Standardization of Broadband Access and IMT-2020/5G transport support in ITU-T SG15

ITU/TSB

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ITU-T SG15 - mandate

ITU-T SG15 is responsible for the development of **standards** on**:**

optical transport network	**access network**	**home network and power utility network infrastructures**
	equipment	
systems	**maintenance**	**optical fibres and cables and their related installation**
instrumentation and measurement techniques	**management**	
	test	**control plane technologies**

to enable the evolution toward intelligent transport networks, including the support of smart-grid applications.

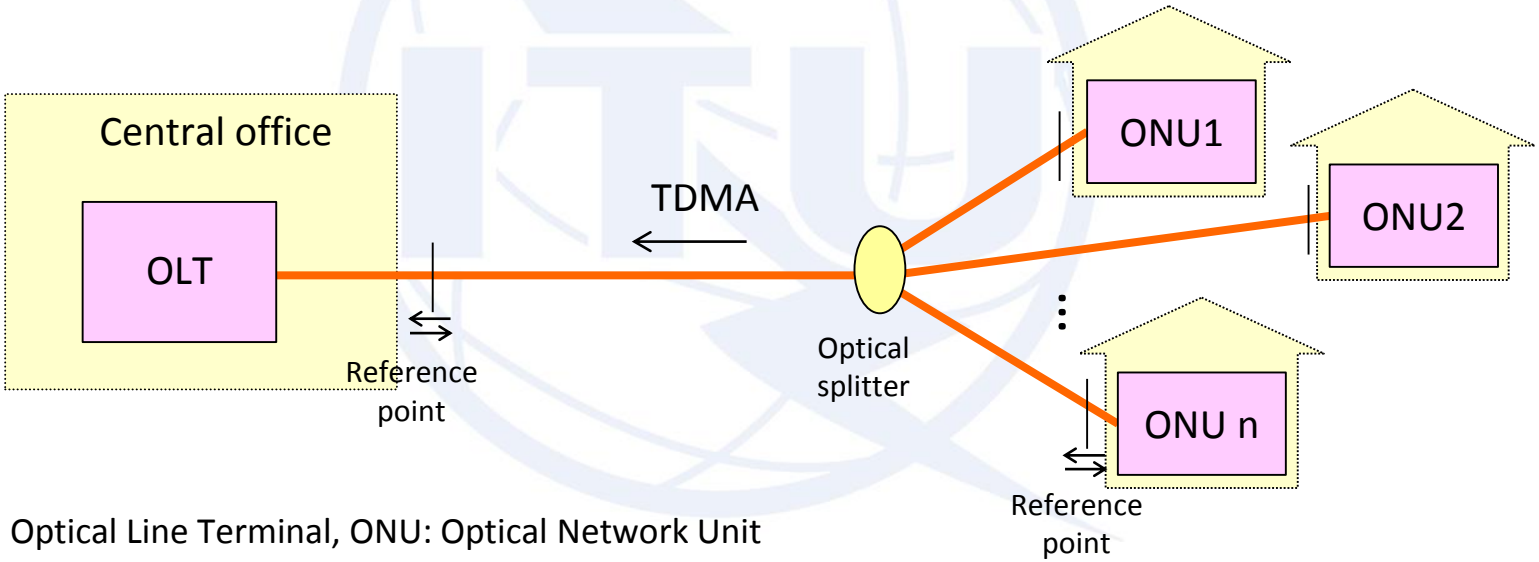
Broadband access – optical fiber or copper?

- Q2/15: Optical systems for fibre access networks
  - PON (Passive Optical Network)
- Q4/15: Broadband access over metallic conductors
  - xDSL (ADSL, VDSL)
  - FTTDp (G.fast, G.mgfast)

Optical access

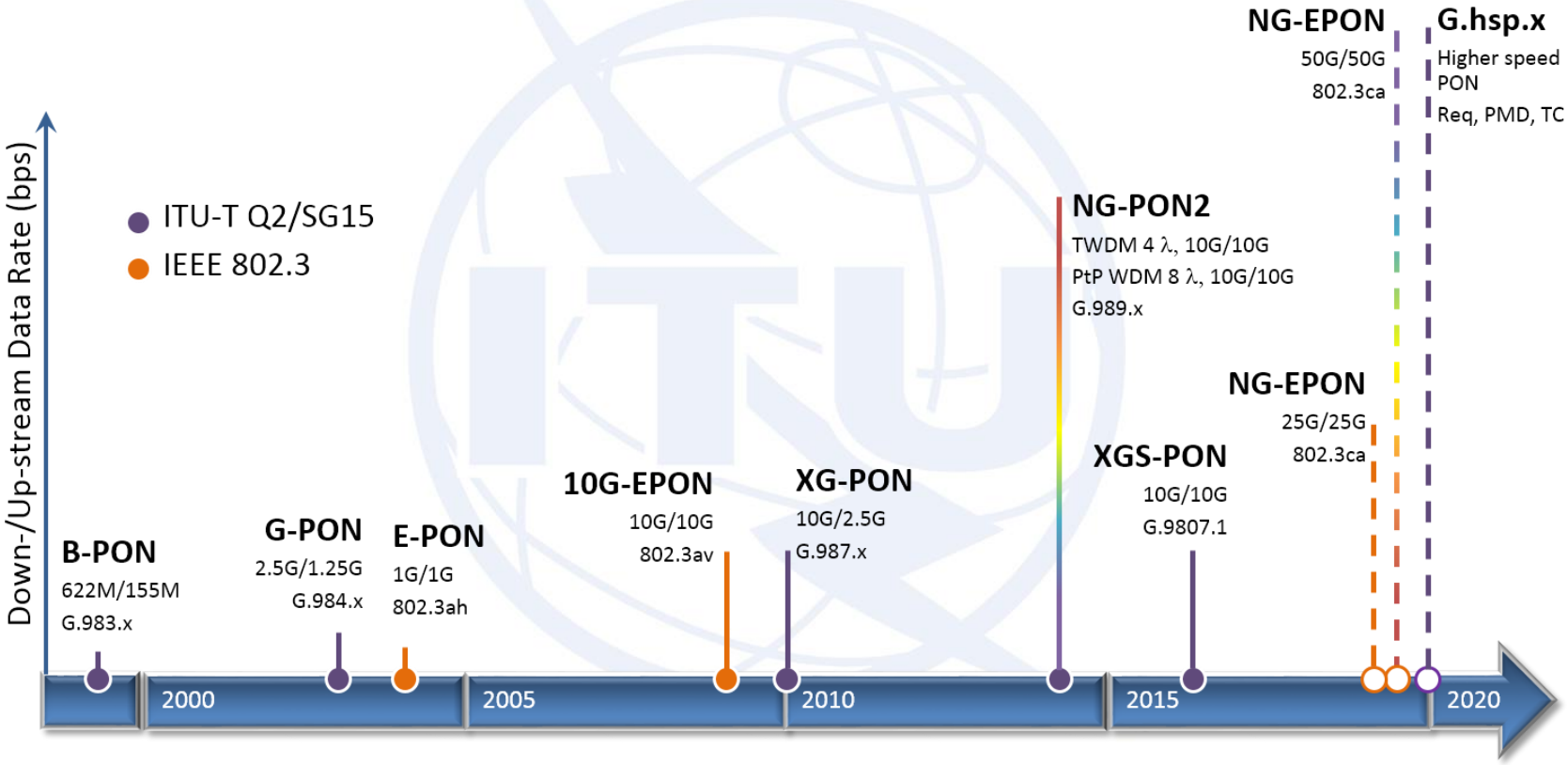
What is PON?

- 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).

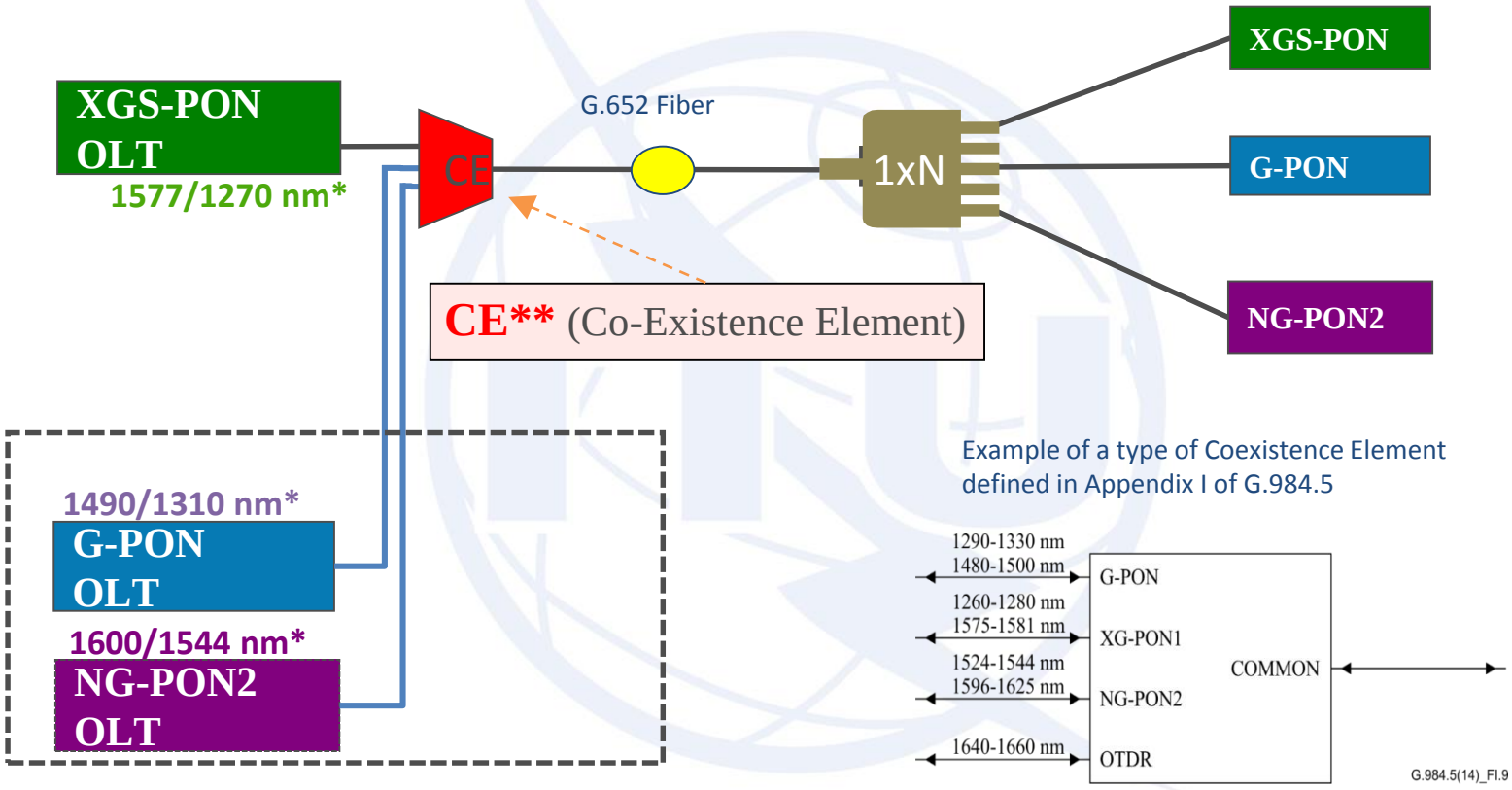


OLT: Optical Line Terminal, ONU: Optical Network Unit
TDMA: Time Division Multiple Access

Recent progress in PON standards



Coexistence of ITU PON Technologies using WDM

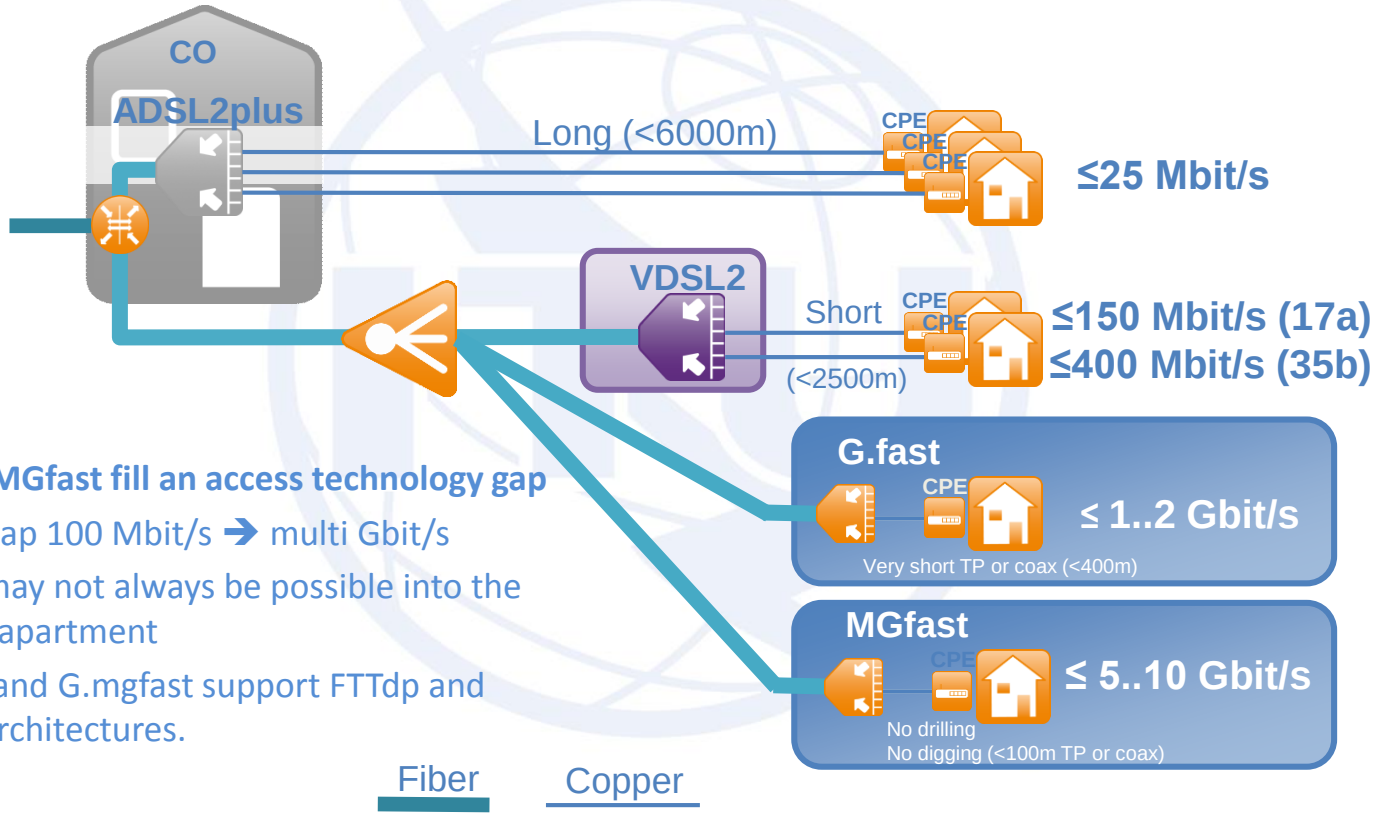


*Downstream and Upstream Center Wavelengths (nm)

**Co-existence Element has been defined in ITU-T G.984.5 Amendment 1 along with additional Coexistence solutions

Metallic access

Overview of Access Network Solutions with metallic cables

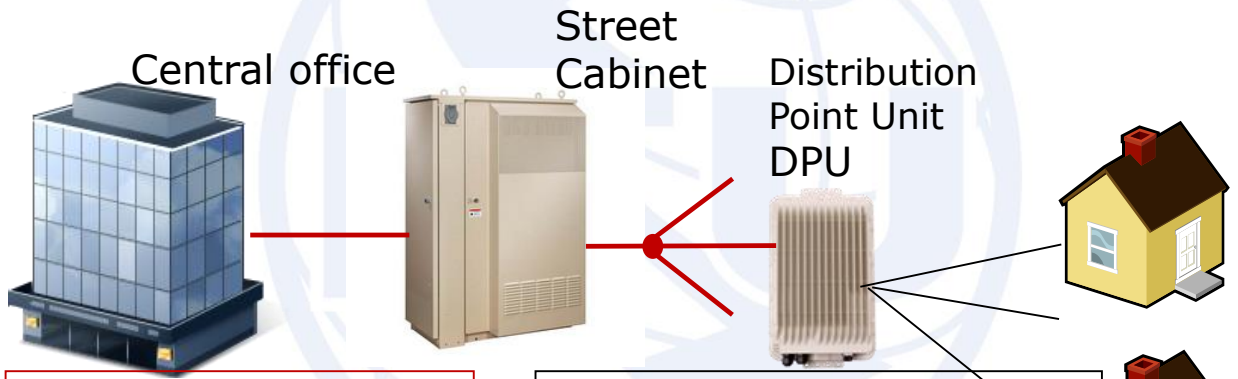


G.fast and MGfast fill an access technology gap

- Huge gap 100 Mbit/s ➔ multi Gbit/s
- Fiber may not always be possible into the home/apartment
- G.fast and G.mgfast support FTTdp and FTTB architectures.

G.fast/FTTdp: Fibre To The distribution point

One FTTdp architecture benefit is that the DPU equipment typically serves 1-20 lines, making it small enough to place on a pole, in a hand-hole or in a small pedestal or in basement



DPU backhaul options:
-G-PON, XG-PON1
-EPON, 10GEPON
-Point-to-Point fibre
-bonded VDSL2 copper

Copper drop options:
-G.fast (opt: reverse power)
-VDSL2
-Vectored VDSL2
-IEEE 802.3 BASE-T

Dynamic Time Assignment (i-DTA)

- Approved April 2017 as part of G.9701 Annex T/X
  - Operation without coordination across lines (i-DTA)
- Concepts:
  - AN/DPU system monitors up/down throughput needs
  - Requests FTU-O to change the TDD up/down ratio
  - FTU-O and FTU-R implement the change synchronously and seamlessly
  - Up/down ratio between 5/30 and 30/5 with default 7/28
- Use case:
  - Improve end user experience (QoE) by dynamically allocating the aggregate capacity to the direction that best serves the instantaneous needs of the user's applications.

Emerging G.mgfast - Multi-Gigabit fast

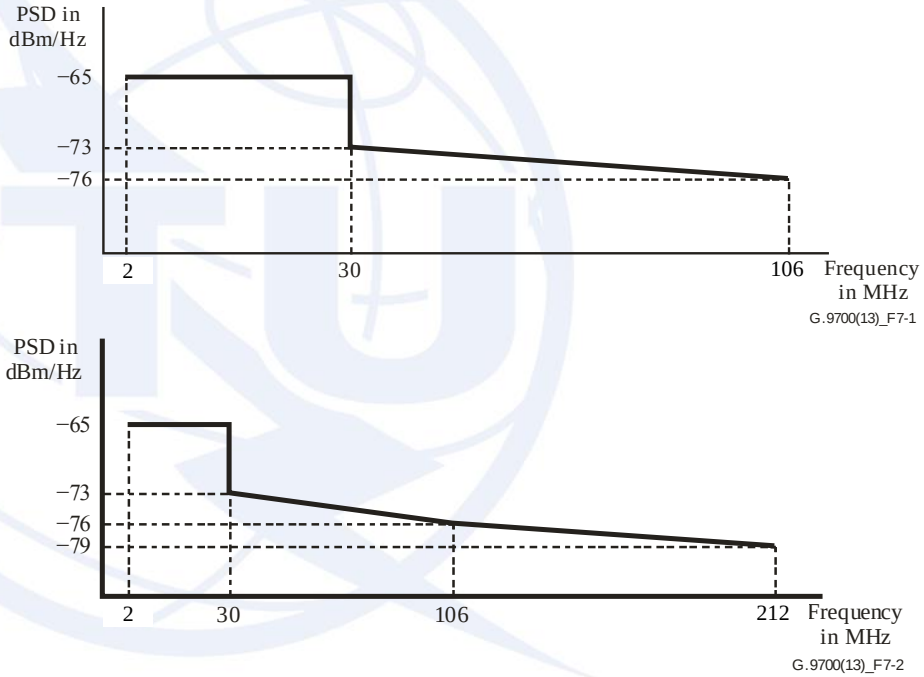
- G.mgfast is the project defining the MGfast technology
- New project to address functionality beyond G.fast
  - Profiles beyond 212 MHz (e.g., 424 MHz and 848 MHz)
  - Full-duplex operation (echo cancelled mode)
  - Co-exist with G.fast in overlapping frequency bands through mutual vectoring
- Targets
  - Aggregate data rates of 5 - 10 Gbit/s over single TP/coax.
  - Operation over twisted pair, quad and coaxial cable.
  - Consent mid 2019.
- Open points under discussion
  - Topologies: (multi?)point-to-(multi?)point
  - Advanced coding (e.g., LDPC)
  - Multi-stream support for QoS differentiation / 5G slicing
  - Convergence of access and in-home networking

PSD Construction Tools

- Subcarrier masking
  - Eliminates transmission on one or more subcarriers
  - A subcarrier mask (SM) is defined as a number of masked frequency bands (start - stop subcarrier index)
- Notching of specific frequency bands
  - To protect radio services one or more specific frequency bands can be notched
  - Notch in the notching mask (NM) in defined start and end subcarrier index
  - Within the notched band, all subcarriers shall be turned off and emission shall be at least 20 dB below the limit mask
- PSD shaping
  - Power spectral density (PSD) shaping allows reduction of the transmit PSD mask in some parts of the spectrum
  - PSD shaping mask (PSM) consists of one or more frequency segments. The boundaries of the segments are defined by set breakpoints
  - Transceiver shall support at least 32 PSM breakpoints

G.fast Profiles & Limit PSD (ITU-T G.9700)

- G.9700 contains the limit mask definitions for the profiles
  - 106 MHz
  - 212 MHz
- G.9700 provides PSD construction tools (masking, notching, shaping)



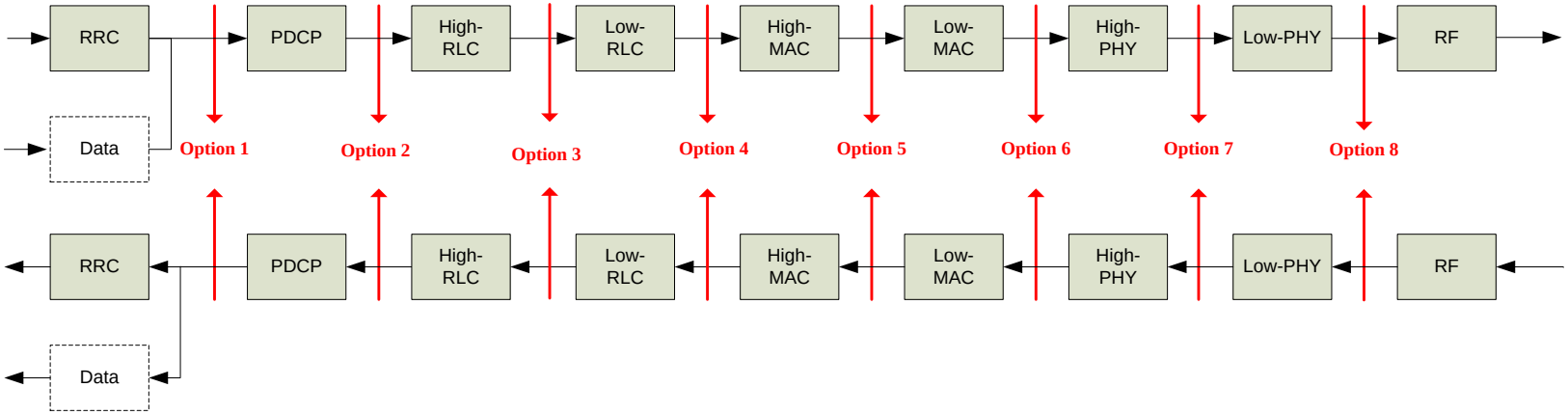
Transport network support of IMT-2020/5G

GSTR-TN5G: Transport network support of IMT-2020/5G (Revised in Oct. 2018)

- A reference model of IMT-2020/5G network and a set of deployment scenarios.
- Requirements on transport networks in order to support IMT-2020/5G networks
- Interfaces between IMT-2020/5G entities and transport networks
- Aspects of transport network support include network slicing (data plane and control plane), synchronization, and Control/Management.

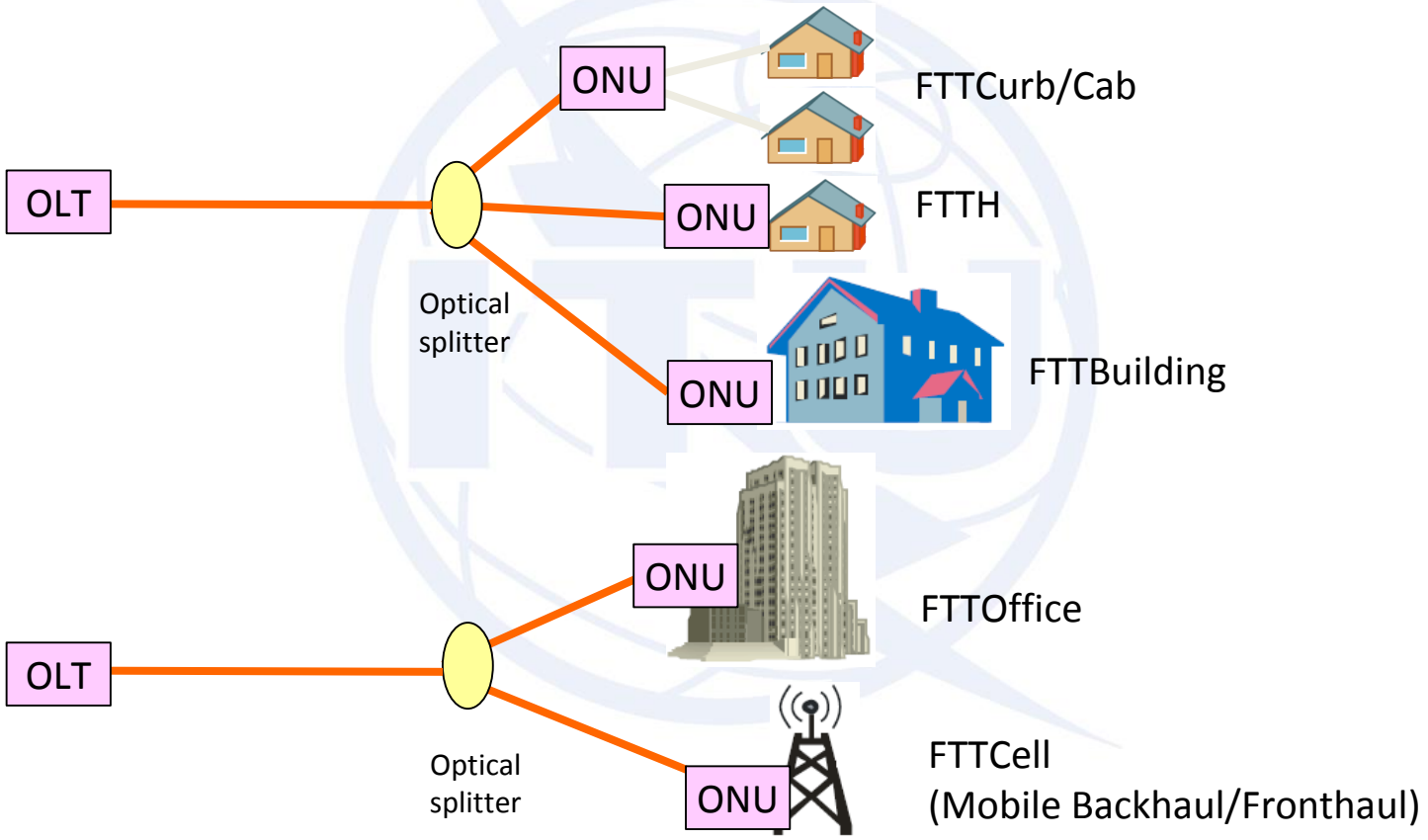
Fronthaul

- Conventionally, the fronthaul link is between RF and the remaining L1/L2/L3 functions (Option 8 split point)
- Option 8 centralizes high layer functions but requires stringent latency and high bandwidth
- It is critical to consider tradeoffs between throughput, latency, and functional centralization.



Signal processing chain of 4G and 5G wireless base stations and optional split points
source: 3GPP TR 38.801, "Technical Specification Group Radio Access Network; Study on new radio access technology: Radio access architecture and interfaces", March 2017

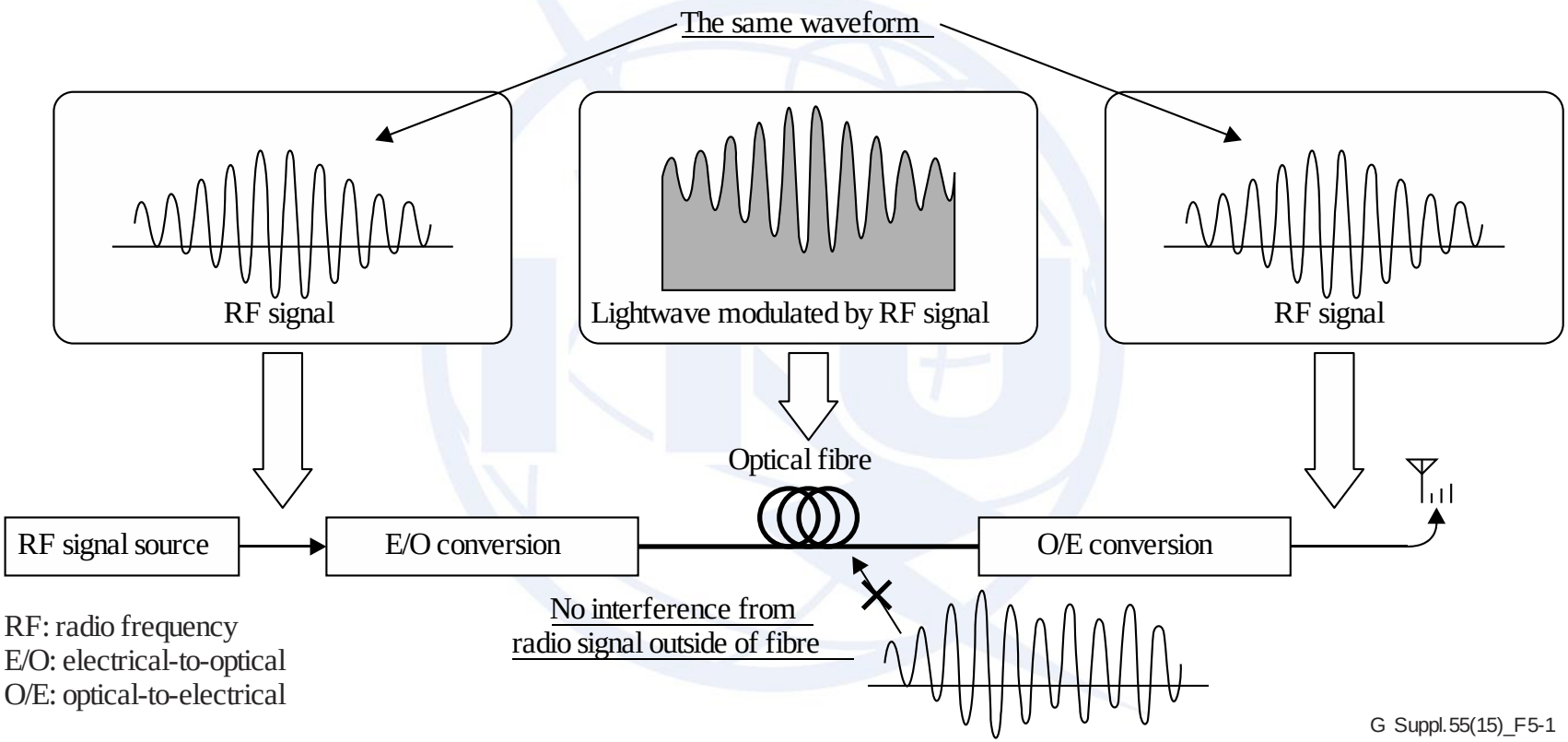
Fronthaul by PON



Standards and supplements on PON

- Related Recommendations include:
  - G.9807 series (XGS PON) – G.9807.1 (10G symmetric PON), G.9807.2 (reach extension)
  - G.989 series (NGPON2) - 40-Gigabit-capable passive optical networks (G.989 (Definitions), G.989.1 (General requirements), G.989.2 (Physical layer), G.989.3 (TC layer))
- Ongoing work:
  - G.suppl.66: 5G wireless fronthaul requirements in a PON context
    - Requirements for 5G wireless fronthaul in the setting of optical access networks
    - Practical passive optical network solutions

Radio over fiber for 5G fronthaul (ITU-T G.9803)



CPRI over OTN for 5G fronthaul

- G Suppl. 56: OTN transport of CPRI signals
  - Describes alternatives for mapping and multiplexing CPRI client signals into the optical transport network (OTN)
  - Shows examples but does not specify standard methods
  - Relates to G.872 (OTN architecture), G.709(.x) series (OTN interfaces), G.798 (OTN equipment) and G.959.1 (OTN physical layer interfaces)

Optical transport network (OTN) beyond 100 Gbit/s

- ITU-T G.709: Interfaces for the optical transport network
- ITU-T G.709.1: Flexible OTN short-reach interface
- ITU-T G.709.2: OTU4 long-reach interface (under approval process)
- ITU-T G.709.3: Flexible OTN long-reach interface
- G.Sup.5gotn: Application of OTN to 5G transport (new work item)
  - Describes how to use the current OTN standards for this application
  - Plan to approve it at July 2019 SG15 meeting
- G.ctn5g: Characteristics of transport networks to support IMT-2020/5G (new work item)
  - Follow-up to GSTR-TN5G: it goes down to the lower level of details
  - Plan to approve it at July 2019 SG15 meeting

Wavelength division multiplex (WDM) technologies

- ITU-T G.695: Optical interfaces for coarse wavelength division multiplexing applications
- ITU-T G.698.4: Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces
- ITU-T G.959.1: Optical transport networks physical layer interfaces

Frequency synchronization for 5G

- Requirements on performance and management of the frequency synchronization are defined in the ITU-T G.826x series
- ITU-T G.8265 describes the architecture and requirements for packet-based frequency distribution in telecom networks
- ITU-T G.8261 provides the network architecture and requirements related to physical layer-based frequency synchronization
- ITU-T G.8262.1 is being developed to define enhanced performance requirements of the physical layer clock, and this clock can be used in supporting a more accurate time synchronization
- ITU-T G.8265.1 defines the Precision Time Protocol telecom profile for frequency synchronization

Time synchronization for 5G

- Requirements on performance and management of time synchronization are defined in the ITU-T G.827x series
- General time synchronization architecture is defined in ITU-T G.8275
- Time synchronization requirements and network reference models have been defined by ITU-T G.8271 and ITU-T G.8271.1
- Requirements on performance and management of time synchronization are defined in the ITU-T G.827x series
- General time synchronization architecture is defined in ITU-T G.8275
- ITU-T G.8273.x series of recommendation defines clocks to be used for time synchronization; A new generation of more accurate clocks is being defined addressing the needs of future networks (e.g., Ethernet-based fronthaul)
- ITU-T G.8275.1 defines the Precision Time Protocol telecom profile for phase/time synchronization with full timing support from the network; G.8275.2 defines Precision Time Protocol Telecom Profile for time/phase synchronization with partial timing support from the network
- Time synchronization requirements and network reference models have been defined by ITU-T G.8271 and ITU-T G.8271.1; New synchronization solutions and network reference models are being developed to allow the distribution of timing with increased accuracy and reliability

Management & Control of Transport Network supporting IMT-2020/5G

- GSTR-TN5G (2/2018) focuses on the requirements on transport networks in order to support IMT-2020/5G networks.
  - Transport network technologies are those that are in the scope of SG15, including Photonic, OTN, Carrier Ethernet, MPLS-TP and PON, etc.
- Q14/15 is responsible to develop the specifications for the management & control of transport network resources, encompassing MCC* requirements, protocol-neutral Information Models (IM) and protocol-specific solutions (Data Model – DM) for common transport functionality, and transport technology-specific functionality (e.g., OTN, Carrier Ethernet, MPLS-TP, Photonic).
  - Common: ITU-T G.7710 (Requirements), ITU-T G.7711 (Core IM)
  - OTN: ITU-T G.874 (Requirements), ITU-T G.874.1 (Base IM)
  - Carrier Ethernet: ITU-T G.8051 (Requirements), ITU-T G.8052 (Base IM), ITU-T G.8052.1 (OAM IM & DM), ITU-T G.8052.2 (Resilience IM & DM)
  - MPLS-TP: ITU-T G.8151 (Requirements), ITU-T G.8152 (Base IM)
  - Photonic: G.media-mgmt (Requirements and Base IM)
- These IM & DM specifications can be used to derive the specific MCC interfaces, such as
  - Between transport NEs and SDN controllers, between SDN controllers of adjacent layers, between SDN controllers and Applications, and between SDN controller and administrative role

* *MCC – Management-Control Continuum: The concept whereby management and control functions are considered to be a continuum is known as the management-control continuum (MCC)*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