ITU-T PON standards - progress and recent activities
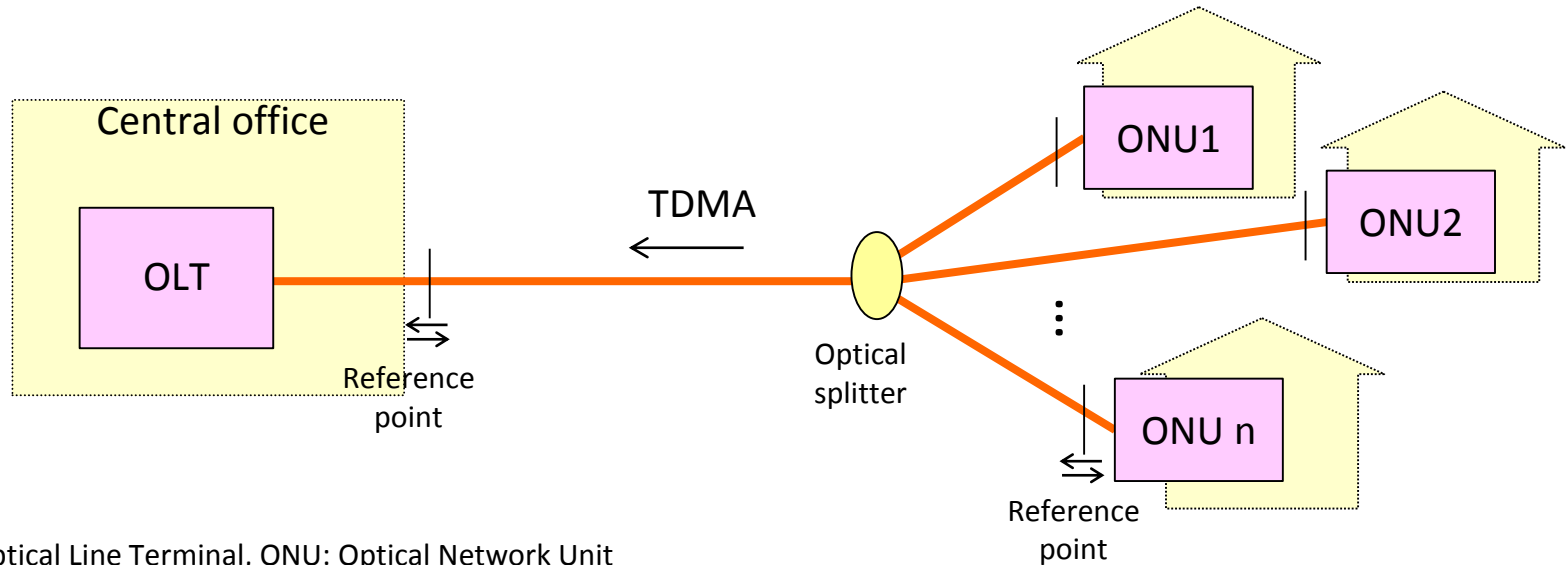

Q2/SG15

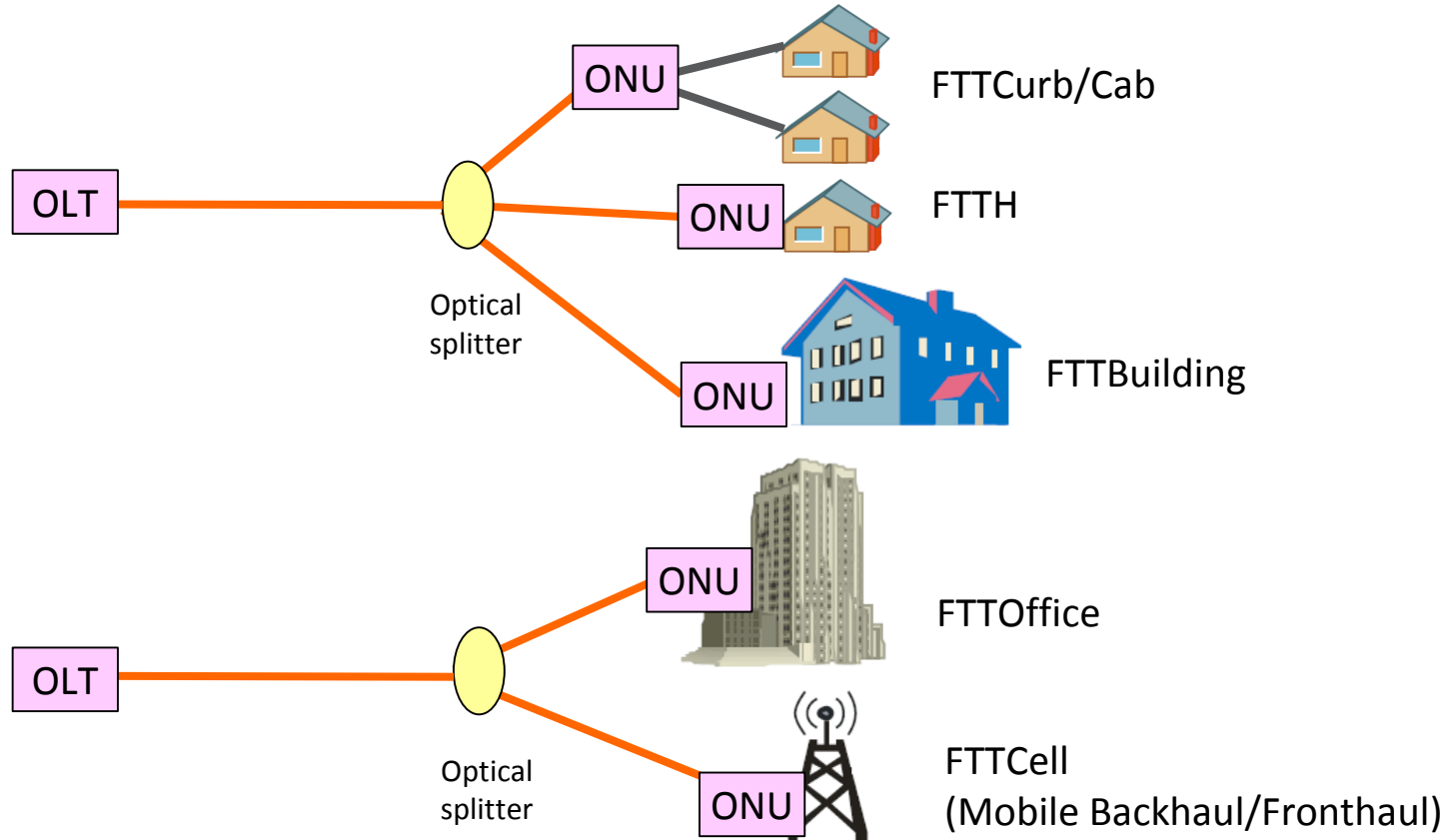# What is PON?

- **Passive Optical Network (PON) system**
  - **A point-to-multipoint optical communication system.**
  - **The most popular system to realize Fiber To The Home (FTTH) in the world.**
- **Multiple (e.g. 16 to 128) ONUs communicate with an OLT via optical splitter(s).**

OLT: Optical Line Terminal, ONU: Optical Network Unit
TDMA: Time Division Multiple Access

Application areas of PON

OLT

Optical splitter

ONU — FTTCurb/Cab

ONU — FTTH

ONU — FTTBuilding

OLT

Optical splitter

ONU — FTTOffice

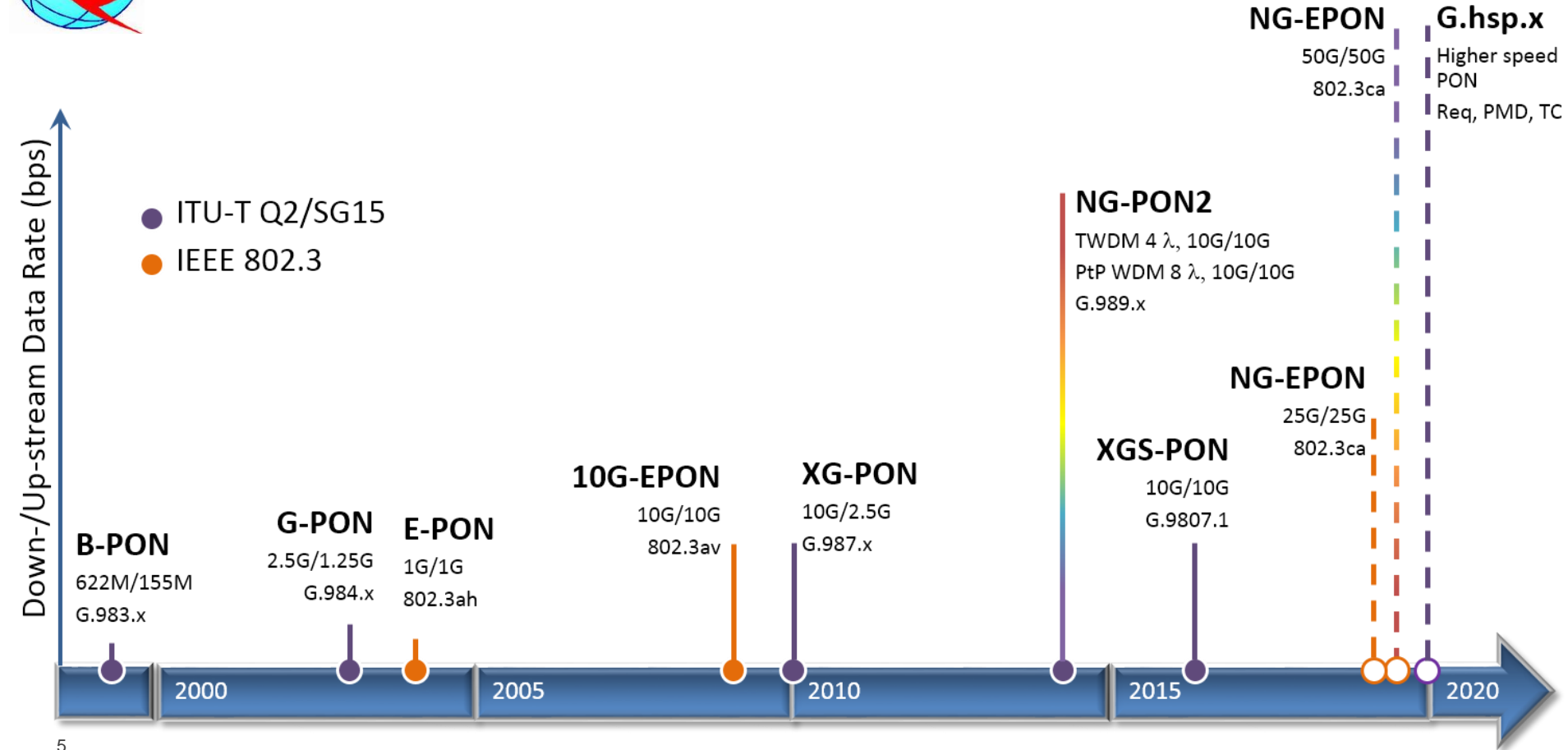ONU — FTTCell
(Mobile Backhaul/Fronthaul)

Q2/15: Optical Access Networks

- Q2/15 belongs to WP1 of SG15
- Over the past, Q2 has worked on several generations of PON
  - G.982 (pi-PON)   Mostly of historical interest
  - G.983 (A/B-PON)   Perhaps 10M ONUs deployed
  - G.984 (G-PON)   Several 100M ONUs deployed
  - G.987 (XG-PON)
  - G.9807 (XGS-PON)   Both beginning to grow now
  - G.989 (NG-PON2)   Ecosystem building stage
- Additionally, several point to point systems were specified
  - G.985 (Bidi 100Mb/s Ethernet access) (aka 100Base-BX)
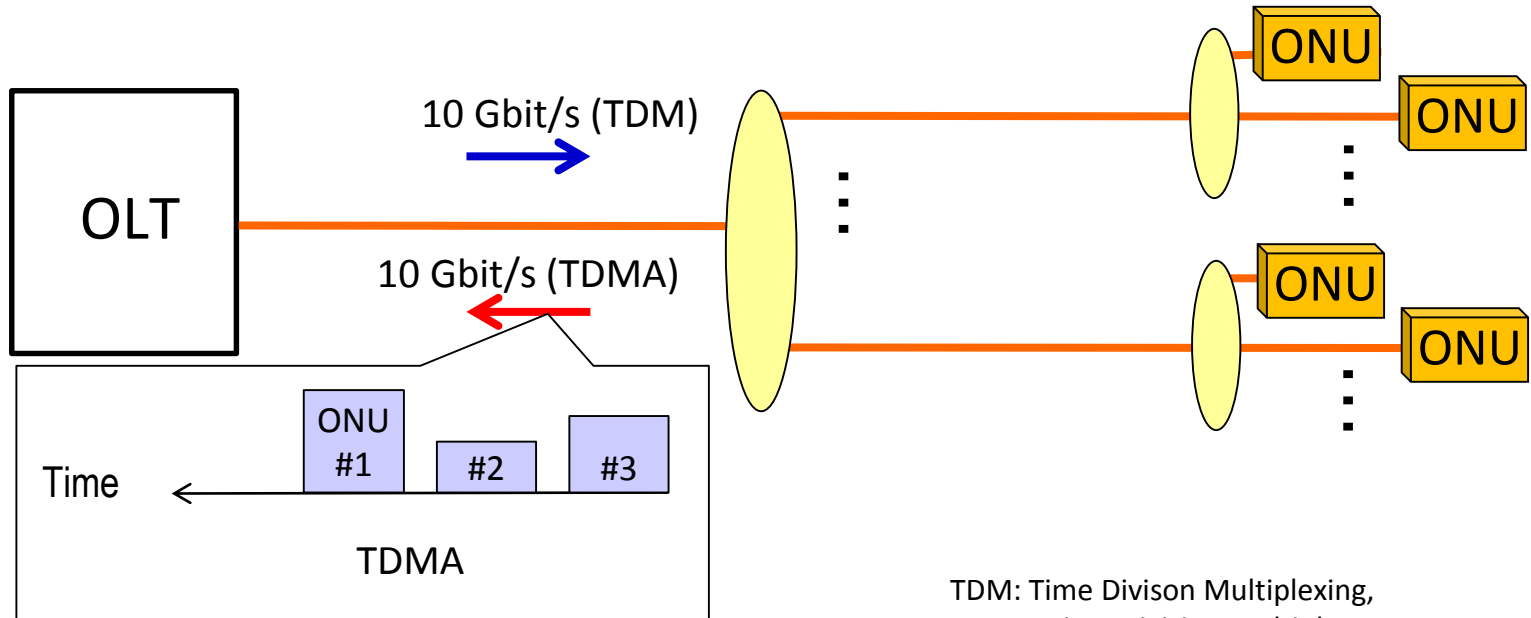 - G.986 (Bidi 1Gb/s Ethernet access) (aka 1000Base-BX)

Recent progress in PON standards

NG-EPON
50G/50G
802.3ca

G.hsp.x
Higher speed PON
Req, PMD, TC

NG-PON2
TWDM 4 λ, 10G/10G
PtP WDM 8 λ, 10G/10G
G.989.x

NG-EPON
25G/25G
802.3ca

Down-/Up-stream Data Rate (bps)

● ITU-T Q2/SG15
● IEEE 802.3

XGS-PON
10G/10G
G.9807.1

10G-EPON
10G/10G
802.3av

XG-PON
10G/2.5G
G.987.x

B-PON
622M/155M
G.983.x

G-PON
2.5G/1.25G
G.984.x

E-PON
1G/1G
802.3ah

2000   2005   2010   2015   2020

5

XGS-PON

- **10-Gbit/s Symmetric PON system based on TDM and TDMA**

10 Gbit/s (TDM)

10 Gbit/s (TDMA)

OLT
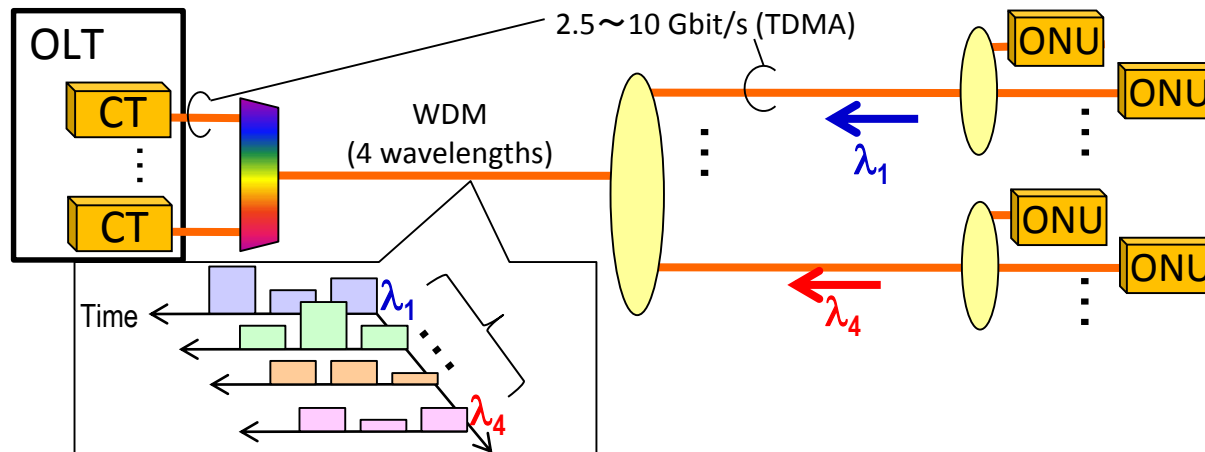
ONU #1 #2 #3

Time

TDMA

ONU

TDM: Time Divison Multiplexing,
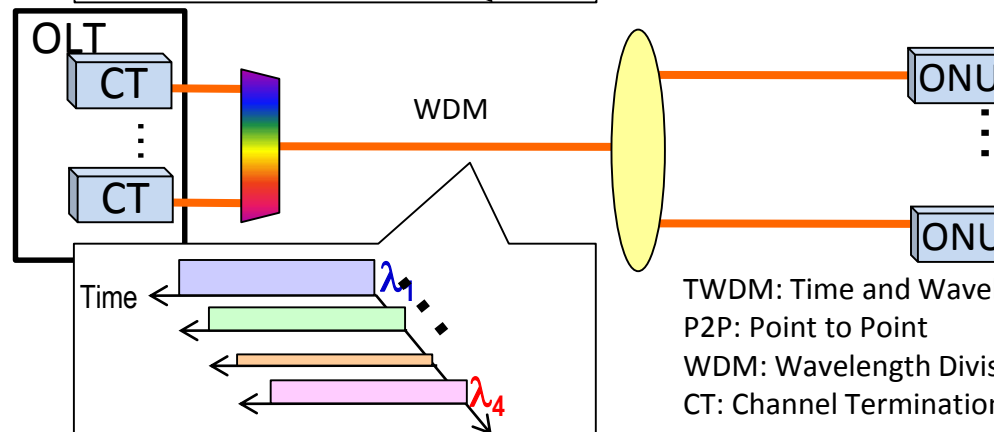TDMA: Time Division Multiple Access.

NG-PON2

- **40-Gbit/s capable PON system based on TWDM (Primary) and PtP WDM overlay (Optional)**
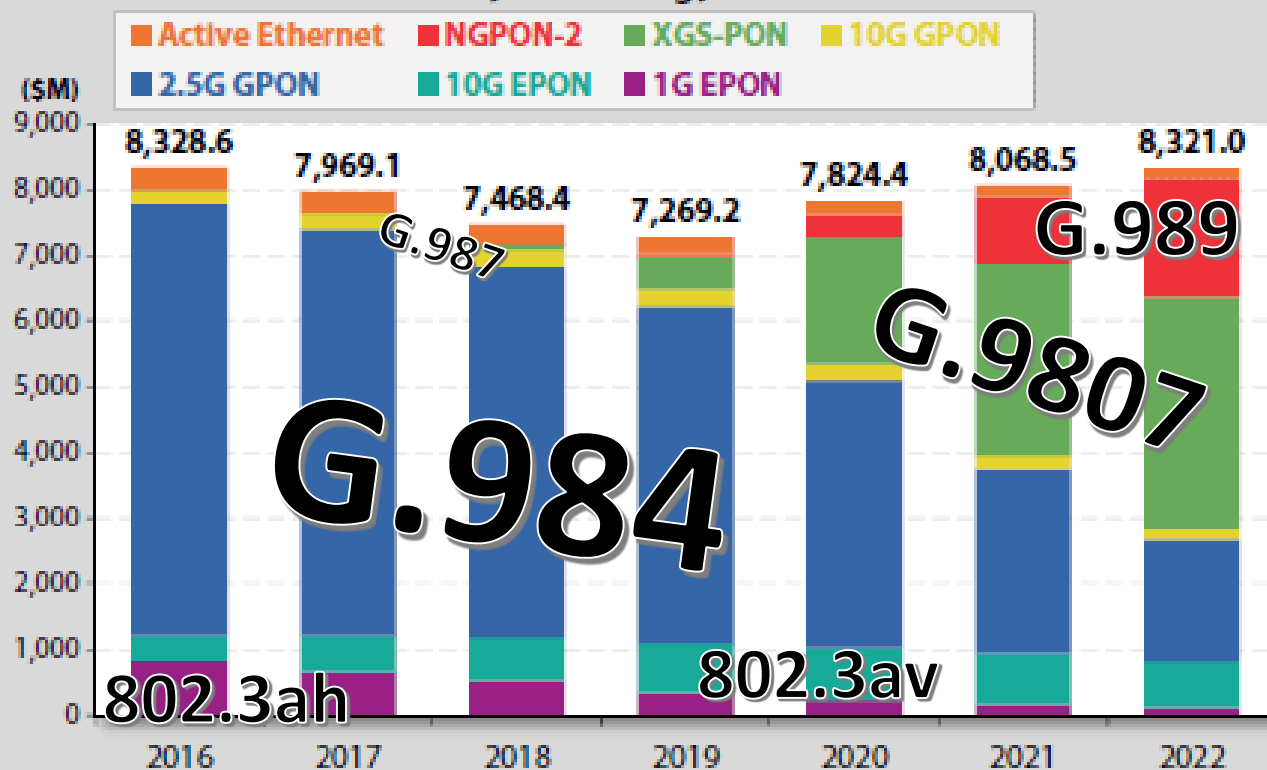

TWDM-PON (Primary)

PtP WDM-PON (Optional)

TWDM: Time and Wavelength Division Multiplexing
P2P: Point to Point
WDM: Wavelength Division Multiplexing
CT: Channel Termination
TDMA: Time Division Multiple Access

FTTH market breakdown

Worldwide FTTH revenue by technology

Legend: Active Ethernet, NGPON-2, XGS-PON, 10G GPON, 2.5G GPON, 10G EPON, 1G EPON

($M)

8,328.6 (2016), 7,969.1 (2017), 7,468.4 (2018), 7,269.2 (2019), 7,824.4 (2020), 8,068.5 (2021), 8,321.0 (2022)
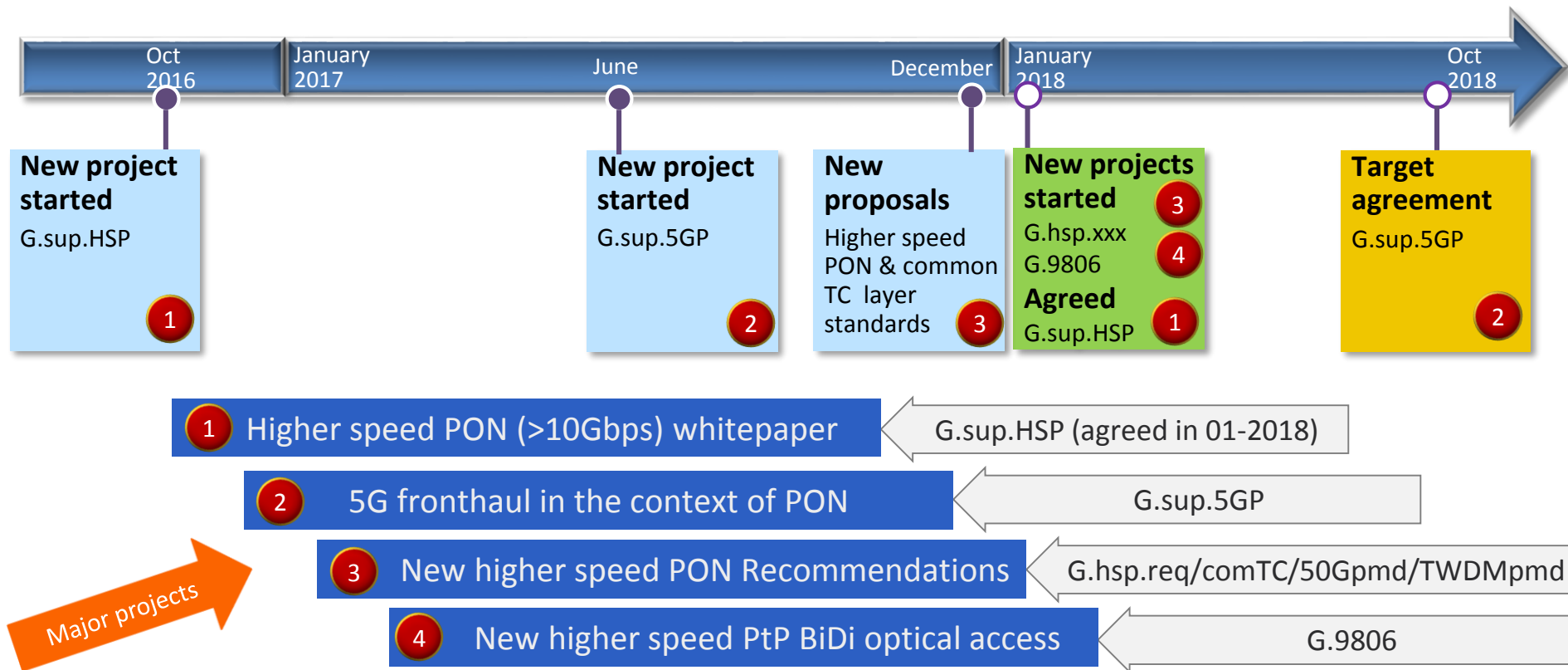
G.987
G.989
G.984
G.9807
802.3ah
802.3av

Kagan, a media research group within the TMT offering of S&P Global Market Intelligence, estimates.
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Higher speed PON and RAN related activities

Timeline:
- Oct 2016
- January 2017
- June
- December
- January 2018
- Oct 2018

New project started
G.sup.HSP — 1

New project started
G.sup.5GP — 2

New proposals
Higher speed PON & common TC layer standards — 3

New projects started
G.hsp.xxx — 3
G.9806 — 4
Agreed
G.sup.HSP — 1

Target agreement
G.sup.5GP — 2

Major projects

1 — Higher speed PON (>10Gbps) whitepaper ⟵ G.sup.HSP (agreed in 01-2018)

2 — 5G fronthaul in the context of PON ⟵ G.sup.5GP

3 — New higher speed PON Recommendations ⟵ G.hsp.req/comTC/50Gpmd/TWDMpmd

4 — New higher speed PtP BiDi optical access ⟵ G.9806

New Higher Speed PON Recommendations

G.hsp.Req: Requirements for higher speed PONs

- Meant to be a collector of all PON requirements, working to find application sets that define reasonable systems

G.hsp.ComTC: Specifications for a converged TC layer

- Meant to cover all HSP systems (single and multiple wavelengths, fixed and tunable optics), and maximum commonality with other systems

G.hsp.50Gpmd: Specifications of fixed 50G PMD

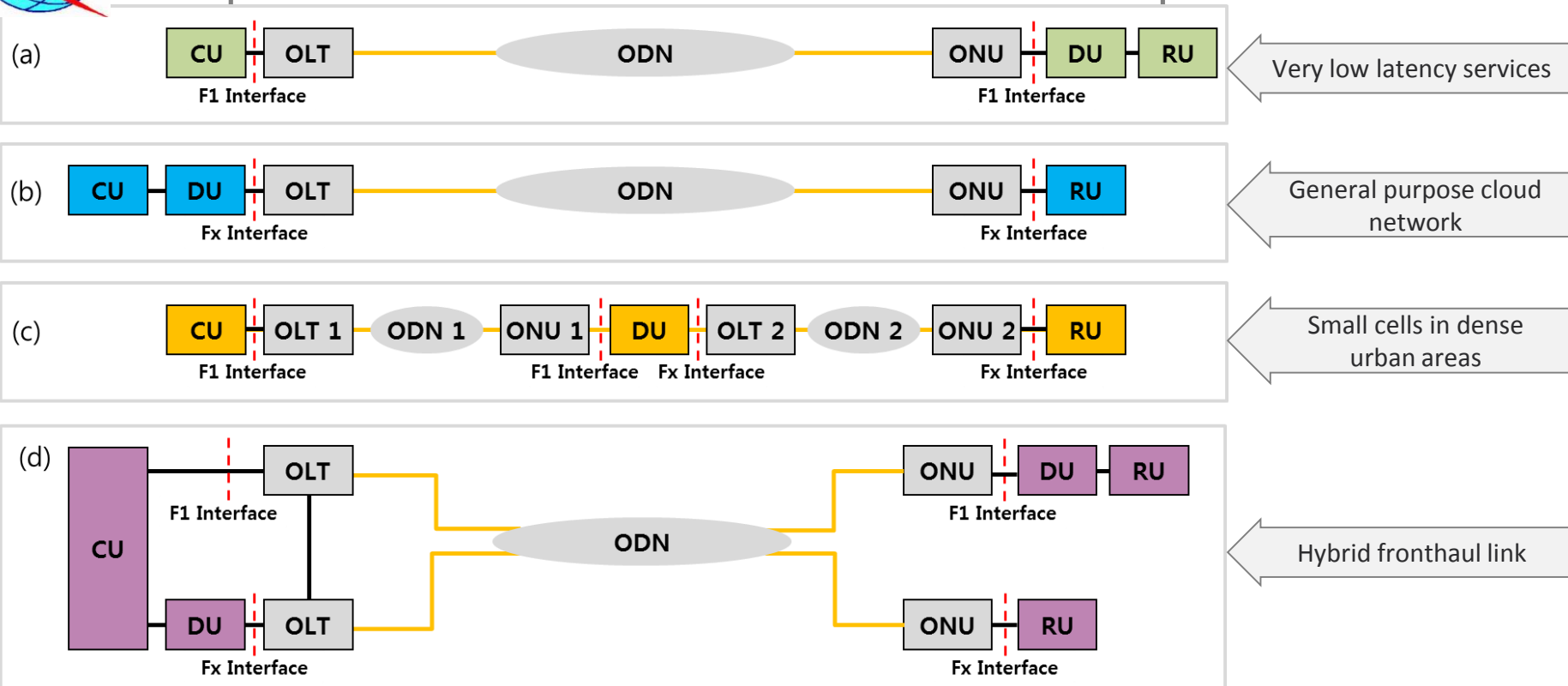**G.hsp.TWDMpmd**: Specifications of the higher rate TWDM PMD

- Consider tunable ONU optics

G.9806: Higher speed BiDi single fibre point to point optical access systems

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Support 5G transport applications with PON
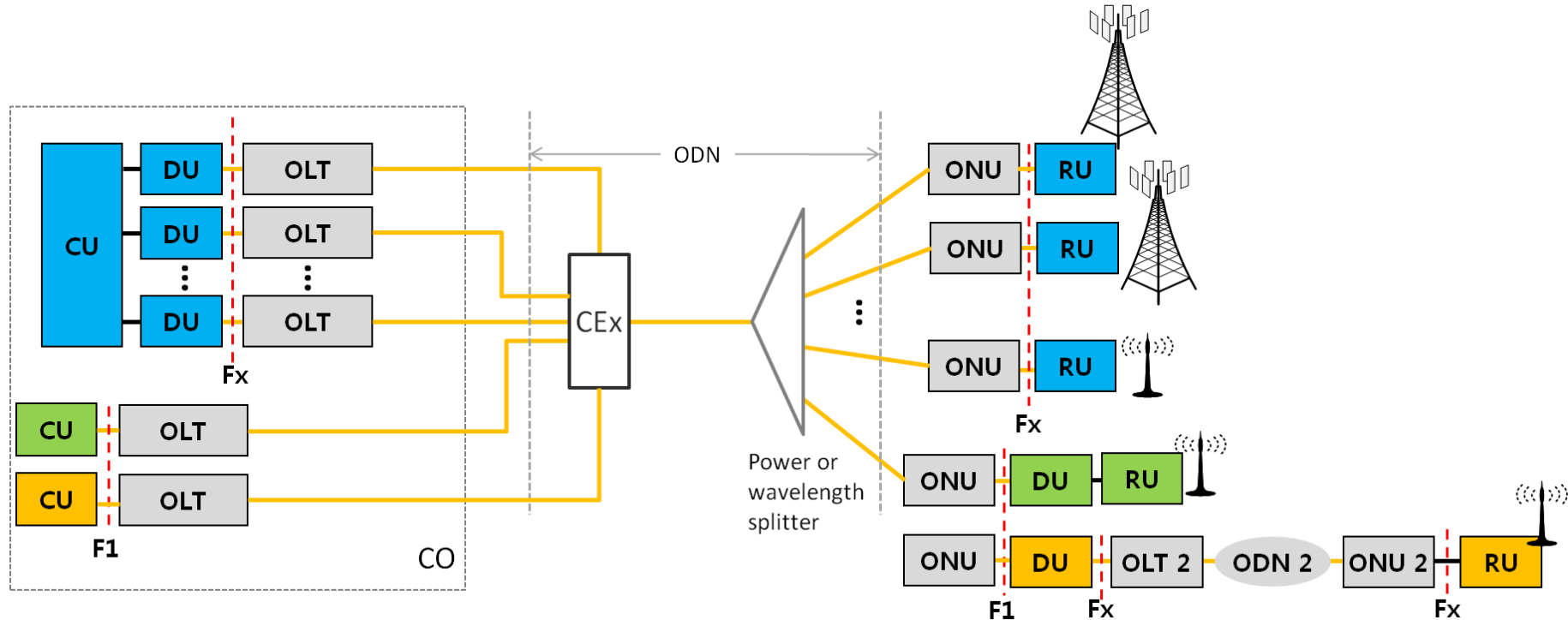## 4 potential use cases identified in ITU-T G.sup.5GP

F1 and Fx Interfaces: Higher and lower layer interface in the future mobile fronthaul under discussion in 3GPP,
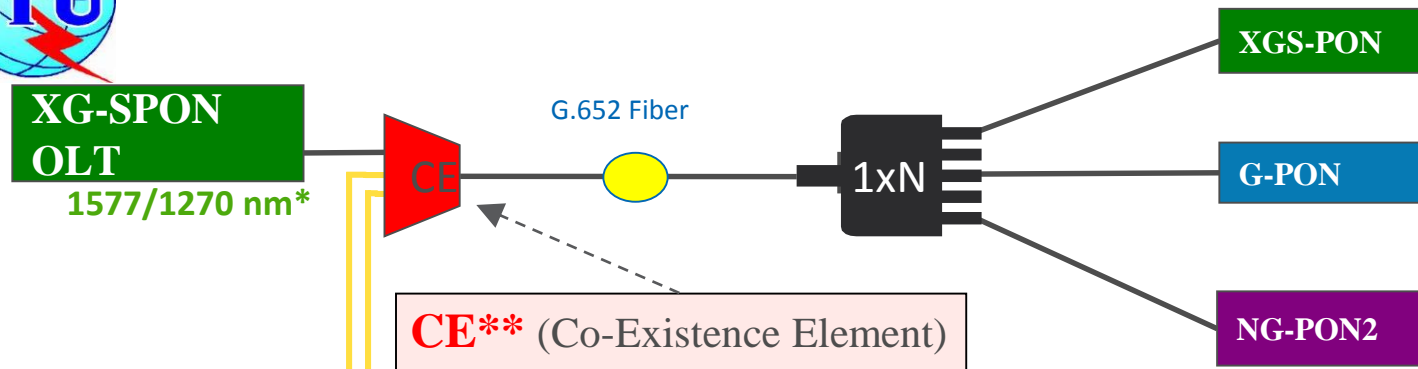CU: Central Unit,   DU: Distributed Unit,   RU: Radio Unit.

Use case example of a dedicated wireless PON
illustrated in ITU-T G.sup.5GP
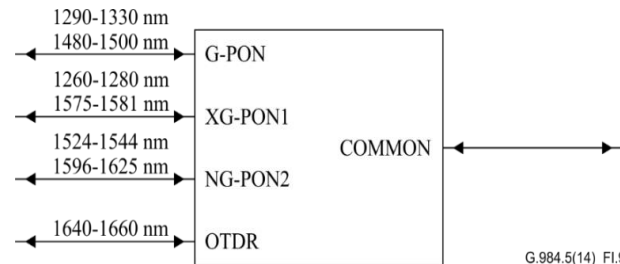
Coexistence of ITU PON Technologies using WDM

XG-SPON OLT
1577/1270 nm*

G.652 Fiber

CE

CE** (Co-Existence Element)

1xN

XGS-PON

G-PON

NG-PON2

1490/1310 nm*
G-PON OLT

1600/1544 nm*
NG-PON2 OLT

Example of a type of Coexistence Element defined in Appendix I of G.984.5

1290-1330 nm
1480-1500 nm   G-PON

1260-1280 nm
1575-1581 nm   XG-PON1

1524-1544 nm
1596-1625 nm   NG-PON2

1640-1660 nm   OTDR

COMMON

G.984.5(14)_FI.9

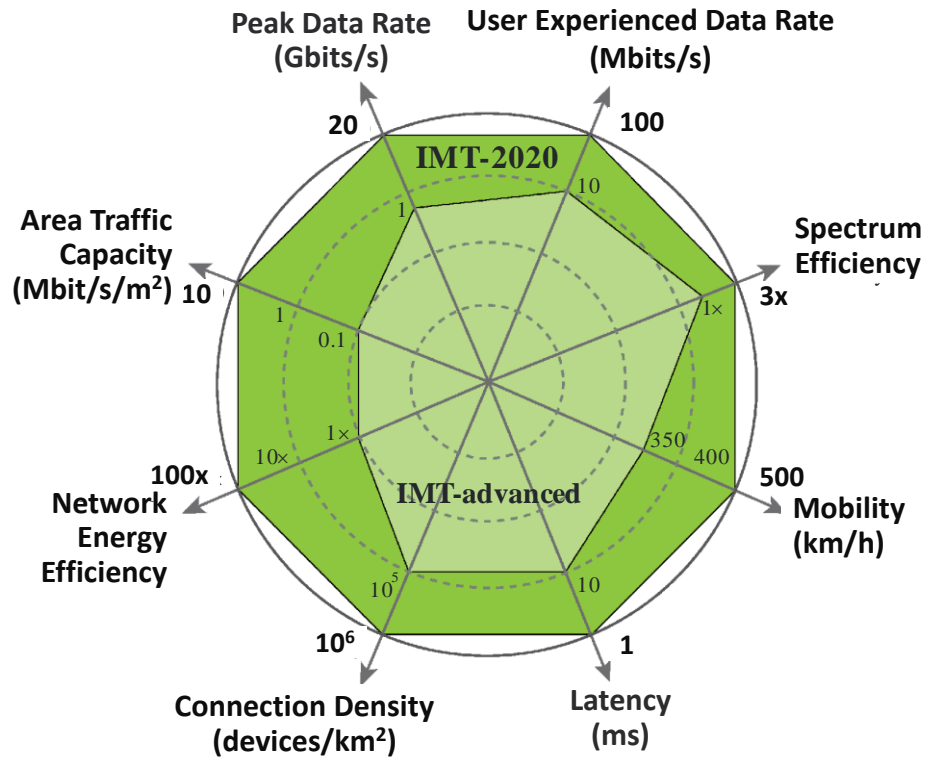*Downstream and Upstream Center Wavelengths (nm)
**Co-existence Element has been defined in ITU-T G.984.5 Amendment 1 along with additional Coexistence solutions

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Backup

Q2/SG15

# Key capabilities of 5G networks specified in ITU IMT-2020

Peak Data Rate (Gbits/s); User Experienced Data Rate (Mbits/s); Spectrum Efficiency; Mobility (km/h); Latency (ms); Connection Density (devices/km²); Network Energy Efficiency; Area Traffic Capacity (Mbit/s/m²)

IMT-2020 / IMT-advanced

M.2083-03

Expected improvement from LTE/Pre-5G to 5G			
Parameter	**4G/4.5G**	**5G**	**Increased by**
Peak data rate	150 Mbps - 1 Gbps	20 Gbps	10 – 200x
User experienced data rate	10 Mbps	100 Mbps - 1 Gbps	10 – 100x
Mobility	350 km/h	500 km/h	1.5x
Latency	10ms - 50ms	uRLLC: 1 ms eMBB: 10 ms	10x
Connection density	1K - 100K/km²	10^6/km²	10 – 1000x
Traffic density	0.1 Mbps/m²	10 Mbps/m²	100x

Transport bandwidth grows 10-100x from 4G to 5G

Source: ITU-R M.2083-0, 9/2015

# 8 options to split signal processing functions in fronthaul
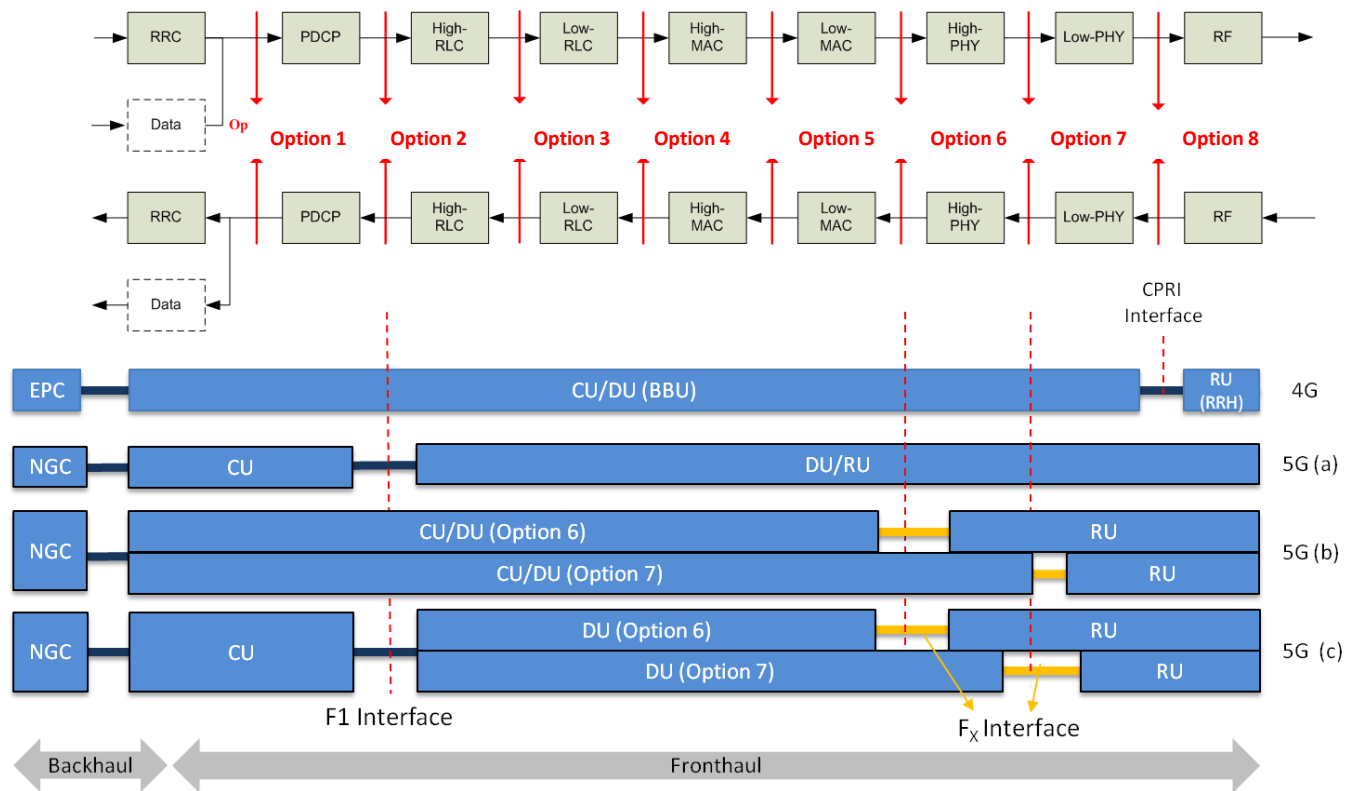
- **Data rate scales with user traffic for split option 2 though 7**
- Meet 5G bandwidth and Latency Requirements
- Relationship between RAN protocol and fronthaul architecture

What is PON?

- **Passive Optical Network (PON) system is a point-to-multipoint optical communication sytem.**
- **Multiple (e.g. 16 to 128) ONUs comminicate with an OLT via optical splitter(s).**
- **Popular PON systems use TDMA in upstream access.**
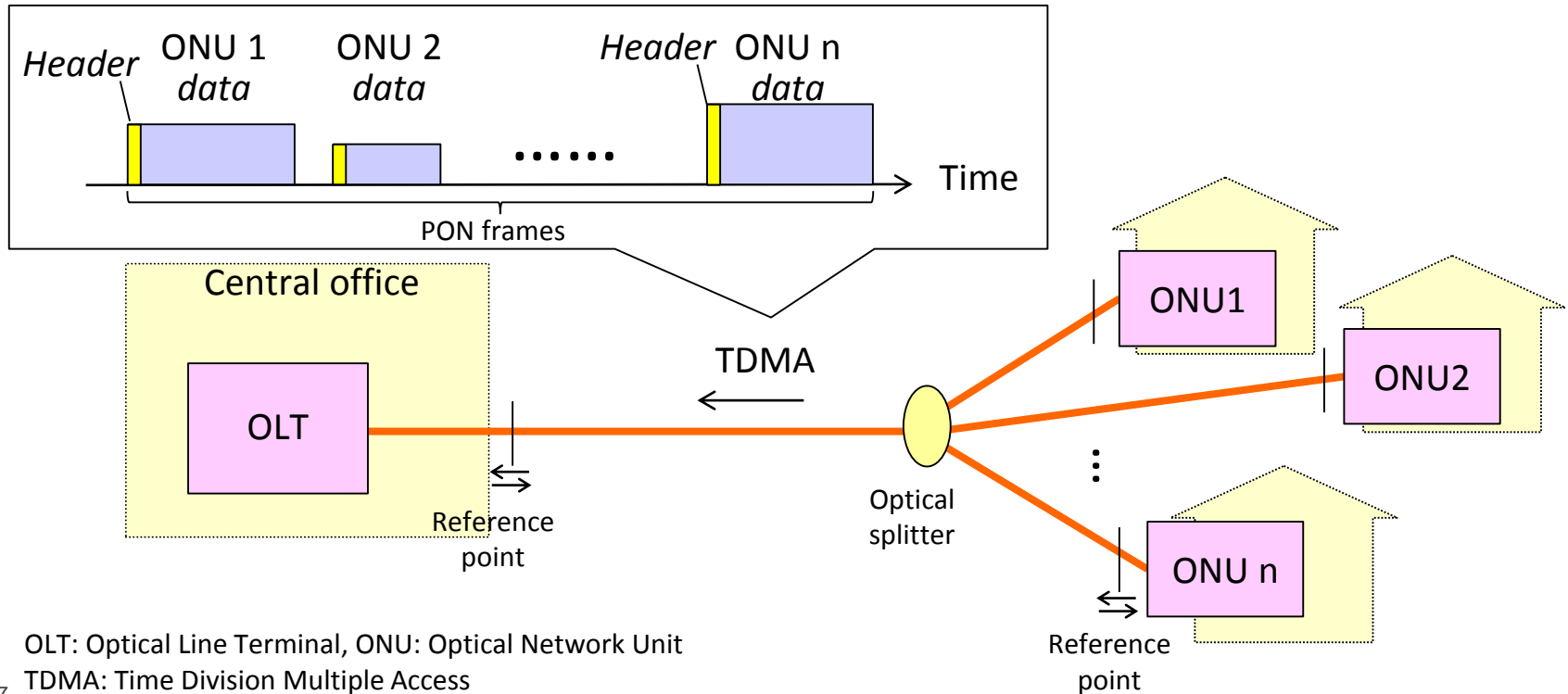
OLT: Optical Line Terminal, ONU: Optical Network Unit
TDMA: Time Division Multiple Access

Recent progress in ITU-T PON standards