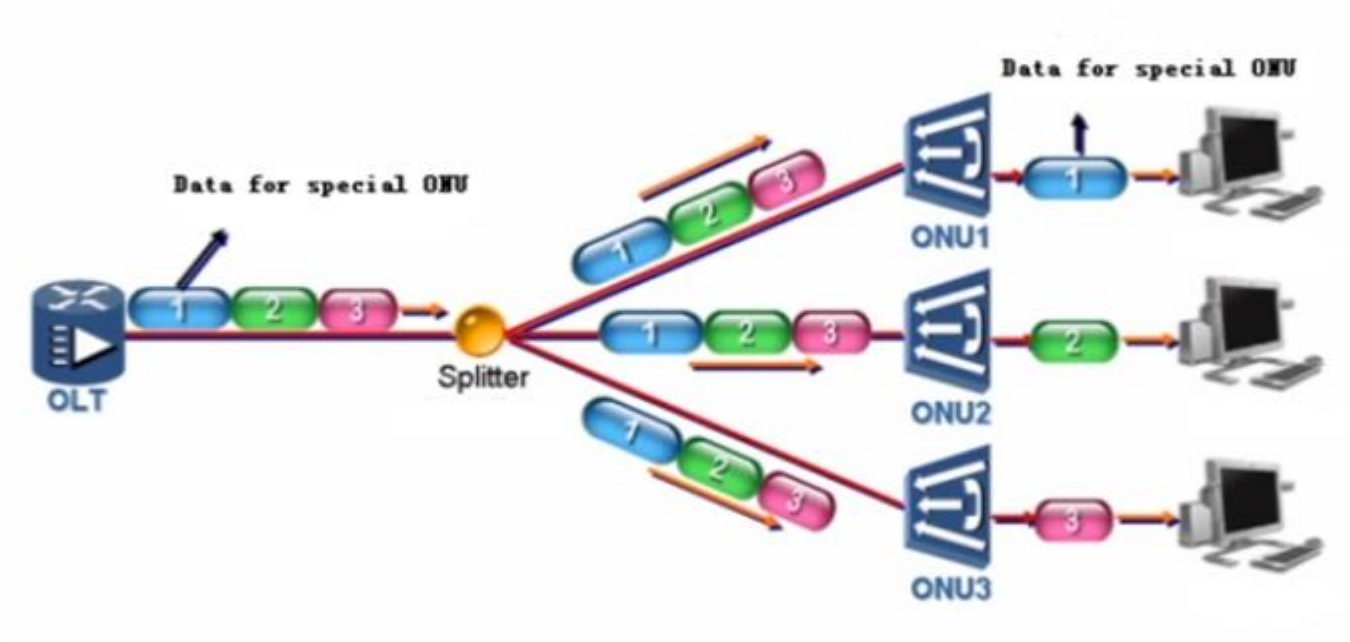


Bandwidth Assignments for T-CONTs

- TDMA (Time Division Multiple Access) mechanism:
  - The OLT assigns timeslots (BWmaps) for every ONU to transmit its upstream transmissions,
  - Every BWmap assigment includes the T-CONT ID (Alloc-ID)



GPON Principle----Downstream Data



- Broadcast mode

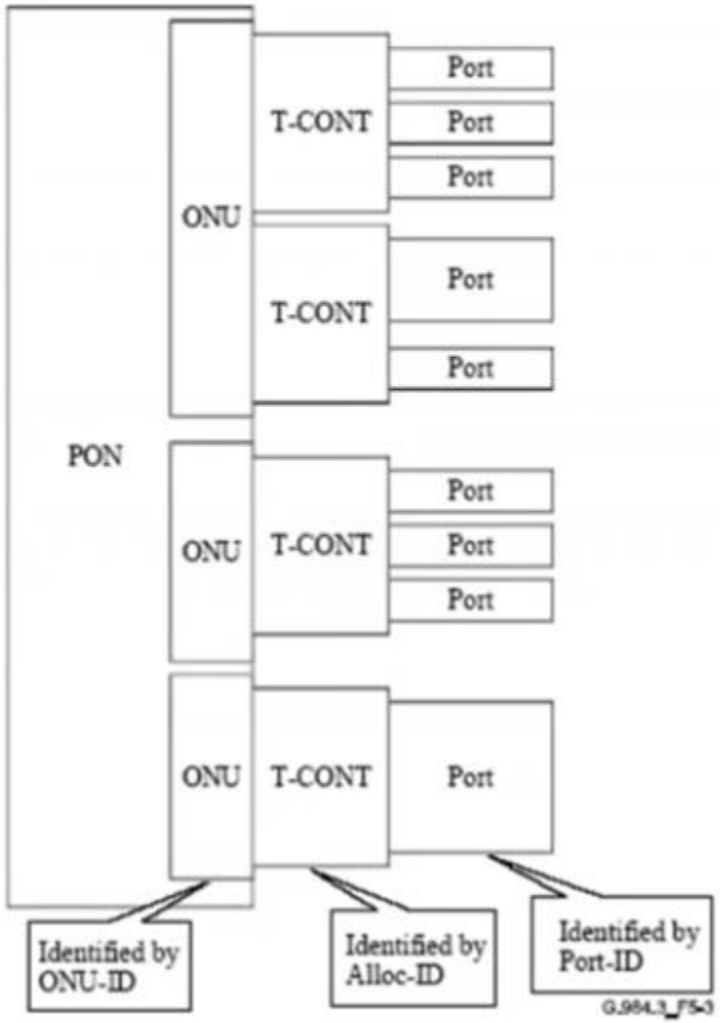
Traffic Containers (T-CONT)

- T-CONT: A grouping of logical connections for the purpose of upstream bandwidth assignment
  - Definition from TR-156: A traffic-bearing object within an ONU that represents a group of logical connections, is managed via the ONU Management and Control Channel (OMCC), and **is treated as a single entity for the purpose of upstream bandwidth assignment on the PON**

- 5 T-CONT types are defined in ITU-T G.984.3
  - Type 1 = Fixed bandwidth
  - Type 2 = Assured bandwidth
  - Type 3 = Assured & Non-Assured bandwidth
  - Type 4 = Best effort
  - Type 5 = Fixed, Assured and Non-Assured

GPON Encapsulation Method (GEM) and Multiplexing Model

- GEM is a method for encapsulating user frame data for transport over the GPON
- "GEM ports" represent a logical connection associated with a specific traffic flow



Control Messages

- Physical layer OAM (PLOAM) messaging channel
  - Supports the PON TC layer management functions, including **ONU activation/deactivation, OMCI channel establishment, encryption configuration and key management**
  - Transported in the 13-byte PLOAM message field within the overhead section of the downstream GTC frame and default Alloc-ID of the upstream GTC burst
  - Specified in ITU-T G.984.3
- ONU management and control interface (OMCI)
  - OMCI messages are transported over a dedicated GEM channel. The OMCI transport mechanism is described in ITU-T G.984.3 clause 14. The syntax of the OMCI is specified in ITU-T G.988

Delivery of Services on PON

- Typical types of services delivered on PON:
  - Voice (phone calls)
  - Internet browsing
  - E-mails
  - Gaming
  - Video Conferencing
  - Broadcast video (TV)
  - Backhaul for mobile networks

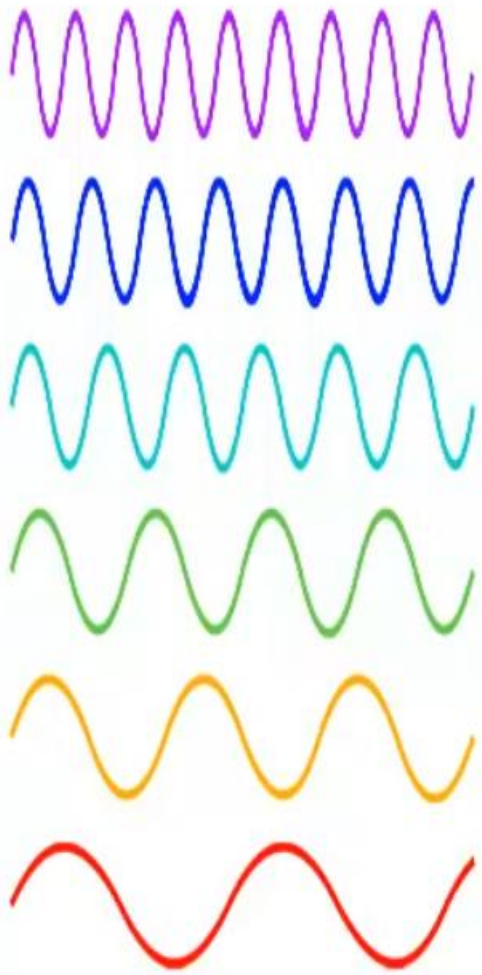
TraceSpan communications
Access Network Visibility

Comparison Between GPON and EPON

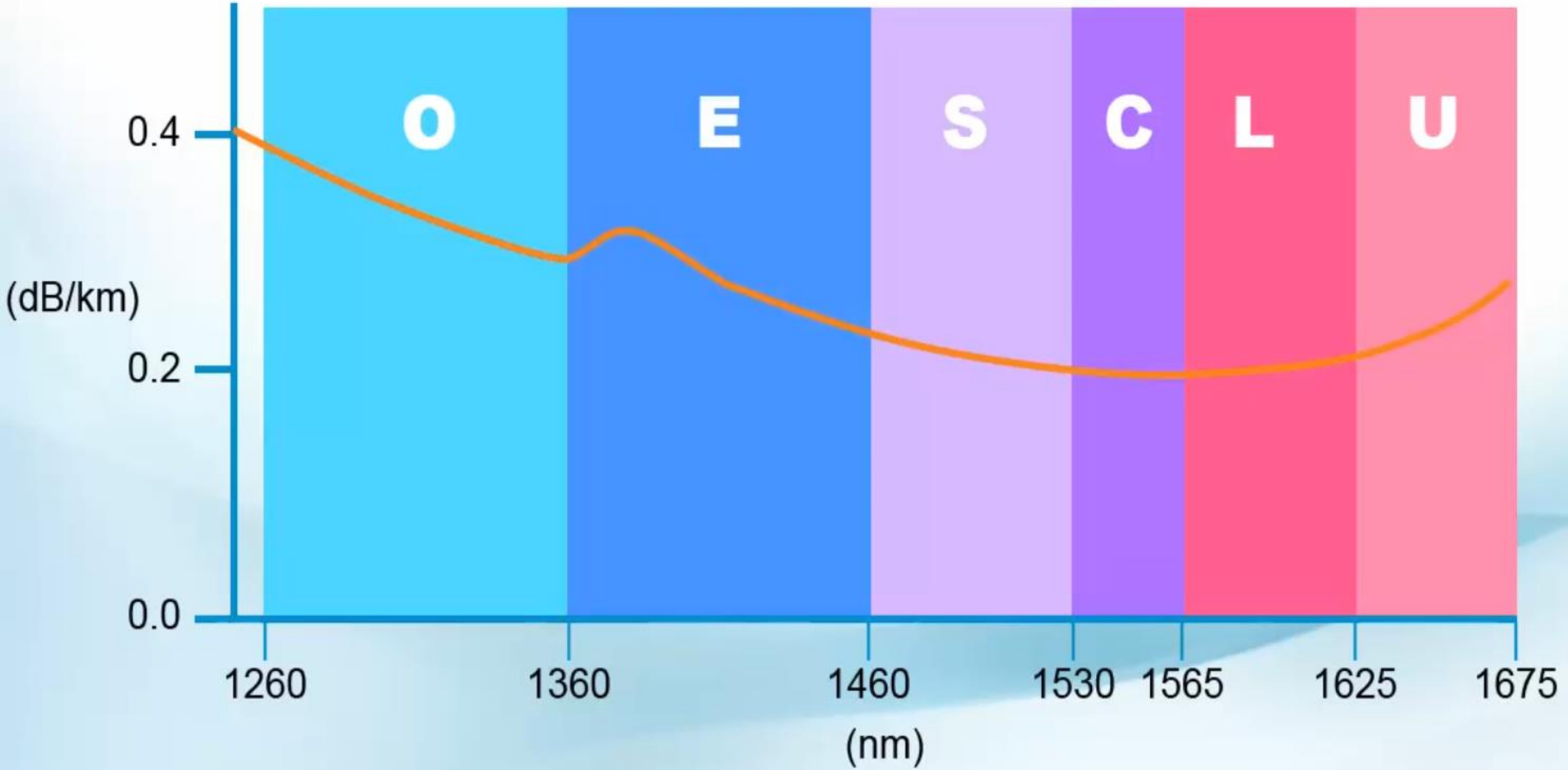
	GPON	EPON
Standard	ITU	IEEE
Rate	2.488G/1.244G	1.25G/1.25G
Split ration	Upto 1:128	Upto 1:32
Data encapsulation mode	GEM/ATM	Ethernet
Broadband efficiency	92%	72%
Application mode	Multi-service/ FTTx	Pure data service
Vendors	Large vendors involved	Small vendors involved

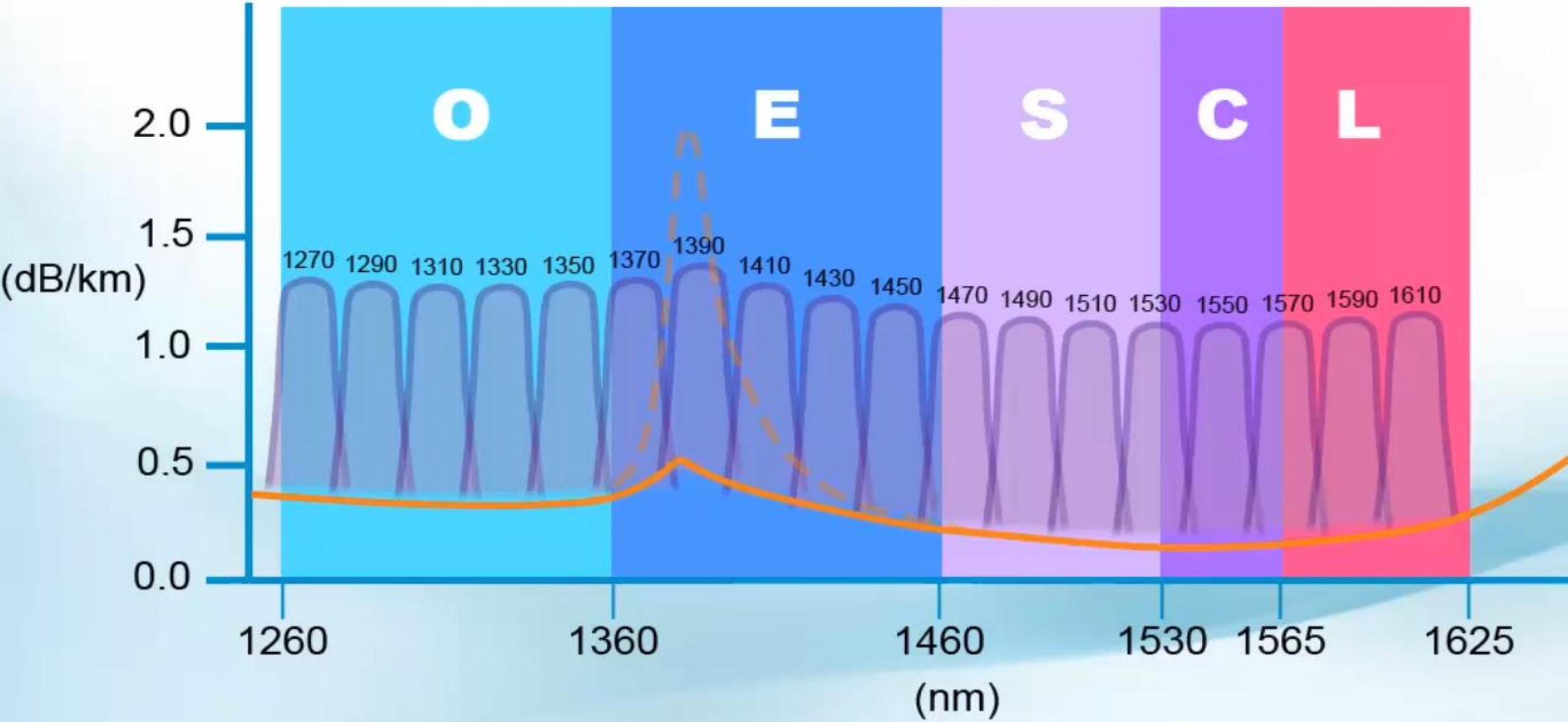
Current Access Technologies

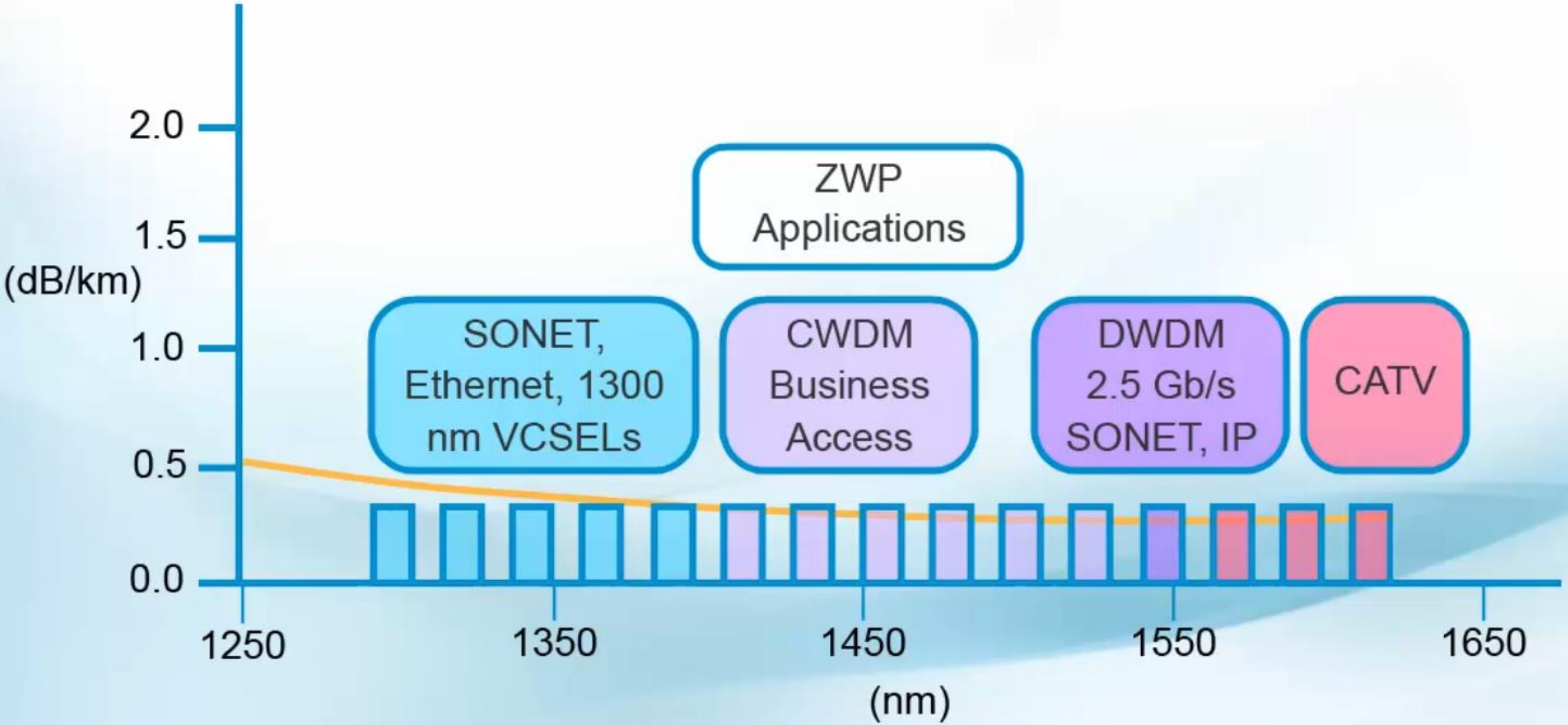
Service	Medium	Downstream (Mb/s)	Upstream (Mb/s)	Maximum Reach (Km)
ADSL	Twisted pair	15	3.8	5.5
VDSL	Twisted pair	100	30	0.5
HFC	Coax cable	40	9	25
Wi-Fi	Free Space	54	54	0.1
Wi - MAX	Free Space	134	134	5
B-PON	Fiber	622	155	20
E-PON	Fiber	1000	1000	20
G-PON	Fiber	2500	2500	20



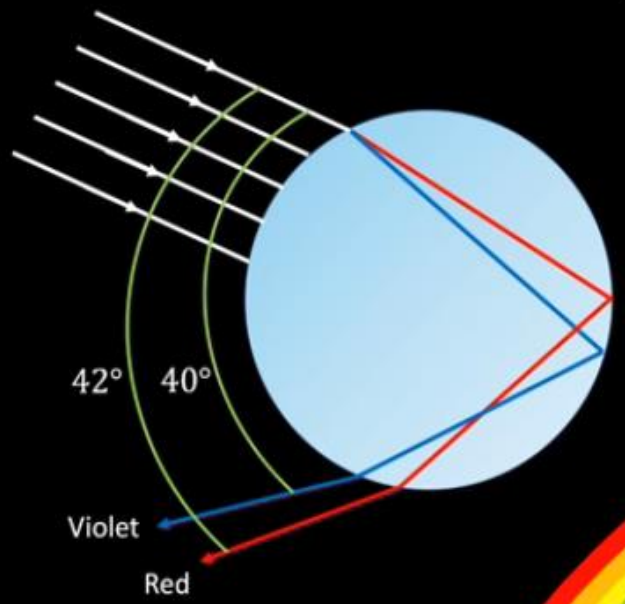
Band	Description	Wavelength Range
O band	original	1260 to 1360 nm
E band	extended	1360 to 1460 nm
S band	short wavelengths	1460 to 1530 nm
C band	Conventional ("erbium window")	1530 to 1565 nm
L band	long wavelengths	1565 to 1625 nm
U band	ultralong wavelengths	1625 to 1675 nm

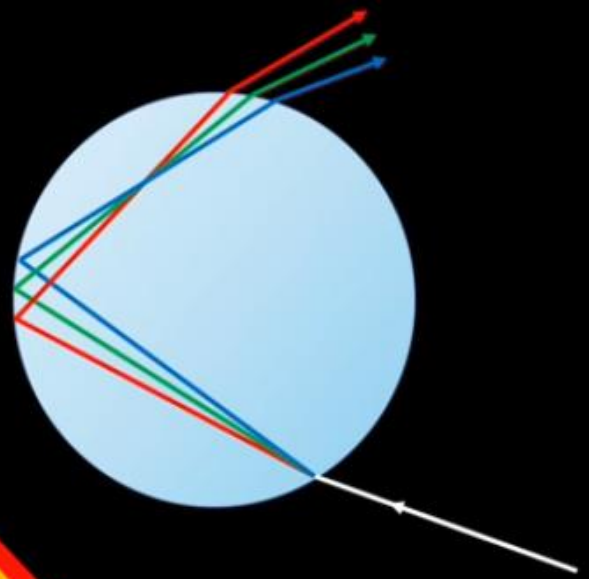

O
E
S
C
L
U
0.4
0.2
0.0
(dB/km)
1260
1360
1460
1530
1565
1625
1675
(nm)

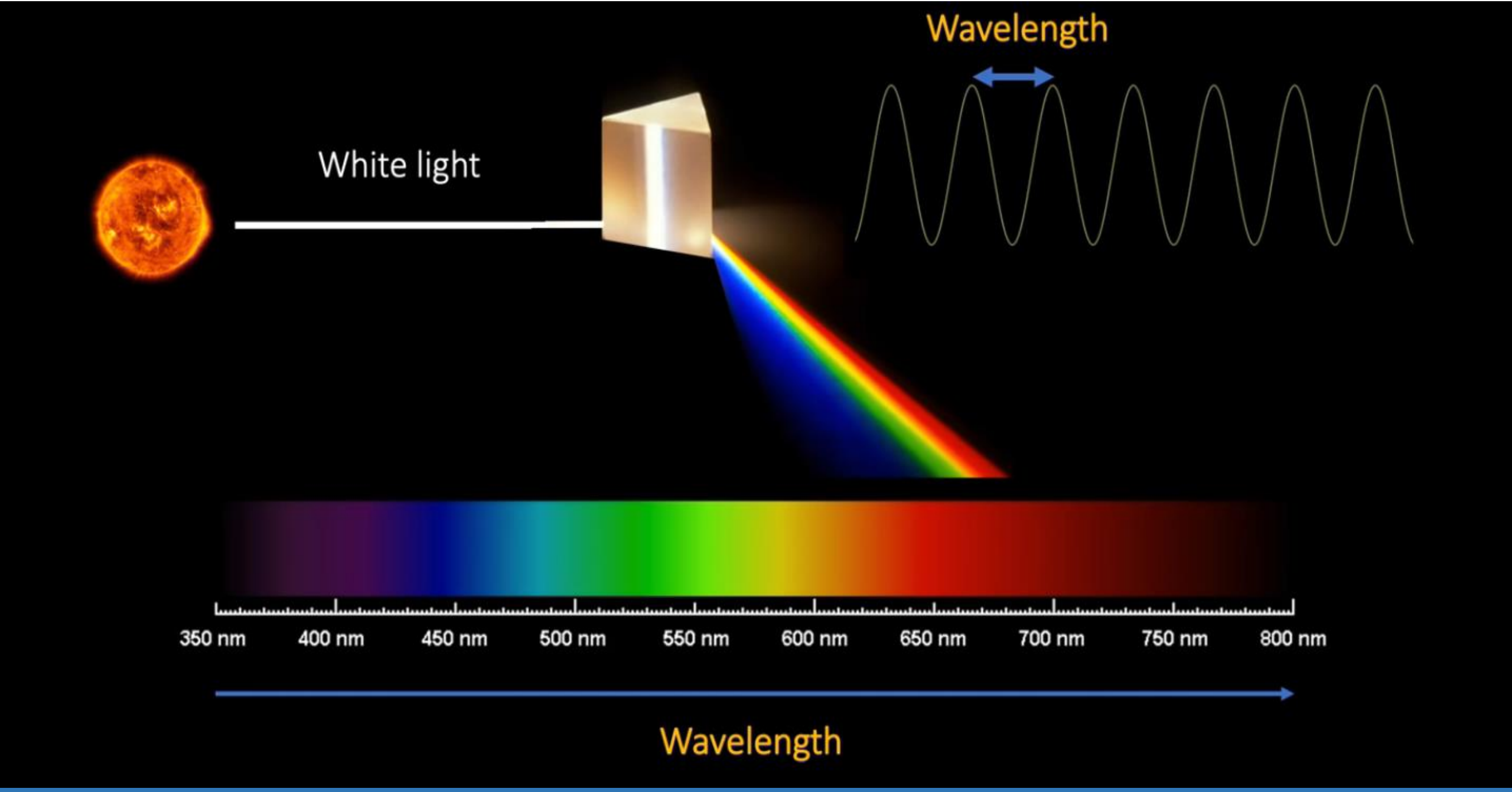

O
E
S
C
L
2.0
1.5
1.0
0.5
0.0
(dB/km)
1270
1290
1310
1330
1350
1370
1390
1410
1430
1450
1470
1490
1510
1530
1550
1570
1590
1610
1260
1360
1460
1530
1565
1625
(nm)


2.0
1.5
(dB/km)
1.0
0.5
0.0
ZWP
Applications
SONET,
Ethernet, 1300
nm VCSELs
CWDM
Business
Access
DWDM
2.5 Gb/s
SONET, IP
CATV
1250
1350
1450
1550
1650
(nm)

The physics of rainbows

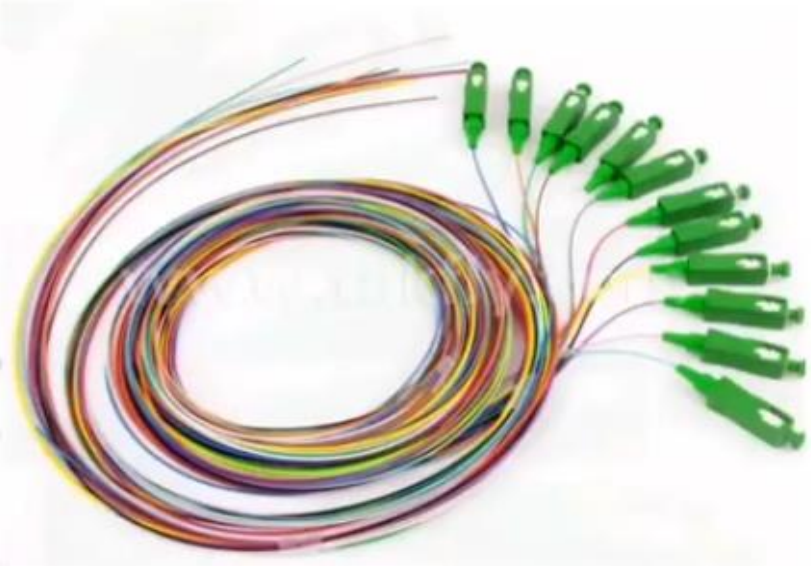





Wavelength
White light
350 nm
400 nm
450 nm
500 nm
550 nm
600 nm
650 nm
700 nm
750 nm
800 nm
Wavelength

Outline

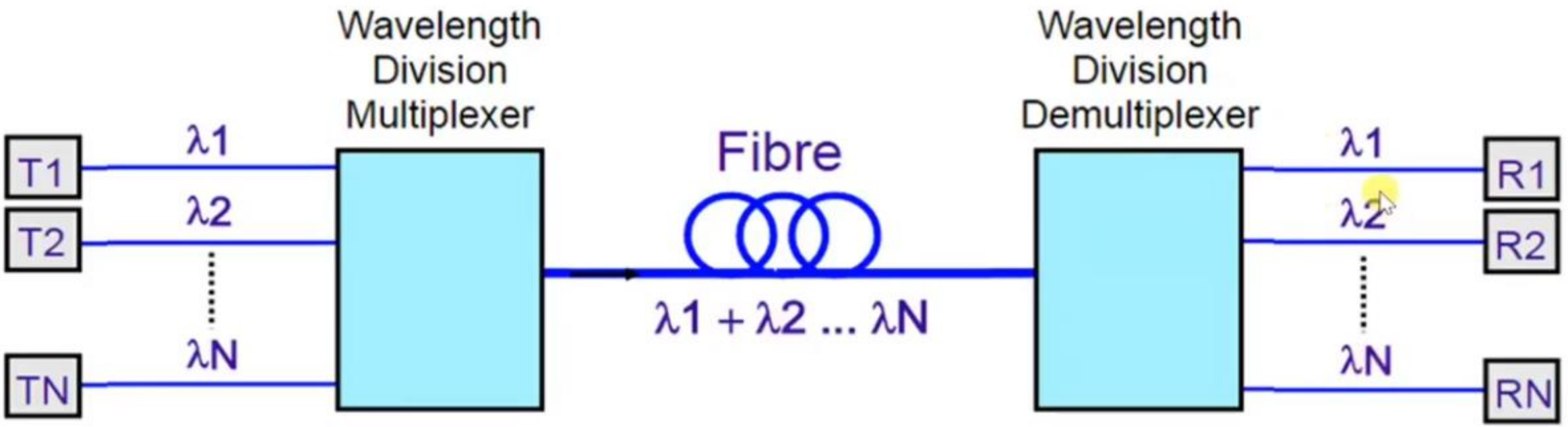
- Basics of WDM
- WDM Architecture
- Bidirectional WDM
- Components of WDM Network
- Different Technologies
- Important features of WDM



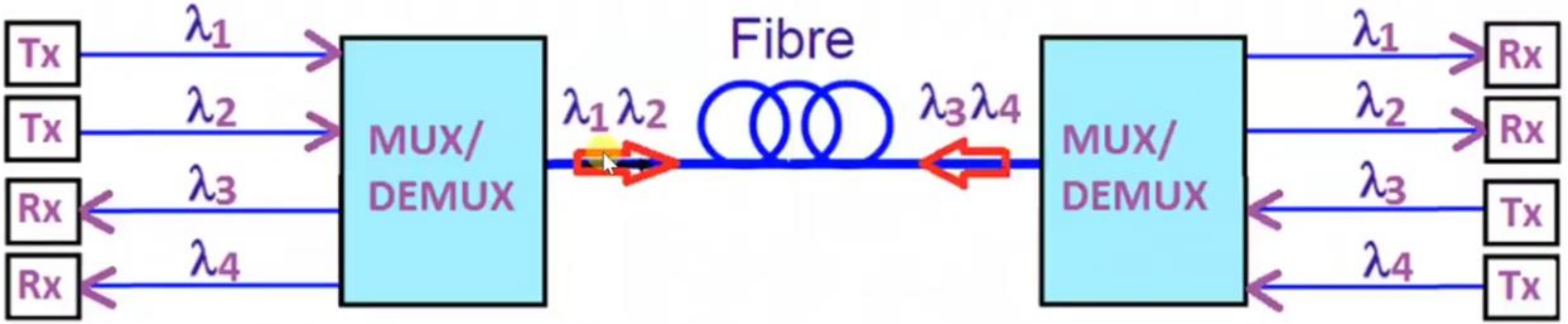
Basics of WDM

- It is Wavelength Division Multiplexing
- WDM is used to increase capacity of single standard fiber
- Here, a number of light sources are used with different wavelength.
- Using Multiplexer, all signals are transmitted by single fiber.
- At receiver side, Demultiplexer separates different wavelength and gives it to different receiver.

WDM Architecture



Bidirectional WDM Architecture



Components of WDM

- Important components of WDM Network is as follows:
  - Optical Line Terminals OLT
  - Optical Add/Drop Multiplexer
  - Optical Cross Connect

Technologies of WDM

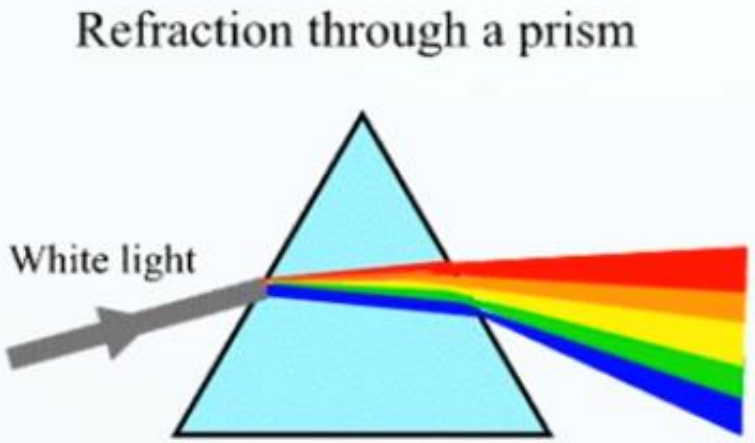
- Thin Film Filter
- Fused Fiber Coupler
- Arrayed Waveguide grating
- Interleaver

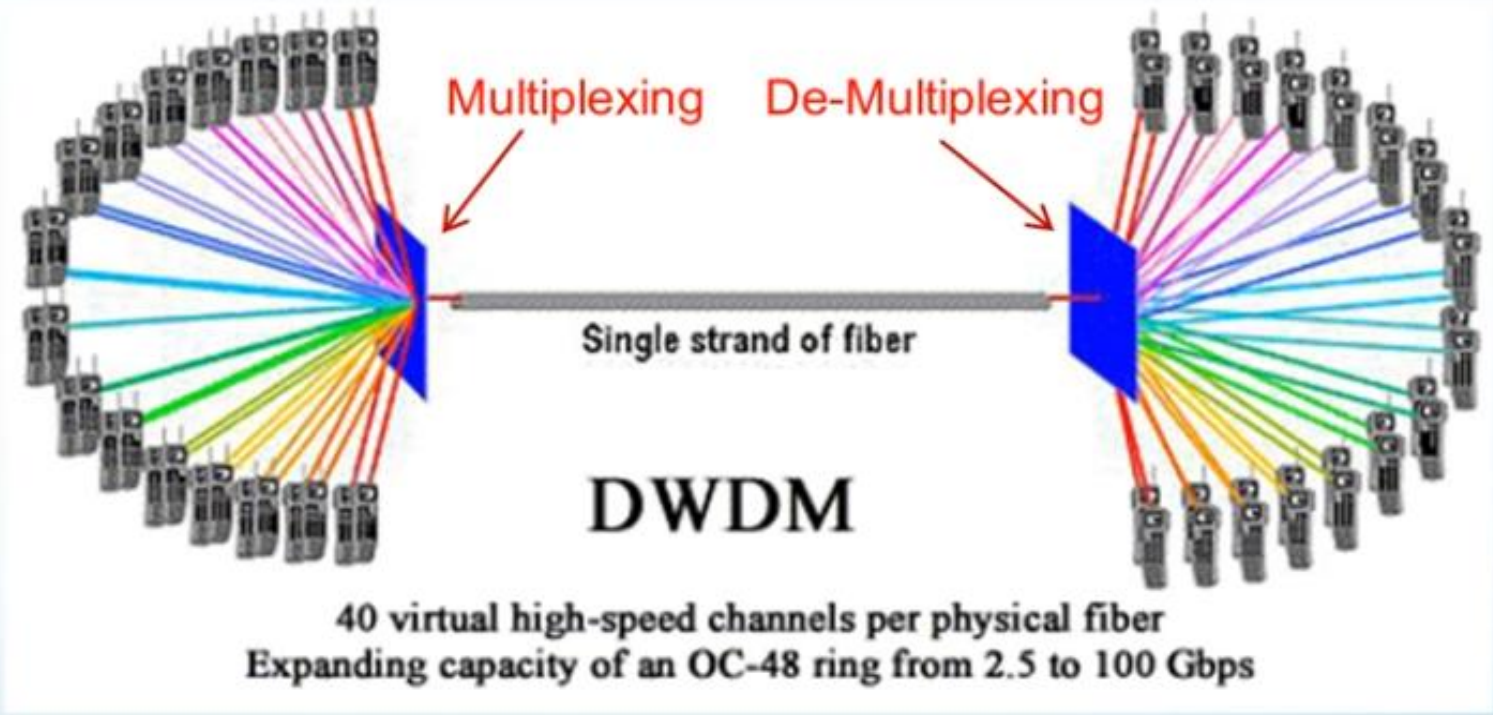
Important feature of WDM

- Wavelength reuse
- Wavelength conversion
- Transparency
- Circuit switching
- Survivability

What is WDM?

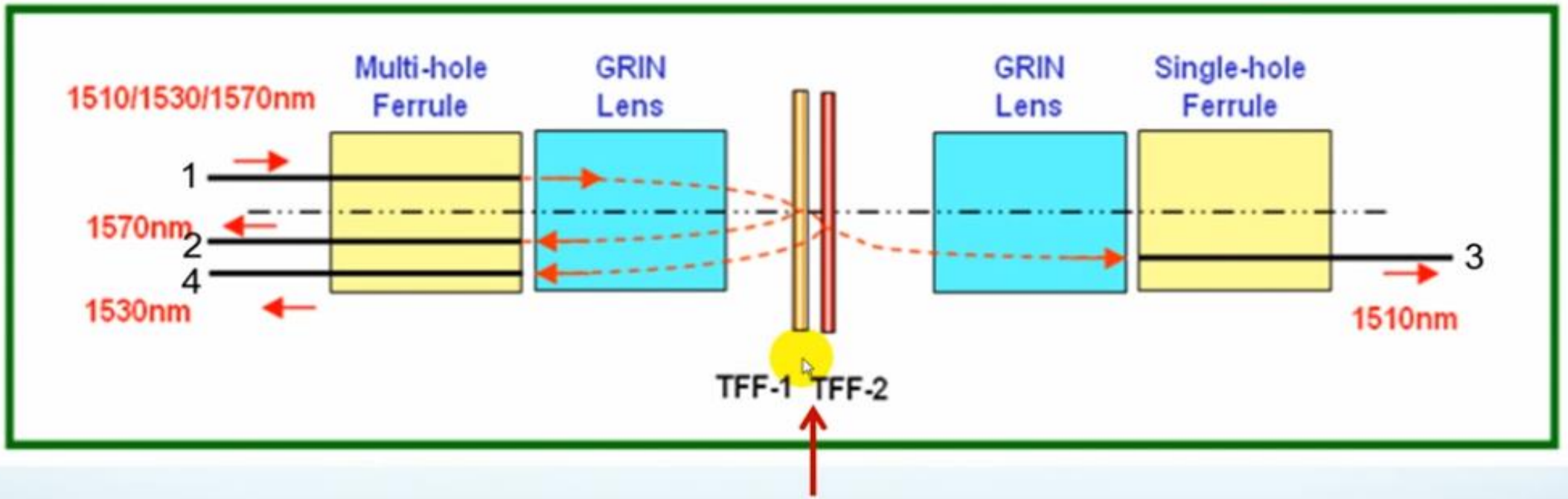
WDM = Wavelength Division Multiplexing





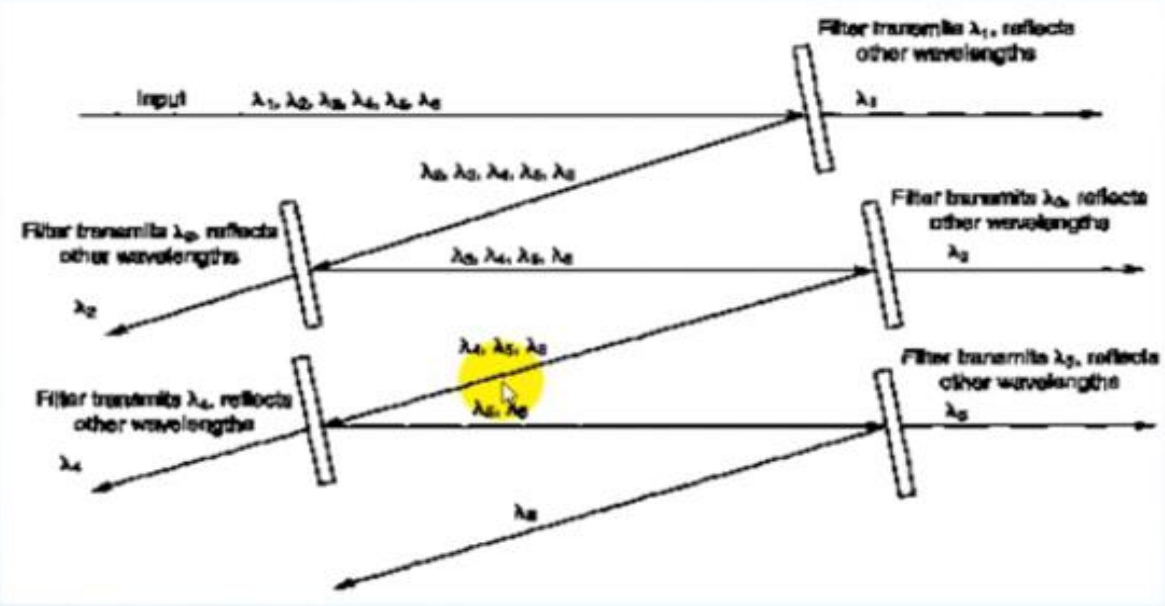
WDM is used on fiber optics to increase the capacity of a single fiber

How are WDMs Made?



Fiber Optics For Sale Co.

WDMs Cascaded Together



WDMs Cascaded

8 Channel WDM

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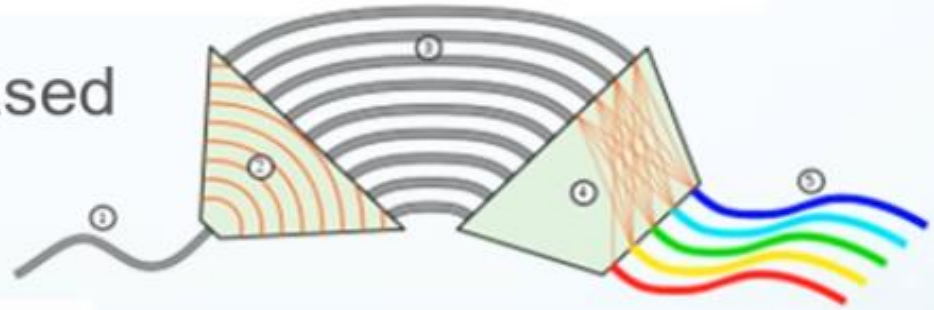
Different WDM Technologies

- Thin-Film Filter Based

- Fused Fiber Coupler Based WDM

- Arrayed Waveguide Grating (AWG) Based



- Interleaver Based

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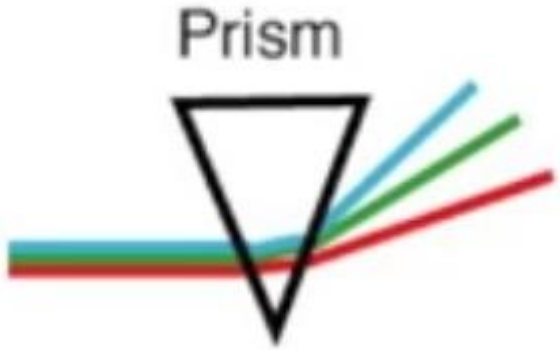
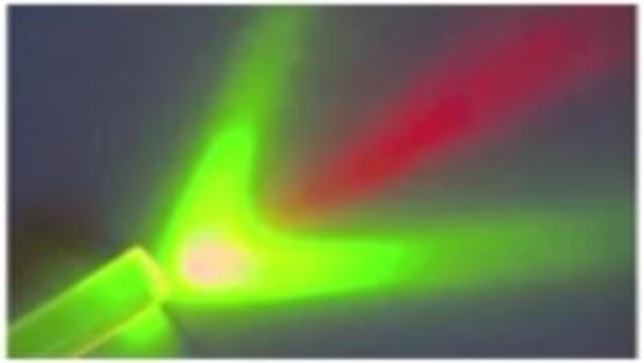
What Is Wavelength Division Multiplexing?

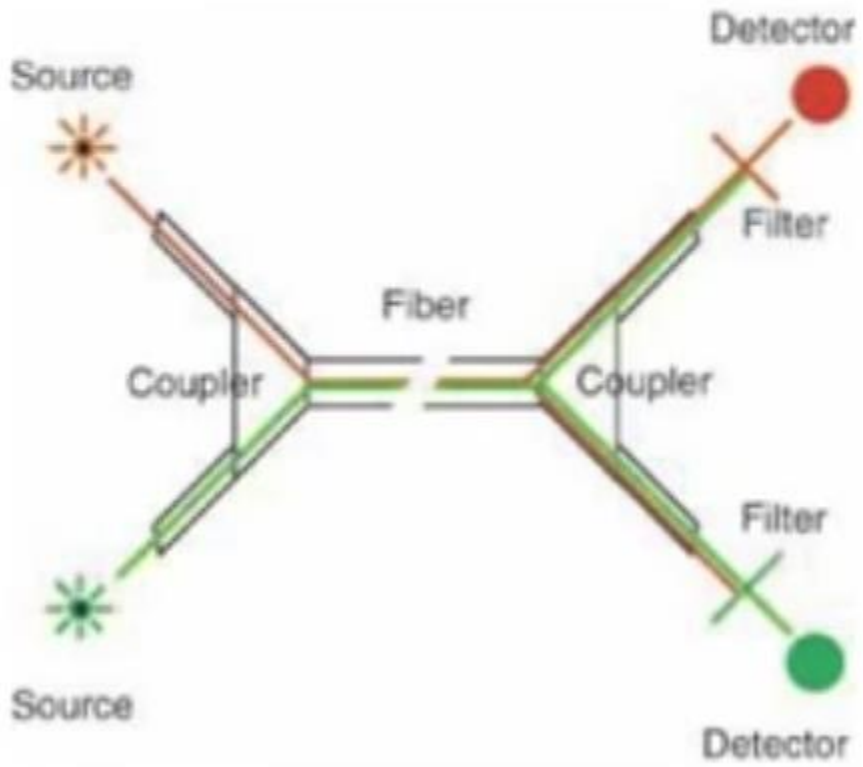
- Light has a property that keeps it from mixing and allows it to be separated into its colors like this by a prism
- WDM uses this property to send signals of different colors down a fiber simultaneously





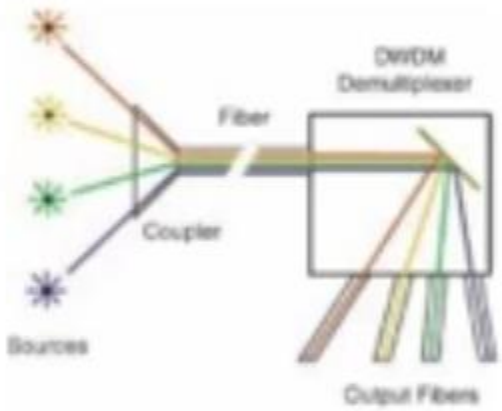
Early Example of WDM

- The first use of WDM was sending two signals over one fiber at the same time.
- Simple couplers and filters were needed
- FTTH PONS work like this today



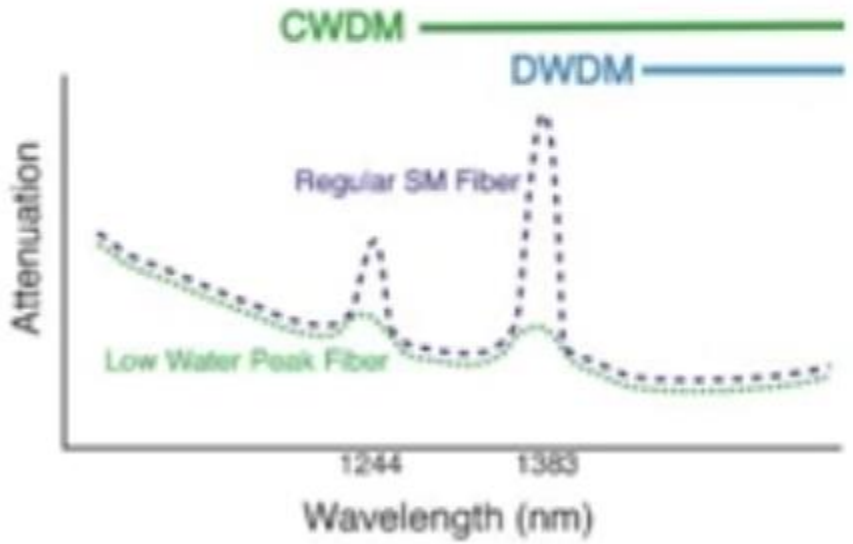
Wavelength-Division Multiplexing

- Now WDM is commonplace
- DWDM >64 channels with fiber amplifiers for repeaters
- CWDM ~20 channels on low-water peak fiber
- Preferred over more fibers
- Use for bidirectional signals over single fiber in FTTH



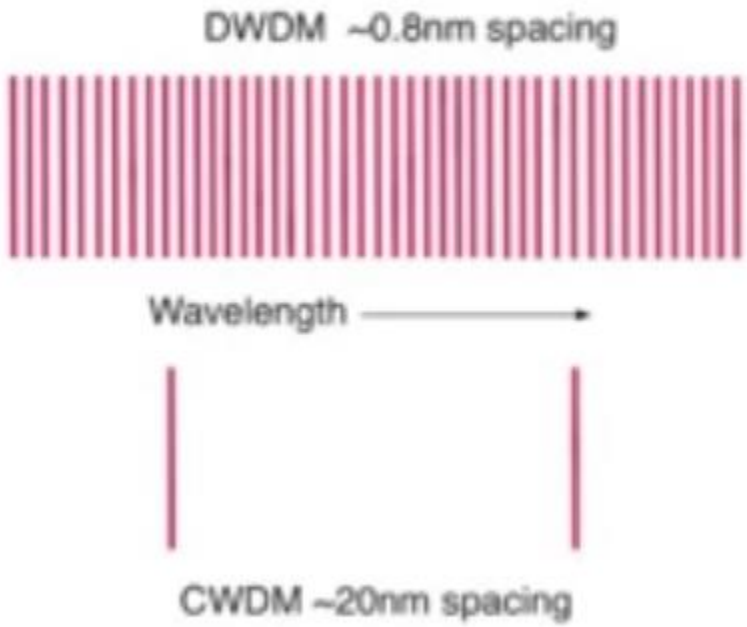
Wavelengths Used in WDM

- DWDM is typically limited to 1450 to 1650 nm
- CWDM may operate over the full range of 1280 to 1650nm



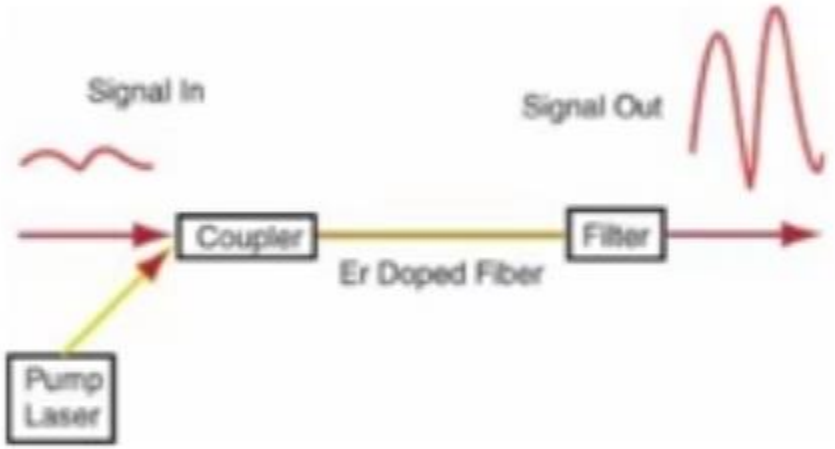
Laser Source Spacing

- DWDM uses lasers at ~0.8nm spacing
- CWDM uses lasers at 20nm spacing



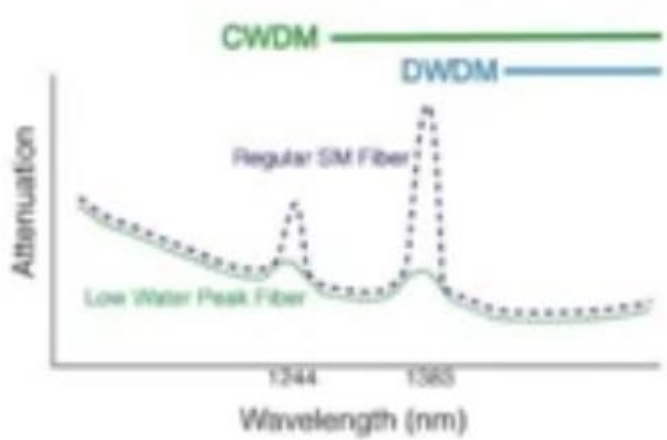
DWDM and Fiber Amplifiers

- Now commonplace on long distance links
- Not a repeater – just an amplifier
- EDFAs (erbium-doped fiber amplifiers) work in the 1450-1650nm range used for DWDM



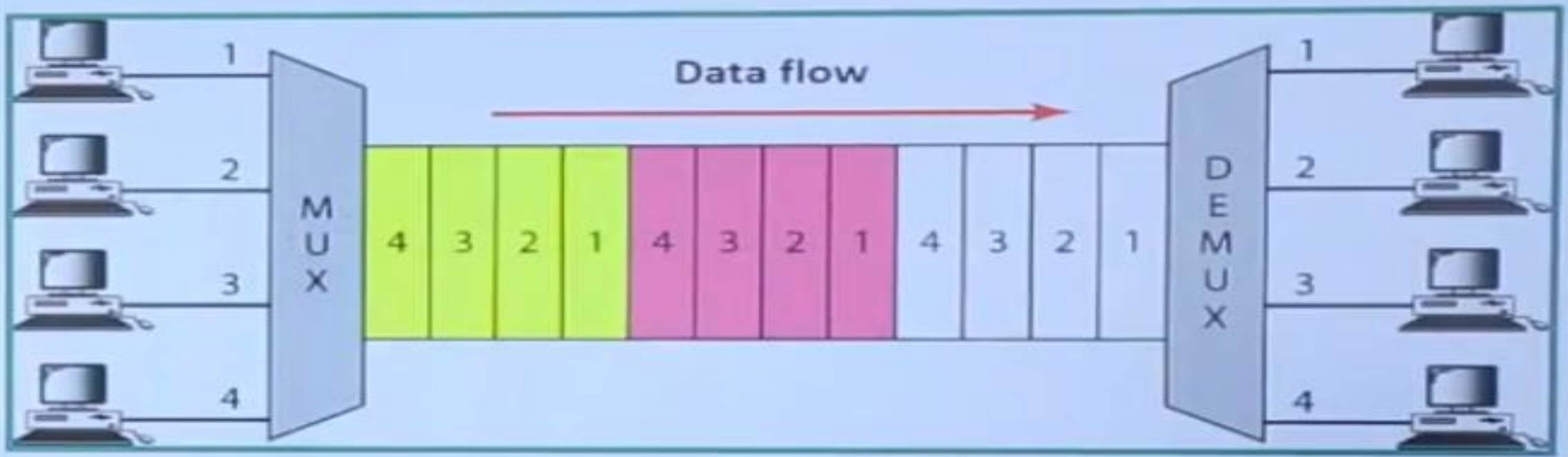
WDM Testing: Spectral Attenuation

- Wavelength division multiplexing systems use wavelengths from 1260 to 1675 nm
- May require testing over whole wavelength range
- Uses broad sources to cover wavelength range

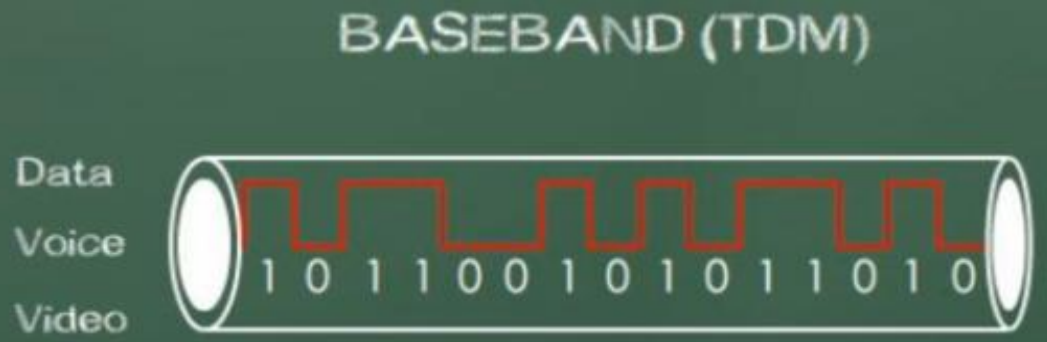


Time Division Multiplexing (TDM)

TDM is a digital multiplexing technique for combining several low-rate channels into one high-rate one.

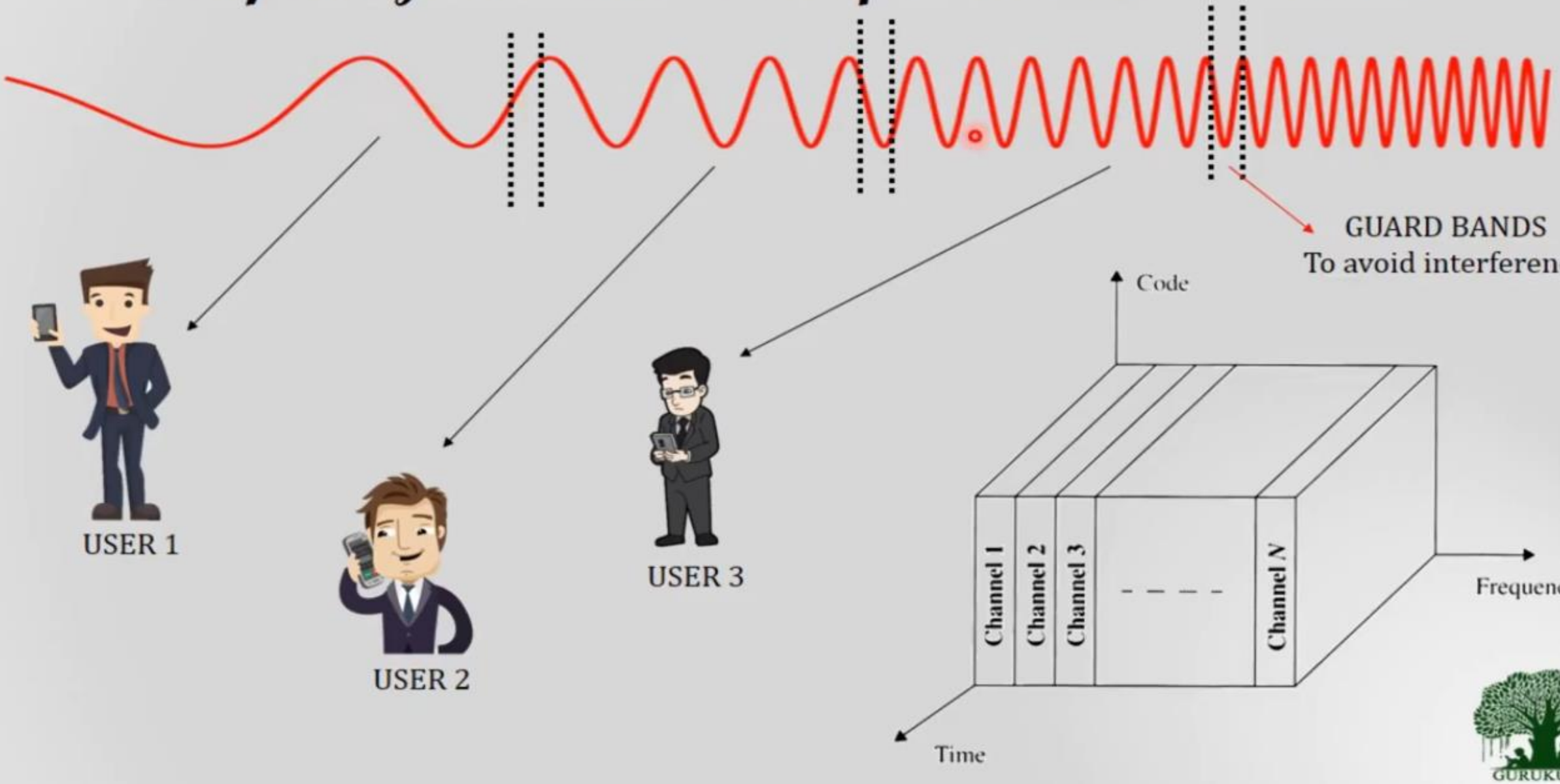


Sunny Classroom



Ethernet is an example of baseband system.

Frequency Division Multiple Access - FDMA



Basic Principle – Multi-Access Technology

- **FDMA (example: AMPS)**
  Frequency Division Multiple Access
  each user has a private frequency (at least in their own neighborhood)

- **TDMA (examples: IS-54/136, GSM)**
  Time Division Multiple Access
  each user has a private time on a private frequency (at least in their own neighborhood)

- **CDMA (examples: IS-95, J-Std.008)**
  Code Division Multiple Access
  users co-mingle in time and frequency but each user has a private code (at least in their own neighborhood)