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## «Текущий прогресс и перспективы развития оборудования FTTx / GPON»

Константин Савин, Эксперт МСЭ по сетевой инфраструктуре,  
Бизнес-партнер IXP Consulting

# Gigabit Broadband era

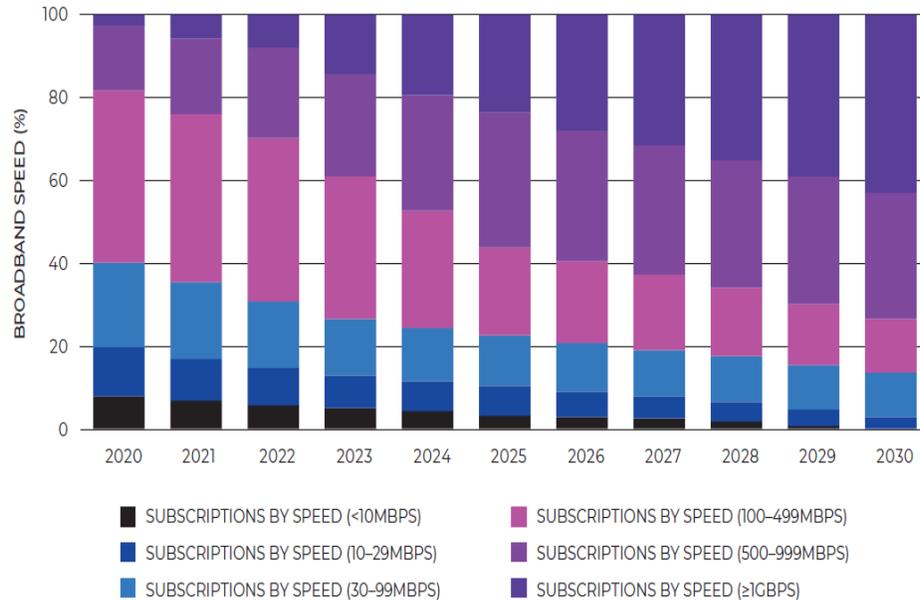


Figure: Take-up of gigabit speed broadband services is expected to accelerate (OMDIA)

by the end of 2022 **only 8%** of global broadband subscriptions were at gigabit broadband speeds or above

There are two categories of Digital Divide, the one pertaining to the “Connectivity-based Digital Divide” (offering basic Internet connectivity) and the other pertaining to “Quality-based Digital Divide” (offering high-speed and high-quality Internet connectivity).

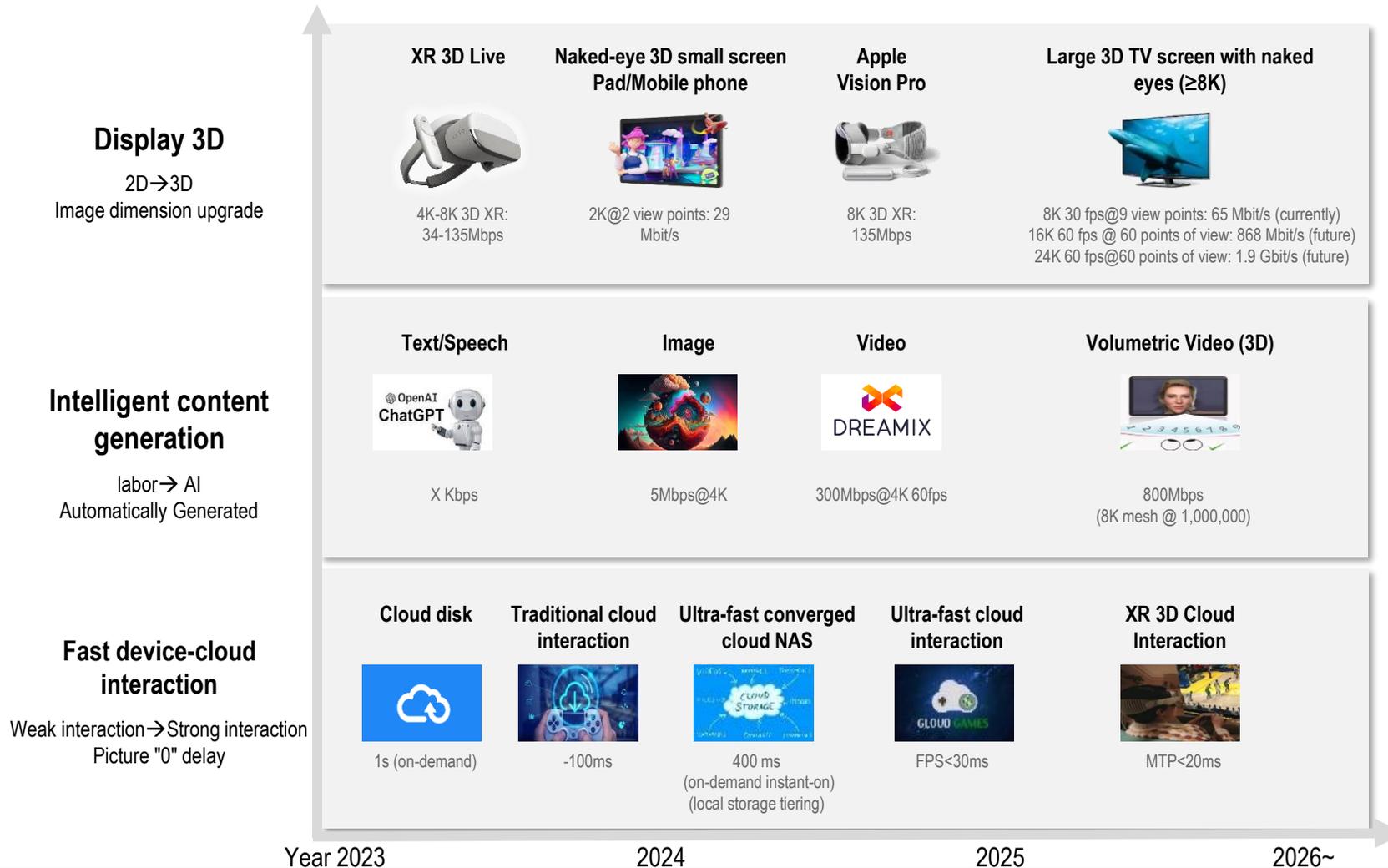
- **Connectivity-based Digital Divide**

- The connectivity-based Digital Divide focused largely on basic connectivity is about to be gradually closing. Indeed, 76% of the world’s population has personal access to the Internet in some form, set to increase to 79% by 2028. However, to increase the impact of digitalization on the global economy of a country, there is a need to go beyond Internet-based basic connectivity and enter into the era of High-speed Internet.

- **Quality-based Digital Divide**

- The way people are connected is unbalanced. By 2028, 41% of the connected population will only be connected **via a mobile device**, and of those that have fixed broadband at home, 7% will still be limited to speeds of less than 30Mbps. Indeed, even by 2028 the average broadband speed in most developing countries is still expected to be lower than 20Mbps, whereas the most developed countries will see average speeds of more than 1.5Gbps. **Therefore, Broadband infrastructure strategy and plans need to be set out by developing countries to enter the Gigabit Broadband era.** The increasing levels of urbanization around the world, requires investment in an efficient way of getting gigabit broadband technology to large portions of the population and industry zones and this is true for developed countries and developing countries.

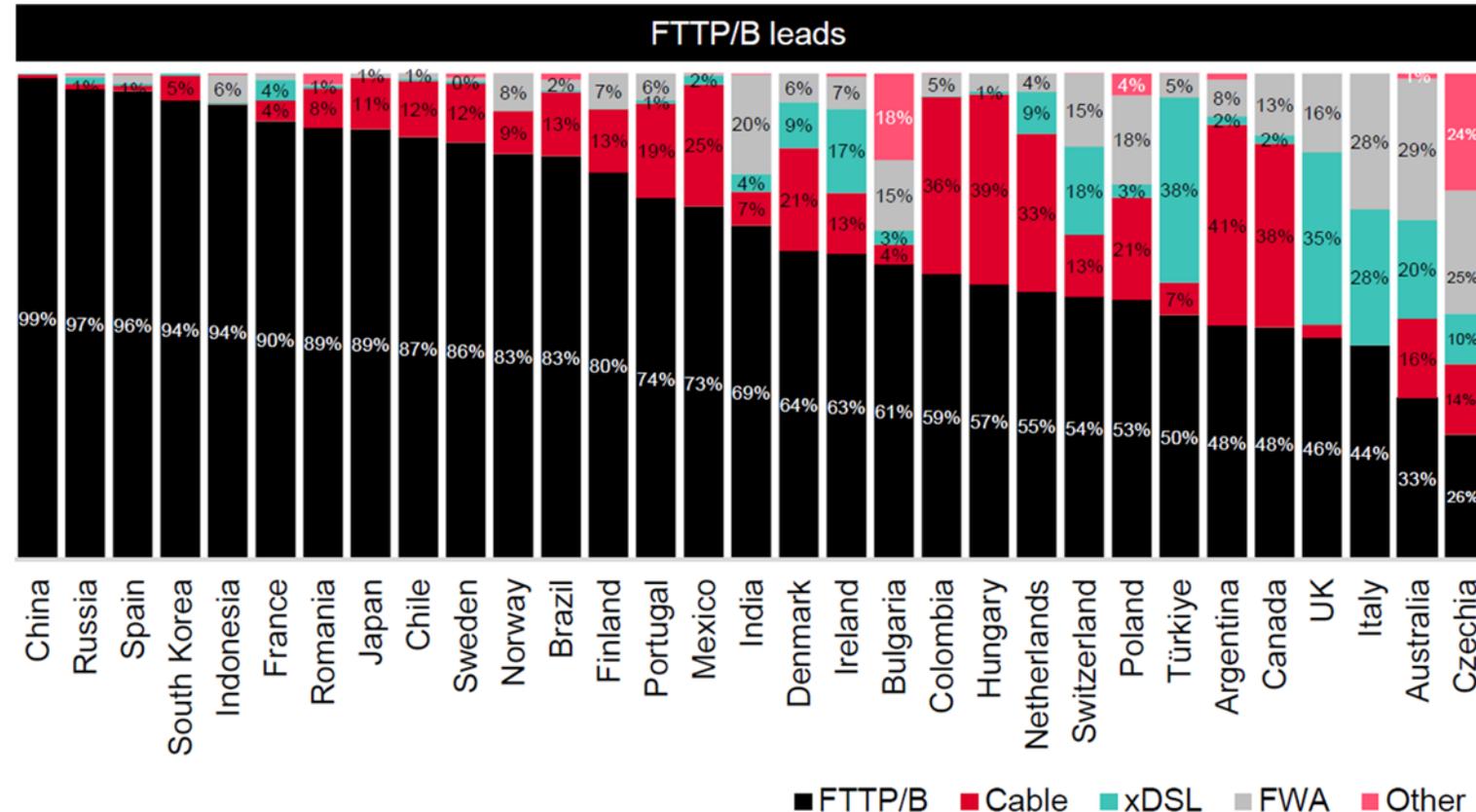
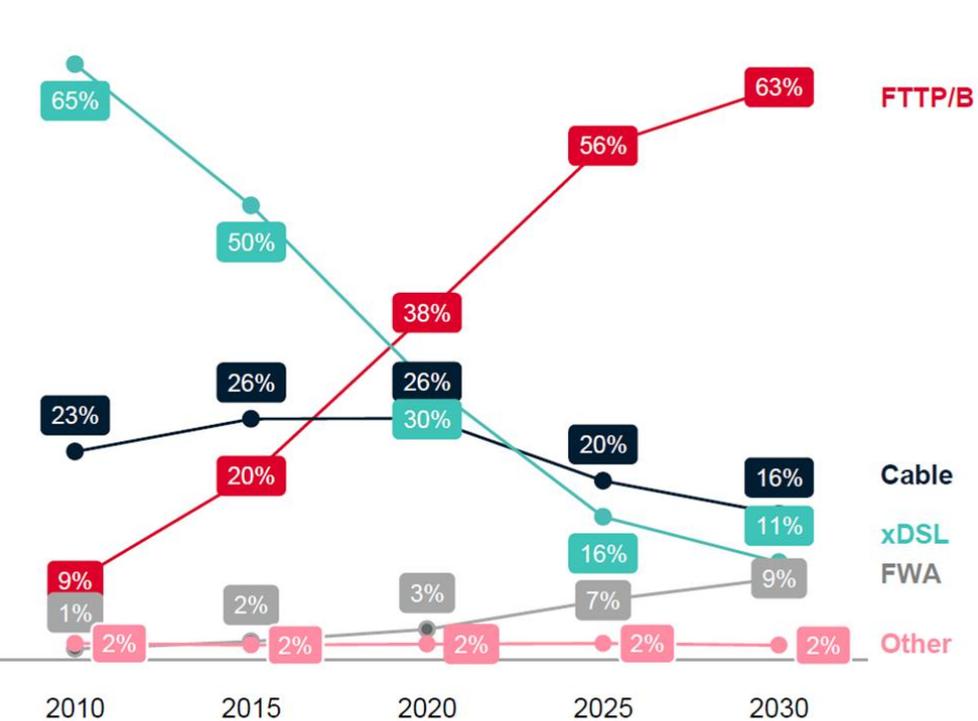
# Home Service Evolve Towards Deterministic Large Bandwidth and Low Latency



- The larger the bandwidth, the lower the latency and the higher the transmission rate
- Computing power goes to edge, premium optical network and low-latency codec technologies reduce E2E operation response latency.

# Fiber technologies replace cable

Fixed broadband connections by access technology  
Share of total fixed broadband connections



Fixed broadband connections include residential and business.

Note: Data for 36 of the world's largest fixed broadband markets, representing 90% of global fixed broadband connections. Simple average of all countries.

Источник: GSMA The future of fixed broadband: trends and drivers disrupting the market (03/2024)

# Overview of Optical Standards Developing Organizations

## ITU-T SG15

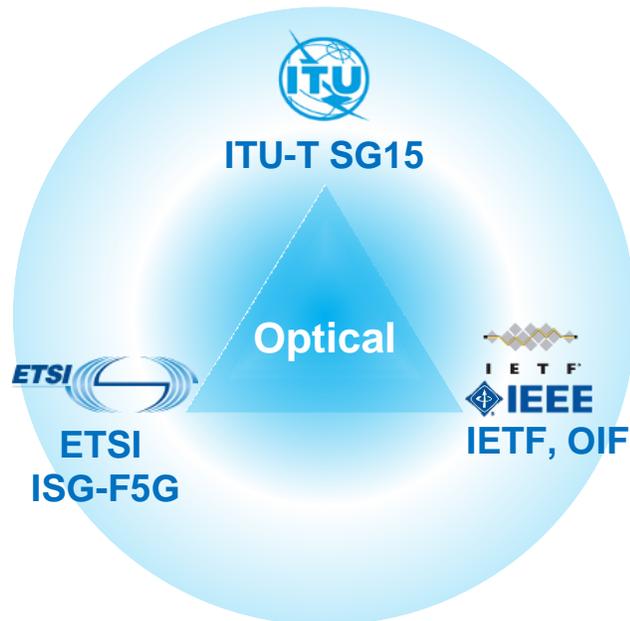
- Most international SDO (**100+ countries**), belongs to **United Nations**
- **Optical** (Q5/Q6): 400G/800G, C+L, fiber, OXC, PON, FTTR...
- **Electrical** (Q11): OTN/fgOTN, frame structure, clock...
- **Mgmt&Ctrl**: (Q14): ASON, Transport SDN ...

## ETSI ISG-F5G

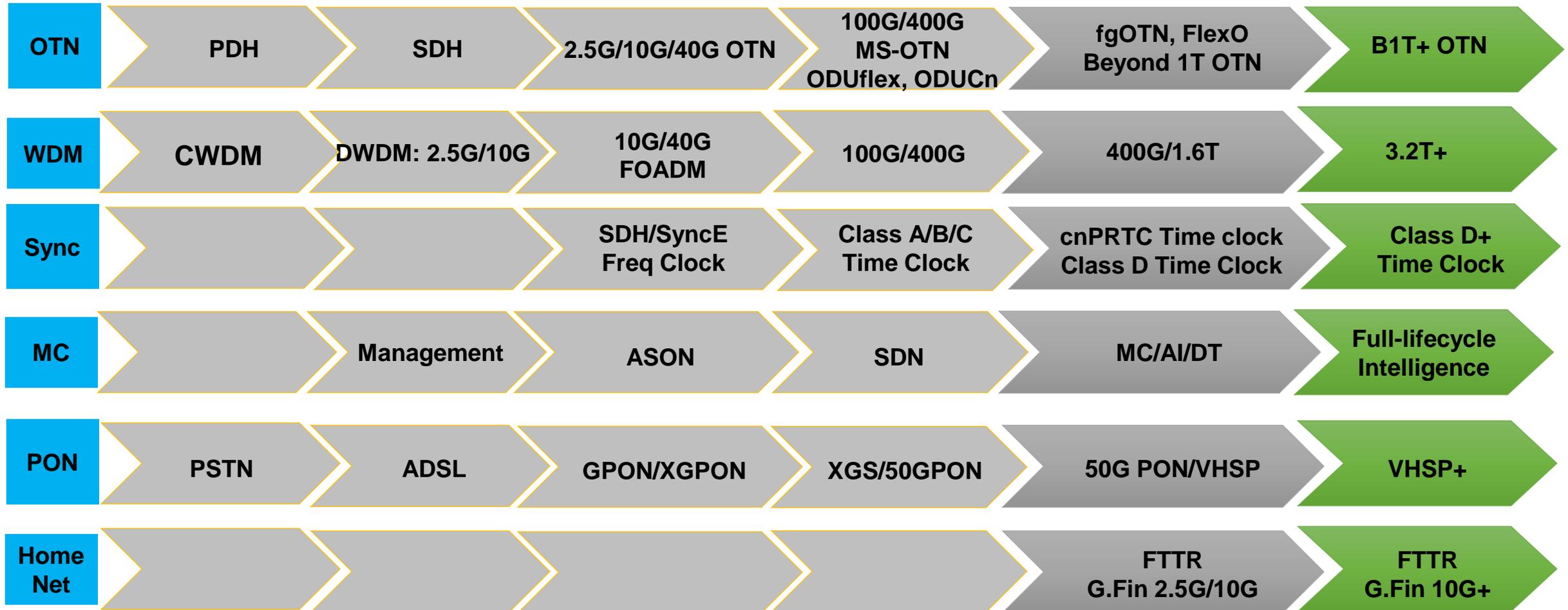
- Located in Europe, influence to world (60+ countries), 3GPP
- Generations definition of fixed network (F5G → F5GA)
- STD development: Use cases, E2E architecture, Test spec., ...
- PoCs & White papers: All-optical green network, F5G, F5GA..

## IETF / IEEE / OIF

- IETF: Mgmt&Ctrl interfaces and protocols (ASON/GMPLS, Transport SDN / ACTN)
- IEEE: Transport client signal (100GE/200GE/400GE/800GE/1.6T...)
- OIF: Coherent modules 400ZR, 800ZR, 1600ZR, 1600ZR+ ...



# ITU-T SG15 covers transport, access and home networks

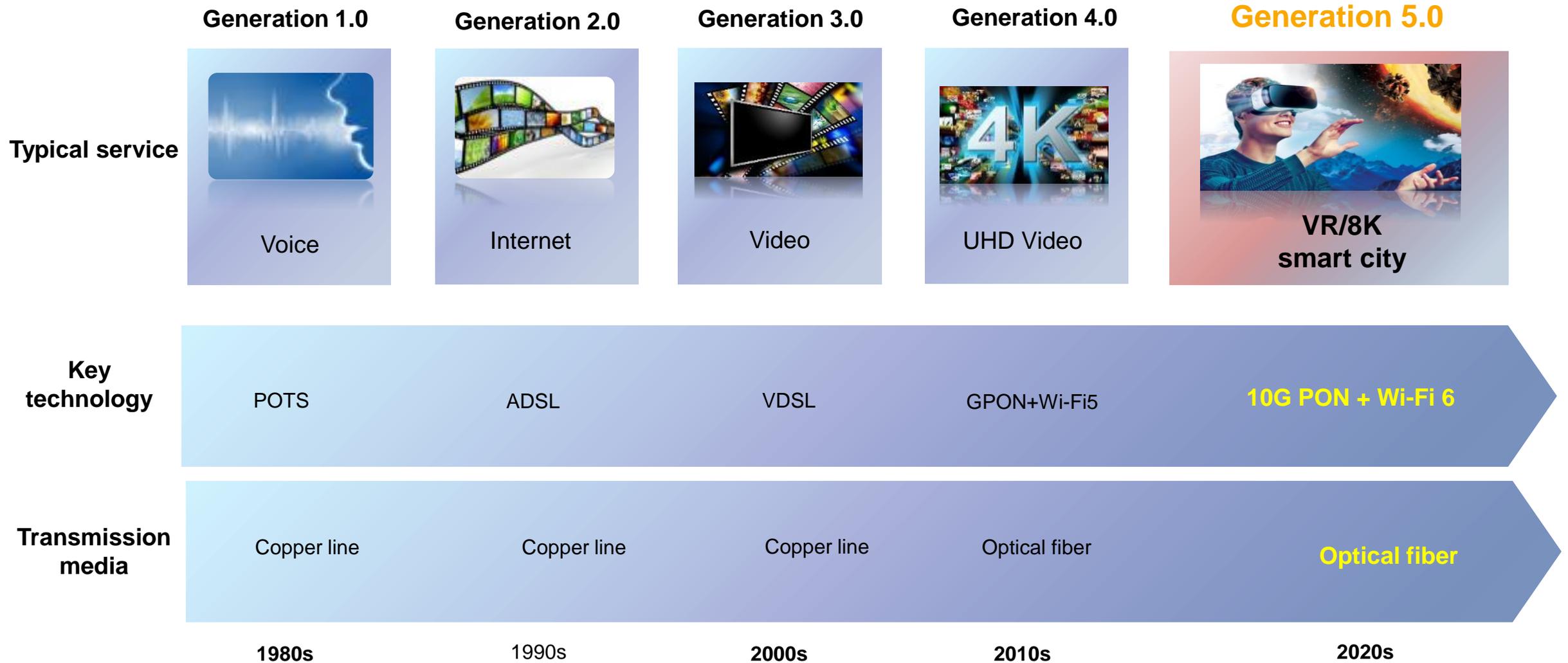


## Access Networks in Daily Life

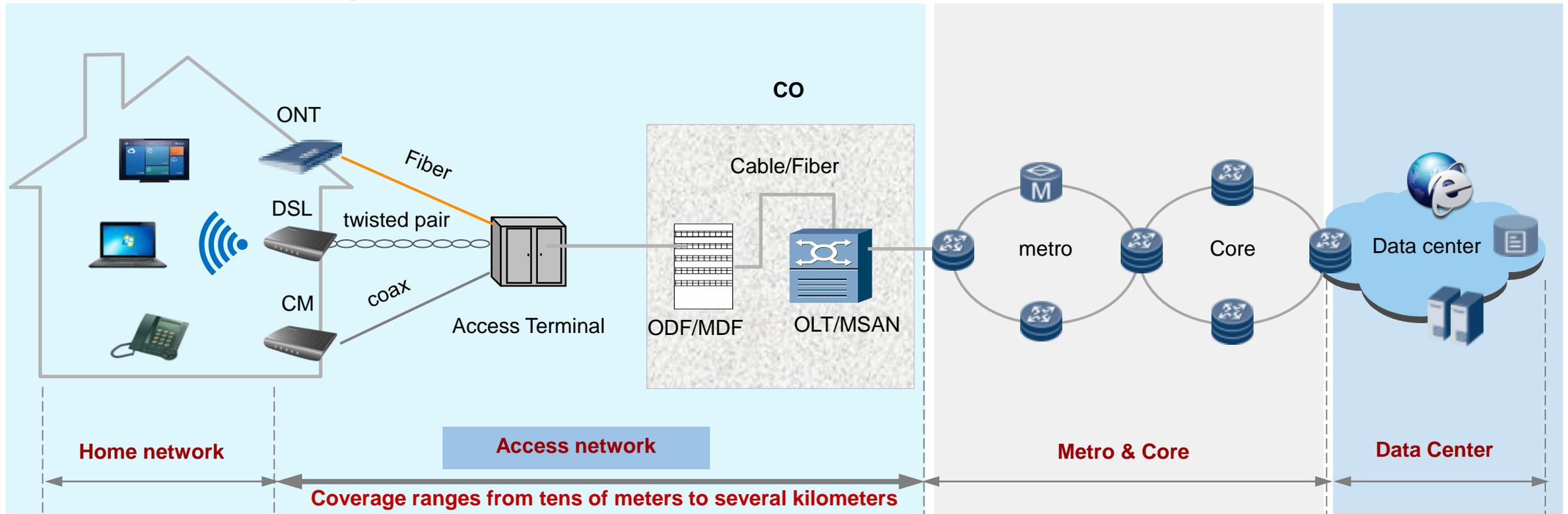


Access networks are pervasive in our daily lives, providing ubiquitous hyper-connectivity in diverse scenarios (including **@home** and **@enterprise**) and enabling connections anytime and anywhere for everything.

# Access Network Enters the Full-Fiber Era After Five Generations of Development



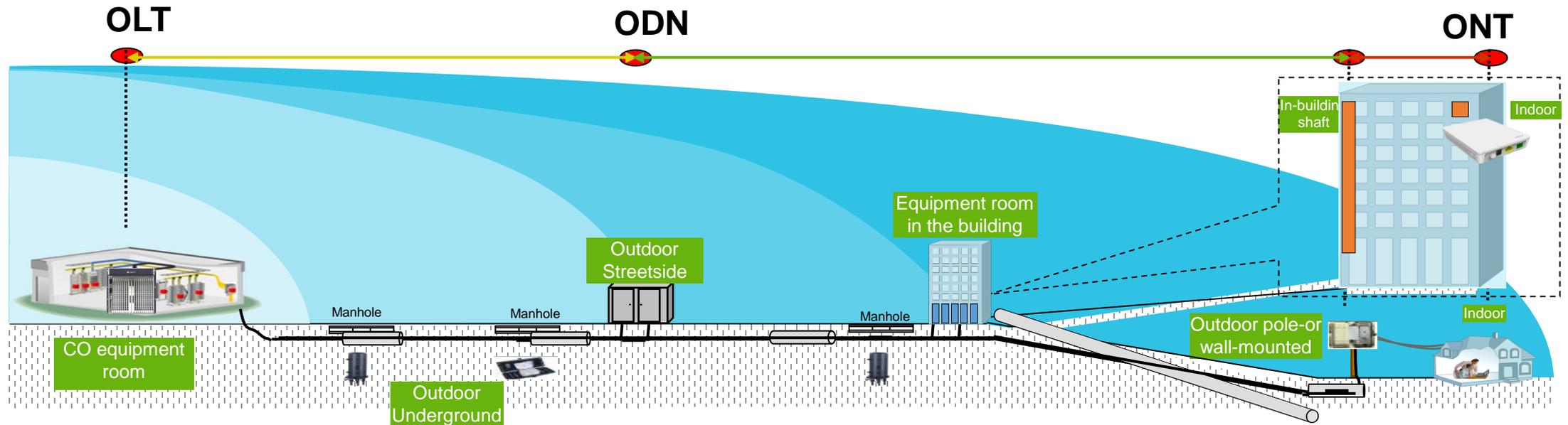
## Basic Concept of the Access Network



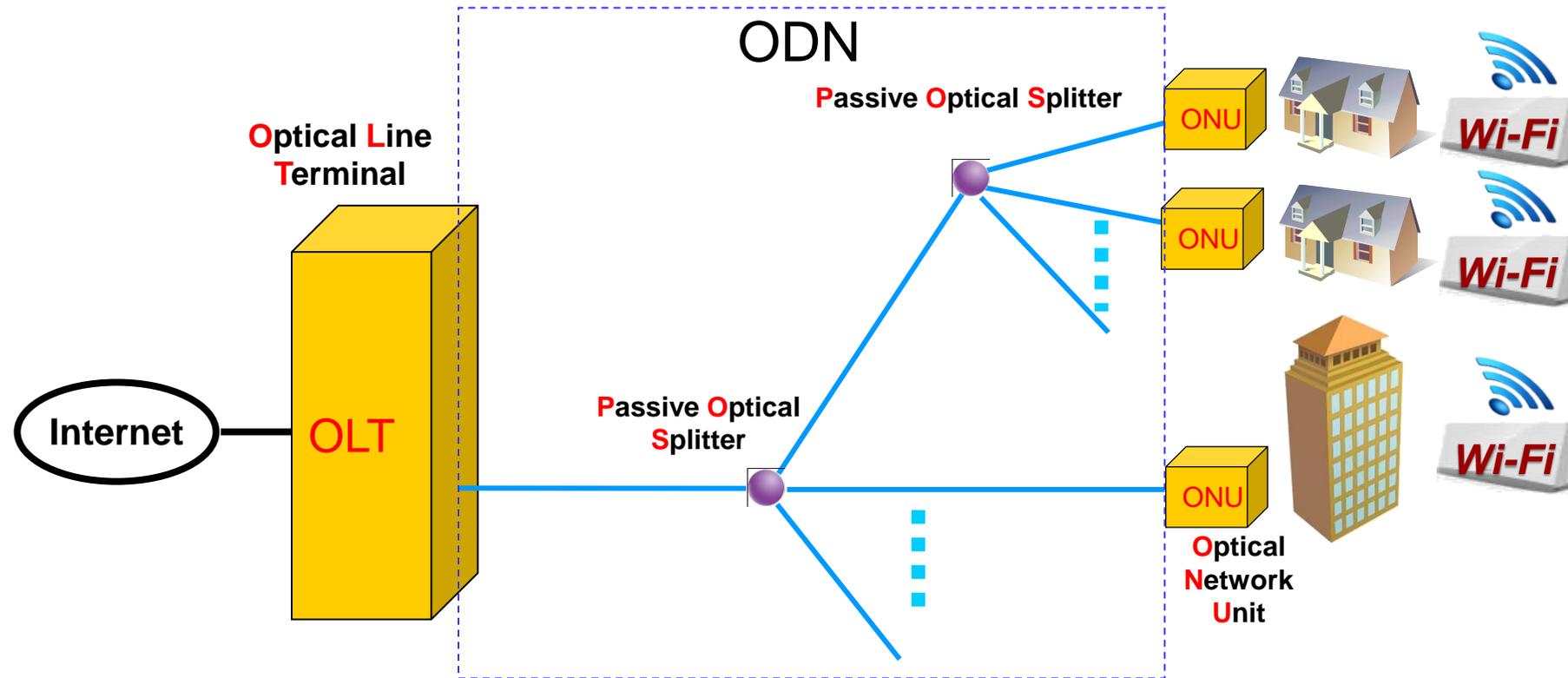
- The access network refers to all active and passive devices between home/enterprise service terminals and the aggregation layer. It directly connects users and provides users with various services through different transmission media (such as optical fibers, copper lines, and coaxial cables). As the biggest part of the telecommunication network, the access network generally occupies 1/3 to 1/2 of the network investment.
- Functions of the access network: service access, aggregation, and upstream transmission; features: abundant service interfaces, flexible access modes, and wide coverage

## Full Fiber Access Network Overview

- Fiber Access Network refers to the access network application where optical network terminals (ONTs) are installed at home or enterprise users and optical fibers are directly connected to users' homes. It consists of the following three parts:
  - **Optical line terminal (OLT):** a core component of Full Fiber Access Network, which is equivalent to a switch or router on a traditional communications network. It is usually located at the CO end and provides optical interfaces for passive optical networks.
  - **Optical distribution network (ODN):** provides optical transmission channels between OLTs and ONTs. ODN products and civil works account for more than 70% of the Full Fiber Access Network cost.
  - **Optical network terminal (ONT):** is a user terminal device in an optical network and provides users with voice, data, and multimedia services.



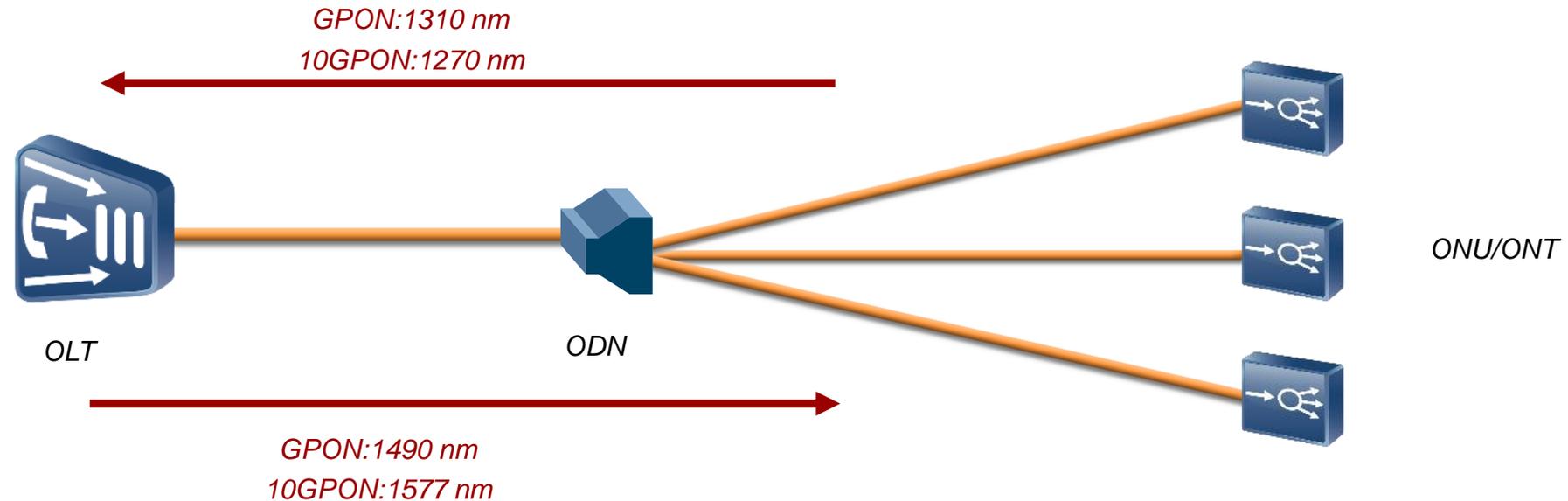
# Basic Concepts of PON



- PON is a point-to-multipoint (P2MP) passive optical network, which is different from P2P.
- PON consists of Optical Line Terminal (OLT), Optical Network Unit (ONU) and Optical Distribution Network (ODN).

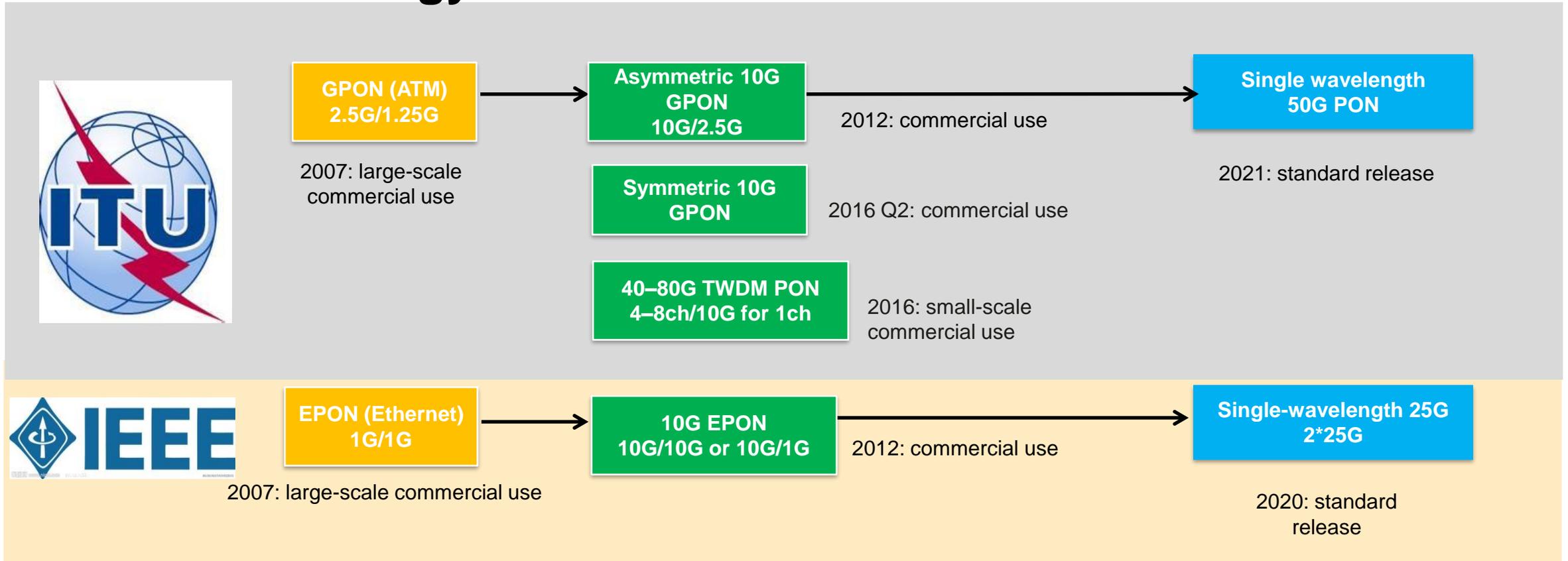
# PON Work Principle: Data Multiplexing

PON 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, PON adopts two multiplexing mechanisms:
- In downstream direction, data packets are transmitted in a broadcast manner;
- In upstream direction, data packets are transmitted in a TDMA manner

# PON Technology Evolution

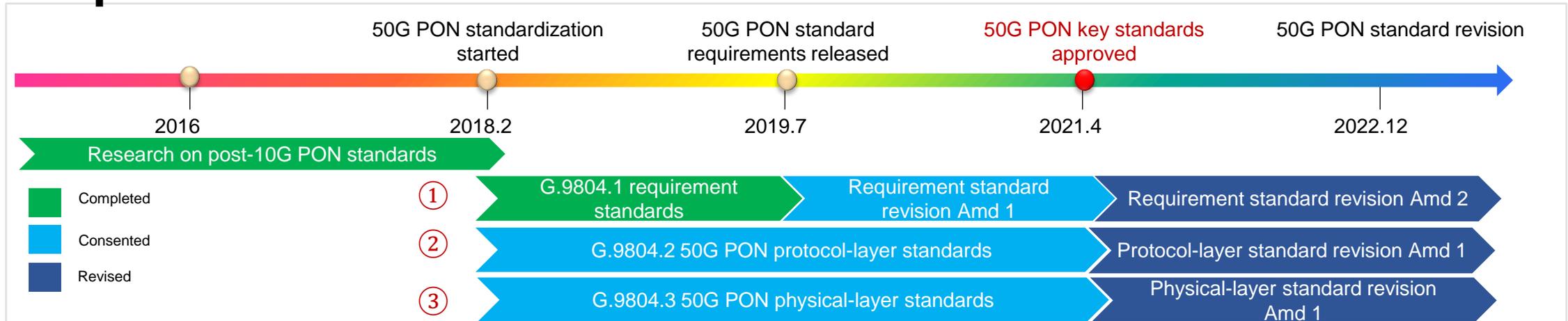


GPON and EPON have been deployed in a large scale, 10G PON is gradually ramping up, and 50G PON standard is set, expecting to be deployed in a large scale in 2025.

## Comparison of Typical PON Systems

	EPON	GPON	10G EPON	XG(S)-PON	2 x 25G PON	50G PON
<b>Standard</b>	IEEE 802.3ah	ITU-T G.984	IEEE 802.3av	ITU-T G.987 (asymmetric) ITU-T G.9807 (symmetric)	IEEE 802.3ca	ITU-T G.9804
<b>Line rate (upstream transmission)</b>	1.25G	1.24416G	1.25G (asymmetric) and 10.3125G (symmetric)	2.488G (asymmetric) 9.953G (symmetric)	10.3125G (asymmetric) 25.78125G (symmetric)	12.44G (asymmetric) 24.8832G (asymmetric) 49.7664G (symmetric)
<b>Line rate (downstream transmission)</b>	1.25G	2.48832G	10.3125G	9.953G	25.78125G	49.7664G
<b>Line coding</b>	8B/10B	Scrambled NRZ	64B/66B	Scrambled NRZ	64B/66B	Scrambled NRZ
<b>Encapsulation format</b>	Ethernet	ATM and GEM	Ethernet	GEM	Ethernet	GEM
<b>Optical module power grade</b>	24dB/PX20 28dB/PX20+	28dB/class B+ 32dB/class B+	29dB/PRX30 29dB/PR30	29dB/N1 31dB/N2	29dB/PQ30 24dB/PQ20	29dB 31dB
<b>Valid downstream bandwidth</b>	About 900M	About 2.3G	About 8.7G	About 8.7G	About 21G	About 41G
<b>Valid upstream bandwidth</b>	About 850M	About 1.2G	About 0.85G (asymmetric) About 7.4G (symmetric)	About 2.2G (asymmetric) About 5.6G (symmetric)	About 17.8G	About 9G (asymmetric: 12.5G) About 18G (asymmetric: 25G) About 35G (symmetric)

# Future of PON: 50G PON Standard Approved by ITU-T in April 2021



## 50G PON Takes A Step Closer to Reality as ITU-T Standard Achieves Consent

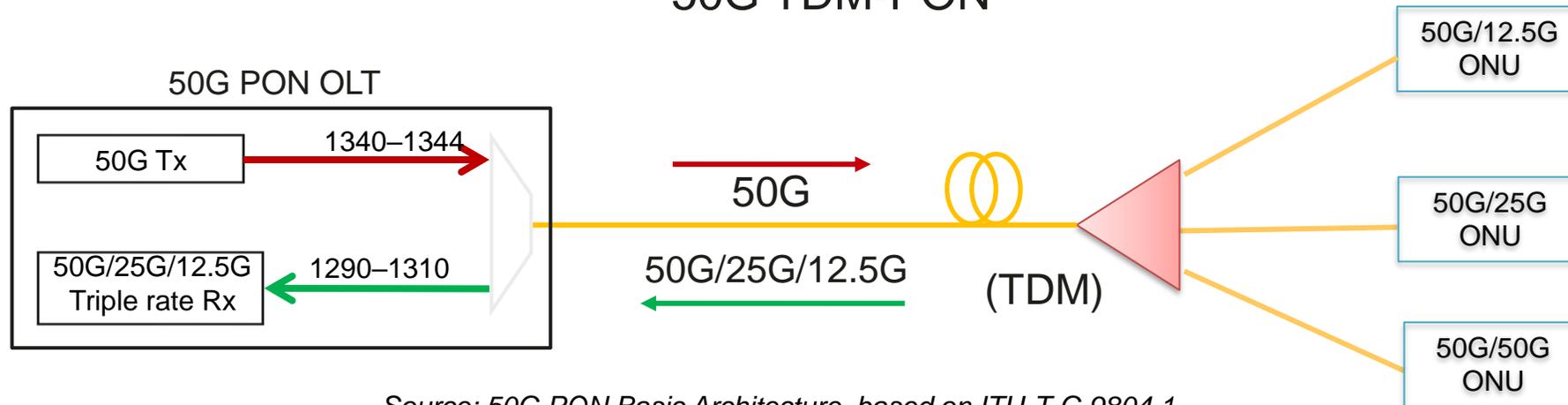
Updated: May 8

The ITU-T 50G PON standard took a big step towards become a reality as consent was achieved on multiple part of the series during the ITU-T SG15 plenary meeting on April 23, 2021. ITU-T Study Group 15/Q2 launched the Higher Speed (HSP) PON project in 2016 which was completed and released in February 2018 as ITU-T G.Sup.64. This supplement described the characteristics of optical transmission above 10 Gbps per wavelength between the optical line termination (OLT) and the optical network unit (ONU) and will be applied towards all PON standards above 10G PON.

Source: <https://www.broadbandtrends.com/post/50g-pon-takes-a-step-closer-to-reality-as-itu-t-standard-achieves-consent>

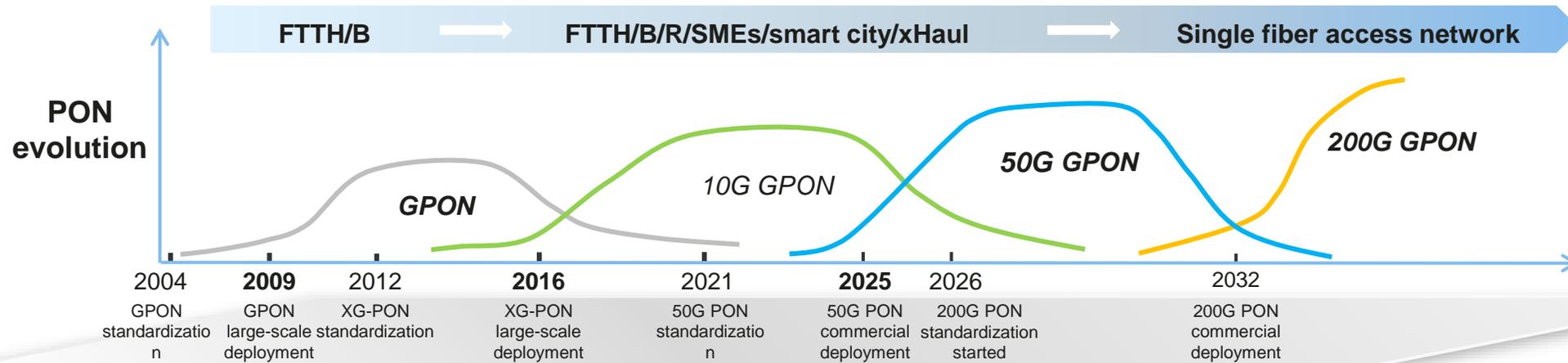
## Future of PON: 50G PON System Architecture

### 50G TDM-PON

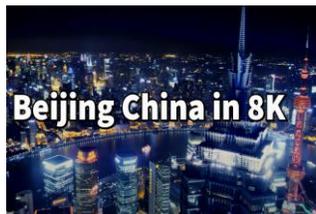


- 50G PON supports single-wavelength 50G in the downstream direction and 12.5G/25G/50G in the upstream direction.
- ONUs with different transmission rates use the TDM technology to transmit data to one OLT PON port.
- Similar to 10G PON, 50G PON features simplified architecture and a single wavelength in the upstream and downstream directions.
- According to ITU-T G.9804.1, 50G PON supports the long-term evolution of 10G EPON.

# PON Development History: GPON → 10G PON → 50G PON



8K/12K UHD video



Remote interactive education



24K 3D cloud gaming



Telemedicine



Bandwidth:  
1.5G  
Latency: 5 ms  
Jitter: 5 ms

VR & AR



Fiber to the desktop for enterprises



The emergence of new services and increase of user bandwidth requirements facilitate optical evolution.

**Благодарю за внимание**