ITU-T SG15 Standards Update

Wednesday, 27 March 2025, 12:45 – 13:45

Panel

- **Moderator**
  - Glenn Parsons, *Ericsson, Canada*
    - *Chair ITU-T SG15*

- **Panelists**
  - Frank J. Effenberger, *Fellow, Futurewei Technologies, USA*
    - *Rapporteur Q2/15*
  - Paul Doolan, *Huawei Hong Kong Research Centre, China*
    - *Chair WP2/15*
  - Tom Huber, *Optical Standards Development, Nokia, USA*
    - *Chair WP3/15 and Vice Chair SG15*

Introduction

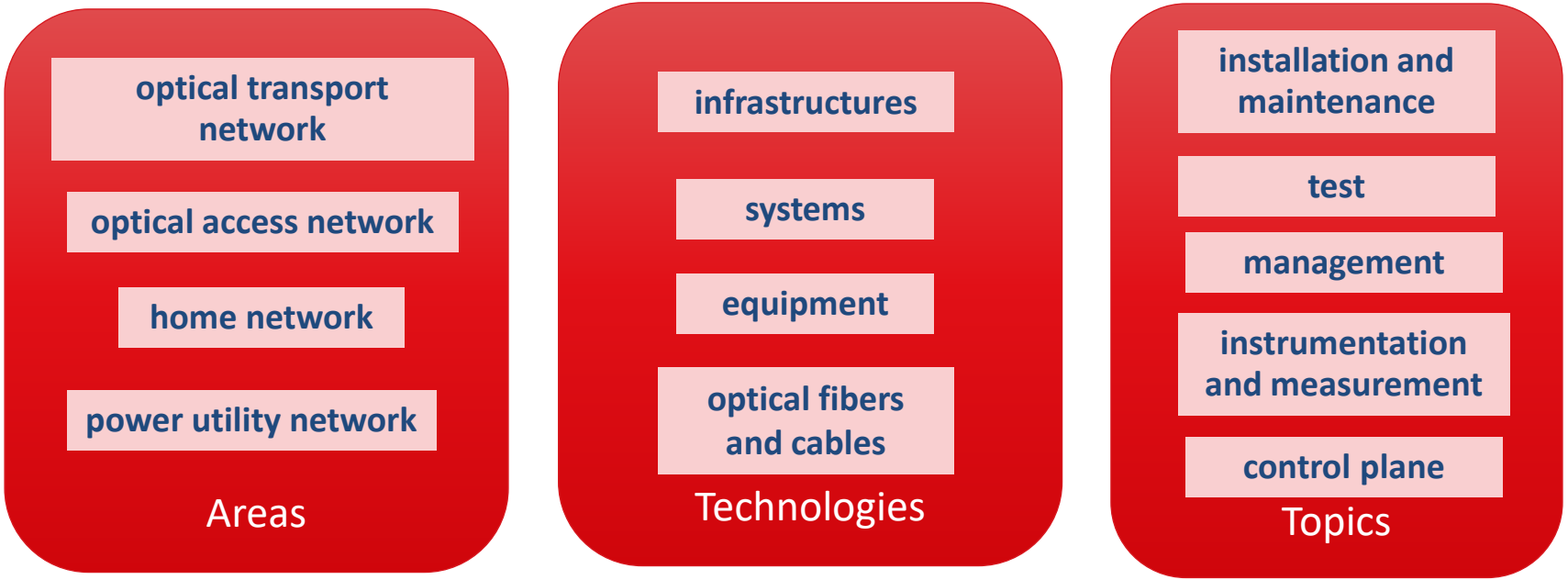
Glenn Parsons

Chair ITU-T SG15

Ericsson, Canada

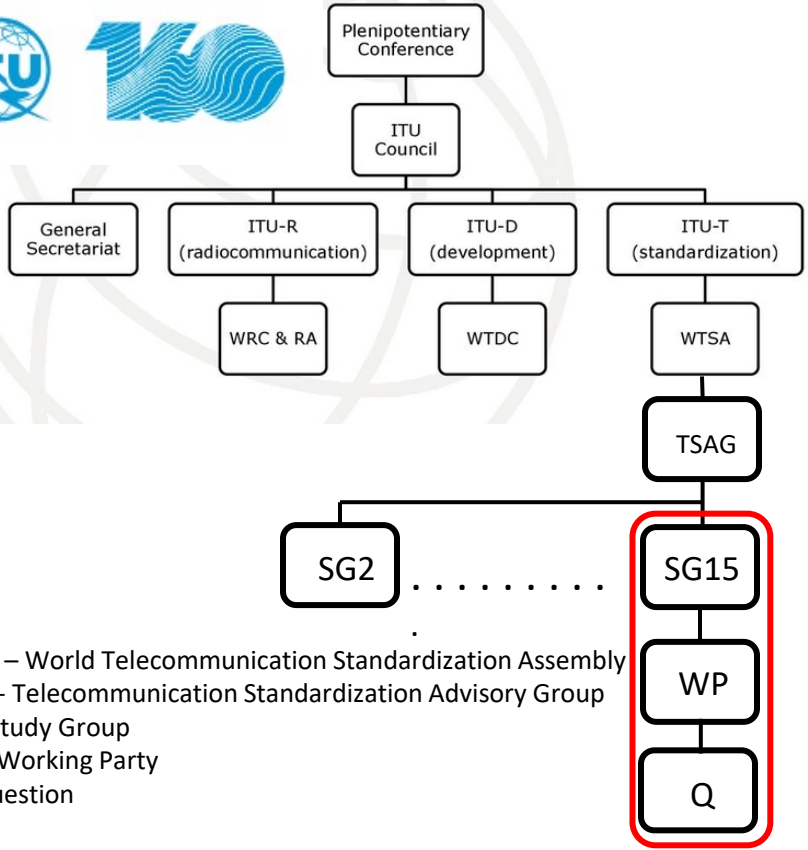
Responsibility of Study Group 15

The development of **standards** on:



to enable the evolution toward intelligent transport networks …

ITU Structure



WTSA – World Telecommunication Standardization Assembly
TSAG - Telecommunication Standardization Advisory Group
SG – Study Group
WP – Working Party
Q - Question

Leadership of ITU

- Plenipotentiary Conference (PP-22) - October 2022
  - Member states elect leadership of ITU

Doreen Bogdan-Martin
Secretary-General ITU

Tomas Lamanauskas
Deputy Secretary-General ITU

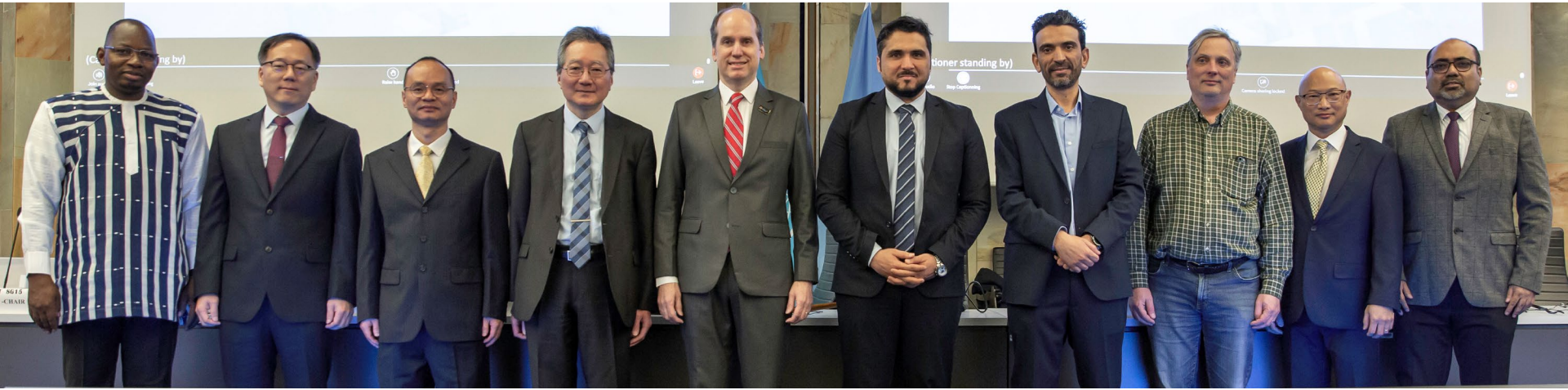
Seizo Onoe
Director of the Telecommunication Standardization Bureau (TSB)

Leadership of ITU-T SG15

- WTSA-24 – October 2024
  - Appointed leadership of Study Groups

Glenn Parsons
Chair, ITU-T SG15
(Ericsson Canada)

ITU-T SG15 management team (2025-2028)



Vice Chairs

- Mohamed Amine BENZIANE
- Sudipta BHAUMIK
- Taesik CHEUNG
- Adel HLILOU
- Thomas HUBER
- Umarbek IZBASAROV
- Marcel KEBRE
- Stephen SHEW
- Fatai ZHANG

WP1/15

- Ian HORSLEY
- Frank VAN der PUTEN

WP2/15

- Paul DOOLAN
- Sudipta BHAUMIK

WP3/15

- Tom HUBER
- Silvana RODRIGUES

Promotion and Coordination

- Taesik CHEUNG
- Vince FERRETTI

TSB counsellors

- Hiroshi OTA
- Hiyato FUKUZONO

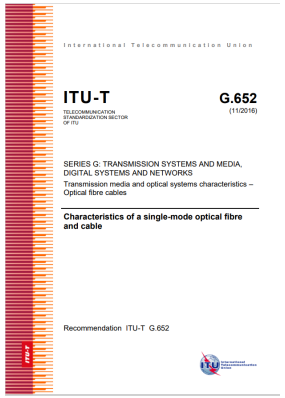
Questions and Working Parties of SG15

	Question Number	Question title
WP1	2/15	Optical systems for fibre access networks
WP1	3/15	Technologies for in-premises networking and related access applications
WP1	4/15	Broadband access over metallic conductors
WP2	5/15	Characteristics and test methods of optical fibres and cables, and installation guidance
WP2	6/15	Characteristics of optical components, subsystems and systems for optical transport networks
WP2	7/15	Connectivity, Operation and Maintenance of optical physical infrastructures
WP2	8/15	Characteristics of optical fibre submarine cable systems
WP3	10/15	Interfaces, interworking, OAM, protection and equipment specifications for packet-based transport networks
WP3	11/15	Signal structures, interfaces, equipment functions, protection and interworking for optical transport networks
WP3	12/15	Transport network architectures
WP3	13/15	Network synchronization and time distribution performance
WP3	14/15	Management and control of transport systems and equipment

WP: Working Party

ITU-T SG 15 deliverables

- **Work products:**
  - Recommendations
  - Supplements
  - Technical papers and reports
  - Flyers



International Telecommunication Union

ITU-T G.652 (11/2016)

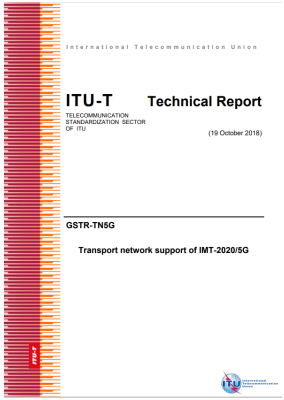
TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Transmission media and optical systems characteristics – Optical fibre cables

Characteristics of a single-mode optical fibre and cable

Recommendation ITU-T G.652



International Telecommunication Union

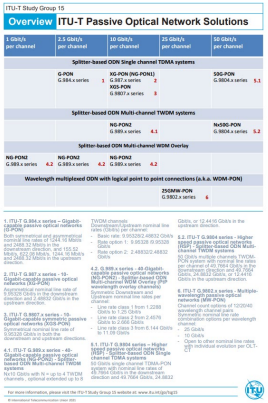
ITU-T Technical Report

TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

(19 October 2018)

GSTR-TN5G

Transport network support of IMT-2020/5G



ITU-T Study Group 15

Overview ITU-T Passive Optical Network Solutions

1 Gbit/s per channel	2.5 Gbit/s per channel	10 Gbit/s per channel	25 Gbit/s per channel	50 Gbit/s per channel
Splitter-based ODN Single channel TDMA systems				
	G-PON G.984.x series 3	XG-PON (NG-PON1) G.987.x series 3 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		NcS0G-PON G.9804.x series 5.2
Splitter-based ODN Multi-channel WDM Overlay				
NG-PON2 G.989.x series 4.2	NG-PON2 G.989.x series 4.2	NG-PON2 G.989.x series 4.2		
Wavelength multiplexed ODN with logical point to point connections (a.k.a. WDM-PON)				
			25GWM-PON G.9802.x series 6	

1. ITU-T G.984.x series – Gigabit-capable passive optical networks (G-PON)

2. ITU-T G.987.x series – 10-Gigabit-capable passive optical networks (XG-PON)

3. ITU-T G.9807.x series – 10-Gigabit-capable symmetric passive optical networks (XGS-PON)

4.1. ITU-T G.989.x series – 40-Gigabit-capable passive optical networks (NG-PON2): Splitter-based ODN Multi-channel TWDM systems

4.2. ITU-T G.989.x series – 40-Gigabit-capable passive optical networks (NG-PON2): Splitter-based ODN Multi-channel WDM Overlay (DS wavelength overlay channels)

5.1. ITU-T G.9804 series – Higher speed passive optical networks: 50-Gbit/s single-channel TDMA-PON

5.2. ITU-T G.9804 series – Higher speed passive optical networks: 50-Gbit/s Multi-channel TWDM systems

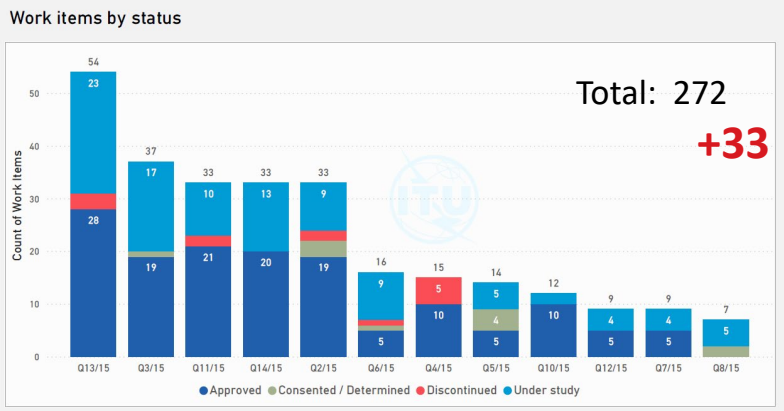
6. ITU-T G.9802.x series – Multiple-wavelength passive optical networks (MW-PON)

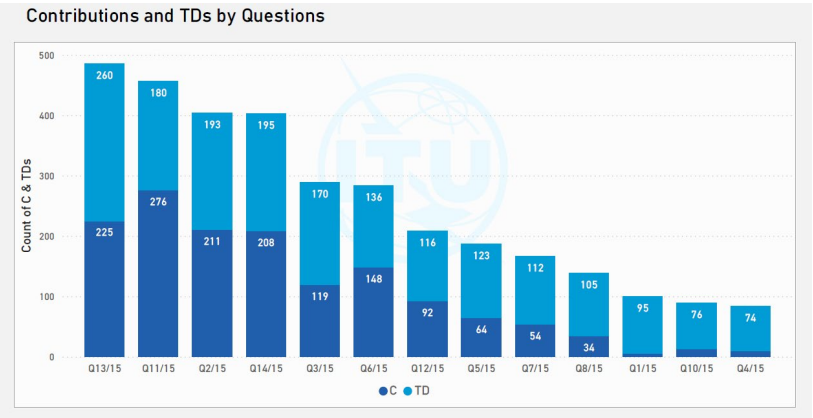
For more information, please visit the ITU-T Study Group 15 website at: www.itu.int/go/tsg15

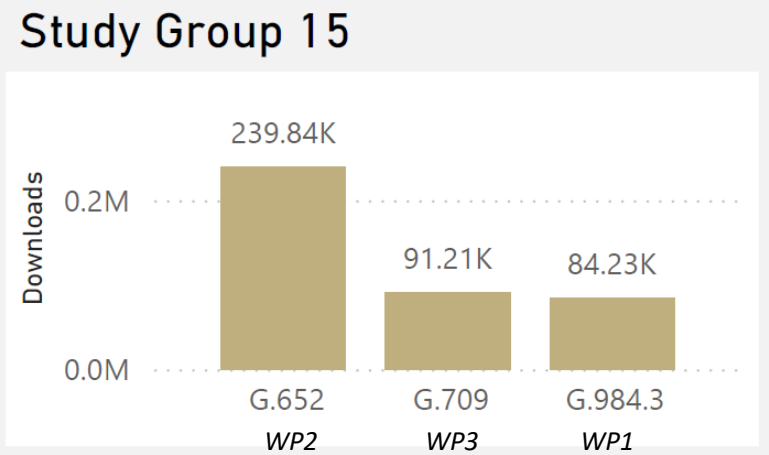
Recommendation series

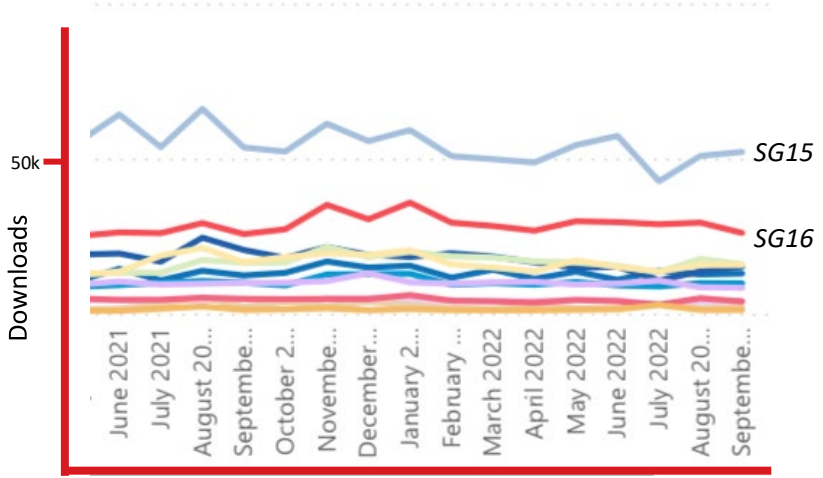
- G.600-G.699: Transmission media and optical systems characteristics
- G.700-G.799: Digital terminal equipments
- G.800-G.899: Digital networks
- G.900-G.999: Digital sections and digital line system
- G.7000-G.7999: Data over Transport – Generic aspects
- G.8000-G.8999: Packet over Transport aspects
- G.9000-G.9999: Access networks
- G supplements: Supplements to ITU-T G-series Recommendations
- L.100-L.199: Optical fibre cables
- L.200-L.299: Optical infrastructures
- L.300-L.399: Maintenance and operation
- L.400-L.429: Passive optical devices
- L.430-L.449: Marinized terrestrial cables
- L supplements: Supplements to ITU-T L-series Recommendations

SG15 – activity and impact









Highlights of WP 1
Optical Networks for Access and Home

Frank Effenberger

Rapporteur, ITU-T Q2/15

Futurewei, USA

Major themes of optical work in Working Party 1

Maintaining the existing optical access systems

- G-PON (G.984), XG(S)-PON(G.98(0)7), and 50G-PON (G.9804)
- OMCI (G.988) and its extensions e.g., WMCI (G.9949)

Studying the future evolution of PON

- Very High Speed PON project

Finding and exploiting new applications of fiber networks

- FTTRoom, for true gigabit in-home networking
- FTTGrid, to better instrument and control power networks
- fgOTN-over-P2MP, to provide end-to-end circuit-based connectivity

The evolution of optical access systems

The industry has developed a whole series of PON systems

Each system employed a new technology to go faster

- A/B-PON: FP lasers and PIN detectors
- G-PON: DFB lasers and APDs
- XG-PON: Mandatory FEC, EML
- 50G-PON: DSP+LDPC, EML-SOA, SiGe APDs

The one thing that is truly constant is the fiber network

- G.652 fiber
- Passive optically split (~3.5 dB per stage of split)
- ~30 dB loss budget (29 dB regular, 32 dB premium, 35 dB super)
- ~20 km reach (40 km viewed as a stretch goal)
- Coexistent with existing PONs (But which ones?)

VHSP capacity objective

Based on inputs from major access service providers, the required information capacity of the VHSP system is ~200 Gb/s

- This is >4X the capacity of the previous 50G-PON system
- It anticipates that 100 Gb/s peak rates might be in the cards

FEC overhead is likely to stay around 20%

- This seems to balance a minimal optical speed penalty, coding gain, and complexity

Hence, we need a line speed of ~240 Gb/s

We note that these requirements are still subject to change

- Importantly, 100 Gb/s might be a fallback capacity if 200 Gb/s ends up being impractical

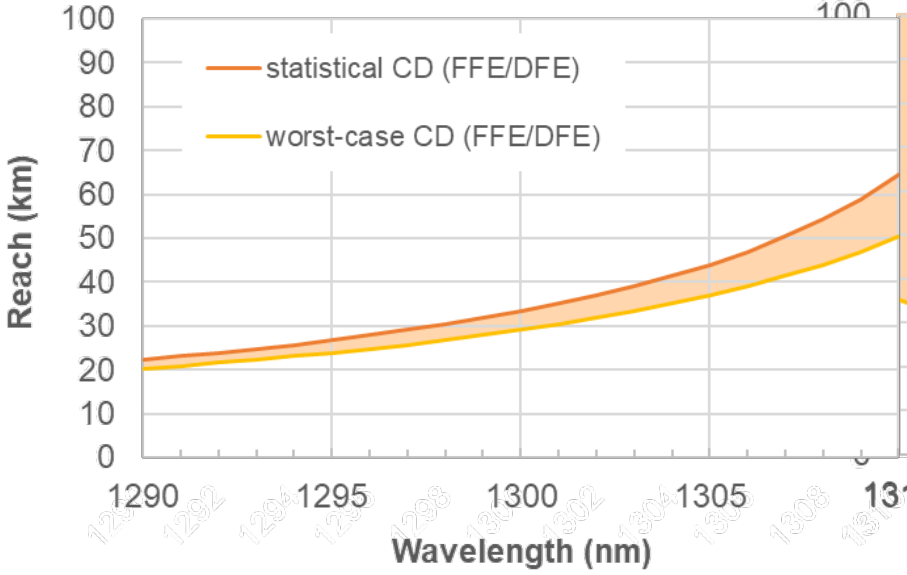
The limitations of IM-DD

All PONs to date have been IM-DD NRZ coded links

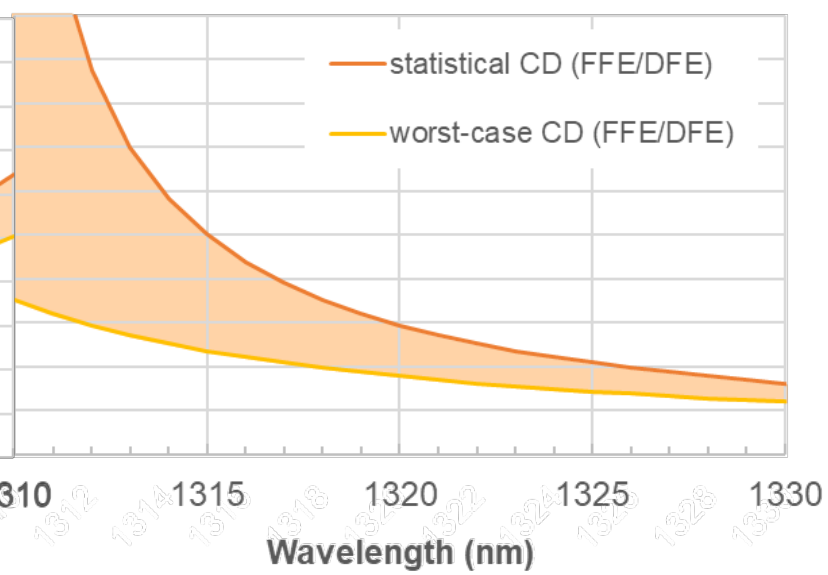
We are now approaching the limits of this tried-and-true design

The following graphs give the reach as a function of wavelength for 120 GBd transmission

Lower limit assuming high ZDW fiber

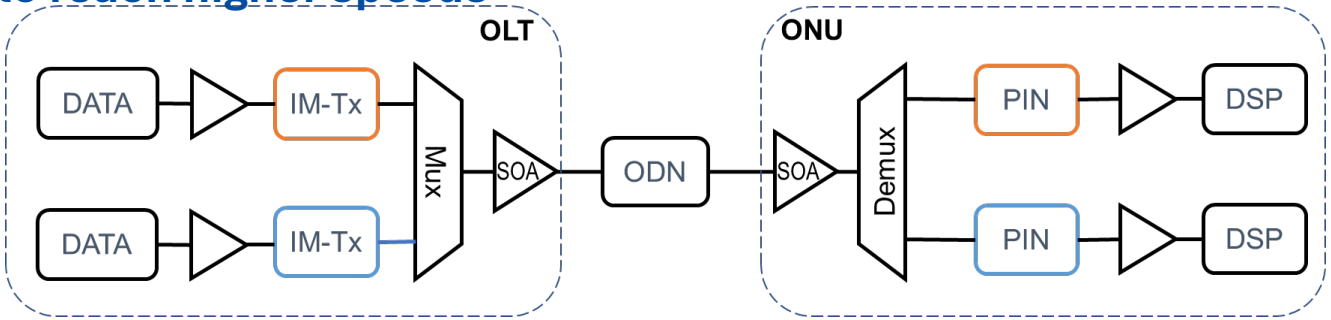


Higher limit assuming low ZDW fiber

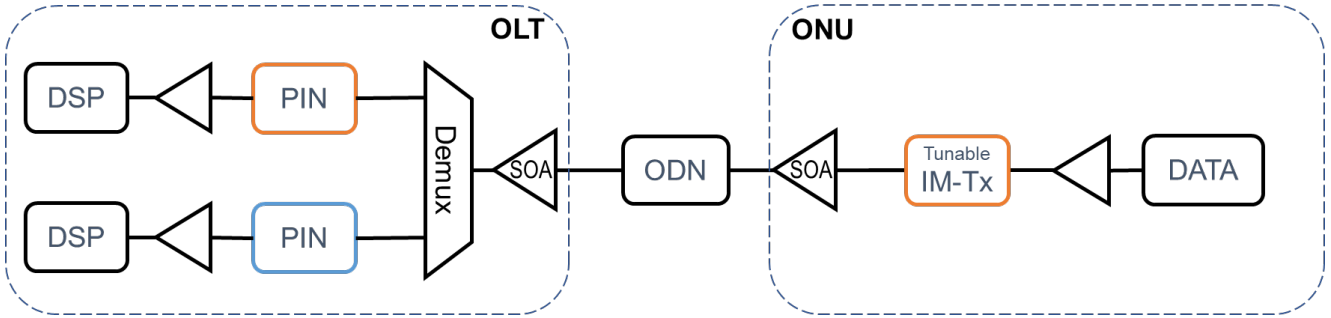


Giving it both barrels: 200 Gb/s IM-DD

If IM-DD is limited to 100G, we can use two (much as Ethernet has used parallel optics to reach higher speeds



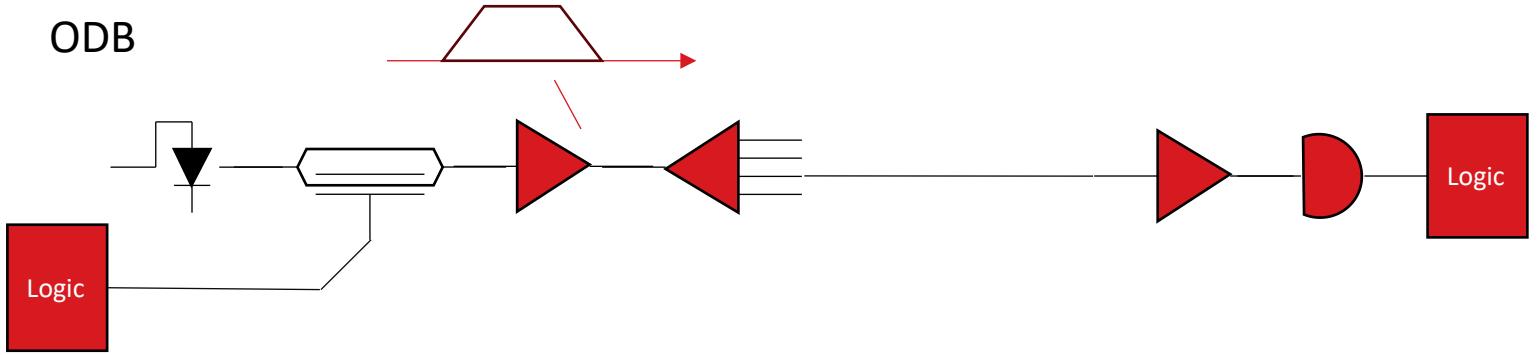
In the upstream, ONUs could have 1, 2, or tunable optics



A first step beyond IM-DD: Optical Duobinary

ODB has been the darling of the research lab

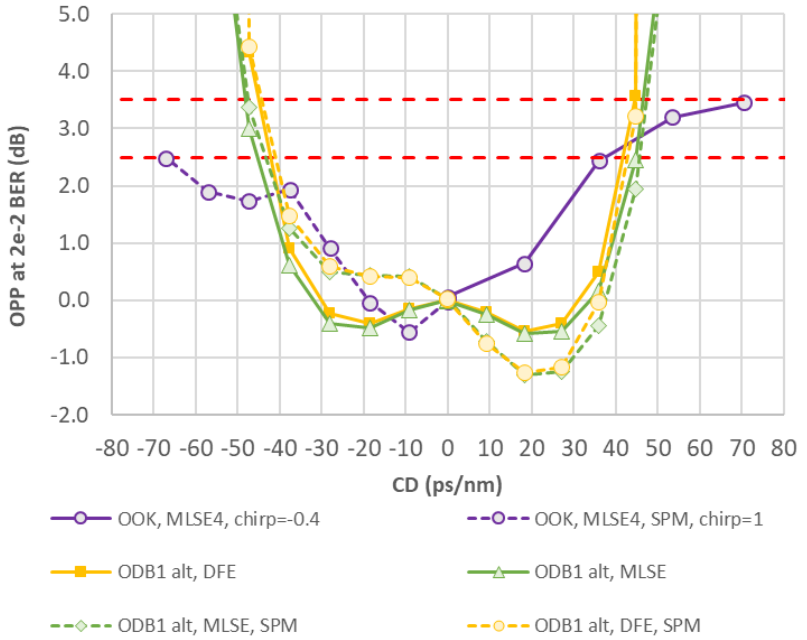
- Uses a fancy transmitter, but the receiver is quite simple – good for PON downstream
- Suppressed carrier also yields much better nonlinear performance
- Gives double the rate for any given dispersion

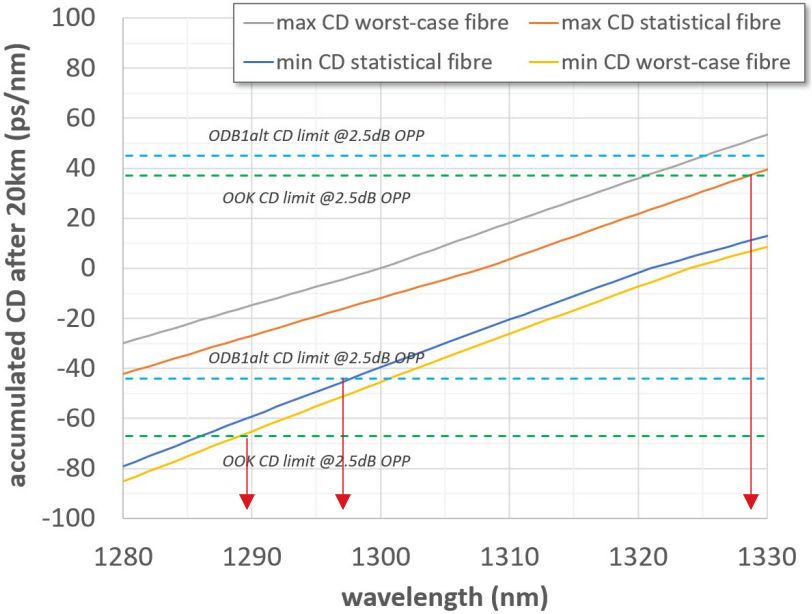


ODB and chirp-controlled NRZ

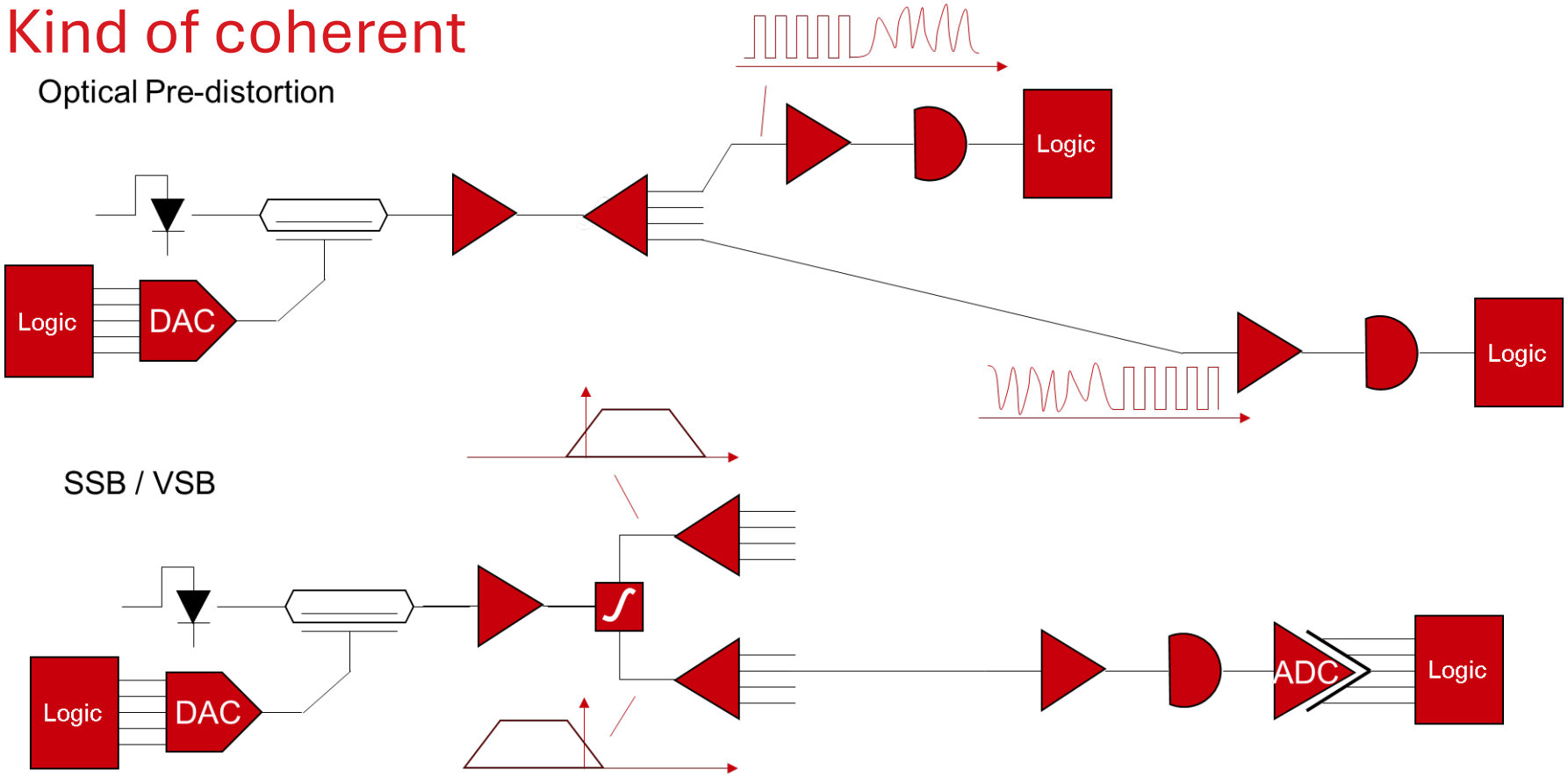
As expected, ODB has a wider dispersion tolerance range

Interestingly, NRZ with chirp control and MLSE can do the same

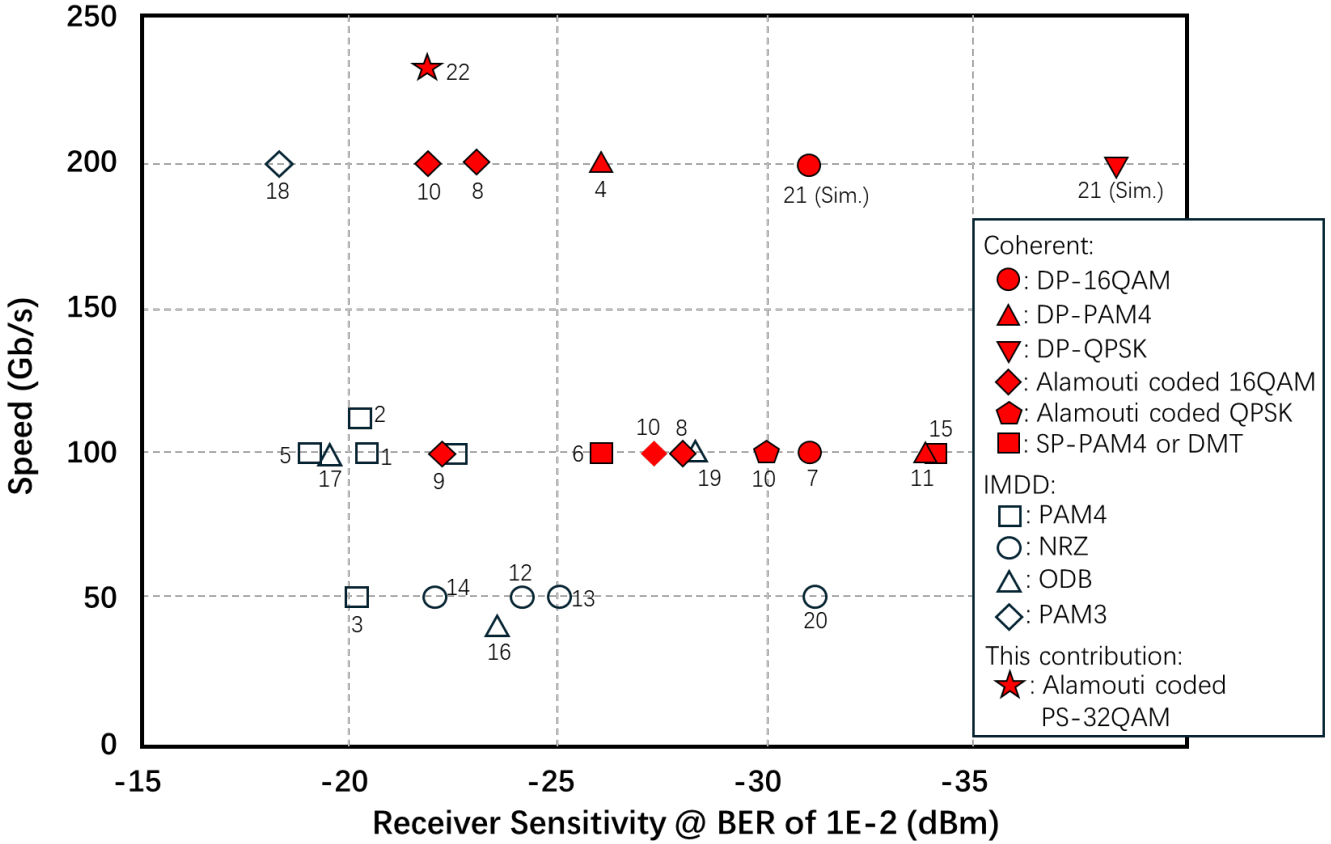




Kind of coherent



Sensitivity as a function of speed



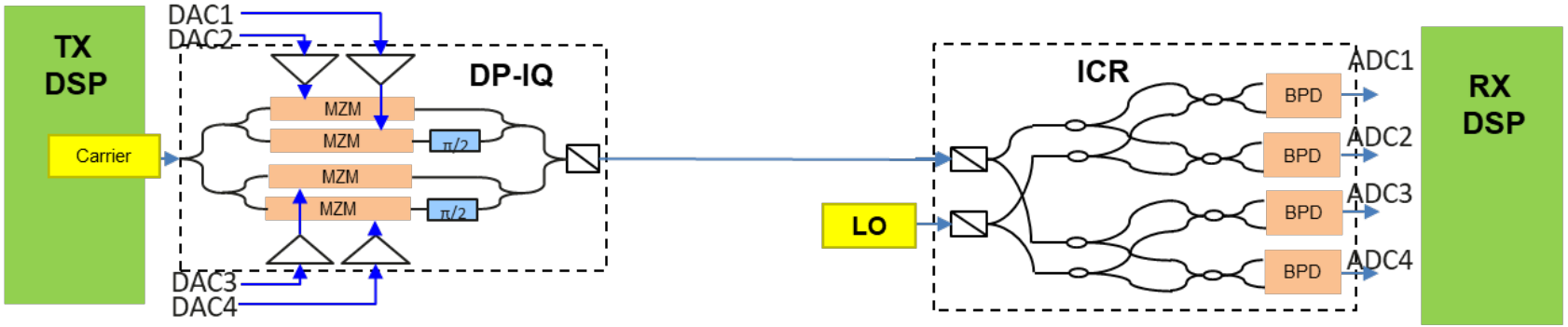
Fully coherent: many possibilities

At the physical layer, either side can implement

- Fully coherent (2 polarizations x 2 quadratures)
- Half coherent (1 pol x 2 quadratures, or 2 pol x 1 quad)
- Low-cost coherent (1 pol x 1 quad)

At the TC layer, the system can employ

- TDM: Best DBA
- FDM: Lowest latency
- OFDM: Fine BW granularity
- Hybrid schemes: TFDM and TWDM



Conclusions

VHSP is a long-range project, aiming to make an initial survey of the technical requirements and possibilities for a very high speed PON

Roughly speaking, we're looking for a 250 Gb/s line-rate system that runs over the existing legacy fiber network, coexisting with XG- and 50G-PON

IM-DD is reaching its limits, so a major focus of the project is to better understand this issue, and see if we can get one more play out of this

- All things being equal, IM-DD should be a lower cost solution
- Operators might consider 2x100G systems, if it enables low cost

Coherent is the technically safe option, but there are many variants there, and the economic outlook for all of those is unclear at this time

- It is easy to imagine datacenter coherent might suddenly drop in cost
- We've seen history of PON driven by sudden moves in optics pricing

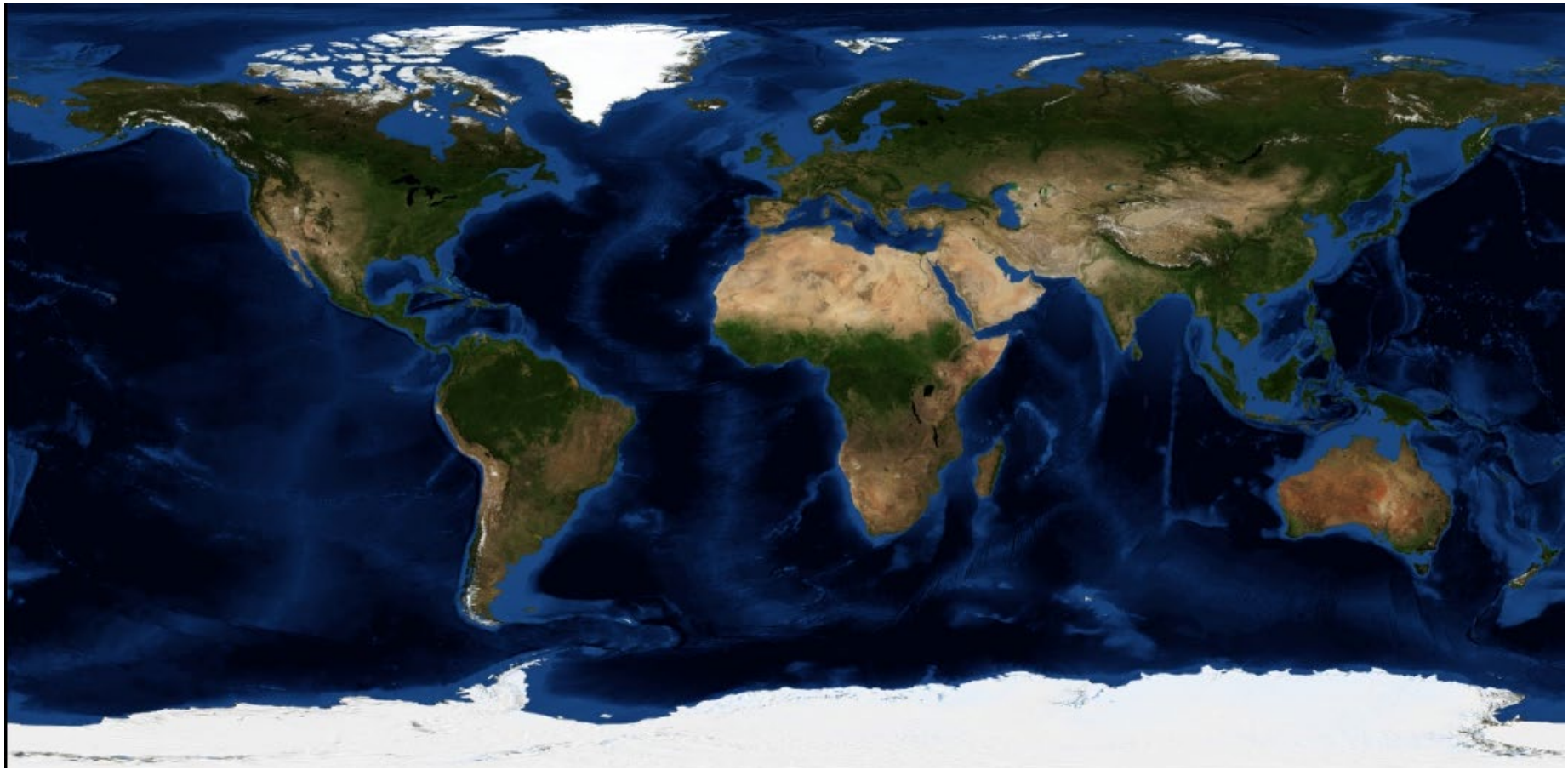
Highlights of WP2 work

Optical technologies and physical infrastructures

Paul Doolan

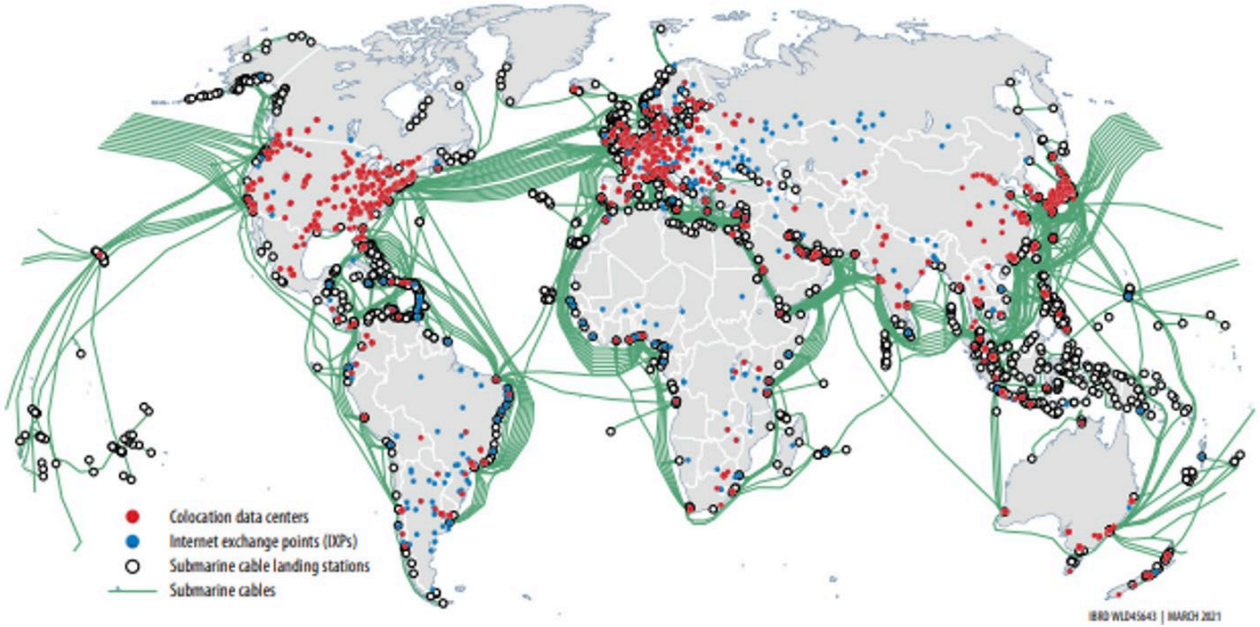
Chair, ITU-T WP2/15

Huawei Hong Kong Research Centre



https://visibleearth.nasa.gov/

Oceans, continents and cables



WP2 addressing capacity, environment and build challenges

WP2/15 at a glance

WP2/15	Optical technologies and physical infrastructures
Q5/15	Characteristics and test methods of optical fibres and cables, and installation guidance
Q6/15	Characteristics of optical components, subsystems and systems for optical transport networks
Q7/15	Connectivity, operation and maintenance of optical physical infrastructures
Q8/15	Characteristics of optical fibre submarine cable systems

Recommendations:
G series: Transmission systems and media, digital systems and networks
L series: Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant

Standards for the infrastructure that allows humanity to communicate

WP2 collaboration with other SDOs/MSAs

- Fibre, cables (Q5,8,7)
  - IEC SC86A, IEC SC86B, IEC SC 86C WG2,
  - ITU-T SG5, SG2, ITU-D Q6/2, ITU-D Q5/2
- Optical interfaces (Q6)
  - OIF, IEEE, OpenROADM
- Hot collaboration topics
  - ZDW in G.652 fibre – IEEE ✓
  - EVM for complex modulation – OIF/IEEE

Recommendations approved since OFC 2024

New Recommendations		
G.9730.1	N	Dedicated scientific sensing submarine cable system
G.9730.2	N	Scientific monitoring and reliable telecommunications submarine cable systems
Revised Recommendations		
G.959.1	R	Optical transport network physical layer interfaces - Amendment 1
G.657	R	Characteristics of a bending-loss insensitive single-mode optical fibre and cable
G.971	R	General features of optical fibre submarine cable systems
G.652	R	Characteristics of a single-mode optical fibre and cable
G.972	R	Definition of terms relevant to optical fibre submarine cable systems
G.654	R	Characteristics of a cut-off shifted single-mode optical fibre and cable
L.101	R	Optical fibre cables for directly buried application
L.103	R	Optical fibre cables for indoor applications

Other documents agreed since OFC 2024

Other texts		
G.Sup.40	R	Optical fibre and cable Recommendations and standards guideline
G.Sup.41	R	Design guidelines for optical fibre submarine cable systems
TR-OFCS	R	Technical Report on "Optical Fibres, Cables and Systems"

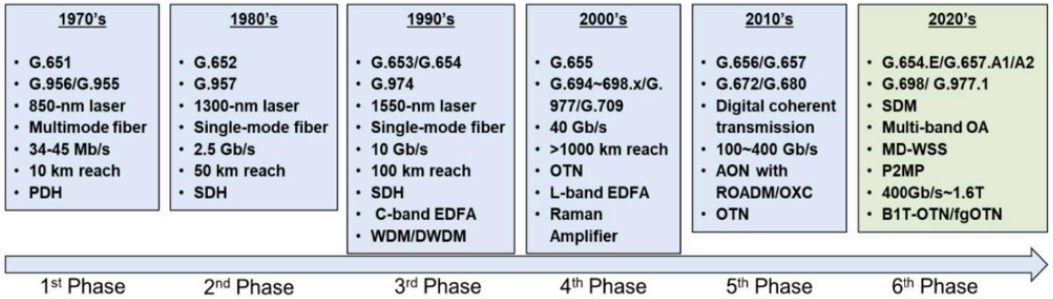


Figure 1 Phases and timeline of fibre-optic communication systems evolution

- Communication capacity per fiber has remarkably increased by >10,000 times over the last 40 years!
- Evolution from single-span transmission to intelligent networks with high throughput and fine granularity.

Reference: Technical Report on Optical Fibers, Cables and Systems (TR-OFCS).

Recommendations agreed 03/2025

Q5		
L.104	R	Small count optical fibre cables for indoor applications
L.105	R	Optical fibre cables for drop applications
Q6		
G.698.4	R	Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces
G.959.1	A	Optical transport network physical layer interfaces
G.672	R	Characteristics of multi-degree reconfigurable optical add/drop multiplexers
G.671	R	Transmission characteristics of optical components and subsystems
G.661	R	Definitions and test methods for the relevant generic parameters of optical amplifier devices and subsystems
Q7		
L.341	R	Maintenance of telecommunication poles and overhead facilities
L.360	R	Operations support system requirements for infrastructure and network elements management using ID techonology
Q8		
G.978	R	Characteristics of optical fibre submarine cables

Supplements agreed 03/2025

Q5		
G.Suppl.47	R	General aspects of optical fibre and cables
G.Suppl.G.65x	N	Standardization framework for optical fibres for space division multiplexing
Q6		
G.Sup39	R	Optical systems design and engineering

New work agreed 03/2025

Q5	
Rec	(L.ocwp.1) Aerial Optical fibre cables along electrical power lines applications with lower voltage
Rec	(L.ocwp.2) Aerial optical fibre cables along electrical power lines applications with higher voltage
Rec	(G.smmcf) Characteristics a single-mode weakly-coupled multi-core optical fibre and cable
Supp	(L.Suppl.ne) National experiences with respect to ITU-T L.1xx-series optical fibre cables, installation methods, and test methods
Q6	
TR	(TR.fsc) Technical Report on feed-forward sensing in optical communication networks
Q7	
Rec	(L.mct) Maintenance of conduits for telecommunication

https://www.itu.int/en/ITU-T/studygroups/2025-2028/15/Pages/default.aspx

TECHNICAL FLYERS

- Flyers from Questions 2, 3, 4, 5, 6, 8, 10, 11 and 13/15 are available here

Special Topics | Related Groups | Past Periods

- Single page overviews
- ~47 available
- 10 WP2
  - Latest from Q7

ITU-T Study Group 15

L.341 Maintenance of telecommunication poles and overhead facilities

- This Recommendation describes detailed inspection technologies and countermeasures for the deterioration of telecommunication poles and overhead facilities.
- The second edition of Recommendation ITU-T L.341 covers outdoor facilities such as poles, closures, wires, cables, and accessories.
- In the latest revision, descriptions of repair methods for wooden poles, which are rarely used at present, are deleted; while repair methods for concrete, steel and GRP poles are newly added.
- Fundamentals of telecommunication infrastructure facility management and considerations on infrastructure structural risks are provided in Recommendation ITU-T L.330.

Table 1 - Typical inspection technologies for poles

Typical inspection items	Technologies	Descriptions
Deflection, Bending Rusting Crack Surface damage Sinkage, tilt	Visual inspection	Visual inspection results are recorded as a sketch or digital image. If rusting is observed on the surface of steel poles, the rust should be scraped off and checked for holes.
Crack	Crack gauge	Adhere where cracks have occurred, and measure the length of cracks and the growth rate of cracks.
Deflection Bending Tilt	Point cloud scanning	Measuring pole shape by obtaining the pole's centre coordinates by using a survey instrument to realize three-dimensional laser scanning.

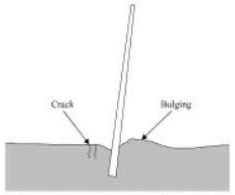


Figure 1 -Visual inspection items for pole foundation

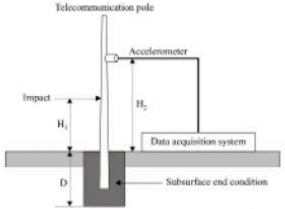


Figure 2 - Pole foundation test configuration

1. Clause 6.2 and 6.3 define the inspection items and technologies.
2. Clause 6.4 describes recommended countermeasures corresponding to the inspection results.
3. Annex A and B provide the inspection methods for a wooden pole and pole foundation.
4. Appendix III introduces the Indian experience with GRP pole application in overhead telecommunication facilities. GRP poles are lighter than other material poles which are easier to handle and install to reduce work time.

For more information, please visit the ITU-T Study Group 15 website at: www.itu.int/go/tsg15

ITU-T Study Group 15

L.250 Topologies for optical access network

- ITU-T L.250 defines optical single-mode fibre access network architectures and provides information on planning new deployments and upgrading existing networks. Moreover, this Recommendation considers optical transmission performance and optical safety which depends on the architecture design of an optical access network.
- ITU-T L.250 recommends cost-effective, quick and efficient access network construction, to meet the demand for high quality network services from FTTH, 5G, IoT and other scenarios.
- The 2nd edition of L.250 introduces optical fibre level and cable architectures, as well as the optical fibres, cables and passive components to be used in access networks.

(1)

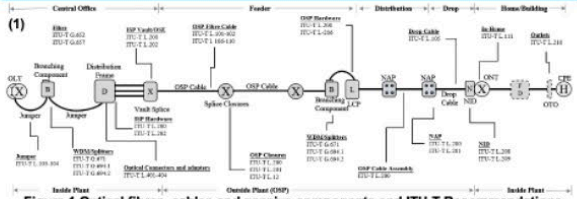


Figure 1 Optical fibres, cables and passive components and ITU-T Recommendations

(2)

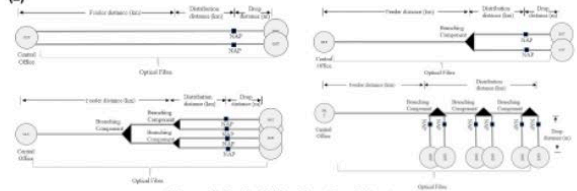


Figure 2 Optical fibre level architectures

(3)

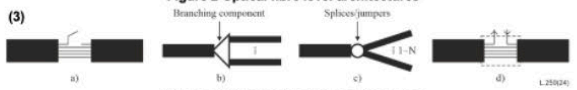


Figure 3 Optical cable level architectures

1. Clause 6 identifies the optical fibres, cables and passive components to be deployed across the access network from central office to home/building.
2. Clause 7 describes basic optical fibre level architectures and cable level architectures, as well as the converged architectures with multiple combinations.
3. Clause 9 and 10 describe the deployment methods for high reliability and guidelines for upgrading access network from architecture point of view, respectively.

For more information, please visit the ITU-T Study Group 15 website at: www.itu.int/go/tsg15

Take aways

In the next five years optical fibre and cable innovations are expected to progress on a pace not seen since the 1980s

- Multicore fibre (MCF), hollow core fibre (HCF), and reduced cladding and coating diameter fibre innovations
- Energy saving solutions, such as co-packaged and linear pluggable optics, are expected to become more prevalent as power requirements double at an ever increasing rate

New applications for the fibre and cable plant

- Fiber **s**ensing applications are expected to be integrated across telecommunications networks to create new value-added services
- **Submarine sensing and monitoring operational; environmental and security aspects**

Increasing interest and participation from developing countries

- **Network infrastructure sharing**
- **Free space optics as an alternative (or complement) to fibre build**

Highlights of recent WP3 Transport Network Characteristics

Tom Huber

Chair, ITU-T WP3/15 and Vice chair, ITU-T SG15

Nokia USA

Beyond 1 Tb/s transport networks

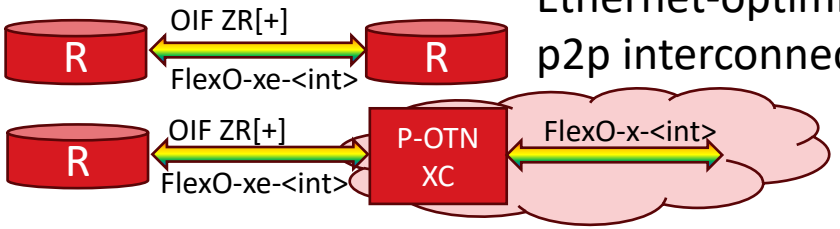
FlexO extension to 1.2 Tb/s and 1.6 Tb/s

- Ethernet-optimized interfaces for p2p applications (FlexO-12e, FlexO-16e)
  - Being developed in conjunction with related OIF work on 1600ZR and 1600ZR+
- Full OTN interfaces for networking applications (FlexO-12, FlexO-16)

New FlexO path layer for 100G, 200G, 400G, 800G, and 1.6T Ethernet clients

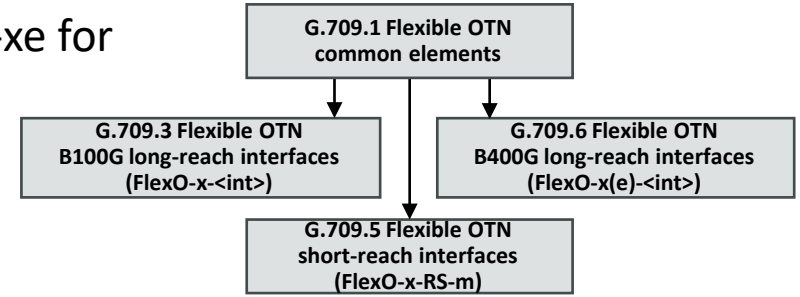
- Extending the current path layer (ODUflex) to 1.6TBASE-R clients is not practical
- New path layer will be optimized for y00G Ethernet clients
- Using the FlexO frame format for the path layer enables greater commonality in designs between p2p and L1 switching applications

Example FlexO-based transport networks

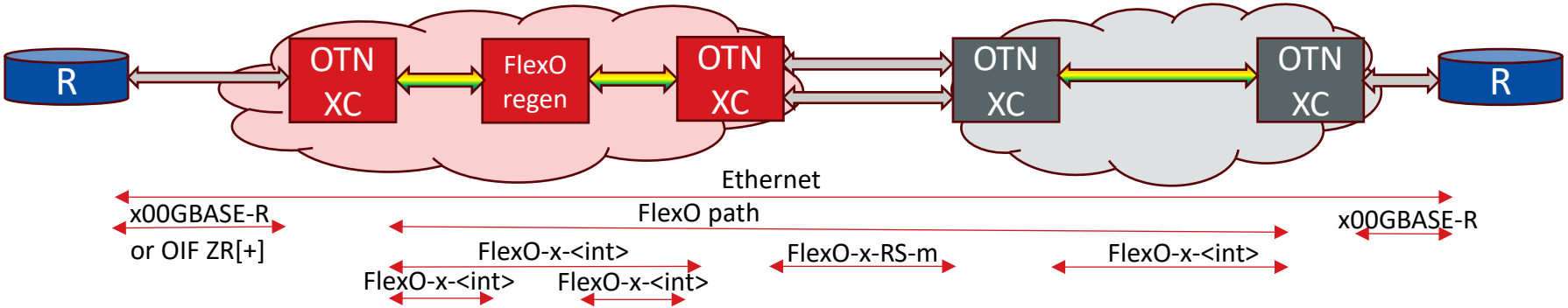


Ethernet-optimized FlexO-xe for p2p interconnection

Note: OIF ZRZR[+] uses FlexO-xe-<int> frame formats



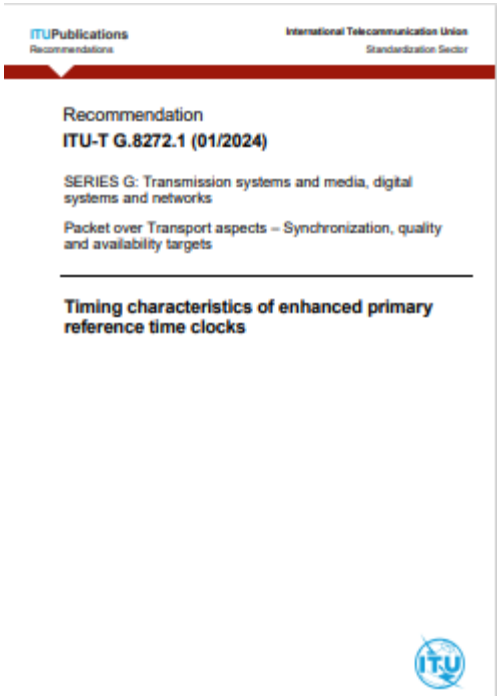
Transport network applications for B1T FlexO short-reach and long reach interfaces



Network synchronization and time distribution performance

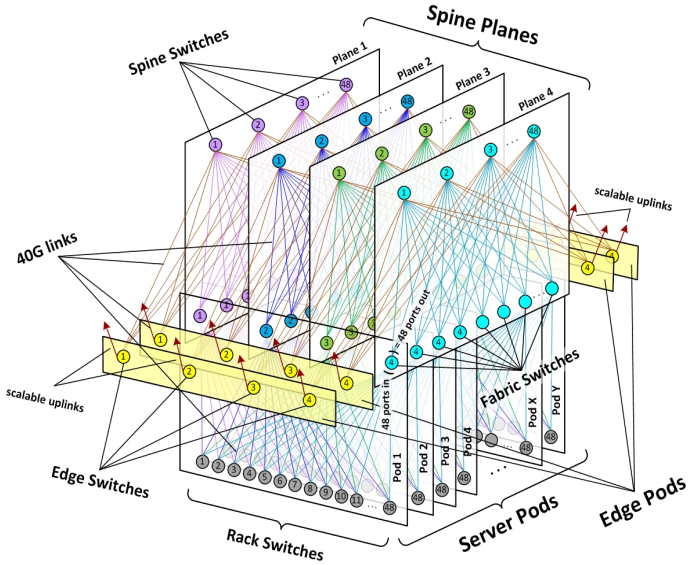
Synchronization continues to be a fundamental function as networks and applications evolve and present new challenges

- Increased resiliency (security, sync monitoring, enhanced holdover, etc.); e.g., G.8272x series, G.8274
- Increased accuracy (e.g., including support for new optical interfaces); e.g., G.8273.2
- Emerging needs in mobile networks (e.g., 5G evolution towards 6G)
- Support connected applications (e.g., Data Centres); G.Suppl.DCSync
- New applications with particularly stringent timing requirements e.g., quantum key distribution (QKD)
- Investigate new technologies (e.g., optical clocks); GSTR-OCN



Sync in Data Centres

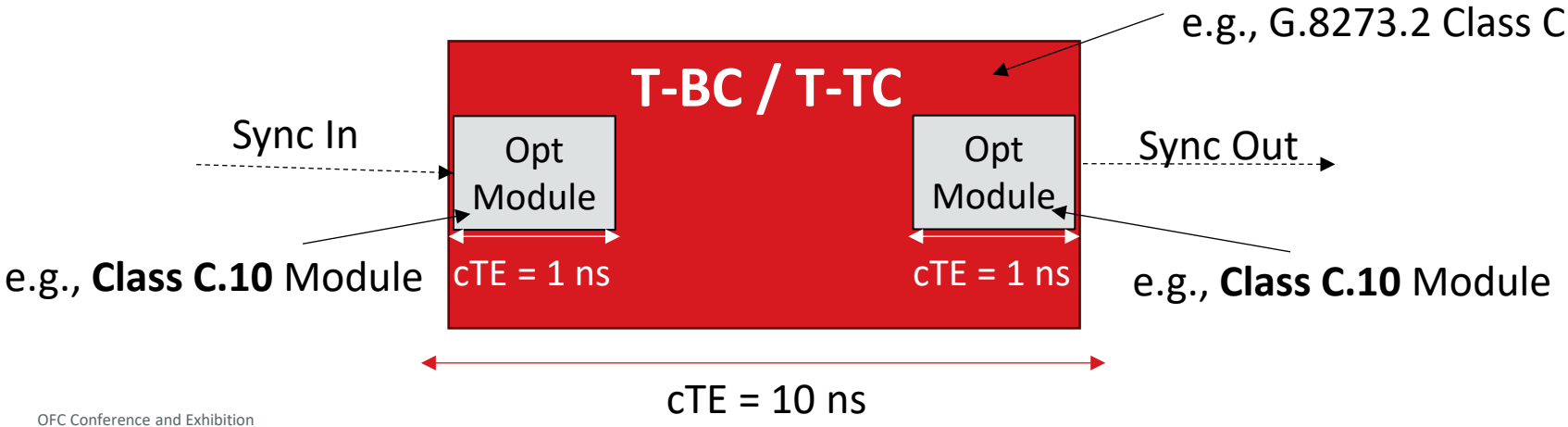
- **Timing has become an important aspect for Data Centres (e.g., to control power consumption)**
- **Q13 is developing an informative document on sync frameworks and profiles for synchronization in Data Centres, G.Suppl.DCSync**
- **Work done in cooperation with the main groups addressing related items (e.g., IEEE P3335, IEEE P1588, IEEE IC timing in data centres, OCP/TAP)**



From C390 (March 2025)
(Meta, Nvidia, Meinberg, Keysight)

SFP module impact on timestamping accuracy

- **Optical SFP can significantly impact the timing performance of clocks**
- **Ongoing initiatives to specify requirements (e.g., in G.8273.2) and methodologies (e.g., in G.8273), based on the MOPA Technical paper on Optical pluggable performance for tight synchronization**



Transport network management

	Generic	Media (L0)	OTN (L1)	Ethernet	Sync	Management and Control
Management and Control Requirements	G.7710	G.876	G.874	G.8051	G.7721	G.7713.x, G.7714.x, G.7715.x G.7716, G.7718
UML Information Model	G.7711	G.876	G.875	G.8052	G.7721	G.7719
YANG Data Model				G.8052.1 G.8052.2	G.7721.1	

YANG Modules

Ethernet YANG

itut-eth-oam-bridge.yang
itut-eth-oam.yang

TimeSync YANG

itut-ptp-telecom-profile-types.yang
itut-ptp-telecom-profile.yang
itut-ptp-tt-telecom-profile.yang

YANG modules will be available from IETF git repository

Incorporation of IEEE Std 802.3 by reference

The IEEE 802.3 Working Group proposed that ITU-T SG15 publish a Recommendation that incorporates IEEE Std 802.3 by reference

- Broadens access to Ethernet standards, expanding on the existing process of publishing IEEE 802.3 as an IEC standard
- Many SG15 Recommendations include normative references to IEEE Std 802.3 and its amendments; converting those to reference an ITU-T Recommendation eliminates some bureaucracy for SG15 editors

Approval of new Recommendation ITU-T G.8020.3 is underway

Incorporation of additional IEEE documents by reference is expected

Thank you !

Come see us at Booth 5073!