Optical Systems for Fiber Access Networks

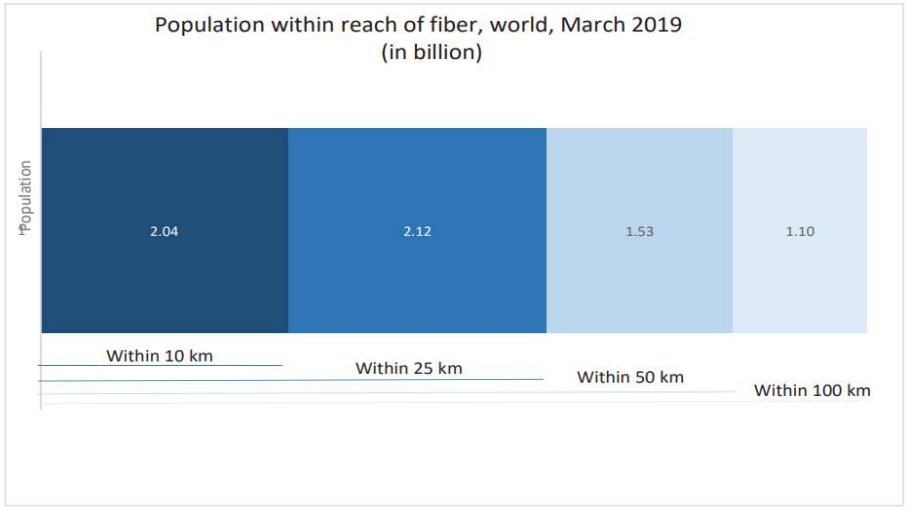
A review of work in ITU-T SG15 Q2, Q3 and Q4

Yuanqiu Luo - Editor, Question 2 of ITU-T SG15

1. Introduction

Fibre Penetration and Contribution to Economic Growth

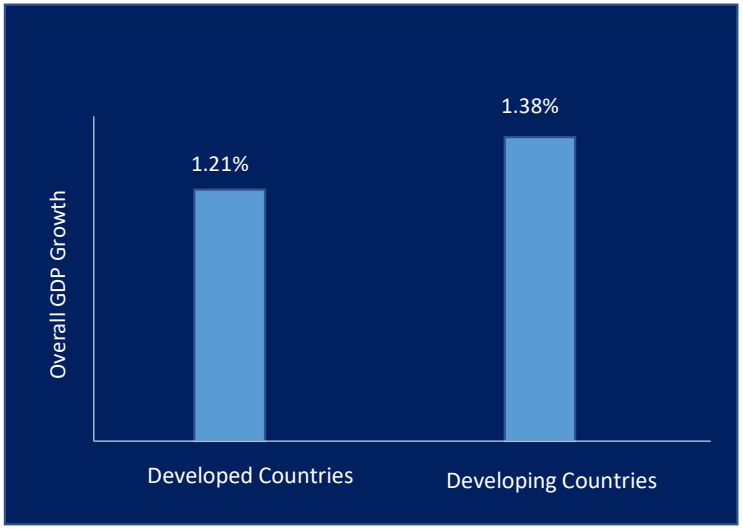
~2B people have fibre access within 10 km



Note: Not cumulative; figure depicts population within category not inclusive of lower thresholds

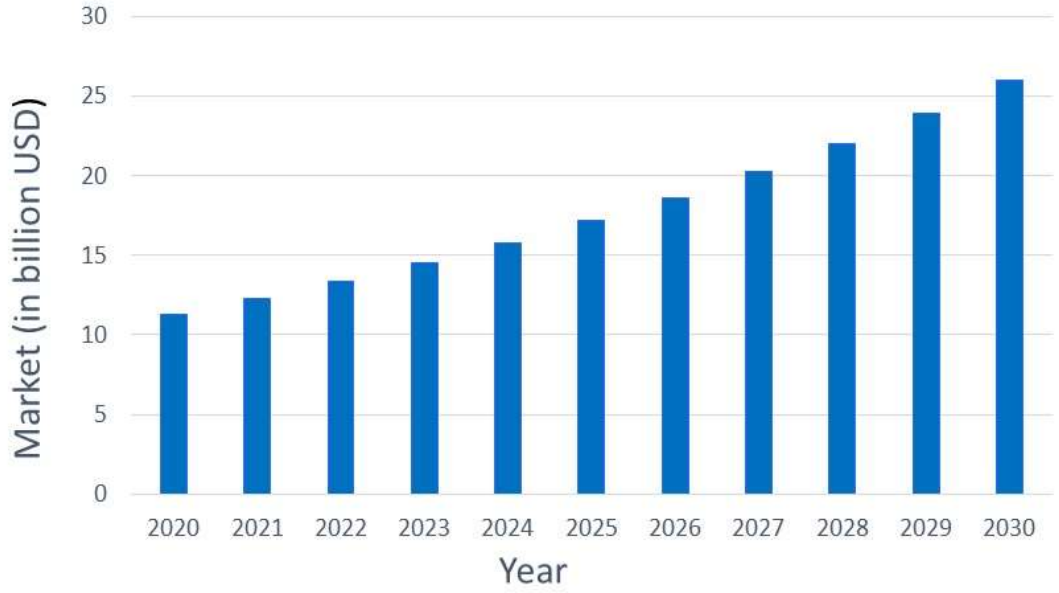
World 2018 population is 7.6B
"The State of Broadband: Broadband as a Foundation for Sustainable Development", ITU/UNESCO Broadband Commission for Sustainable Development, 2021

10% increase in FBB penetration -> 1.21%~1.38% GDP growth



"World Development Report: Exploring the Relationship Between Broadband and Economic Growth", The World Bank, 2016
"World Development Report: Data for Better Lives", The World Bank, 2021

Global Fibre Access Market

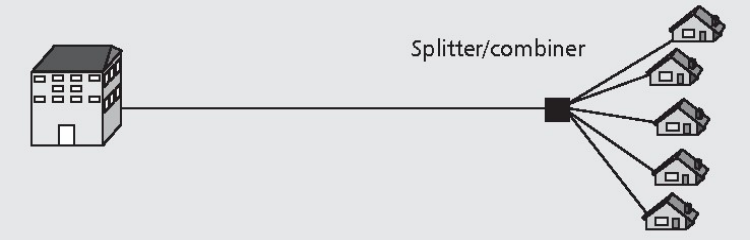


- Global fibre access market was 11.3 billion USD in 2020 and is estimated to be 25.8 billion USD by 2030
- Anticipated CAGR is about 8.7%

"Market Research Report", Prophecy Market Insights, 2021

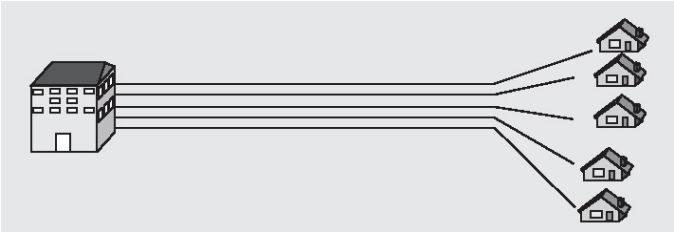
Two Types of Solutions for Fibre Access

Point-to-multipoint (PtMP) access using passive optical networks (PONs)



- Passive outside plant
- TDM/TDMA for medium sharing and access control
- High loss budget due to splitter loss
- Low port density at central office

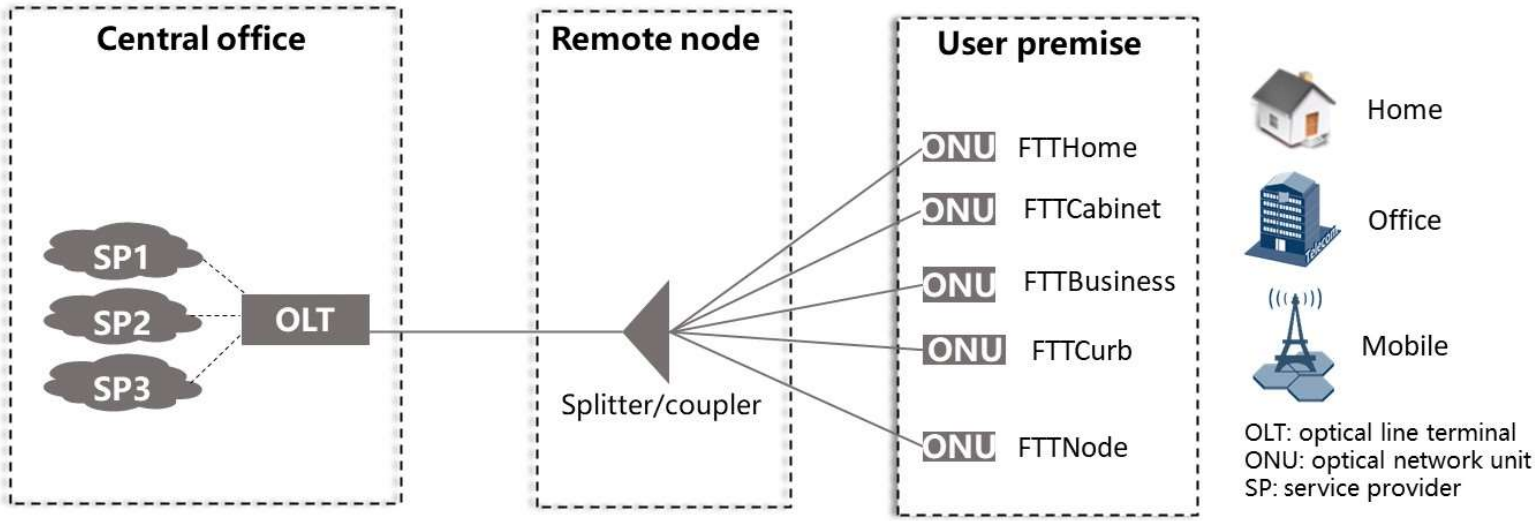
Point-to-point (PtP) single fibre bidirectional (BiDi) access



- Passive outside plant
- Dedicated fibre for each user
- Low loss budget
- High port density at central office

2. ITU-T PtMP Optical Access System Std

Where to Use PON



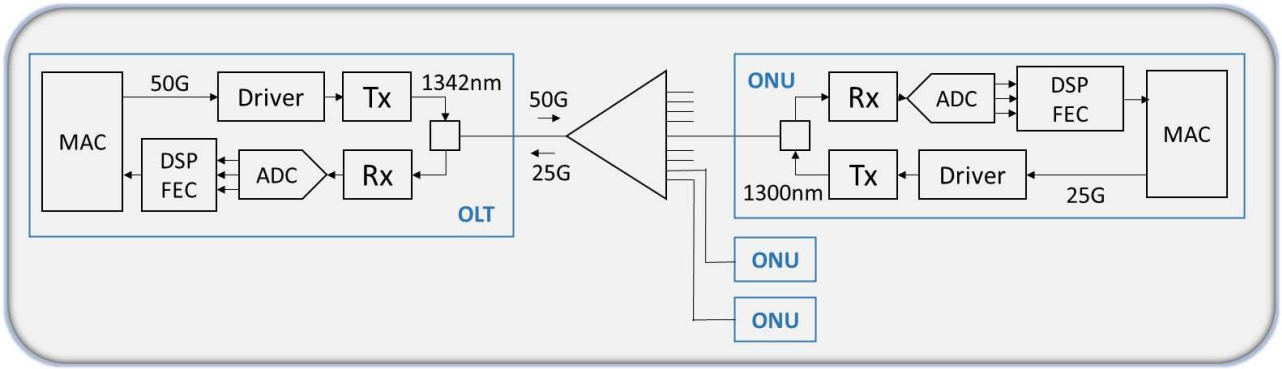
- PON is for FTTx broadband access, it connects users to core networks and delivers service from the central office to user premises

ITU-T PON Standards with Commercial Products

PON system	Downstream rate (bps)	Upstream rate (bps)	Standards	Standard approval year	Note
BPON	622M	155M	ITU-T G.983 series	1998	First commercial PON
GPON	2.5G	1.25G	ITU-T G.984 series	2003	Most widely deployed optical access system, market size >10B$
XG-PON	10G	2.5G	ITU-T G.987 series	2010	large scale deployment from 2018, >10M XG(S)-PON ports have been deployed, each port supports 32, 64, or 128 users
XGS-PON	10G	10G	ITU-T G.9807.1	2016	
NG-PON2	40G (4x10G)	10G (4x2.5G)	ITU-T G.989 series	2015	

BPON: Broadband passive optical network
GPON: Gigabit-capable passive optical network
XG-PON: 10-Gigabit-capable passive optical network
XGS-PON: 10-Gigabit-capable symmetric passive optical network
NG-PON2: 40-Gigabit-capable passive optical network

Latest Effort: 50G-PON (G.9804 Series)



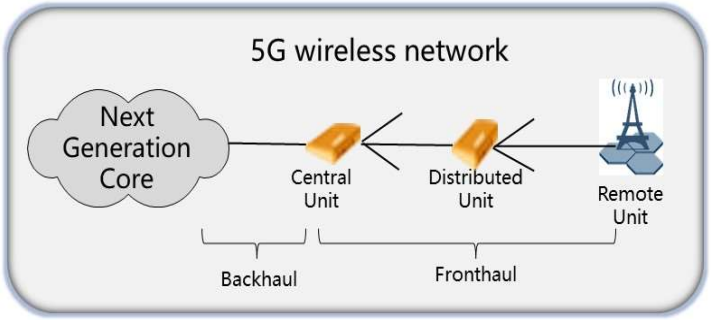
Recommendation	Scope	Editor companies	Status
G.9804.1	Requirements for higher speed PONs	AT&T, China Telecom	Consented in 2019
G.9804.2	Converged MAC layer	Futurewei, Nokia	Consented in 2021
G.9804.3	Single channel 50G-PON PMD Downstream 50G, Upstream 12.5G, 25G, 50G	China Mobile, Huawei	Consented in 2021
G.hsp.TWDMpmd	Higher rate TWDM PMD	Adtran, Calix	Under development

- 50G-PON is the next generation after 10G (XG-PON and XGS-PON)
- Top operators (AT&T, China Telecom, China Mobile) and vendors (Adtran, Calix, Huawei, Nokia, ZTE) play a key role in editing 50G-PON specifications
- It makes use of advanced technologies in DSP and FEC to achieve 50G over 20km or 40km
- Commercial products will be available in 2024

3. ITU-T PtP Optical Access Std

ITU-T PtP Optical Access Standards

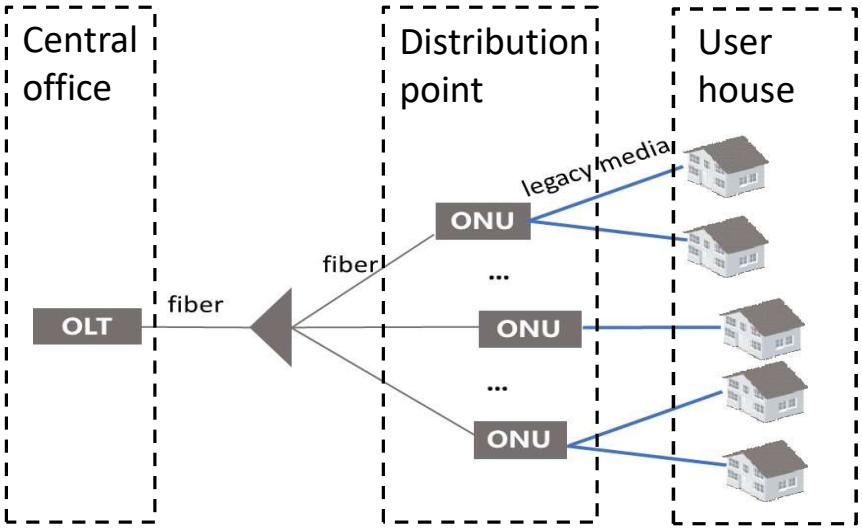
PtP Rate	Loss budget (distance)	Standards	Approval year
1 Gb/s	15dB (10km), 20dB (20km), 25dB (30km)	ITU-T G.986	2010
10 Gb/s	15dB (20km), 23dB (40km)	ITU-T G.9806	2020
25 Gb/s	15dB (20km), 23dB (40km)	ITU-T G.9806 Amd1	2020
50 Gb/s	15dB (20km), 23dB (40km)	ITU-T G.9806 Amd2	2021
100 Gb/s	10dB (10km), 15dB (20km)	ITU-T G.9806 Amd3	2023



- ITU-T has specified 11 types of optical access links to support 1G, 10G, 25G, 50G, 100G PtP
- Main implementations of these links are wireless xHaul (fronthaul, backhaul)

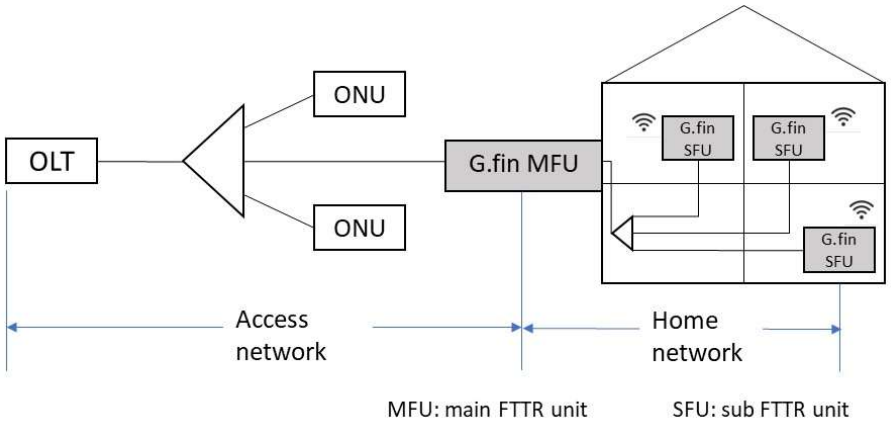
4. ITU-T fibre Access Application Std

ITU-T Standards on FTTdp



- ITU-T Recommendations G.9700 and G.9701 for G.fast specify fibre to the distribution point (FTTdp) application by using 1G DSL links to connect user houses
- Fibre access is employed as FTTdp backhaul
- This Rec set enables reuse of deployed copper links for 1G broadband access

ITU-T Standards on FTTR



- Project G.fin specifies fibre to the room (FTTR) application
- Fibre systems are employed for both access and home networks
- This work targets to resolve the last meter broadband bottleneck

Other Aspects of fibre Access

Fiber Access Topic	ITU-T Standards	Scope
Power saving	G.Sup45	Optical access system power saving requirements, power saving techniques, ONU power states, OLT power saving methods
Security	G.Sup49, G.Sup.ponSecurity	Rogue ONU mitigation methods, enhanced security to resolve emerging cyber security challenges
5G fronthaul transport	G.Sup66	Requirements on PON to support 5G fronthaul, possible PON solutions to transport CPRI/eCPRI signals
5G backhaul transport	G.Sup75	Optical access solutions of backhauling a large amount of 5G wireless small cells
WDM-PON	G.9802.1, G.9802.2	Wavelength multiplexed PON to support 5G fronthaul
Deterministic capability	G.Sup.PONLatency	Industrial network use cases, requirements, technologies for latency control and deterministic improvement in PONs

5. Summary

Summary

- ITU-T provides a rich family of fibre access standards
  - PtMP systems (BPON, GPON, XG-PON, XGS-PON, NG-PON2, 50G-PON)
  - PtP systems (1G, 10G, 25G, 50G, 100G)
  - Applications (FTTR, FTTdp, 5G xHaul, Industry 4.0)
  - Various aspects of broadband access (power saving, security, slicing)
- ITU-T fibre access systems are the mainstream products of broadband access, driving a global market of >10B USD revenue


thank you
danke
謝謝
ngiyabonga
متشكرم
рахмат
teşekkür ederim
gracias
obrigado
merci
dziękuję
bedankt
sukriya
go raibh maith agat
kop khun krap
terima kasih
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arigatō
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