

# Real-Time Demo of Fiber-to-the-Room for $>1\text{Gb/s}$ Home Networking

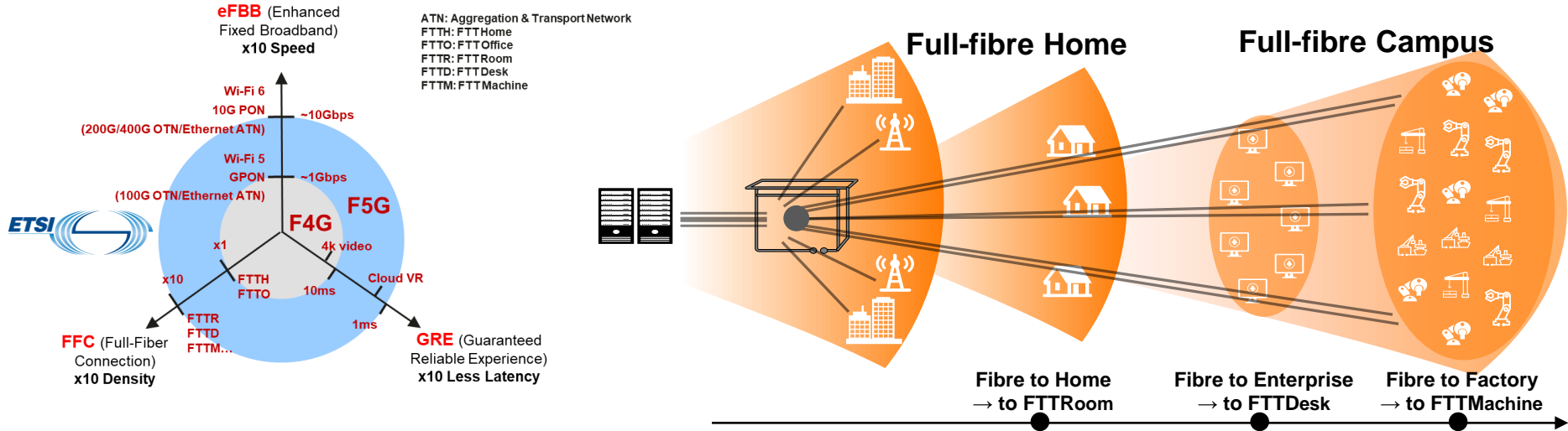
Fabienne Saliou, Gael Simon, Philippe Chanclou,  
Stéphane Le Huérou

ECOC 2022 workshop « F5G and Evolution towards F6G »  
18th of Septembre 2022



# Fibre to Everywhere for an unlimited future

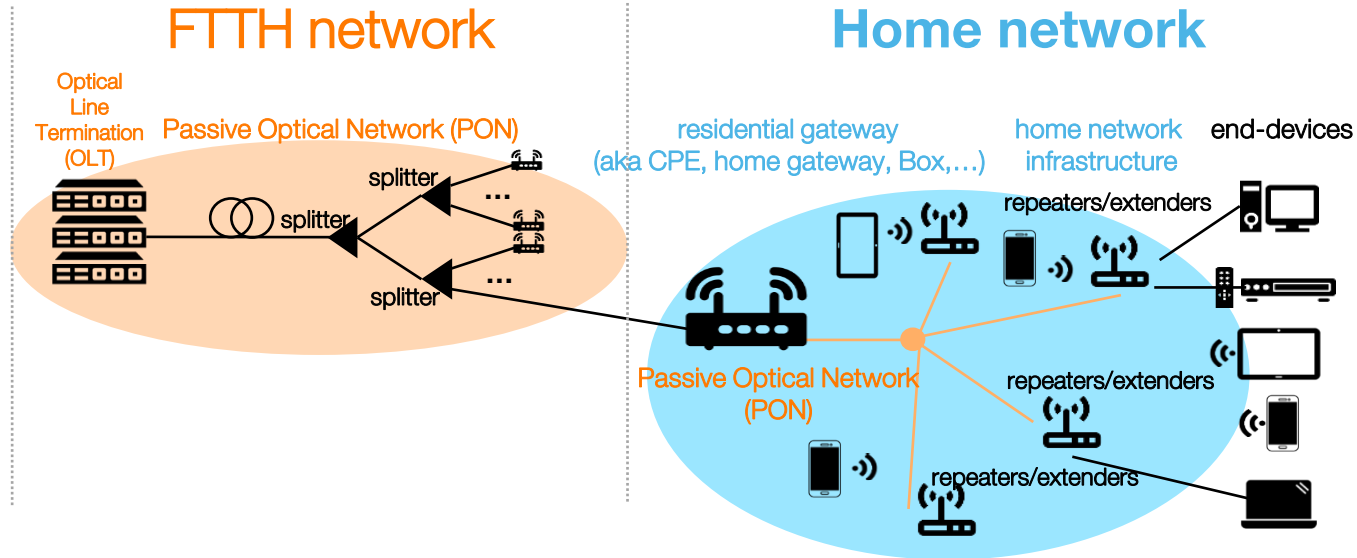
## Allow evolution of technology and services with F5G



### Fiber to Everywhere to make fixed access future proof

- Extending to **more end-user** : Home, Room, Business, Mobile, Device, Machine, etc.
- Reducing everywhere the **fibre-to-end user distance**: Km → 100m → 10m → 1m
- **Number of connections** expanding: X3 (Room), X10 (Desk), X30 (Machine), X100 (Smart city)

# Re-using PON in Home networks



FTTH with GPON or XGS-PON

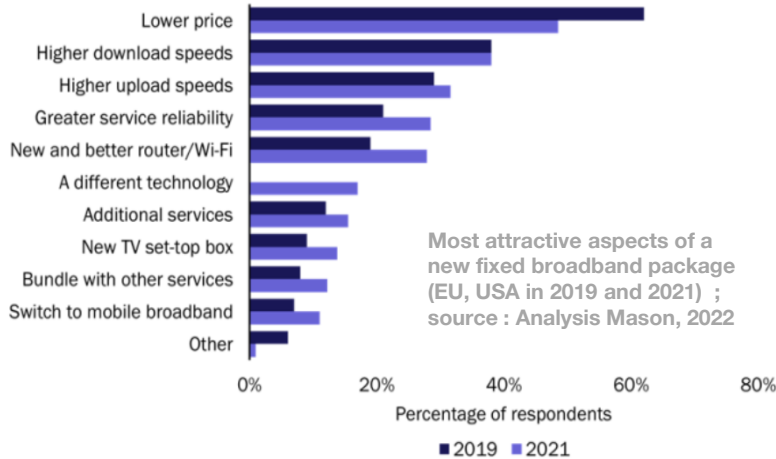
FTTR Gateway : OLT functions included in the residential gateway

PON fibre plant : FTTR fibre + passive optical Splitter (1:4 stages, x4 max)

FTTR ONUs : Wi-Fi extenders with the benefits of a fibre backhaul

# Introducing Fibre in Smart Home Networks

**FTTR can build on and enhance existing multi-Wi-Fi access point solutions**



**User experience are strongly linked to Home LAN performances (Wi-Fi, other...)**

A cost effective, Home network infrastructure associating **optical fiber and radio** for a **wireless end connectivity** to the **very high bit rate** services everywhere in the home

Offer in-home network **speed guarantees >Gbit/s**

Permitting **higher throughput in the future (>100 Gbps)**

Serve as a **reliable basis** for new connected home services  
Enhanced high-quality in-home connectivity experience for reliable connectivity in Homes

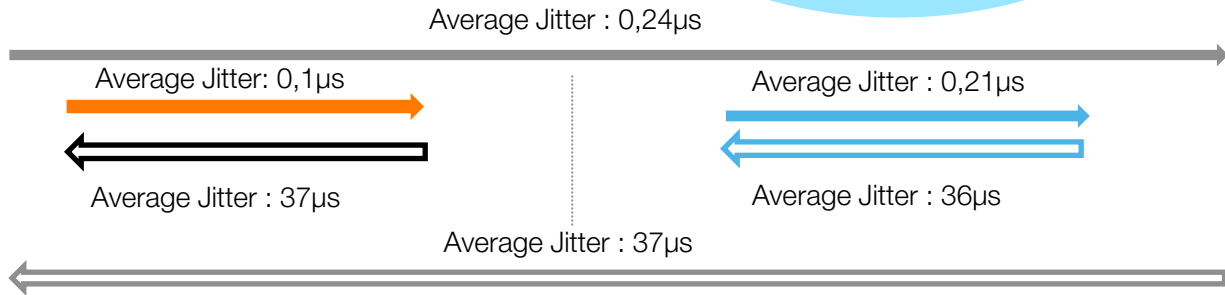
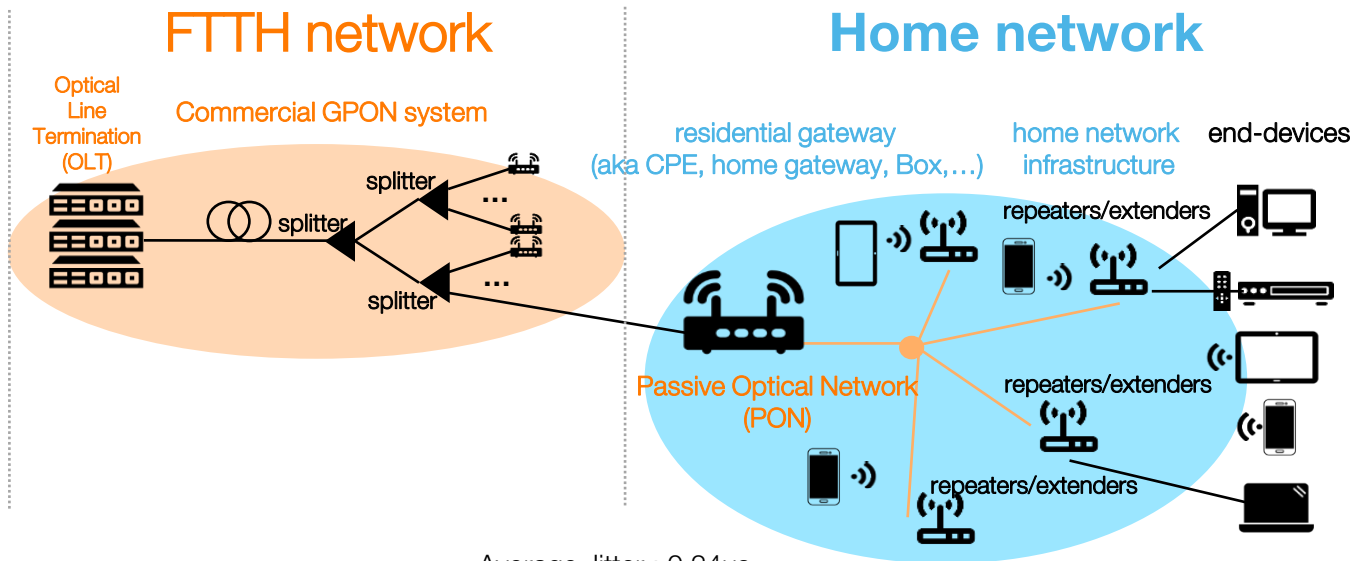
Home Wi-Fi motion detection for home security and assisted living for the elderly

**Bundle installation with FTTH** : connecting end-user devices to the Wi-Fi network **by the FTTH operational technicians**

**Remote operation and maintenance** from CO up to each access points (>60% users calls for complaints comes from Home Networks issues)

# FTTR evaluation : jitter measurements

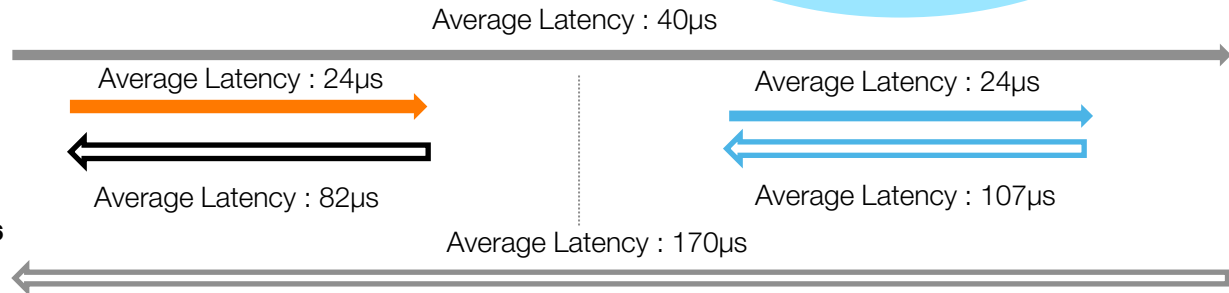
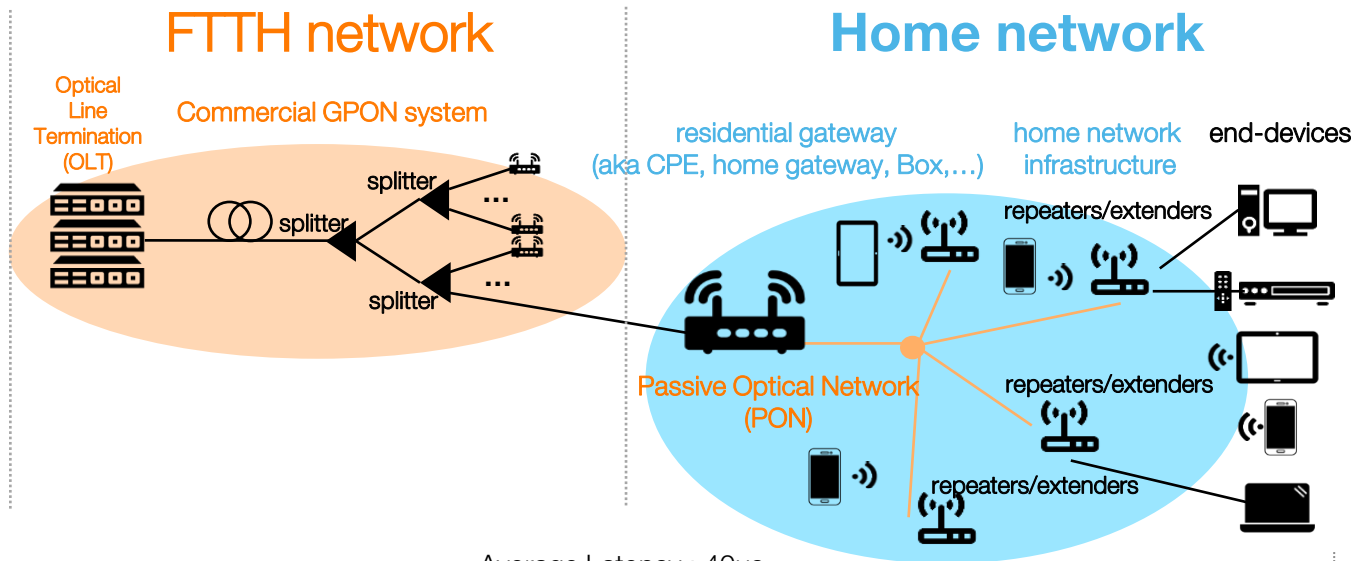
Measurement performed with commercial PON and FTTR systems with 1 ONU connected on each PON (DT=1, T-Cont type 1, 50 Mbit/s throughput , <50m reach)



➔ No/ Negligeable additional packet jitter due to cascading 2 PON systems for FTTH +FTTR

# FTTR evaluation : latency measurements

Measurement performed with commercial PON and FTTR systems with 1 ONU connected on each PON (DT=1, T-Cont type 1, 50Mbit/s throughput, <50m reach)

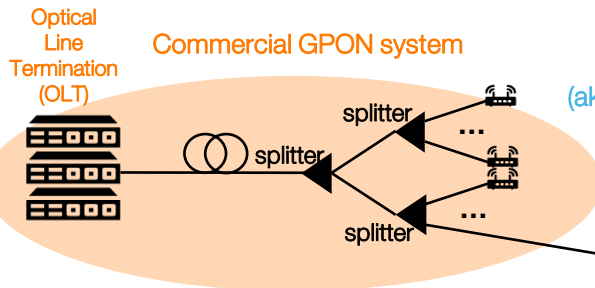


Latency depends on number of user connected  
for Wi-Fi 6 : 10 to 50ms  
For Wi-Fi7 : <20ms

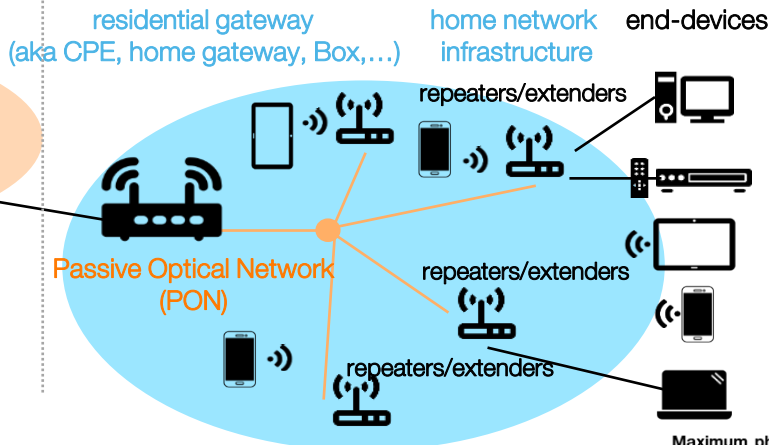
# FTTR evaluation : throughput, latency and jitter measurements

## Throughput of commercial PONs and FTTR systems

### FTTH network



### Home network



#### With GPON :

Line rate 2,5Gbit/s – Throughput 1Gbit/s max



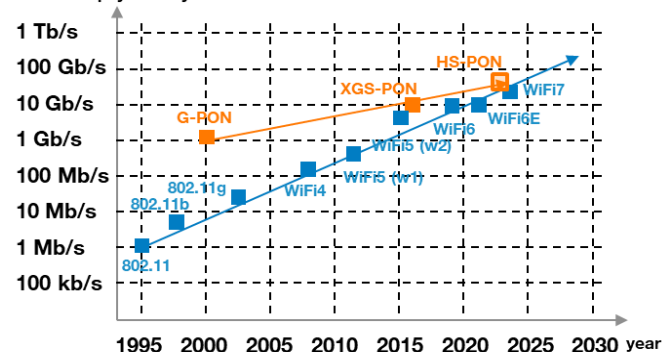
Line rate 1,25Gbit/s – Throughput 1Gbit/s max

Line rate 2,5Gbit/s – Throughput 1Gbit/s max



Line rate 1,25Gbit/s – Throughput 1Gbit/s max

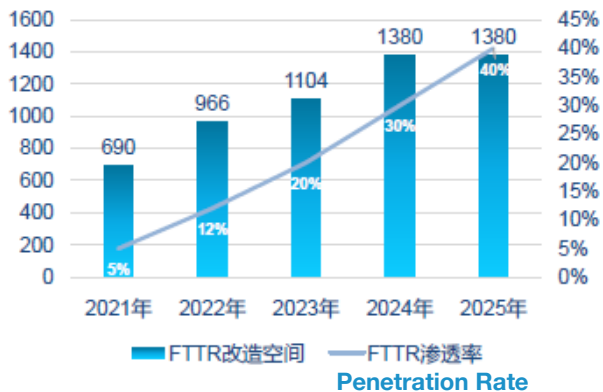
Maximum physical layer data rate



# FTTR market : for homes and small enterprises

FTTR solutions available with GPON, XGS-PON and PtP access networks

 FTTR forecast in Chinese Households



ITU-T recently published technical paper on "Use cases and requirements of fibre-to-the-room"

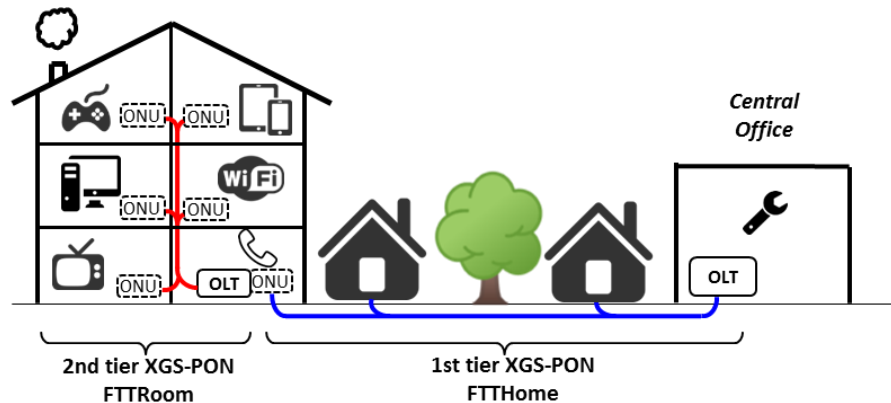
>400k FTTR already deployed in China

40% of the 460 millions houses with FTTR in 2025

FTTR is also a solution for small enterprises

16 FTTR ONUs max / FTTR gateway

Small enterprises (Hotel, restaurants, shared housing ...)





# Conclusions

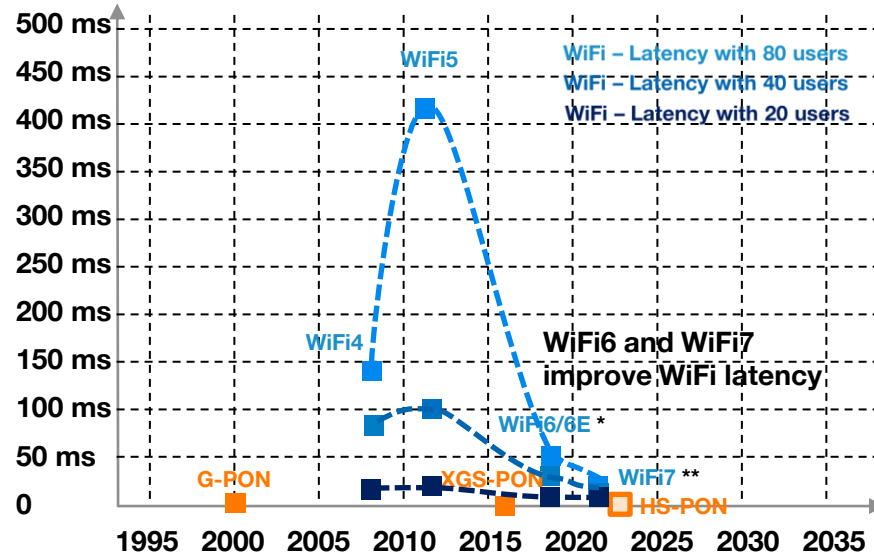
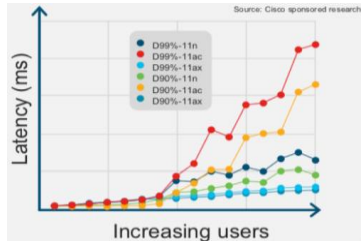
- 1** FTTR is an **emerging technology** for enhanced services
- 2** « **FTTH like** » experience for users & continuity of our field expertise **up to the rooms**
- 3** PON is the ideal companion of WiFi with an “ideal” in-house backhaul performance for jitter and latency.
- 4** Valorise and manage Wi-fi connectivity as the Home Operator

**Thank you !**  
**Merci**

# FTTH and WiFi companion technologies for throughput

Latency is not a driver for FTTRoom.

Source Cisco:



Without fiber, Latency PON D/S  $40\mu\text{s}$  & U/S  $<1\text{ms}$  ( $n \times 125\mu\text{s}$ )

\* OFDMA, preamble puncturing features

\*\* Multi-Link Operation (MLO)



# FTTH and WiFi companion technologies for throughput

## The main developments of WiFi

	WiFi 6 /6E	WiFi 7
Frequency	2.4 , 5 , 6 GHz	2.4 , 5 , 6 GHz
Maximum bandwidth	160 MHz	320 MHz
Best modulation	QAM 1024	QAM 4096
MIMO	8	16



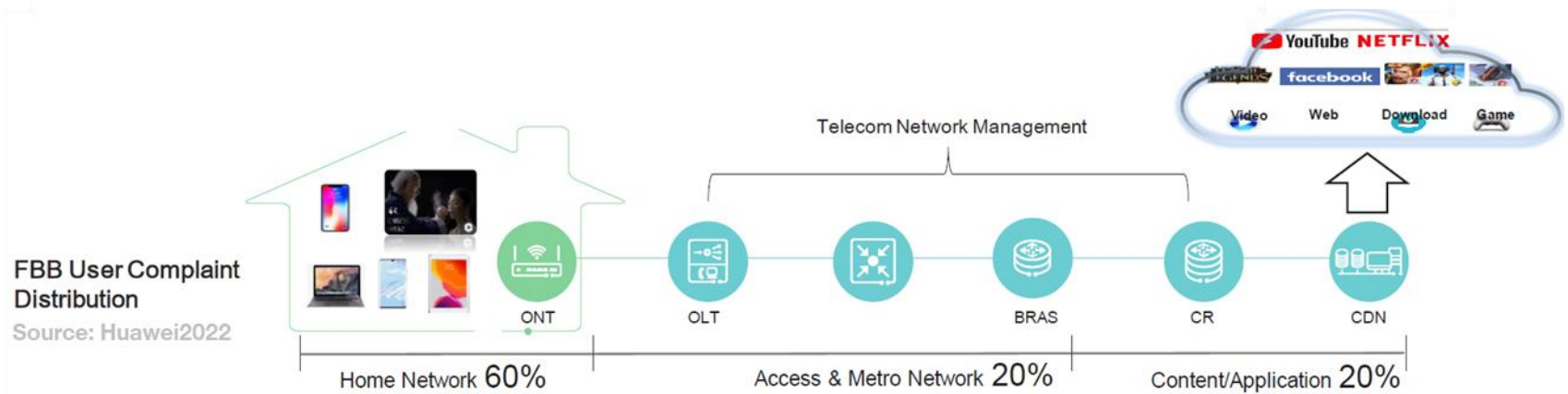
WiFi 7 is 20% more data rate close to the access point

	WiFi 6 /6E		WiFi 7		
Bandwidth	80 MHz	160 MHz	80 MHz	160 MHz	320 MHz
Maximum theoretical physical layer data rate	4.8 Gbps (8x8)	9.6 Gbps (8x8)	11.5 Gbps (16x16)	23 Gbps (16x16)	46 Gbps (16x16)
e.g. laptop → → → Maximum theoretical physical layer data rate (3x3:3)	1.8 Gbps	3.6 Gbps	2.1 Gbps	4.3 Gbps	8.6 Gbps
e.g. smartphone → → → Maximum theoretical physical layer data rate (2x2:2)	1.2 Gbps	2.4 Gbps	1.4 Gbps	2.8 Gbps	5.7 Gbps

Supported by G-PON

Supported by XGS-PON

# Managing Services up to all rooms from OLTs at Central Offices



**With FTTR :**

**More demarcations points** in Homes at the hand of operators for remote troubleshooting, fixing and optimization of home networks

**Management by the operators or/and by the users :**

**inherent to PON management layer or simplified (proprietary cloud management)**

# Building and in-home optical cabling

## Apparent installation on the wall

Refusal from some customers because of aesthetic reasons

→ New solution for a more aesthetic cabling

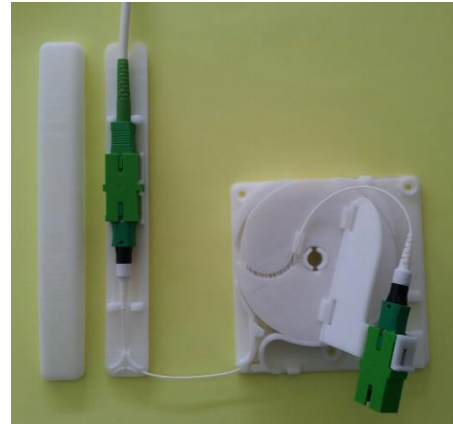
- 900 $\mu$ m cable connectorized at both sides
- Optical outlet with a wiring system to manage the overlength of cable
- Accessories to ensure a minimum bending radius in the corners and accessories to pass through the walls



Standard cable



900 $\mu$ m cable



Holes of installation on the wall or junction box

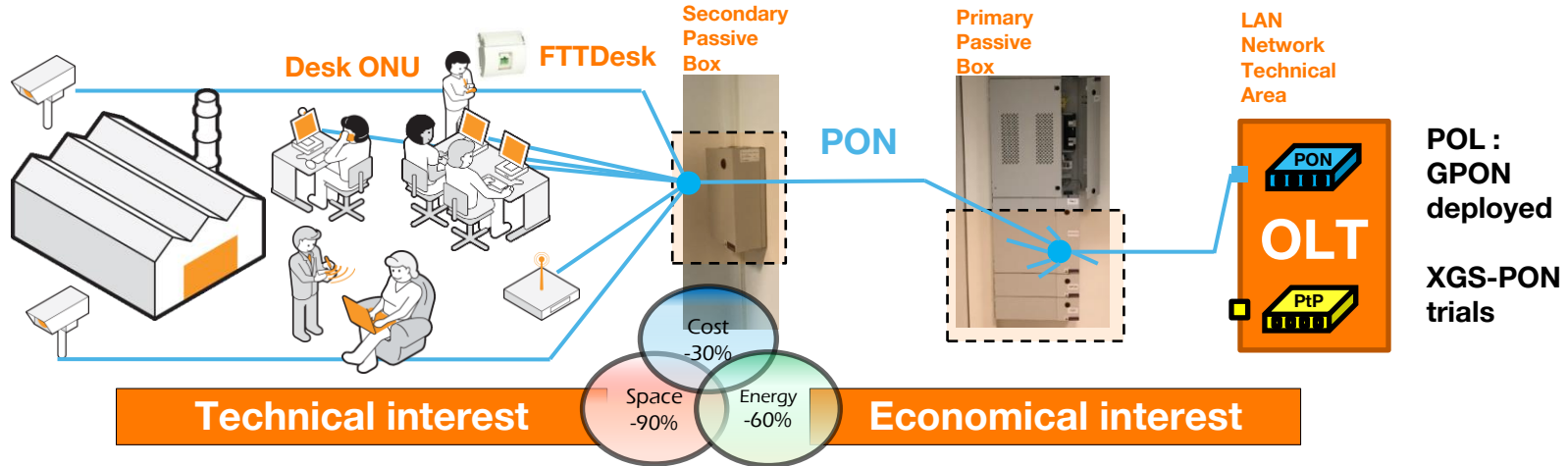


Standardisation in ITU-T Q18/SG15 for « In-premises Networking »

# Fiber for smart Cities & Factories: Passive Optical LAN (POL)



Deeper fiber to connect everything: Fiber inside the building with POL



- A **High reliable architecture** thanks to OLT redundancy, power supply, network card, PON interface redundancy (optical infrastructure redundancy, B-type)
- An easy way to manage solution with **centralized management**
- A **futureproof optical infrastructure** and a sustainable architecture for increase of the demanded bandwidth

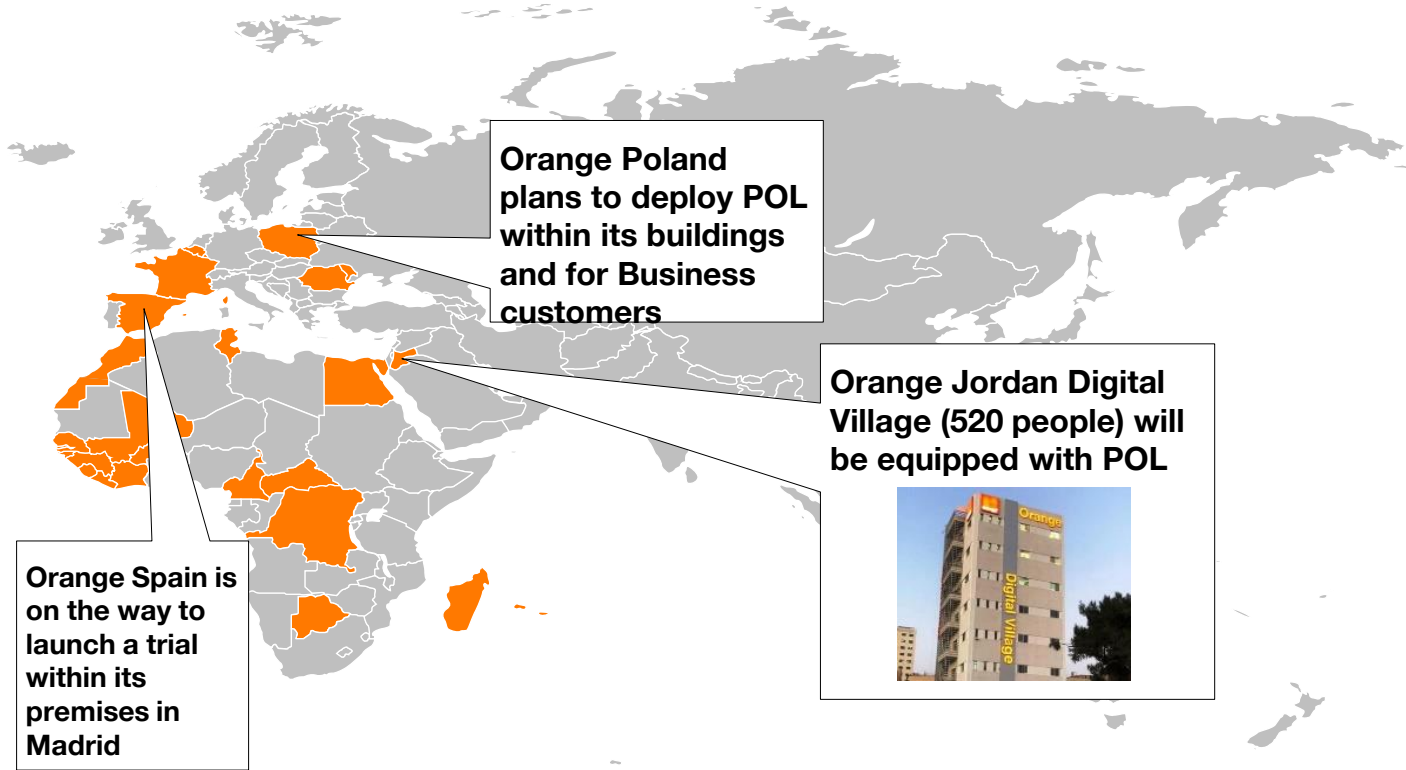
- Building Network Room simplified
- Floor Network Room suppressed: no need for cooling and powering
- Optimization of OPEX for powering, cooling, O&M
- **POL is Green: reducing the power consumption, using sustainable optical infrastructure**

# 2018, major Decision Orange France: all new large tertiary buildings will have a POL infrastructure





# Other Orange affiliates are also on the way to deploy POL...



## **FTTR**

**Cascading PONs**

**Designed for <16 terminations :  
Homes or FTTE**

**Limited to « gateway like » management**

**GPON or XGS-PON + GPON in home**

**or**

## **POL**

**Real Backhaul up to POL OLT + PON**

**Designed for 100s of terminations :  
FTTO, campus, Buildings**

**Service management by the on-site OLT**

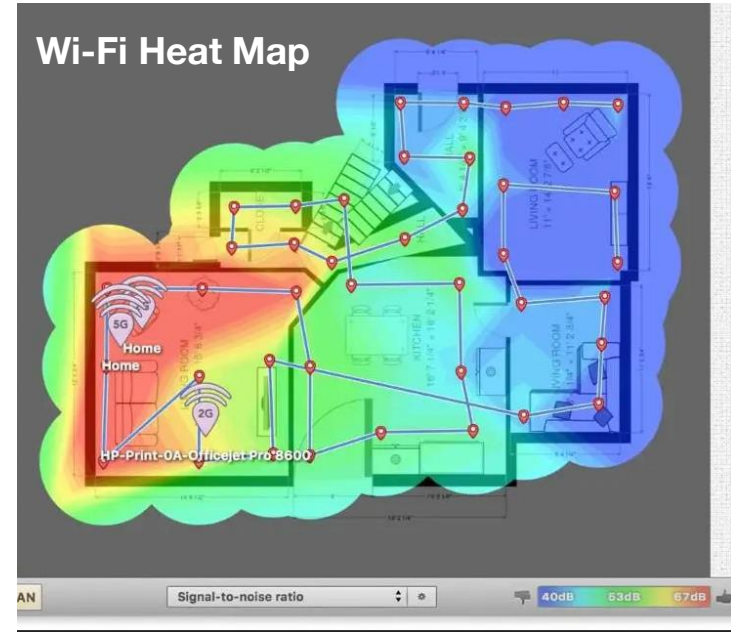
**Protection type B possible**

**XGS-PON POL available :  
8Gbit/s Ethernet to the desk**

# FTTR or WiFi ?

WiFi version	WiFi standards	Release time	Maximum rate	Operating frequency band
WiFi 6	IEEE 802.11ax	2019	11Gbps	2.4GHz or 5GHz
WiFi 5	IEEE 802.11ac	2014	1Gbps	5GHz
WiFi 4	IEEE 802.11n	2009	600Mbps	2.4GHz or 5GHz
WiFi 3	IEEE 802.11g	2003	54Mbps	2.4GHz
WiFi 2	IEEE 802.11b	1999	11Mbps	2.4GHz
WiFi 1	IEEE 802.11a	1999	54Mbps	5GHz
WiFi 0	IEEE 802.11	1997	2Mbps	2.4GHz

•For proper coverage, you may need Wi-Fi boosters



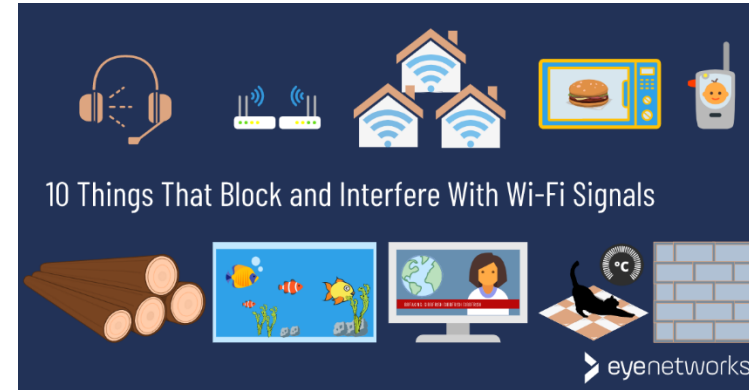
A general rule of thumb in home networking says that Wi-Fi routers operating on the **2.4 GHz band reach up to 46 m indoors** and 92 m outdoors. Older 802.11a routers that ran on 5 GHz bands reached approximately one-third of these distances

A general rule is that **if you double the distance between the router and client (or device), throughput decreases by one-third** of its original strength. Objects, such as metal or water, will also act as a signal block

# FTTR or WiFi ?

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WiFi 1	IEEE 802.11a	1999	54Mbps	5GHz
WiFi 0	IEEE 802.11	1997	2Mbps	2.4GHz

- Wireless connections are less secure
- For proper coverage, you may need Wi-Fi boosters
- Interference from other Wi-Fi connections or devices



A general rule of thumb in home networking says that Wi-Fi routers operating on the **2.4 GHz band reach up to 150 feet (46 m) indoors** and 300 feet (92 m) outdoors. Older 802.11a routers that ran on 5 GHz bands reached approximately one-third of these distances

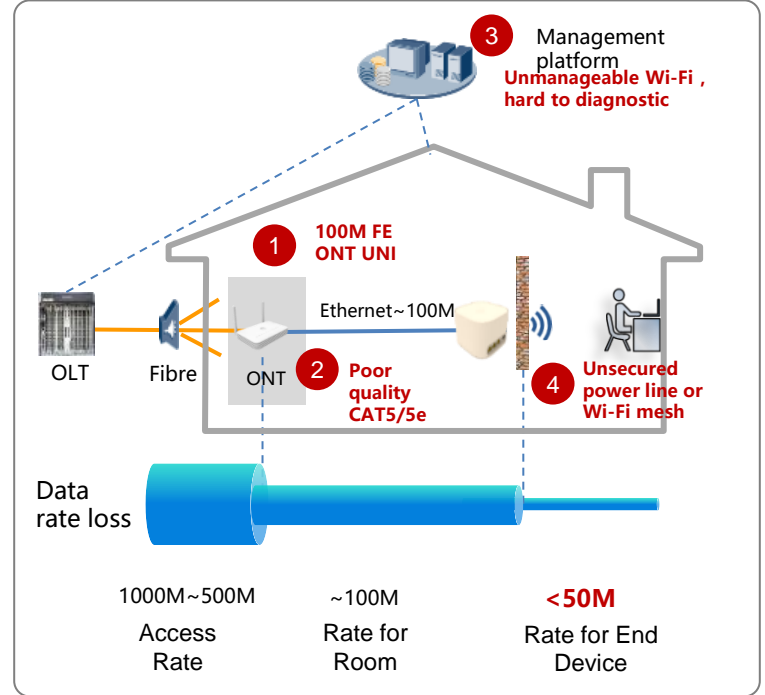
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# FTTR or Ethernet Cable

UTP Categories - Copper Cable

UTP Category	Data Rate	Max. Length	Cable Type	Application
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Ring & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)

In Homes  
→

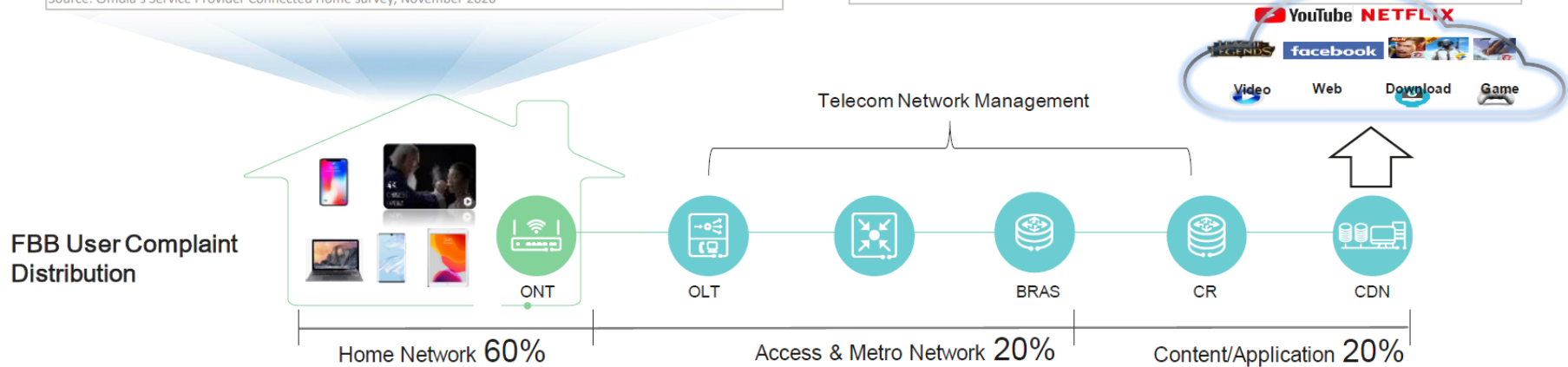
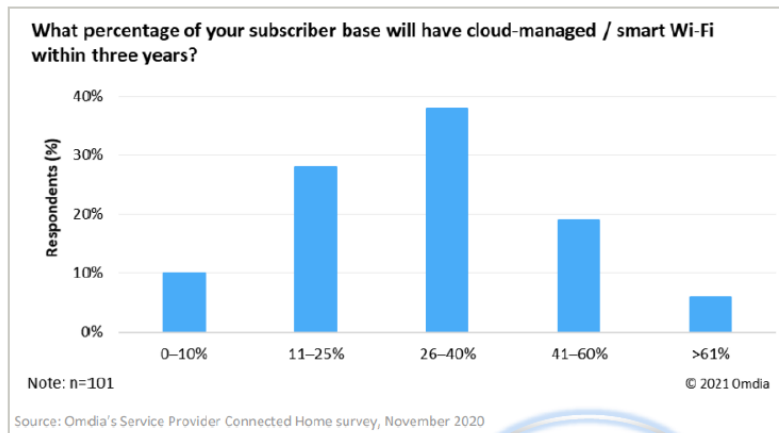
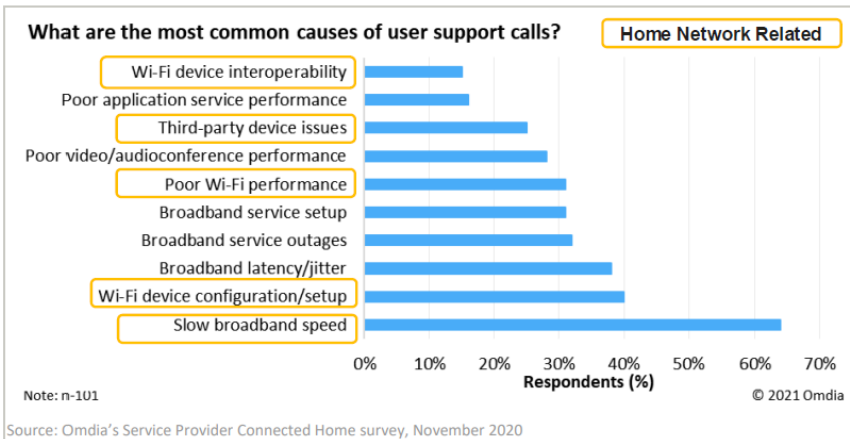


Take an example of FTTH in China, the optical Fibre is only to information box, access broadband is around 200M for 70% cases. However, the actual downloading average broadband is around **41Mbps (2020 Report of Broadband Development Alliance)**

# Merci



# Home network management become a necessity



# Home Local Area Networks (HAN)

## Home LAN requirements:

- Keep the throughput promise of FTTH everywhere at home
- High world wide connectivity (many network access points)
- Intra house connectivity (e.g. Network Attached Storage (NAS))
- Low latency (gaming, ...)
- Low cost
- Easy configuration (from both end user and service provider)

## Wi-Fi ? Copper ?

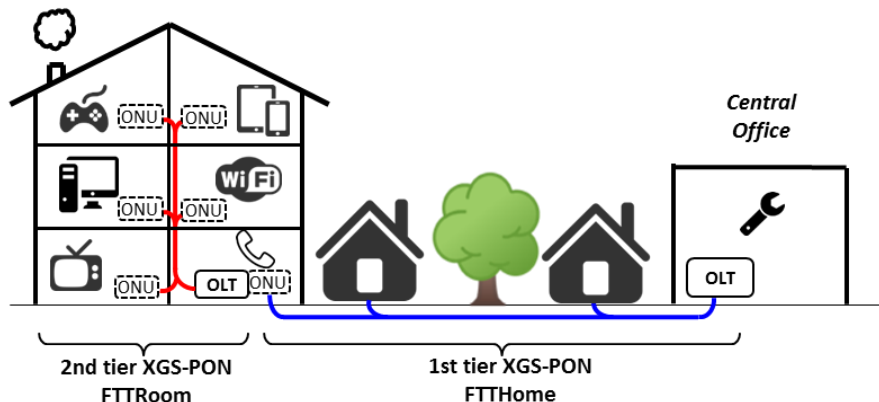
yes, but only for last meters, since bitrate is limited

- WiFi6 [IEEE 802.11ax; 2019]  
→ 10Gb/s over a few meters)
- WiGig [IEEE 802.11ad; 2009]  
→ 4,6Gb/s over a few meters ;  
mmWave)

## PON (Passive Optical Networks) ?

- low cost (mass market)
- mass connectivity (64 terminations)
- PON operating as an “in-house backbone” completed with Wi-Fi

Home Local Area Network (HAN):  
House, apartment, ...

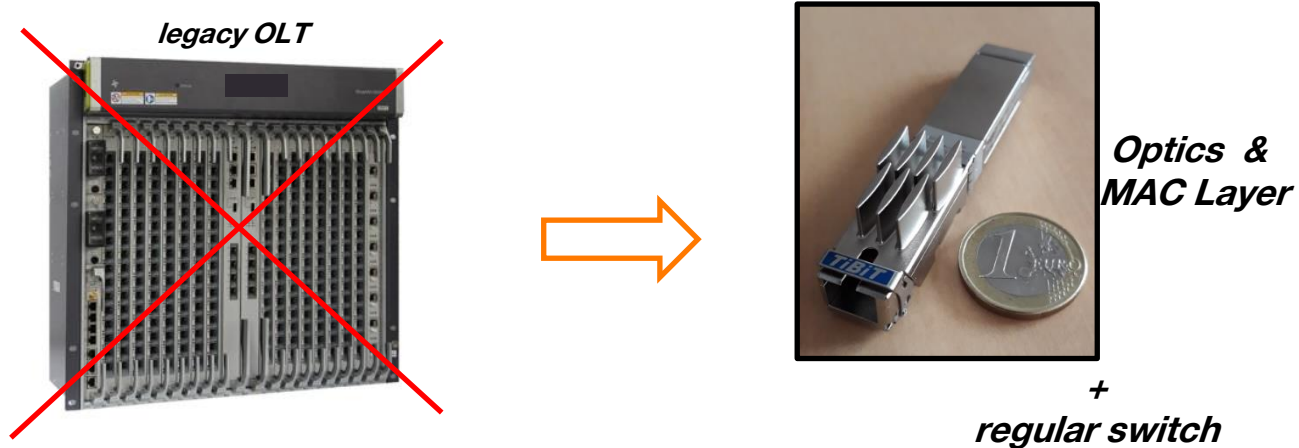




# Management of POL and HAN: PON virtualization

An OLT made of a regular switch and a « smart » SFP+:

- Get rid of traditionnal dedicated hardware (line cards, chassis)
- Modularization of the infrastructure, scalability
  - e.g. one SFP+ for Home LAN, several for POL
- Remote configuration
  - OLT interfaces management is performed in a virtualization environment
  - new protocol known as “ONU Management and Control Interface (OMCI) over Ethernet”



# Huawei FTTR Products

## Main ONT



### OptiXstar HG8141XR

GPON Uplink  
**Fiber downlink**  
4 GE ports  
Wi-Fi 6 2+2, 160MHz

TR5 2021Q4

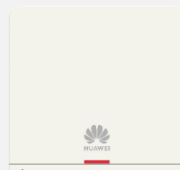
## Edge ONT



### OptiXstar K662d

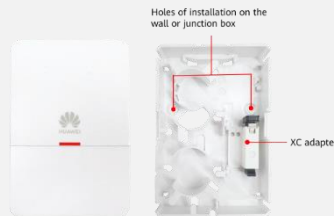
**Fiber Uplink**  
2 GE ports  
Wi-Fi 6 2+2, 160MHz

TR5 2021Q4



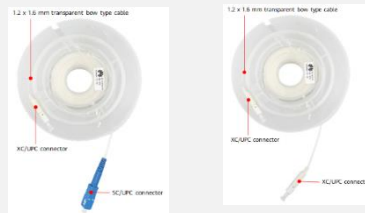
## Passive splitter

1:5 asymmetric:  
1 cascading port + 4 branch ports  
Up to 4-level cascading



## ATB

Supports storage of 4 m patch cords ( $\Phi 2$  mm).  
XC adapters  
No need for splicing.



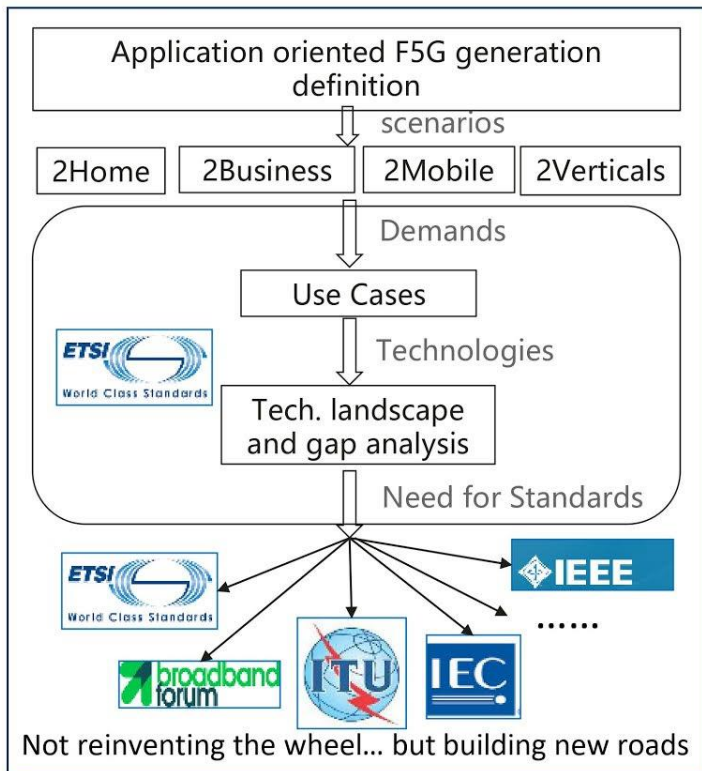
## Transparent Fiber

Invisible in open wire scenario  
Low bending radius  
Support hot melt glue

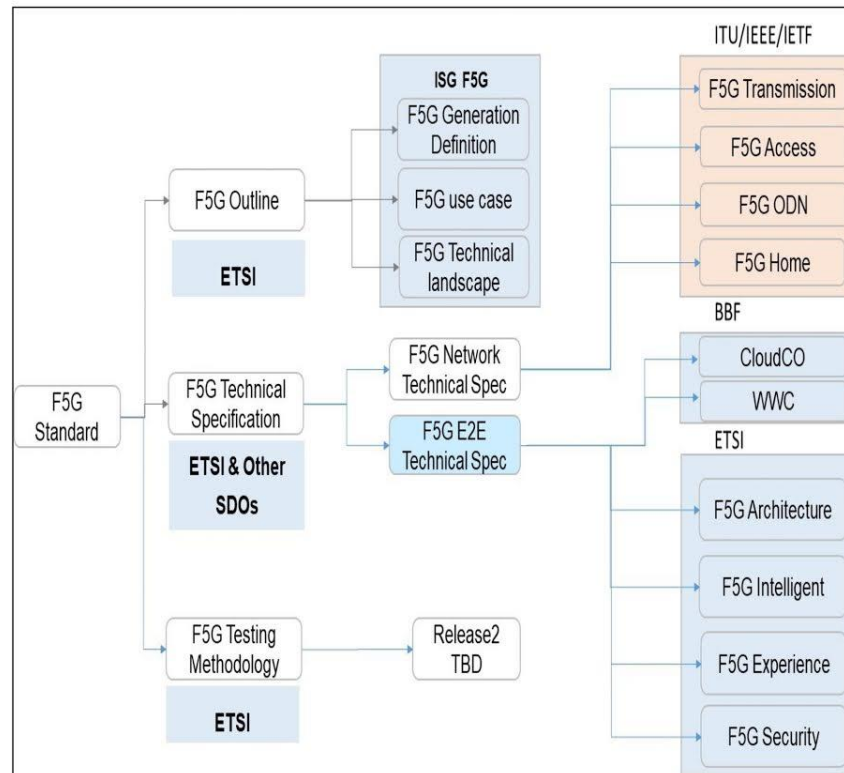
# Value Proposition of ISG F5G and its Approach to Standards



## ISG F5G as Portal

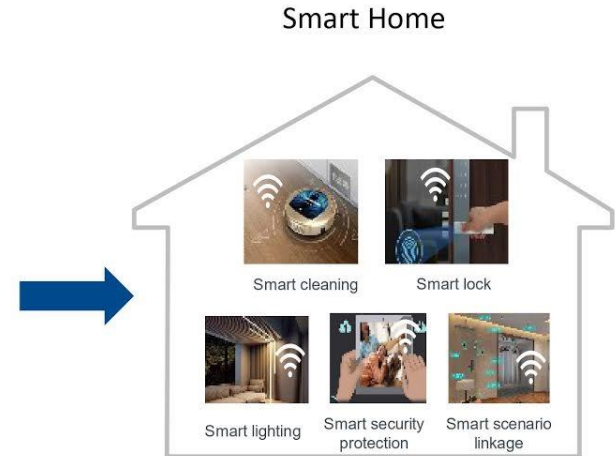
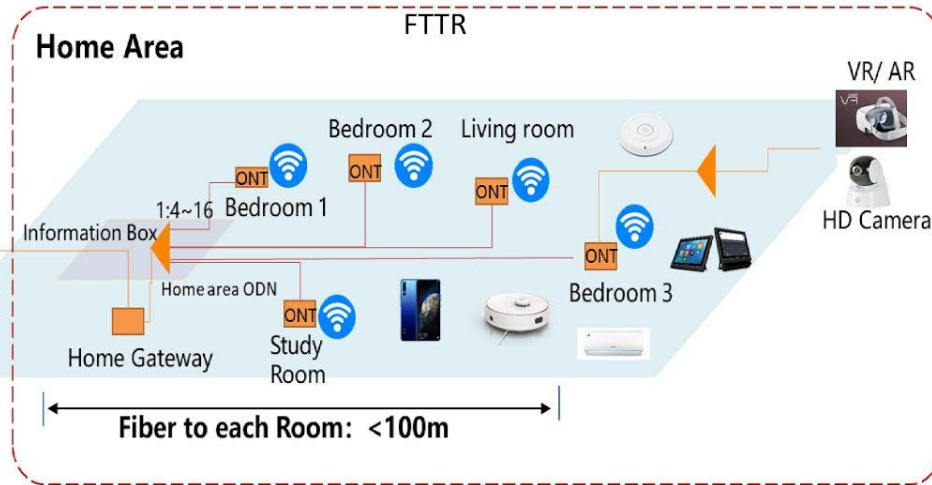


## F5G approach to Standards Overview



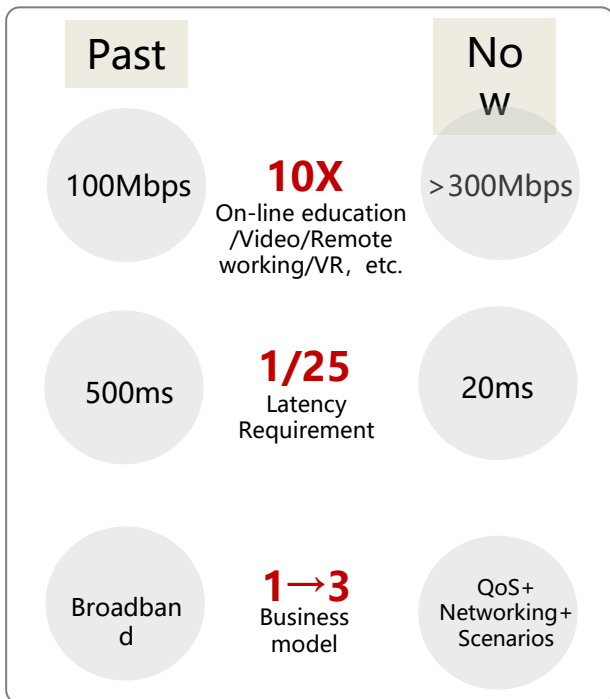
# Deep Dive of FTTRoom of ISG F5G

- Fiber on premises: future proof for bandwidth upgrade and lifetime (30years+)
- Bring Gbit/s to end-system with last few meters wireless
- Cascaded XG(S)-PONs (may upgrade with higher speed PON)
  - Shorter loop length (up to 1km) and less splitting ratio
  - Different cost structure (e.g. consumer)
- ONT: merged with WiFi for unified user experience and device compatibility
  - Lower wireless launch power, less interference, lower power
- Advanced feature:
  - Coordinative multi-AP with optimized experience through fibre (C-RAN like Wifi)
  - CPN Slicing

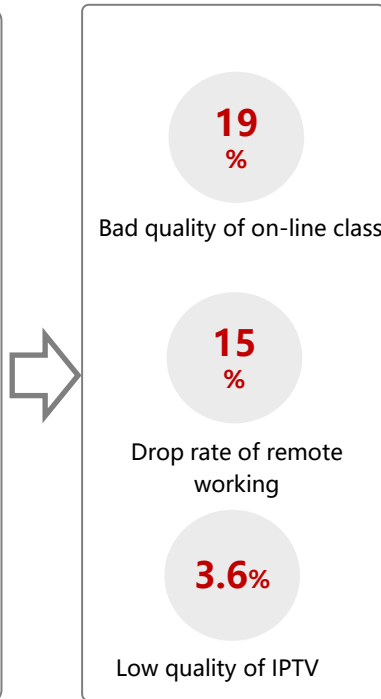


# Background—Bottlenecks in Giga Home Broadband

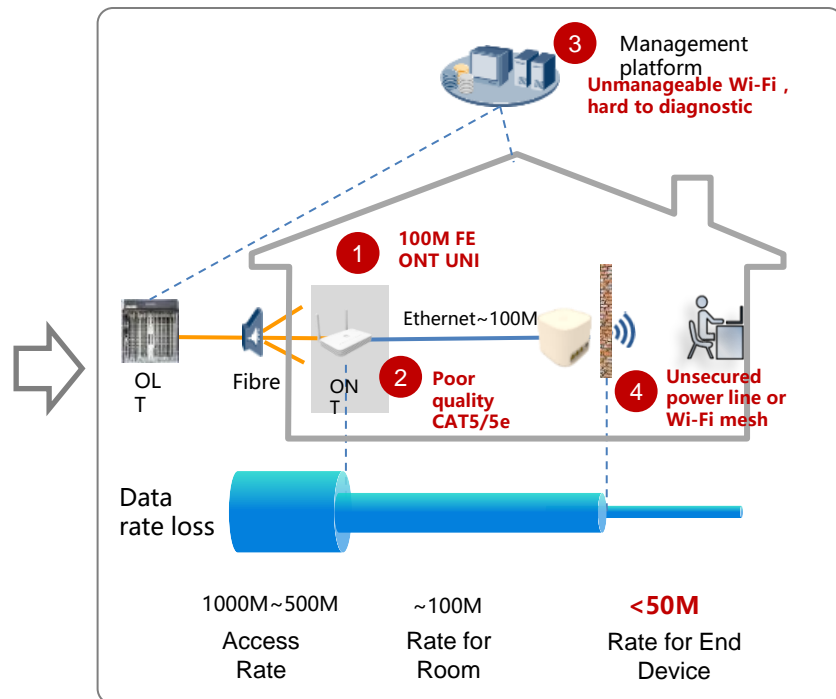
## Evolving Home Broadband Requirement



## Poor Experience under Current Home Network



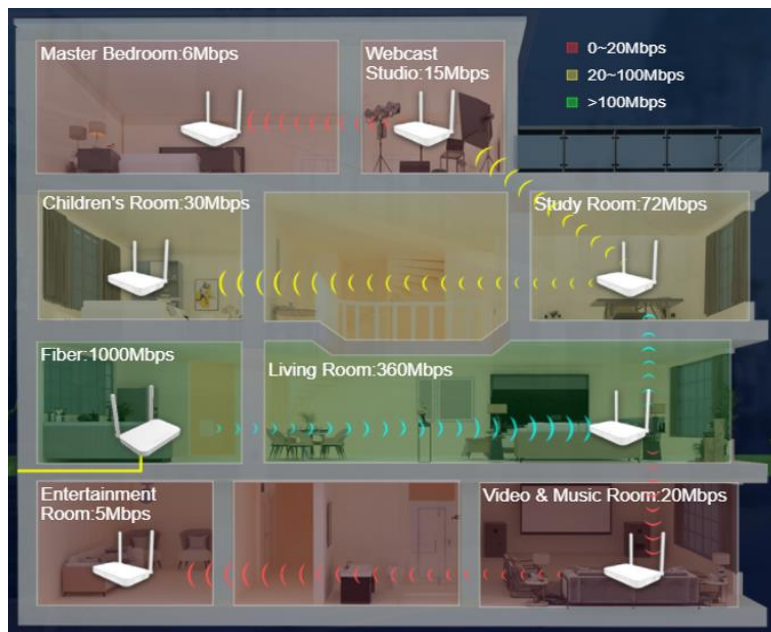
## 4 key factors affecting Giga Broadband experience



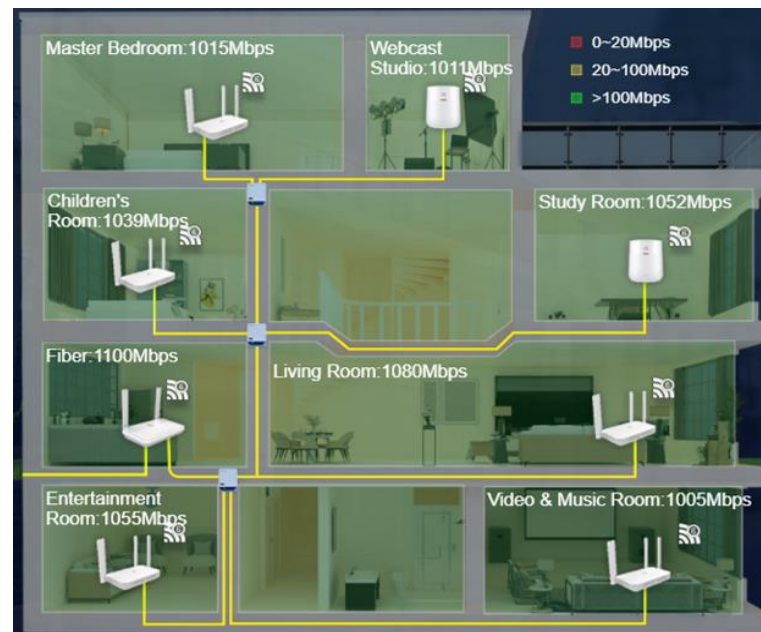
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# Wi-Fi Mesh and FTTR Comparison

## Wi-Fi Mesh



## FTTR



### Wi-Fi Cascading Loss

50% slower after each cascading

### Wi-Fi Attenuation Loss

80% slower cross floor  
60% slower cross concrete wall

>1 Gigabit to every room  
Seamless <100ms roaming



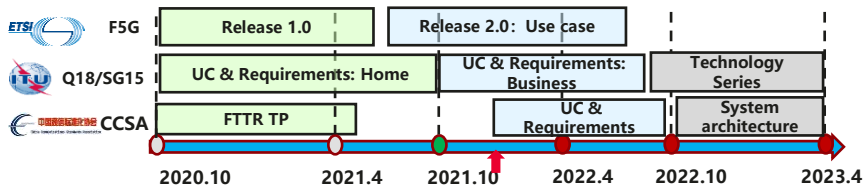
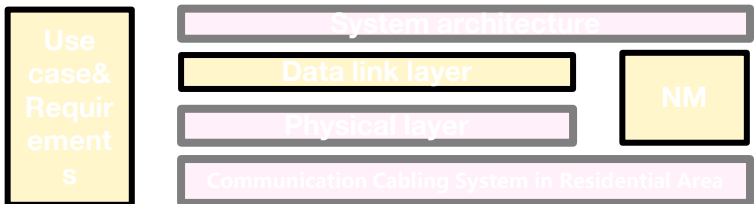
# Standards progress and challenges for fibre cabling in-premises

## ● ITU-T Q18 / SG15

FTTR (G.fin) series: Fibre based in-premises networking

Work item	Question	Subject/title	Timing	Study group	Study period
G.fin-DLL	Q18/15	High speed fibre-based in-premises transceivers – data link layer	2022-09	SG15	2017-2020
G.fin-NM	Q18/15	High speed fibre-based in-premises transceivers – network management	2022-09	SG15	2017-2020
G.fin-PHY	Q18/15	High speed fibre-based in-premises transceivers – physical layer	2022-09	SG15	2017-2020
G.fin-SA	Q18/15	High speed fibre-based in-premises transceivers – system architecture	2022-09	SG15	2017-2020

## ● CCSA TC6 WG2



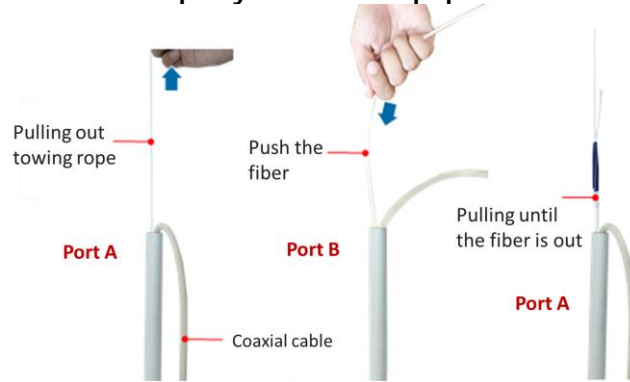
## Different cases of in-house wiring



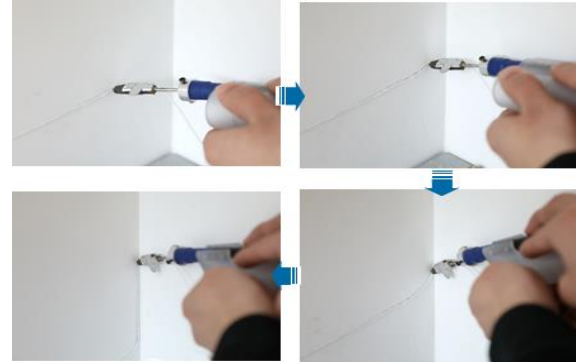
No recommendation and specification exists for in-house wiring, it is quite difficult to deploy fiber without breaking current infrastructure.

# Fiber deployment in home and business building is major challenge

## Fiber deployment via pipeline



## Invisible fiber cable deployment in home area



## Fiber deployment in business building



## AP devices deployment





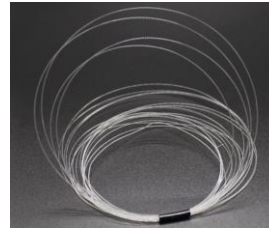
# Devices and tools for Fiber to The Room deployment



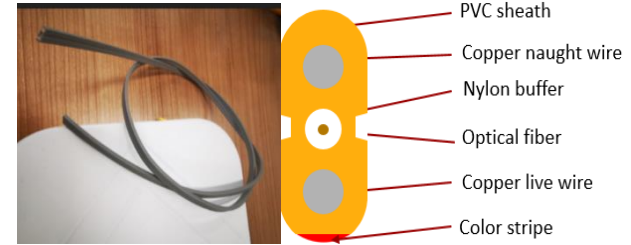
Optical socket



Fiber with small connector



Invisible Fiber



Optical and electrical hybrid cable



Pipe threader



Talcum powder



Fiber layout tool



Towing rope



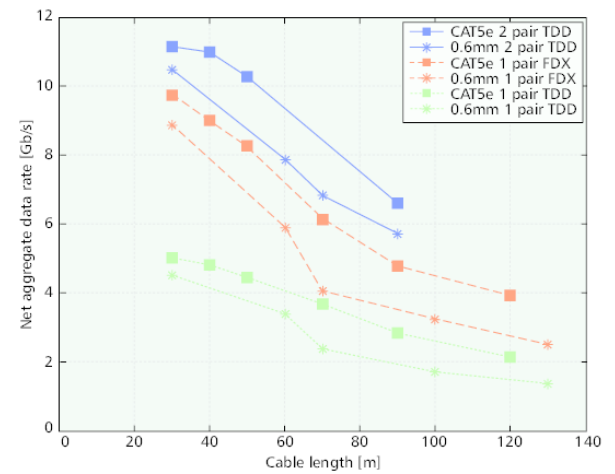
Laser pointer

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**Devices and tools for Fiber to The Room deployment are different from outdoor deployments.**

# FTTR or Ethernet Cable

UTP Categories - Copper Cable				
UTP Category	Data Rate	Max. Length	Cable Type	Application
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Ring & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)



Source : Werner Coomans, « XG-fast: the 5th generation broadband », December 2015, IEEE Communications Magazine 53(12):83-88, DOI:10.1109/MCOM.2015.7355589