ITUWebinars

Fourth Joint ETSI ISG F5G, BBF, CCSA TC6 and ITU-T SG15
Workshop on "FTTR"
(Fibre-to-The-Room)

10 July 2024
14:00 – 18:00 CEST
Montreal, Canada

https://itu.int/go/FTTR-4

FTTR : Fiber To The Room
Move forward (fiber) broadband coverage in the home LAN

P. Chanclou, S. Le Huerou, H. Le Bras, J-Y Cloarec, F. Saliou, Olivier Bouffant
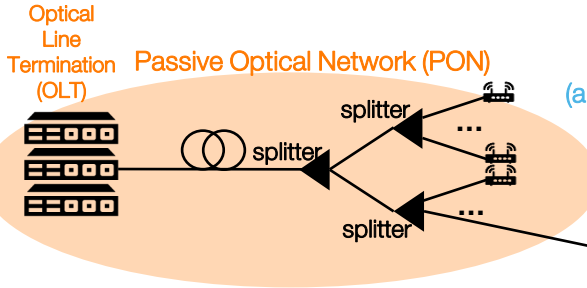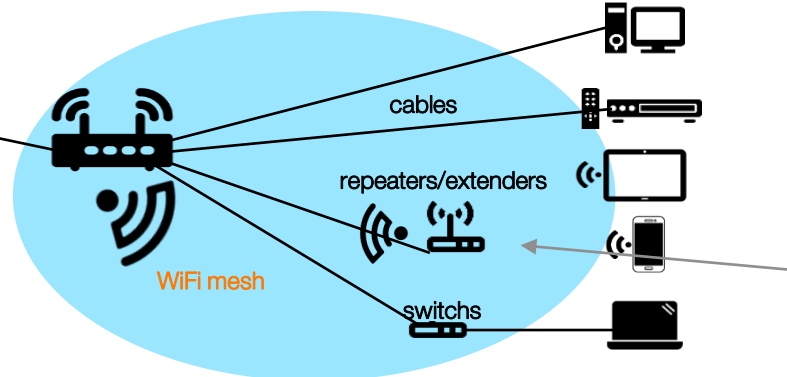
Orange Innovation Networks,

The 10th July 2024

orange™

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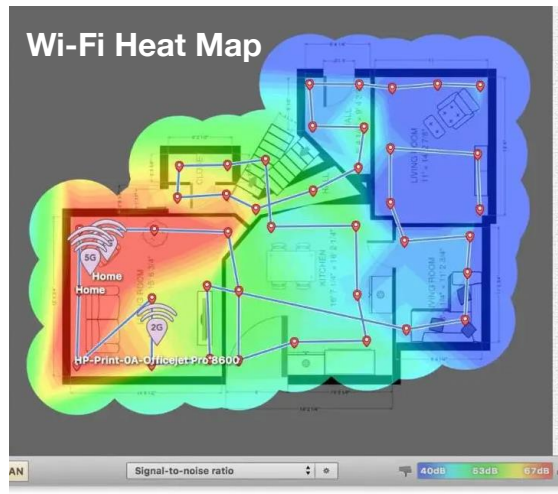# What role does the **smart connectivity at home** have in telco strategy

FTTH network

Home network

Optical Line Termination (OLT)

Passive Optical Network (PON)

splitter

splitter

splitter

...

...

residential gateway
(aka CPE, home gateway, Box,...)

home network infrastructure

end-devices

WiFi mesh

cables

repeaters/extenders

switchs

Power Line Comm.

Ethernet cable (Cat. 5/6)

WiFi extender

For proper coverage, you may need Wi-Fi Extenders

Wi-Fi Heat Map

Signal-to-noise ratio   40dB 53dB 67dB

What role does the smart WiFi have in telco strategy

Key benefits of Orange Smart Wi-Fi solution

Improve the Wi-Fi of the customer with the best throughput
✓ The gateway is always on the best Wi-Fi channel (Automatic Channel Selection algorithm) by periodically scanning Wi-Fi environment
✓ Devices are automatically put on the best Wi-Fi band (Band Steering algorithm)
✓ IPTV service over Wi-Fi is protected

Extend Wi-Fi coverage at home with a Wi-Fi repeater
✓ Orange Smart Wi-Fi solution is integrated in the Wi-Fi repeater
✓ Devices are automatically put on the best Wi-Fi access point (Client Steering algorithm) in order to provide the best throughput
✓ Seamless roaming between access points: fast roaming, without service interruption

MESH Wi-Fi system to create an optimal Wi-Fi coverage
✓ Adapt the number of Wi-Fi repeaters to customer's home (up to 4 repeaters)
✓ The topology of Wi-Fi repeaters is automatic & dynamic : best access point connection
✓ Compatible with IPTV and VoWi-Fi services
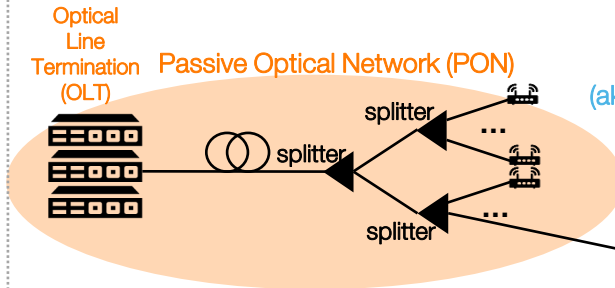✓ The Smart Wi-Fi system has a global view to

Offer the best user experience
✓ Wi-Fi repeater easy to install: push button pairing
✓ One Wi-Fi network (same name & security key) for all the access points, with auto-configuration
✓ Mobile application, to help the user to install and find a good position for the repeater
✓ Home network map and status available to the customer
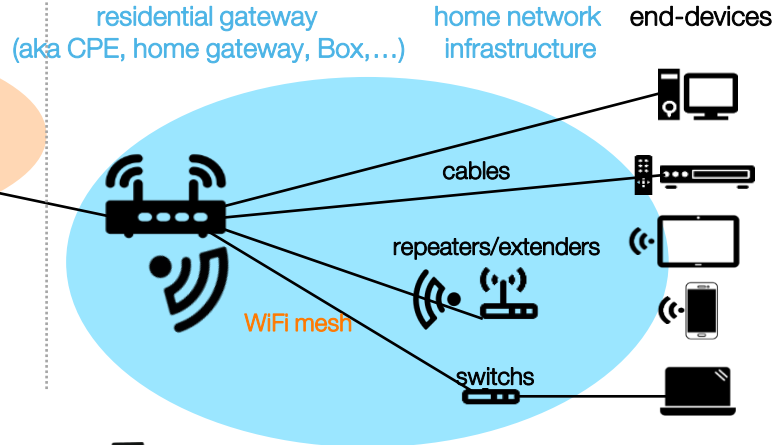✓ Lot of data are available to evaluate and improve the solution

What role does the smart connectivity at home have in telco strategy

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home network infrastructure

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cables

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WiFi mesh

switchs

Vendor OLT-A
Vendor OLT-A (new card/shelf)
Vendor OLT-B
Vendor OLT-C

Vendor Gateway-D
Vendor Gateway-E
Vendor Gateway-F
Vendor Gateway-G
Vendor Gateway-H

Vendor WiFi Extender-I
Vendor WiFi Extender-J
Vendor WiFi Extender-K
Wifi Extender not sourced by Telco-L/M….

Example of combinatory OLT/Gateway/Wifi Extender by footprint (country):		
≈ 2 OLT vendors	≈ 4 fiber Gateway vendors	≈ 2 WiFi extender vendors
≈ 6 to 8 OLT cards / shelfs	≈ 12 Gateway products	≈ 3 WiFi extender products

Interoperability is a must to support multi-vendors and multi-versioning operations

Fiber for smart Home: Optical Home LAN

An ideal WiFi backhauling of several WiFi Extenders : limit RF interference and optimize spectrum resource allocation.

Optical Home LAN connectivity: PtP and PON technologies are the relevant technologies. We must have a perennial Home LAN infrastructure (fiber) permitting higher throughput in the future.

Smart WiFi is still a must for **Home LAN.** For Orange, the smart WiFi ecosystem is home-based to achieve the HomeLAN excellence. Smart WiFi must rely on WFA EasyMesh.

Optical Home LAN interoperability :

- FTTRoom existing deployments [2022 – 2025?] : preliminary business:

- Necessary to install ONU-WiFi Extender from same vendor as FTTH fiber Gateway

-To address mass market Optical Home LAN deployment, we need to decrease prices and reduce vendors dependency:

- Interoperability based standard specification, the key word for sourcing and to respond to increasing volume demands

- Multi-source purshases

- Open to telco's ecosystem (Management, Smart Wi-Fi ...) for Home LAN

Fiber for smart Home: Optical Home LAN

The prpl's open-source based residential gateway software allows to achieve a reliable and innovative Home LAN. It could also simplify the management of combinations and the optimization of the different equipment connected to the Home LAN.

So, it is obvious that Optical Home LAN should be supported connectivity by prpl specification to ease of use.

Management:

BBF TR-069 & TR-181 data model must describe the specific component objects for such devices connectivity

Interoperability:

- Optical Home LAN based on PON must be certified as "BBF.247" with potential adaptations

- Optical Home LAN based on PtP must support ITU-T G.986 & 9806 with PLOAM and OMCI optionally
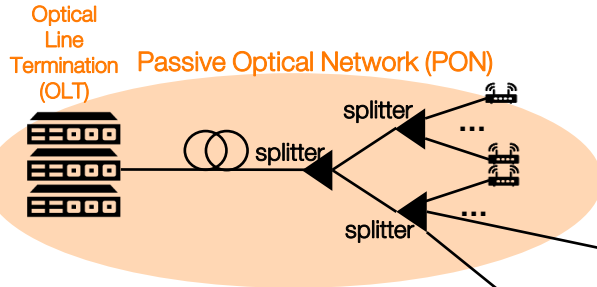
Energy efficiency:

Optical Home LAN (PtP and PON) must support the ITU-T G.suppl.45 mechanisms

Fiber infrastructure : We need to define a single optical fiber connector type. Do we need specific connector for power over optical cable?
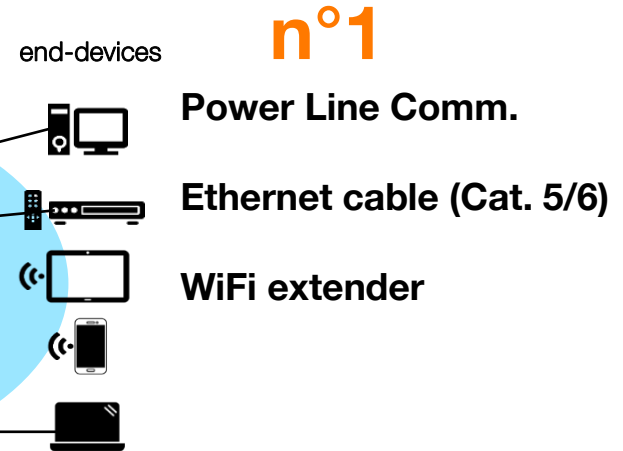
What role does the smart connectivity at home have in telco strategy
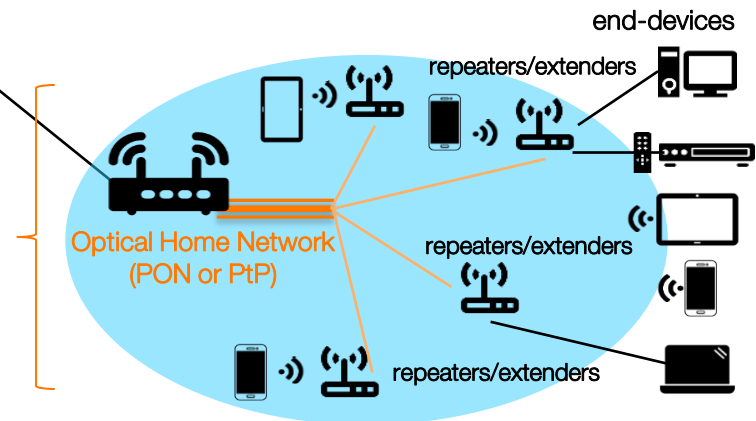
FTTH network

Optical Line Termination (OLT)

Passive Optical Network (PON)

splitter

splitter

splitter

...

...

FTTH with GPON or XGS-PON

Home network

n°1

end-devices

cables

repeaters/extenders

switchs

Power Line Comm.

Ethernet cable (Cat. 5/6)

WiFi extender

n°2

end-devices

repeaters/extenders

repeaters/extenders

repeaters/extenders

Optical Home Network (PON or PtP)

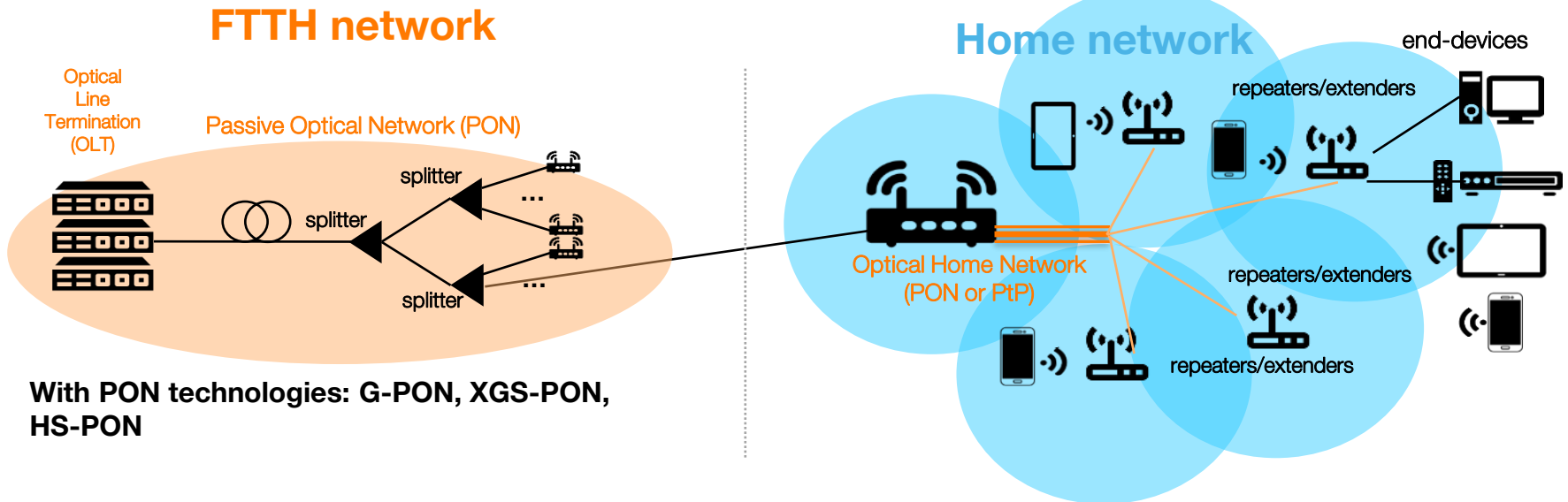**Gateway :** OLT (PON or PtP) **functions included** in the residential gateway

Fibre plant : Optical Home LAN optical fibre

Several Wi-Fi extenders **with the benefits of a fibre backhaul**

Coverage

Home LAN connectivity and WiFi coverage

FTTH network

Optical Line Termination (OLT)

Passive Optical Network (PON)

splitter

splitter

splitter

...

...

With PON technologies: G-PON, XGS-PON, HS-PON

Home network

end-devices

repeaters/extenders

repeaters/extenders

repeaters/extenders

Optical Home Network (PON or PtP)

To achieve an efficient WiFi coverage, we need several WiFi extenders with an ideal backhaul connectivity through a Home LAN infrastructure : PtP or PtMP topologies

Building and in-home optical cabling

Apparent installation on the wall

Refusal from some customers because of aesthetic reasons

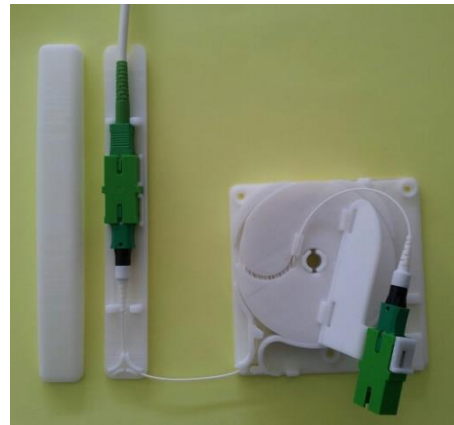> **➔ New solution for a more aesthetic cabling**

- **900µm 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**
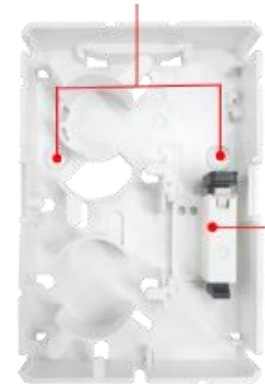

Standard cable   **900µm cable**
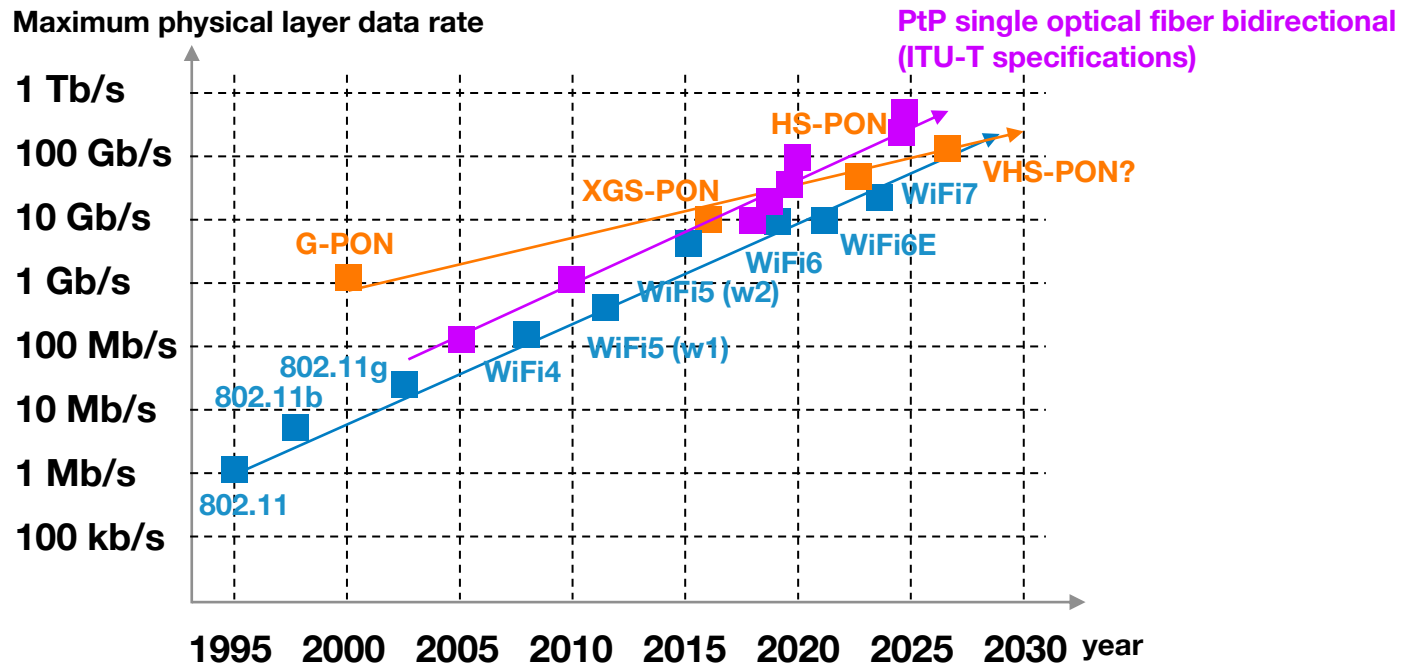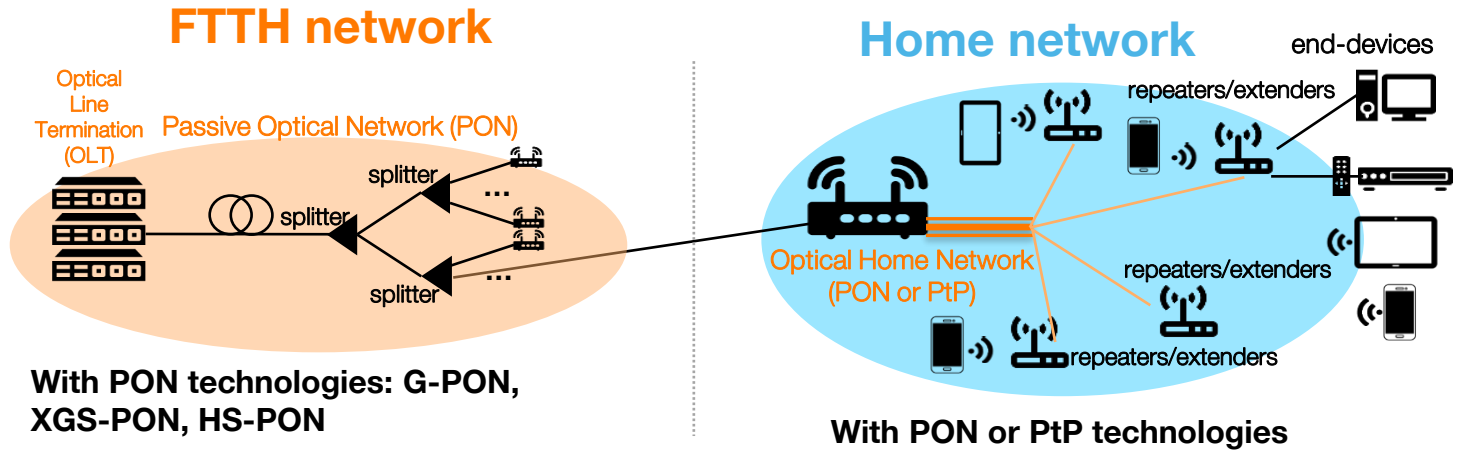
Holes of installation on the wall or junction box

XC adapter

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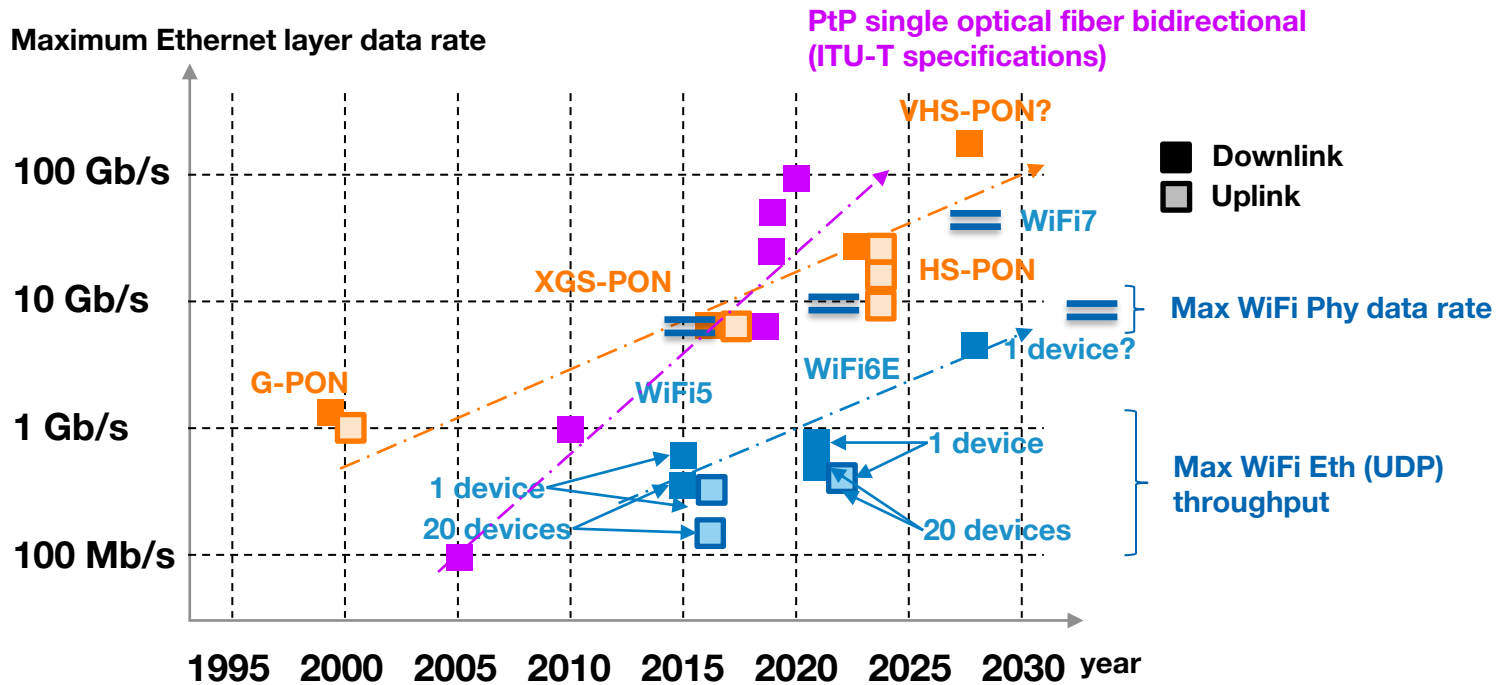
Data rates

PON, PtP and WiFi maximum data rates

FTTH network

Optical Line Termination (OLT)

Passive Optical Network (PON)

splitter
splitter
splitter
...
...

With PON technologies: G-PON, XGS-PON, HS-PON

Home network

end-devices
repeaters/extenders
repeaters/extenders
repeaters/extenders

Optical Home Network (PON or PtP)

With PON or PtP technologies

Maximum physical layer data rate

PtP single optical fiber bidirectional (ITU-T specifications)

- 1 Tb/s
- 100 Gb/s — HS-PON
- 10 Gb/s — XGS-PON — VHS-PON?
- 1 Gb/s — G-PON
- 100 Mb/s
- 10 Mb/s
- 1 Mb/s
- 100 kb/s

WiFi7, WiFi6E, WiFi6, WiFi5 (w2), WiFi5 (w1), WiFi4, 802.11g, 802.11b, 802.11

1995 2000 2005 2010 2015 2020 2025 2030 year

PON and WiFi maximum Ethernet throughput

FTTH network

Optical Line Termination (OLT)

Passive Optical Network (PON)

splitter

splitter

splitter

With PON technologies: G-PON, XGS-PON, HS-PON

Home network

end-devices

repeaters/extenders

Optical Home Network (PON or PtP)

repeaters/extenders

repeaters/extenders

With PON or PtP technologies

Maximum Ethernet layer data rate

PtP single optical fiber bidirectional (ITU-T specifications)

VHS-PON?

100 Gb/s

XGS-PON

10 Gb/s

WiFi7

HS-PON

Downlink
Uplink

Max WiFi Phy data rate

1 device?

G-PON

WiFi5

WiFi6E

1 Gb/s

1 device

Max WiFi Eth (UDP) throughput

1 device

20 devices

20 devices

100 Mb/s

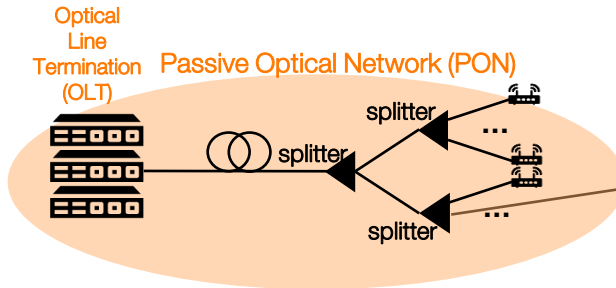1995 2000 2005 2010 2015 2020 2025 2030 year

The number of antennas on the WiFi device side has a great impact : you can double the throughput with a device with two antennas (2x2) compared with a device with one antenna (1x1)
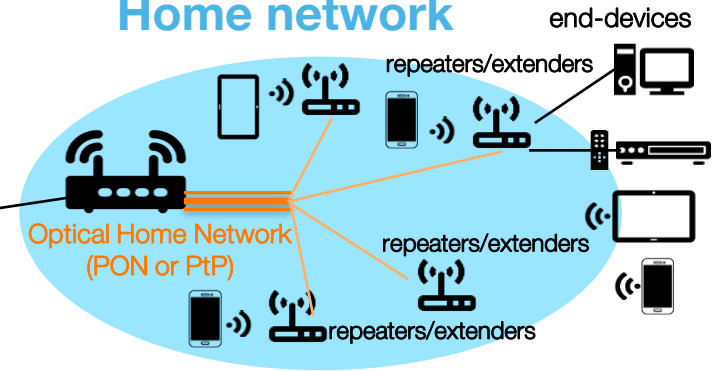
PON and WiFi maximum Ethernet throughput

FTTH network

Optical Line Termination (OLT)

Passive Optical Network (PON)

splitter

With PON technologies: G-PON, XGS-PON, HS-PON

Home network

end-devices

repeaters/extenders

Optical Home Network (PON or PtP)
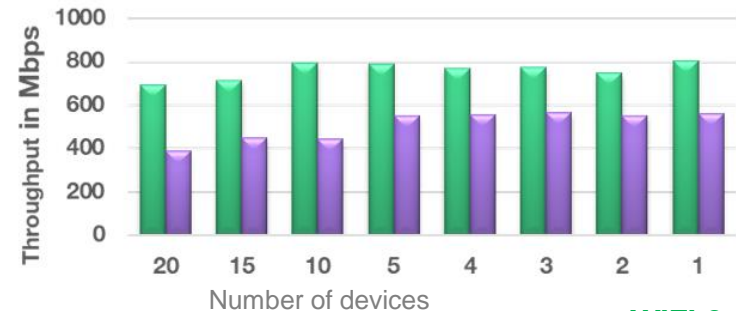
repeaters/extenders

repeaters/extenders

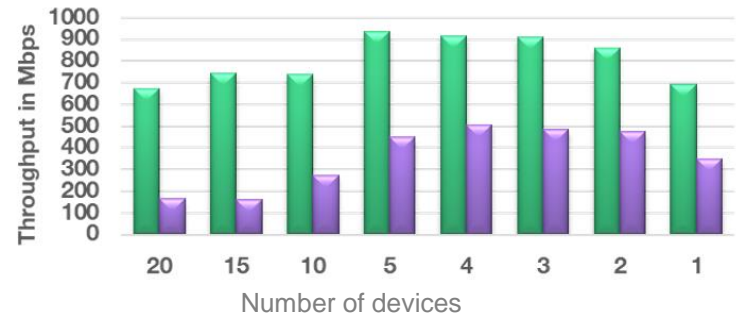**With PON or PtP technologies**

WiFi traffic load measurements (device with 2 spatial streams) : nearly constant with WiFi 6

Downlink

Throughput in Mbps

Number of devices

WiFi 6
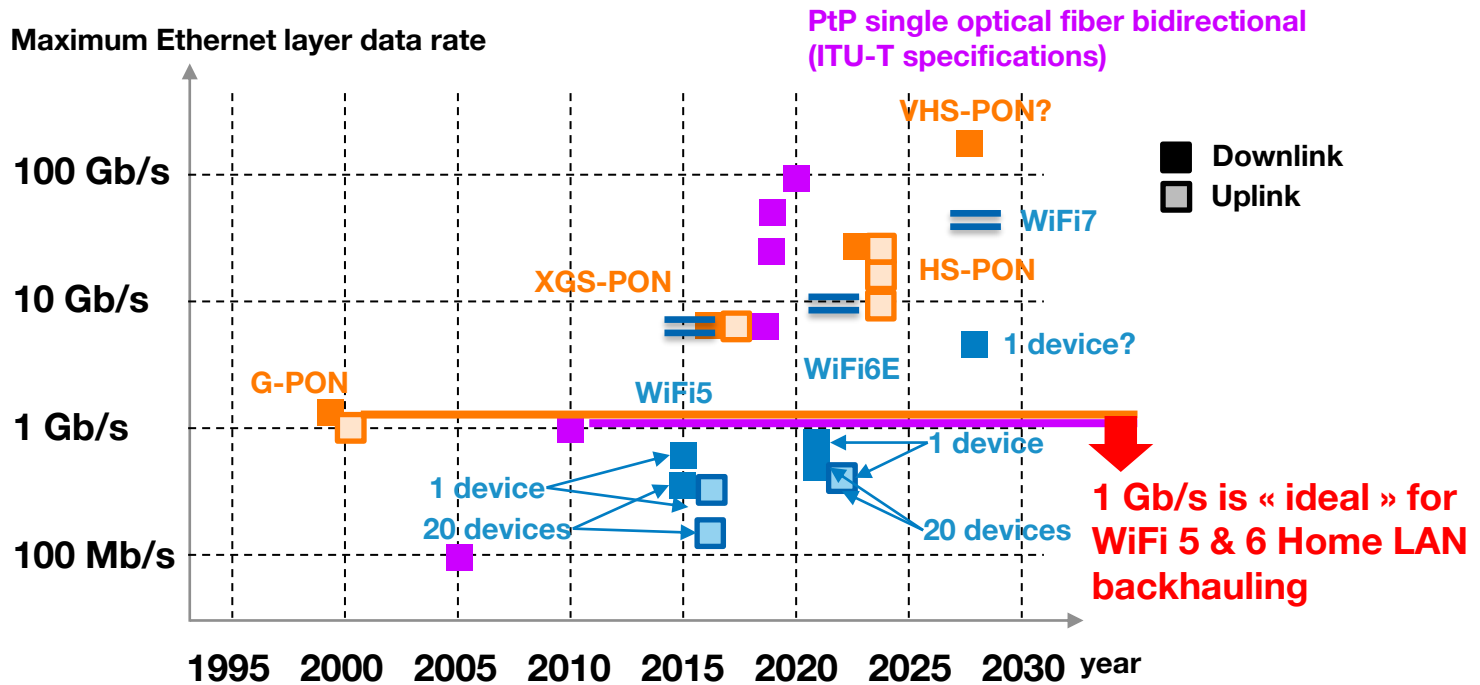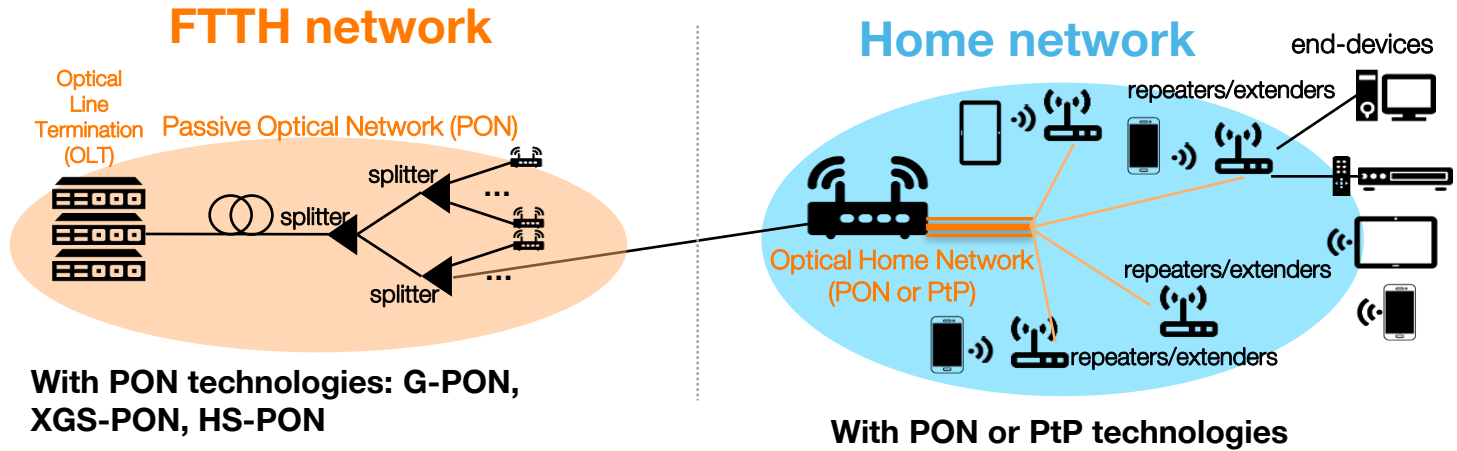**WiFi 5**

Uplink

Throughput in Mbps

Number of devices

PON and WiFi maximum Ethernet throughput

The number of antennas on the WiFi device side has a great impact : you can double the throughput with a device with two antennas (2x2) compared with a device with one antenna (1x1)
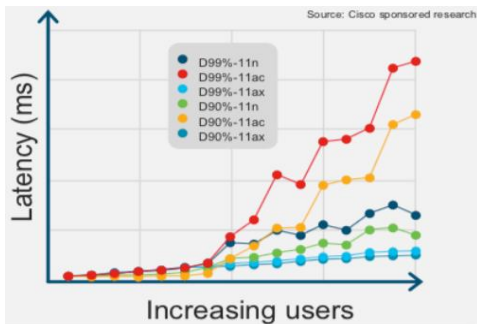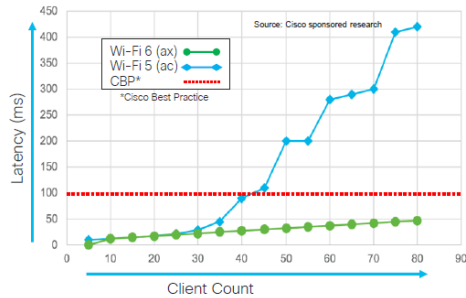
Latency

WiFi latency and jitter

Source Cisco:

WiFi KPI Jitter:

<20 ms   : good
20-40 ms : acceptable
>40 ms   : poor

WiFi – Latency with 80 devices
WiFi – Latency with 40 devices
WiFi – Latency with 20 devices

Latency

500 ms
450 ms
400 ms
350 ms
300 ms
250 ms
200 ms
150 ms
100 ms
50 ms
0

WiFi5
WiFi4
WiFi6/6E *
WiFi7 **

WiFi6 and WiFi7 improve WiFi latency

1995 2000 2005 2010 2015 2020 2025 2030 2035
year
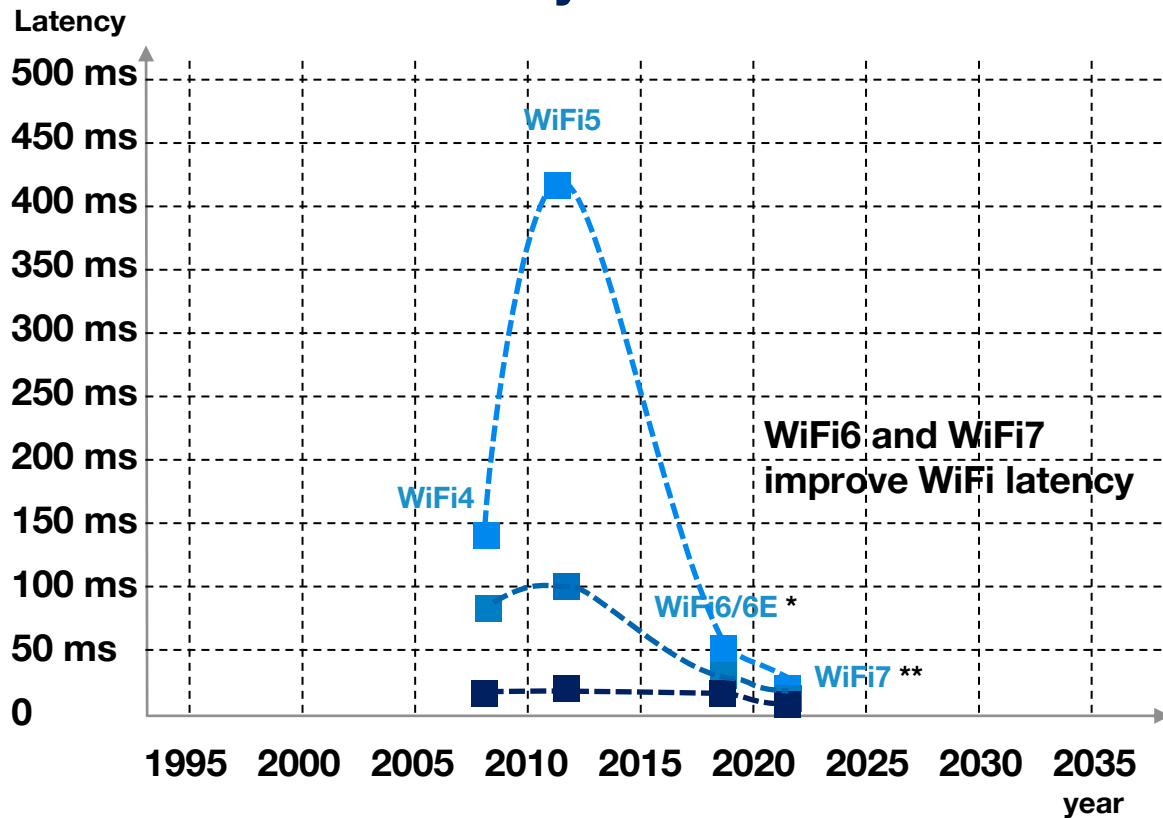
* OFDMA, preamble punctunring features
** Multi-Link Operation (MLO)

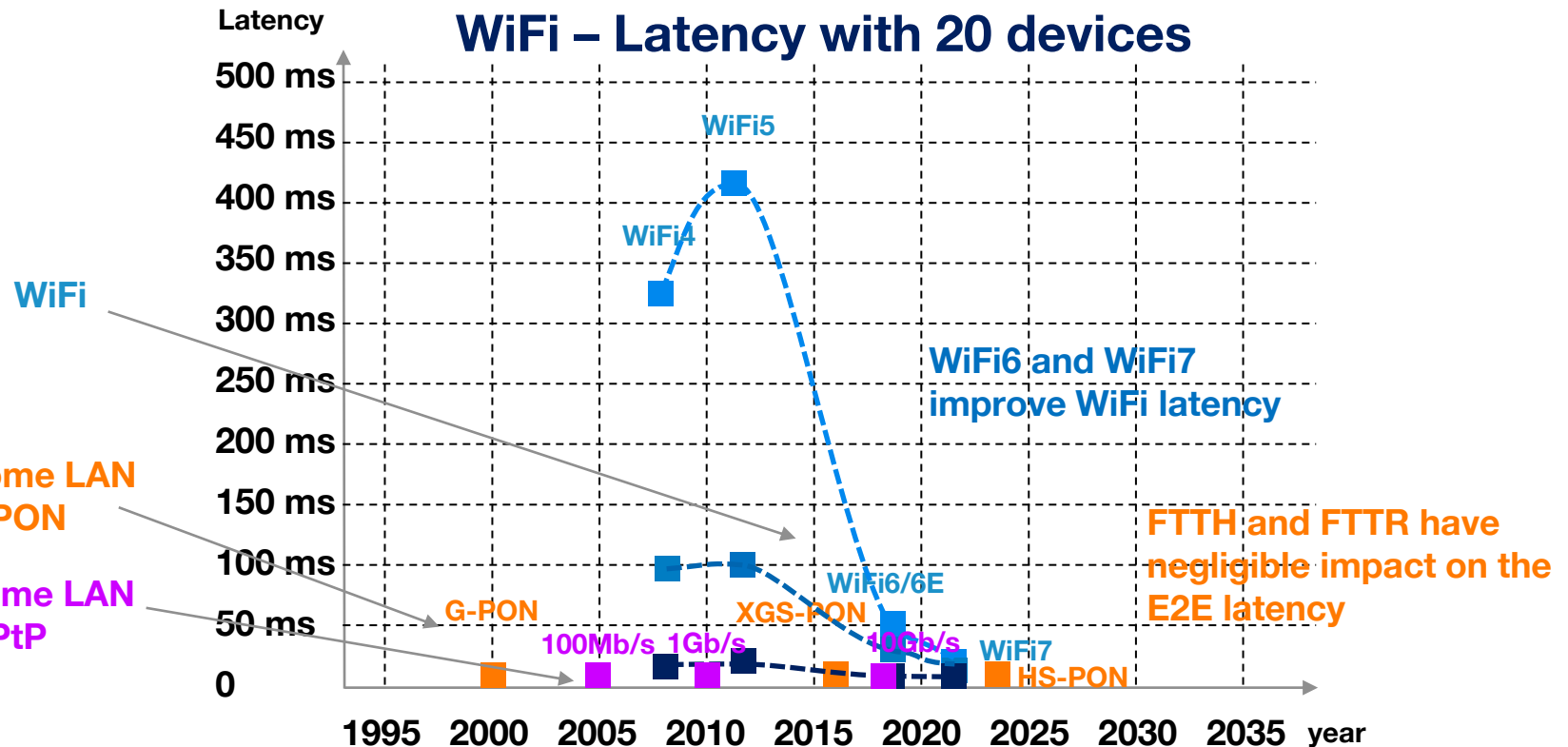# PON and WiFi latency

WiFi – Latency with 80 devices
WiFi – Latency with 40 devices
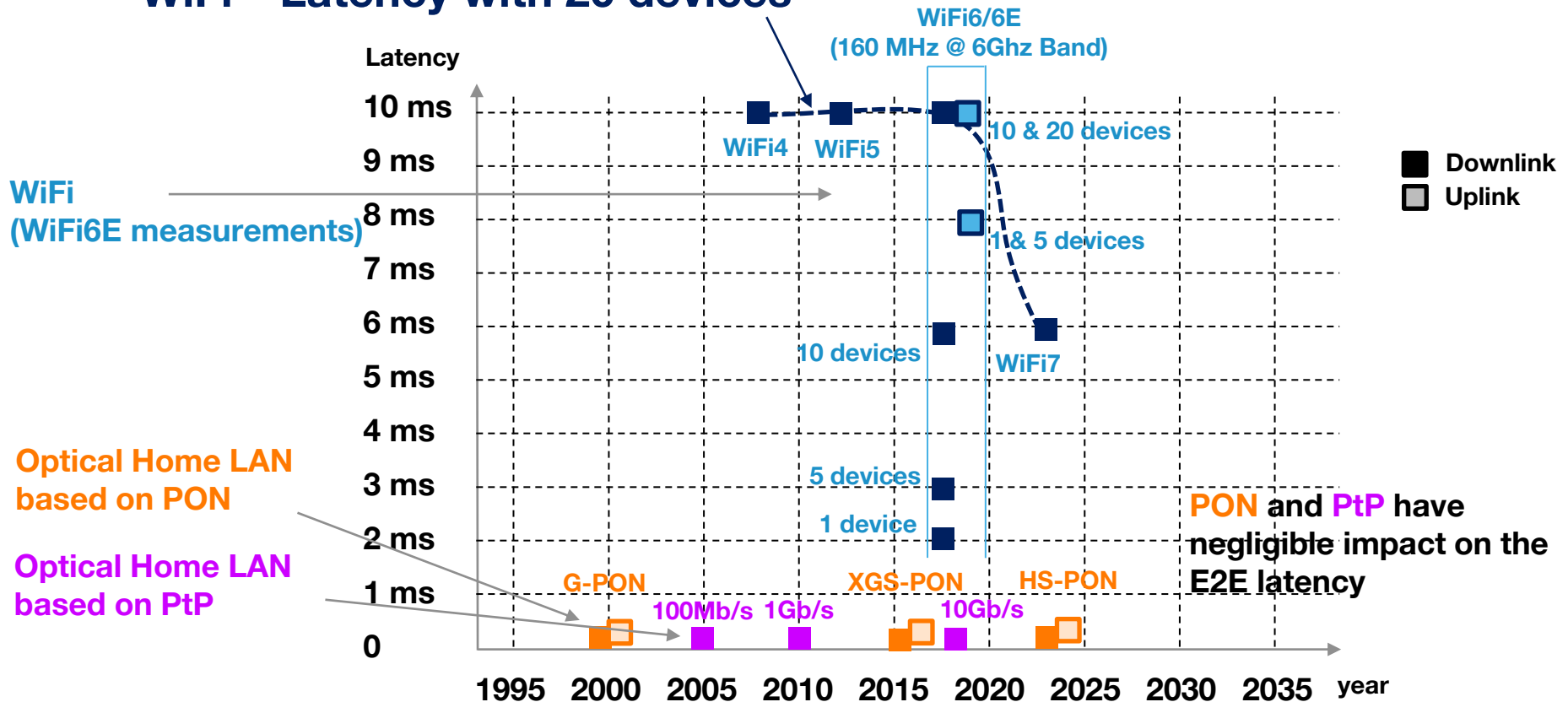**WiFi – Latency with 20 devices**

Latency

500 ms
450 ms
400 ms
350 ms
300 ms
250 ms
200 ms
150 ms
100 ms
50 ms
0

WiFi

Optical Home LAN based on PON

Optical Home LAN based on PtP

WiFi5
WiFi4
WiFi6 and WiFi7 improve WiFi latency
FTTH and FTTR have negligible impact on the E2E latency
G-PON
100Mb/s 1Gb/s
XGS-PON
WiFi6/6E
10Gb/s
WiFi7
HS-PON

1995 2000 2005 2010 2015 2020 2025 2030 2035 year

Without fiber (5 µs /km), Latency PON D/S 25 µs & U/S ≈86 µs

Without fiber (5 µs /km), Latency PtP D/S & U/S 20 µs

18

PON, PtP and WiFi latency

WiFi – Latency with 20 devices

WiFi6/6E
(160 MHz @ 6Ghz Band)

Latency

WiFi
(WiFi6E measurements)

Optical Home LAN
based on PON

Optical Home LAN
based on PtP

10 ms
9 ms
8 ms
7 ms
6 ms
5 ms
4 ms
3 ms
2 ms
1 ms
0

WiFi4   WiFi5

10 & 20 devices

Downlink
Uplink

1 & 5 devices

10 devices   WiFi7

5 devices

1 device

G-PON   XGS-PON   HS-PON

100Mb/s 1Gb/s   10Gb/s

PON and PtP have
negligible impact on the
E2E latency

1995 2000 2005 2010 2015 2020 2025 2030 2035   year

Without fiber (5 µs /km), Latency PON D/S 25 µs & U/S ≈ 86 µs

Without fiber (5 µs /km), Latency PtP D/S & U/S 20 µs

Data Rates, Latency and Jitter:
FTTH, Optical Home LAN and WiFi

Coverage synthesis: a Home LAN connectivity based on an efficient and easy-install cable infrastructure.

Throughput synthesis:
- With advanced WiFi (WiFi6), the traffic load is nearly constant in function of number of devices.
- 1 Gb/s optical Home LAN is a possible for backhauling WiFi 5&6 and 10Gb/s could be relevant for all WiFis including WiFi 7 and future WiFi.

Latency synthesis:
- For advanced WiFi typical average value is about **2 to 10 ms**. WiFi latency decrease by clustering the devices.
- For Optical Home LAN based on PON & PtP typical average value is about 25 & 20 µs downstream and 86 & 20 µs upstream, respectively.

Jitter synthesis:
- For advanced WiFi typical average value is < 1 ms (typ. 100 µs).
- For Optical Home LAN based on PON & PtP typical average value is about **0.2 µs** downstream and < 50 µs & 0.2 µs upstream.

Conclusion:

- PON and PtP are the ideal Wi-FI companions to achieve an "ideal" Home LAN backhaul.

Conclusion

The three broadband companions
FTTHome, Optical Home LAN, WiFi

1 Optical Home LAN is an emerging connectivity

2 « FTTH like » experience for users & continuity of our field expertise up to the rooms

3 PON and PtP are the ideal companions of WiFi with an "ideal" in-house backhaul performance for throughput, jitter and latency.

4 Interoperability and open to Home LAN ecosystem are keys for mass deployment

orange™

Thank You.
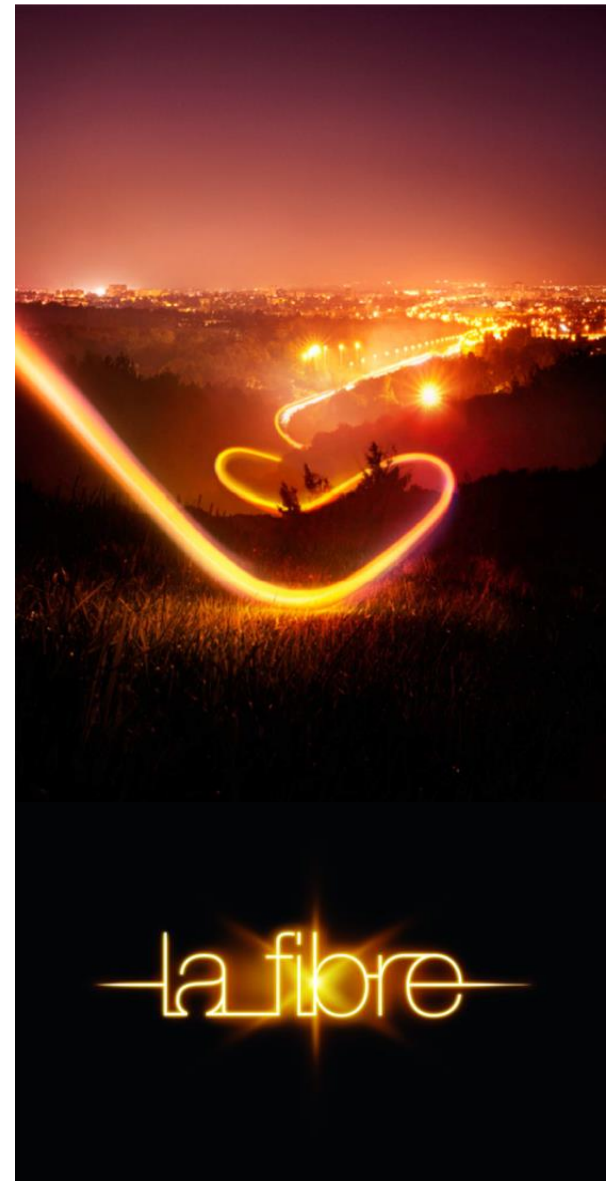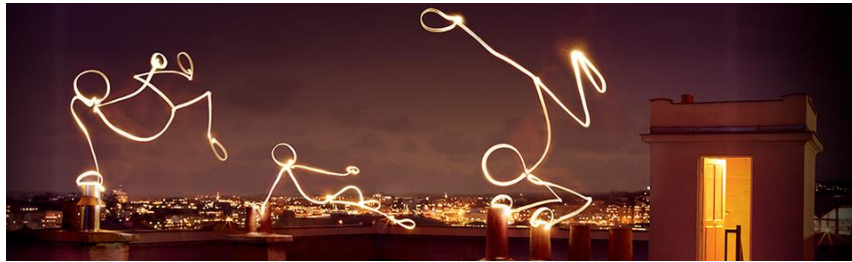
PON and WiFi maximum throughput for laptop and smartphone devices

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)
Maximum theoretical physical layer data rate (3x3:3) *e.g. laptop* ➔➔	1.8 Gbps	3.6 Gbps	2.1 Gbps	4.3 Gbps	8.6 Gbps
Maximum theoretical physical layer data rate (2x2:2) *e.g. smartphone* ➔➔	1.2 Gbps	2.4 Gbps	1.4 Gbps	2.8 Gbps	5.7 Gbps

Supported by G-PON

Supported by XGS-PON
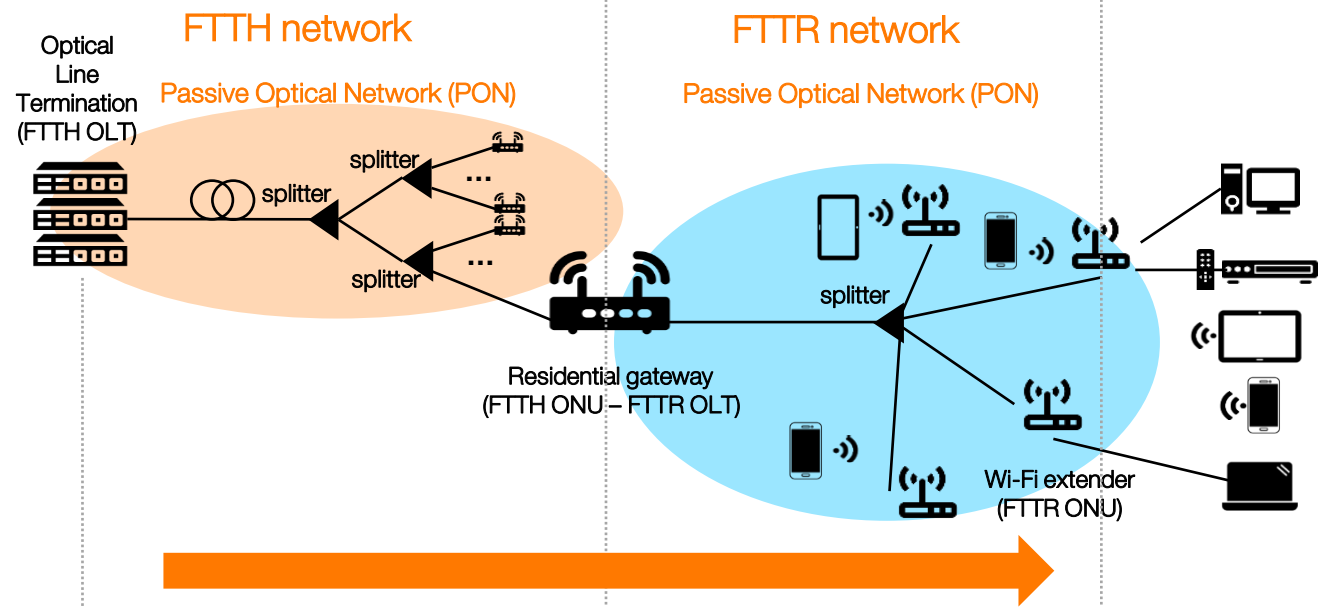
FTTHome + FTTRoom latency and jitter
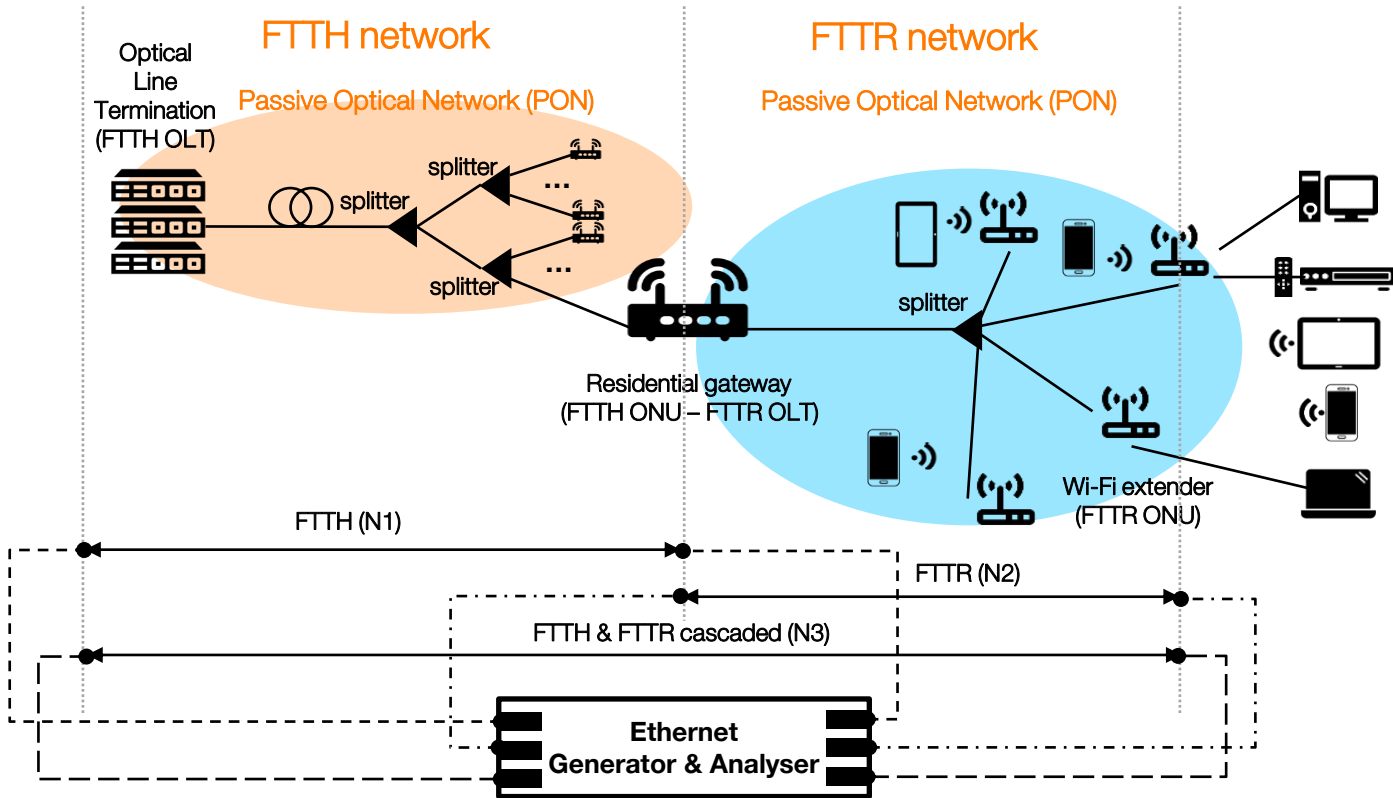
G-PON technology
  - **DT (Delay Tolerance) of 1 (125 µs long cycle)**
  - **100 Mbit/s T-CONT (Transmission-CONTainer) type 1 ("fixed")**
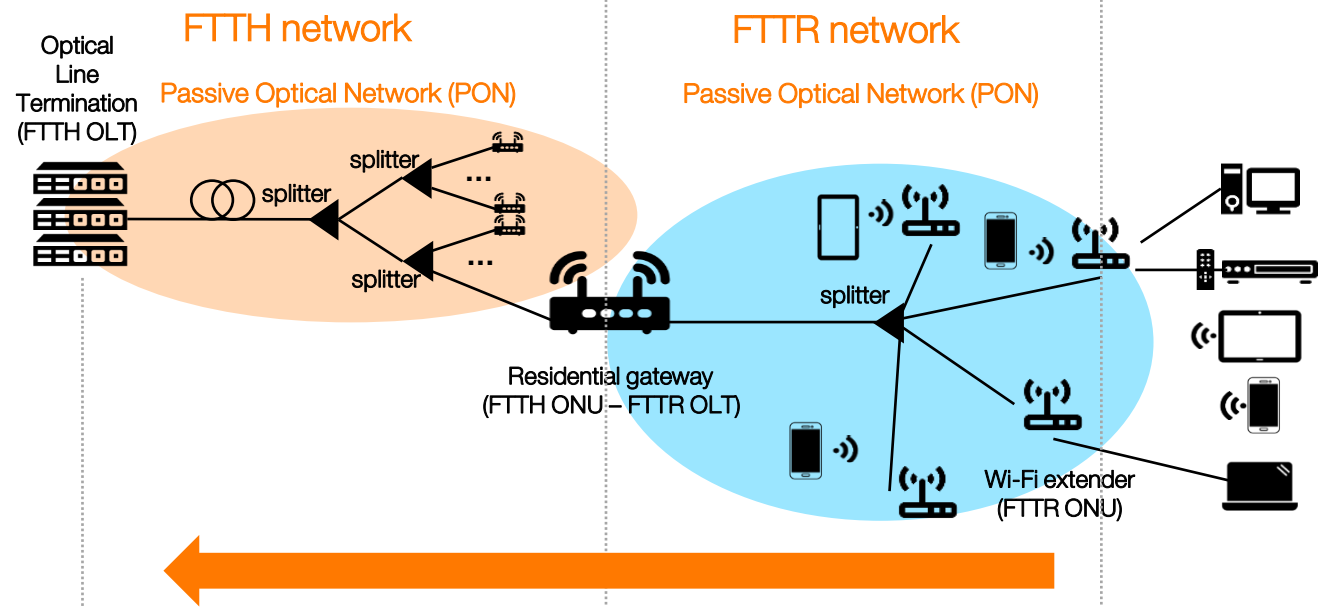**No fiber (only patch cord) : 5 µs/km**

FTTHome + FTTRoom latency and jitter

Dowstream	FTTHome	FTTRoom
Latency (µs)	**Mean = 24.17** [Min 25.57 / Max 28.45]	**Mean = 23.64** [Min 22.01 / Max 24.23]
	Mean = 40.19 [Min 38.24 / Max 51.34]	
Jitter (µs)	**Mean = 0.09** [Min 0 / Max 3.87]	**Mean = 0.21** [Min 0 / Max 1.84]
	Mean = 0.24 [Min 0 / Max 3.81]	

FTTHome + FTTRoom latency and jitter

Upstream	FTTHome	FTTRoom
Latency (µs)	**Mean = 82.01** [Min 26.65 / Max 391.86]	**Mean = 106.7** [Min 19.03 / Max 455.6]
	Mean = 170.05 [Min 39.24 / Max 590.34]	
Jitter (µs)	**Mean = 36.78** [Min 0 / Max 348.28]	**Mean = 35.75** [Min 0 / Max 230.52]
	Mean = 36.96 [Min 0 / Max 348.36]	