Session 1: Fiber Access Technology Updates

Optical Access Standards Progress in ITU-T Q2/15

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Overview of ITU-T PON Solutions

1 Gb/s per channel	2.5 Gb/s per channel	10 Gb/s per channel	25 Gb/s per channel	50 Gb/s per channel
Splitter-based ODN Single channel TDMA systems				
	G-PON G.984.x series **1**	**XG-PON (NG-PON1)** G.987.x series **2** **XGS-PON** G.9807.x series **3**		**50G-PON** G.9804.x series **5.1**
Splitter-based ODN Multi-channel TWDM systems				
		NG-PON2 G.989.x series **4.1**		**Nx50G-PON** G.9804.x series **5.2**
Splitter-based ODN Multi-channel WDM Overlay				
NG-PON2 **4.2** G.989.x series	**NG-PON2** **4.2** G.989.x series	**NG-PON2** **4.2** G.989.x series		
Wavelength multiplexed ODN with logical point to point connections (a.k.a. WDM-PON)				
For more information on optical access, please check the ITU-T Study Group 15 website at: www.itu.int/tsg15			**25GMW-PON** G.9802.x series **6**	

SG-15 Flyers are on-line

https://www.itu.int/en/ITU-T/studygroups/2017-2020/15/Pages/tflyers.aspx

Committed to connecting the world

Technical Flyers

MGFast: Multi-Gigabit fast access to subscriber terminals

PON Overview: ITU-T Passive Optical Network Solutions

G.984: Gigabit Passive Optical Networks

G.984.5 Amendment: Gigabit Passive Optical Networks: Enhancement band and PON Coexistence

G.987: 10-Gigabit Passive Optical Networks

G.9807: 10-Gigabit Symmetric Passive Optical Networks

G.989: NG-PON2 Passive Optical Networks

G.988: ONU Management and Configuration Interface

G.986: 1 Gbit/s point-to-point optical access system and G.9806: Higher-speed bidirectional point-to-point

G.9802: Multiple-Wavelength Passive Optical Networks

G.9803: Radio over fibre systems

G.9804: HSP: Higher Speed Passive Optical Networks

G.Suppl.66: 5G wireless fronthaul in a PON context

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G.984: Gigabit Passive Optical Networks

- Full-service support – including voice, TDM, Ethernet (10/100/1000 BaseT), xDSL, leased lines, wireless extension and more
- Logical reach of up to 60 km. Basic physical reach 20 km, and reach extension provides 60 km physical reach
- Support for bit-rate options, the most important being 2.5 Gbit/s downstream and 1.25 Gbit/s upstream
- Strong Operation, Administration, Maintenance and Provisioning (OAM&P) capabilities for end-to-end service management
- Security at the protocol level for downstream traffic due to the broadcast nature of PON
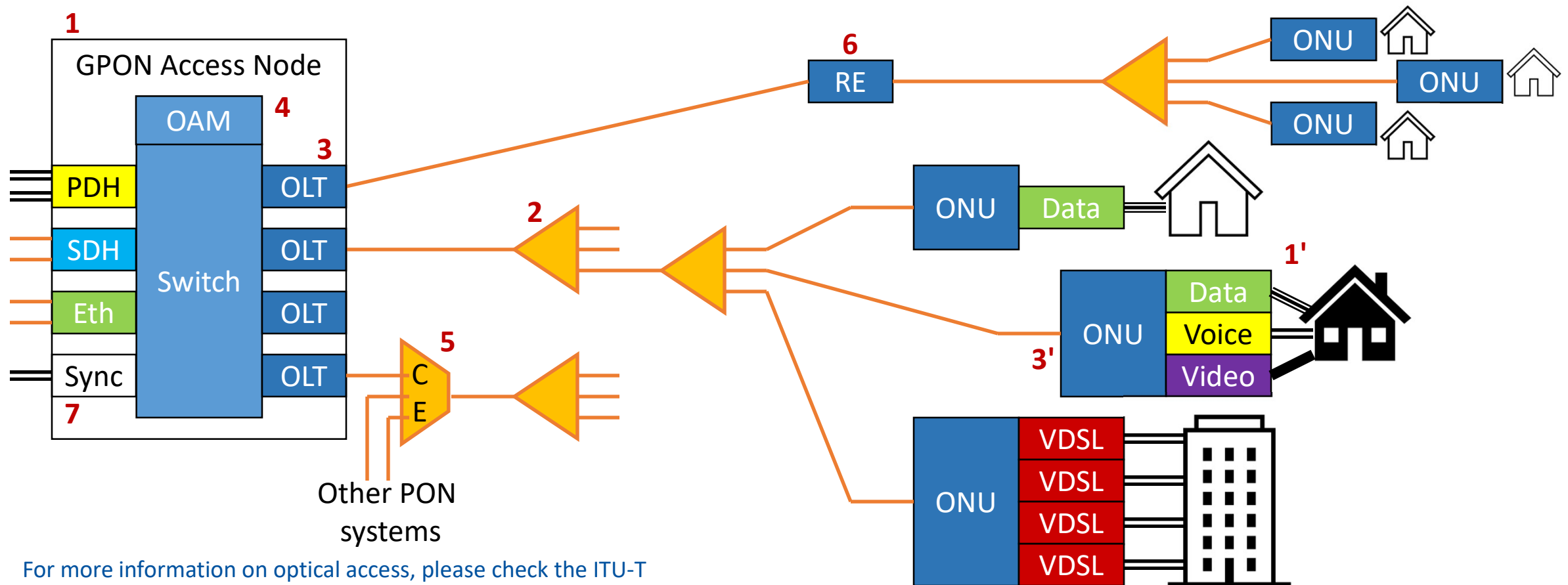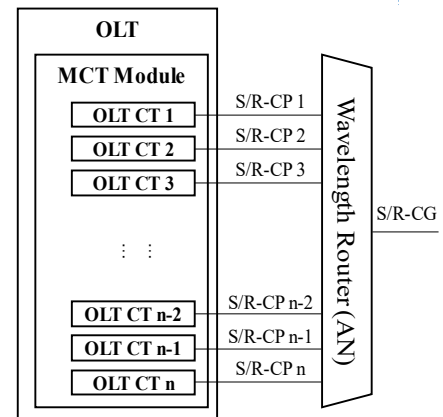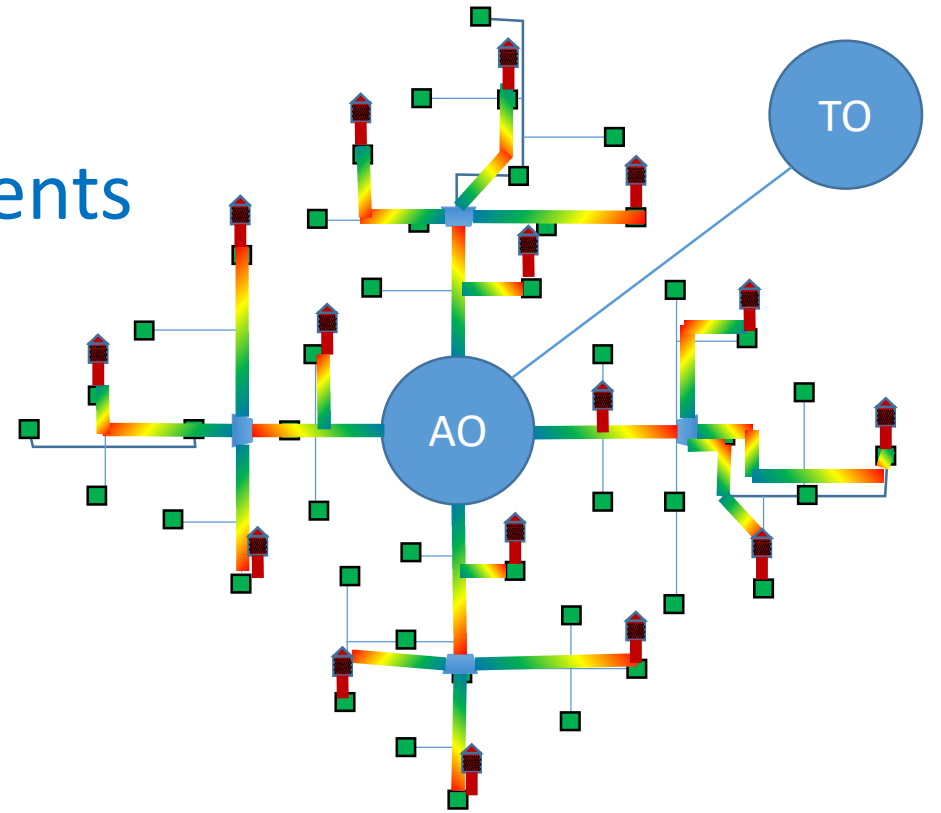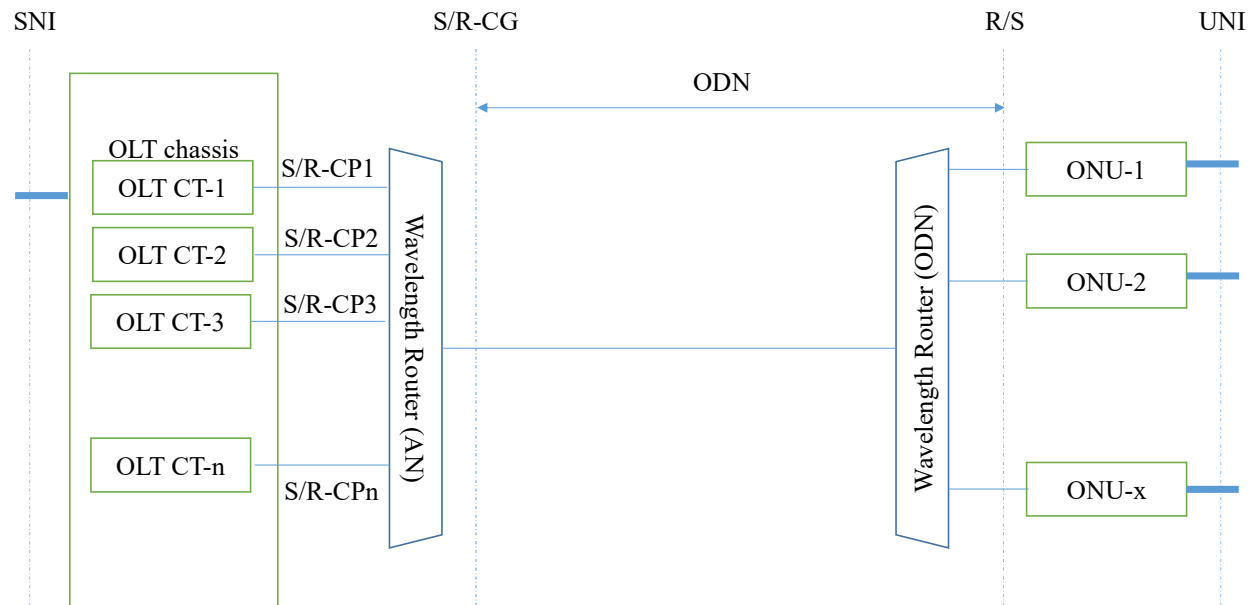

For more information on optical access, please check the ITU-T
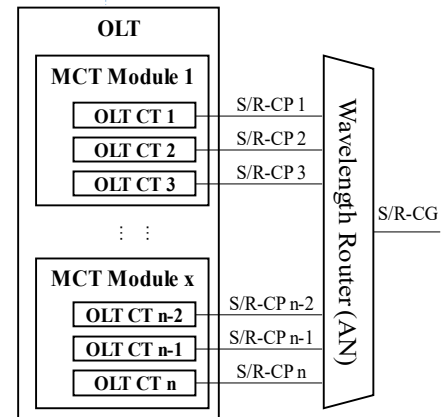Study Group 15 website at: www.itu.int/tsg15

Major recent consented documents

- G.9802.1: WDM-PON: General requirements
- G.9806 Amd.2: Bidirectional point to point PHYs
- G.sup.CoDBA: OLT Capabilities for supporting CO DBA
- G.9804.1 Amd.1: Higher speed PON: Requirements
- G.9804.2: Higher speed PON: Common TC layer specifications
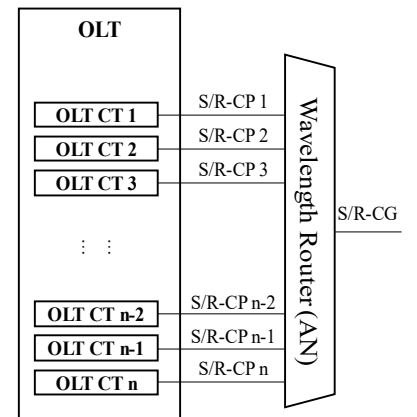- G.9804.3: Higher speed PON: 50Gb/s PMD specifications

G.9802.1: WDM-PON: General requirements

SNI   S/R-CG   R/S   UNI

ODN

OLT chassis

OLT CT-1 — S/R-CP1
OLT CT-2 — S/R-CP2
OLT CT-3 — S/R-CP3

OLT CT-n — S/R-CPn

Wavelength Router (AN)

Wavelength Router (ODN)

ONU-1
ONU-2
ONU-x

OLT

MCT Module

OLT CT 1 — S/R-CP 1
OLT CT 2 — S/R-CP 2
OLT CT 3 — S/R-CP 3

OLT CT n-2 — S/R-CP n-2
OLT CT n-1 — S/R-CP n-1
OLT CT n — S/R-CP n

Wavelength Router (AN) — S/R-CG

(a) All integrated

OLT

MCT Module 1

OLT CT 1 — S/R-CP 1
OLT CT 2 — S/R-CP 2
OLT CT 3 — S/R-CP 3

MCT Module x

OLT CT n-2 — S/R-CP n-2
OLT CT n-1 — S/R-CP n-1
OLT CT n — S/R-CP n

Wavelength Router (AN) — S/R-CG

(b) Grouped

OLT

OLT CT 1 — S/R-CP 1
OLT CT 2 — S/R-CP 2
OLT CT 3 — S/R-CP 3

OLT CT n-2 — S/R-CP n-2
OLT CT n-1 — S/R-CP n-1
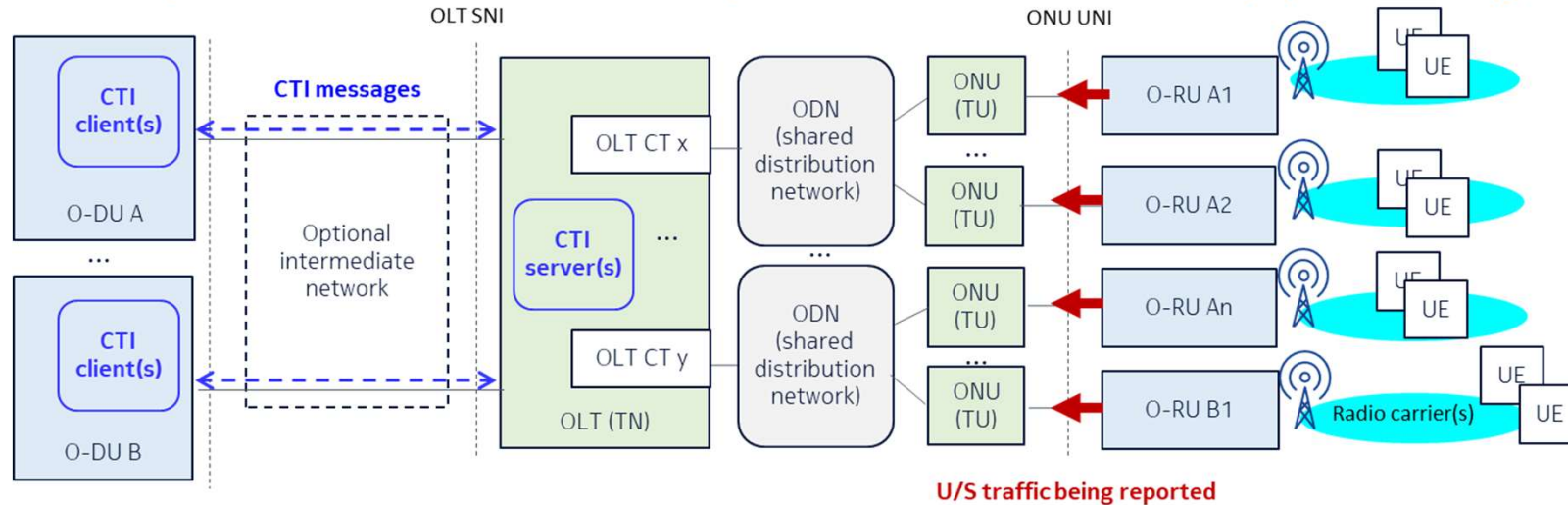OLT CT n — S/R-CP n

Wavelength Router (AN) — S/R-CG

(c) Individual CT

MCT: Multi Channel Termination Module

G.sup.CoDBA: OLT Capabilities for supporting CO DBA

OLT is integrated with wireless headend equipment, exchanging CTI messages to gain information on when the subtending UE's (and their serving ONUs) will have traffic

Latency of every step of the process is critical – there is no time for buffering or retransmission. Wireless system must be configured with enough schedule anticipation so that the entire signal chain is feasible
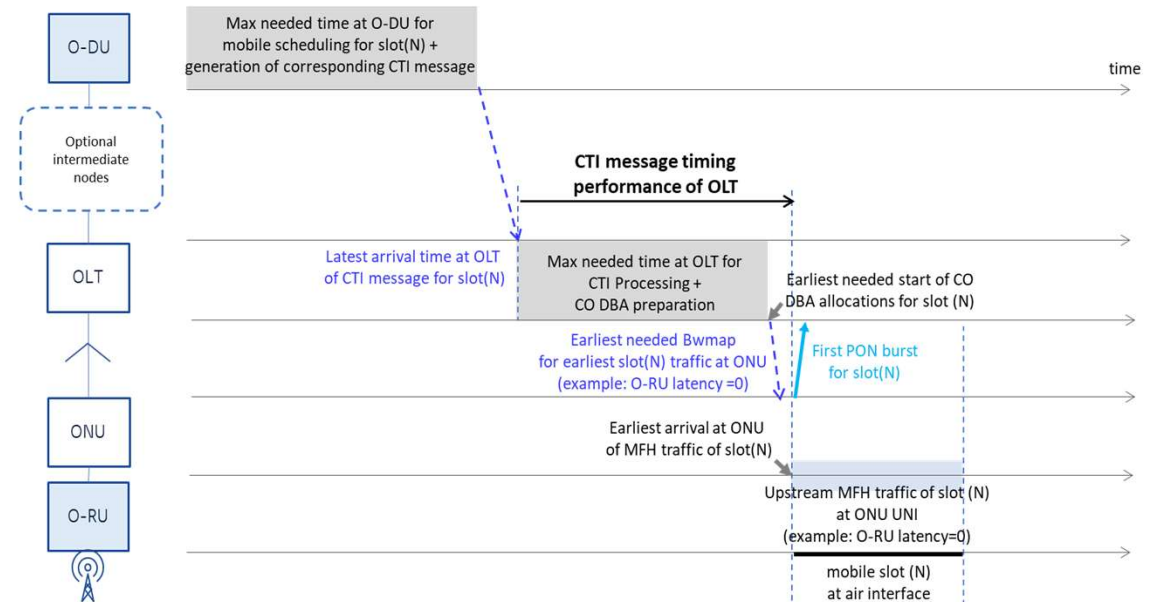
The G.9804 series: Higher Speed PON

- Work on the system that will come after 10G-PON began in 2017, with an informative supplement that analyzed the technical situation of higher speed PONs was prepared

- It was agreed to begin work on a new standards series in 2018

- Meta-requirements for this project:
  - Maximum compatibility with our previous PON systems, both single channel and multi-channel systems
  - Meet the deployment requirements and profile for the majority of PON deploying operators in the world: >4X BW, >10 years lifetime
  - Leverage the best available technologies in the <u>relevant time frame</u>, and focus the industry on as few options as possible to improve volume effects

G.9804.1: Higher speed PON requirements

- Higher speed PONs share many requirements with existing systems
  - Must reuse the fiber plant based on splitters and G.652 fiber
  - Must support the same loss budgets and distances
  - Must coexist with existing systems in a passive way

- System must have 50 Gb/s per channel downstream
  - The current deployment of 10G systems means that the HSP system will be deployed in 2024, and must have at least 4x capacity of the 10G system
  - The upstream can be a lower rate, 25 Gb/s looks attractive

- G.9804.1 was approved in Dec 2019, and amended Apr 2021

G.9804.2: Higher speed Common TC

- The common TC is intended to be used for PON 50G and up
- It is largely based upon XGS-PON protocol constructs, with enhancements
  - A better LDPC FEC code, which allows raw BER of 1e-2 or more
  - Interleaving to further condition burst errors
  - Allowance for contention-based transmission for efficient low latency signaling
  - Cooperative DBA, so that bursty low latency services can be supported
  - Better transport security with longer keys and multiple algorithms
  - Multiple upstream rates, allowing for link budget adaptation

G.9804.3: Specifications of fixed 50G PMD
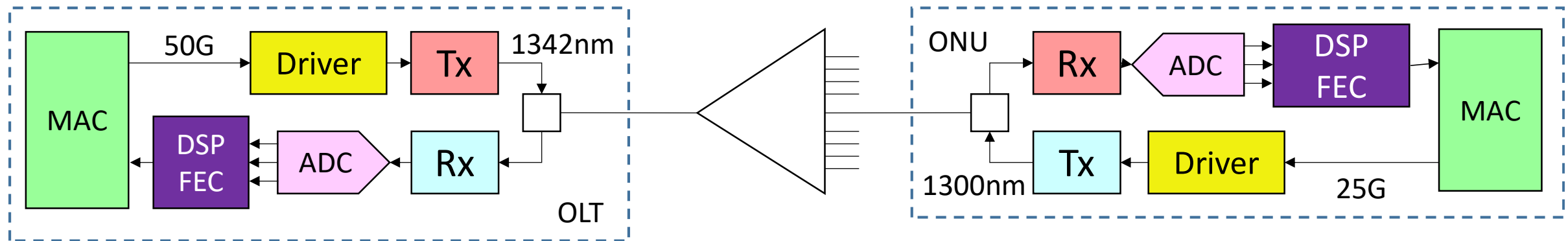
- Single channel system for low cost overall
- Use DSP in both directions for equalization, burst mode reception, low density parity check (LDPC) code with soft decoding for high sensitivity, and flexible rate decoding for link budget elasticity
  - Once we have an ASIC, its cost quickly tends to zero with 100M volumes
- With DSP, 25G optics can be used for 50G, meaning there is no cost advantage for a hypothetical 25G-PON system. With the China demand volume behind it, the 50G-PON system will become the lowest cost
- Wavelength plan reuse of 802.3ca and coexistence with either G-PON or XG-PON

Test result of 50G-PON Carrier Lab Trial (ECOC'21 We3F.5)

❏ *39.948Gbps DS service throughput*

➢ *LDPC is the primary overhead factor at 17.8% so a throughput of 40.908Gbps is the best*

➢ *some small loss of capacity can be attributed to the PON framing (XGEM)*

❏ *15.986Gbps US service throughput*

➢ *LDPC, a best case of 20.454Gbps throughput could be expected*

➢ *guard time, extra burst overhead*

➢ *some hardware limitations in the prototype (also result in an efficiency reduction vs the ideal case)*

Carrier Lab Trial of a Real Time 50G-PON Prototype (We3F.5)

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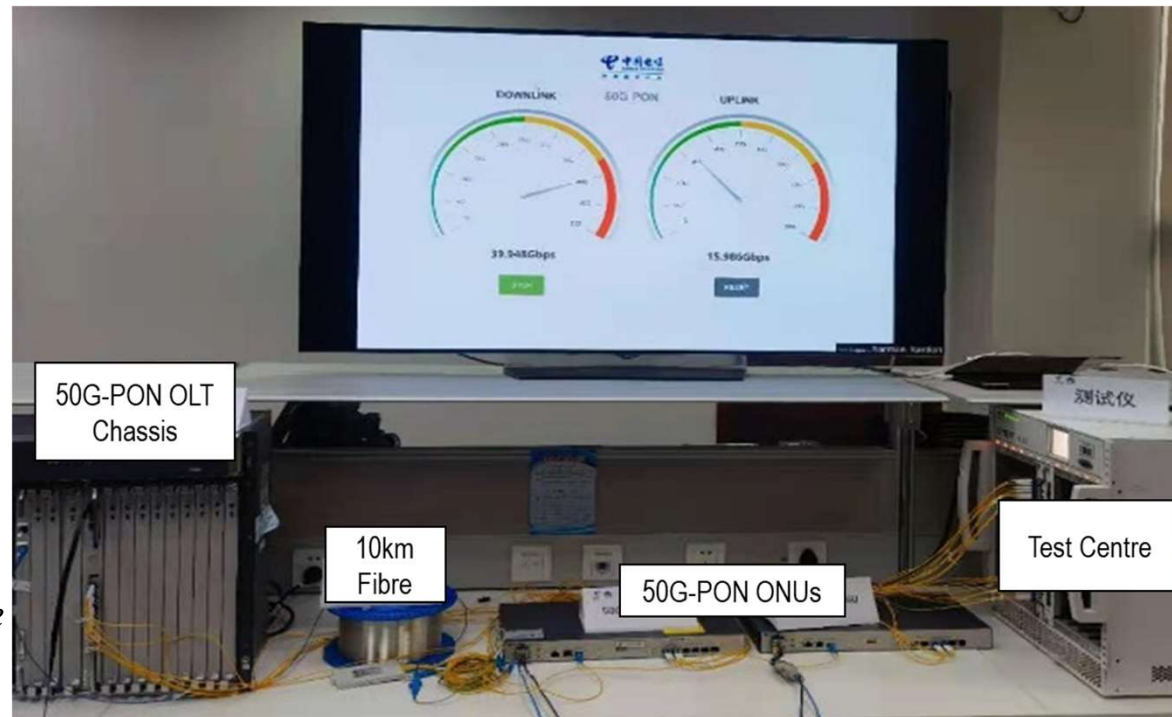
Summary

- Q2/15 is the standing group that works on optical access networks, with a wide range of projects spanning several PON generations

- Substantial work plan on higher speed (>10G) access

- Aim is to make this the "Last PON"
  - Common requirements and TC layer that is scalable to any reasonable rate combination: 50G, 100G, and even 200G
  - Many PMD projects to allow development at the pace of the technology (The PMD is generally the gating item on systems)
  - Single channel 50G-PON has been fully standardized, and system development and testing is underway: Coming to PON near you