# Outline

- The "Fiber to the Room" *proposition*

- Fiber in the Home, *so far*

- Potential *challenges and solutions* for in-home fiber

- Possible *motivations* for FTTR

- *Non-fiber* options

- *Fiber-based* options

- *Conclusions*

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The "Fiber to the Room" Proposition

- Proposition: extend fiber deep in the home to provide higher speed *WiFi backhaul*
  - PON is assumed to be the solution. Focus on GPON (possibility of XGPON)
  - Requires OLT and ONTs inside the home
- Pursued as a China national standard since 2020
  - Has been brought to ITU SG15 Q18 and pushed elsewhere

NB: End devices assumed to be connected by WiFi
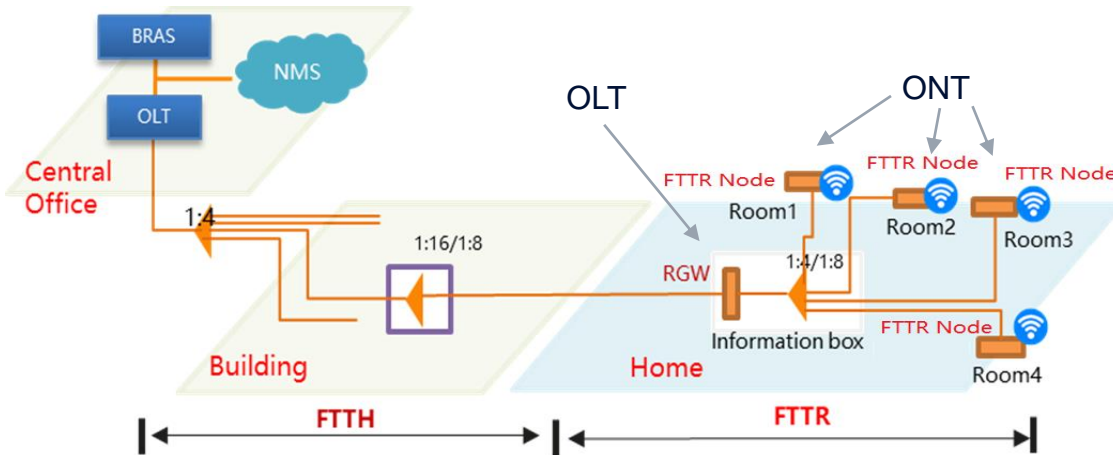
From SG15-TD715R1/PLEN

This presentation will step back, assess drivers and potential solutions

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Fiber in the Home - is Not New

- Fiber to indoor ONTs
  - Fiber installed in the home to reach ONT
    - ONT often in living room in center of house
    - Sometimes through hallways and risers in MDU

- Fiber from FWA receiver to gateway
  - Receiver on wall/roof not the right place for GW
  - Generally no existing copper or coax from roof

- Passive Optical LAN (POL) for small biz.
  - Fiber in the building to ONTs at the desk

Drivers for FTTR have thus far seemed to be lacking, but some In-home fiber wiring solutions exist today.

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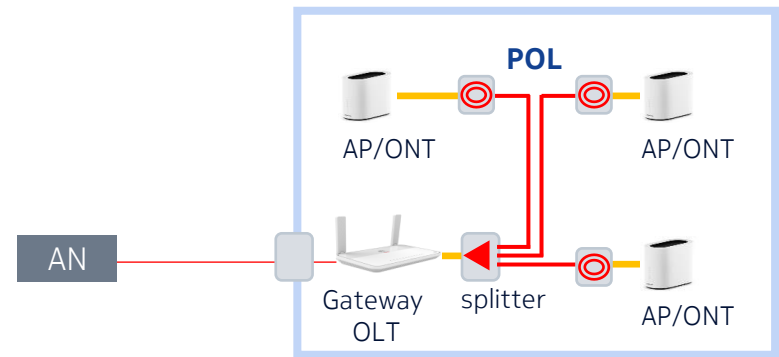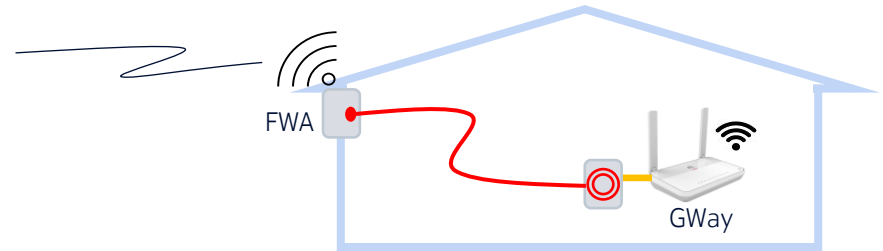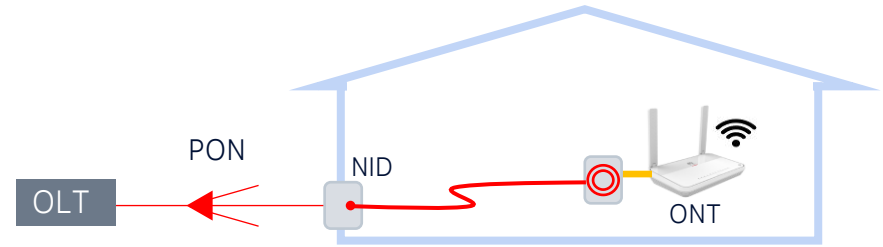
Addressing Challenges of Fiber in the Home
1. Installing fiber

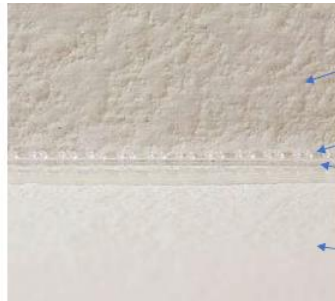- Fiber vendors have developed good solutions
  - Relatively easy installation ...for technician
  - Low visibility

e.g. Corning Clear Track

Ceiling
Clear track
Fiber
Wall

CORNING | Information Technology

e.g. OFS InvisiLight®

ADHESIVE APPLICATION TOOL

nearly invisible
(600 μm ILU Cord pictured)

Solutions exist but require technician (a few hours to do complete installation)

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Addressing Challenges of Fiber in the Home
2. Maintenance

- Running fiber in concrete construction requires either,
  - Drilling through concrete to get to another room
    → hard to do
  - Deploying fiber at bottom of doorframe at the floor
    → exposes the fiber to damage (e.g. vacuum cleaners, pets, children, moving door, etc.)
- Possibility of dirty connectors with single mode glass fiber
  - Maybe use plastic fiber (IEEE 802.3bv = 1Gbps)? …But has high loss.
- Should not be handled by customer
  - Could lead to troubles

Fiber may eliminate some customer prem problems but might lead to others

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So what are potential motivations for FTTR?

- Bandwidth needs / desires
  - BW for 32 users is approaching GPON exhaust
  - BW needs for single service could be **a few 100Mbps**
    - BW demands seem over-estimated by Q18, exclude coding gains
  - Possible desire for speed test **>1Gbps** → 10Gbps

  vs. Existing solutions range from **1 to 10Gbps**
  - Still plenty of capacity *(See next slide)*

- Service provider motivation
  - Extra revenue for "all-fiber" service (Marketing)
  - Possible reduction in in-home trouble reports

- Real estate motivation
  - Premium value for new SDU, MDU, condo with fiber

- Government policy and incentives

Peak hour sustained demand, 32 subscribers
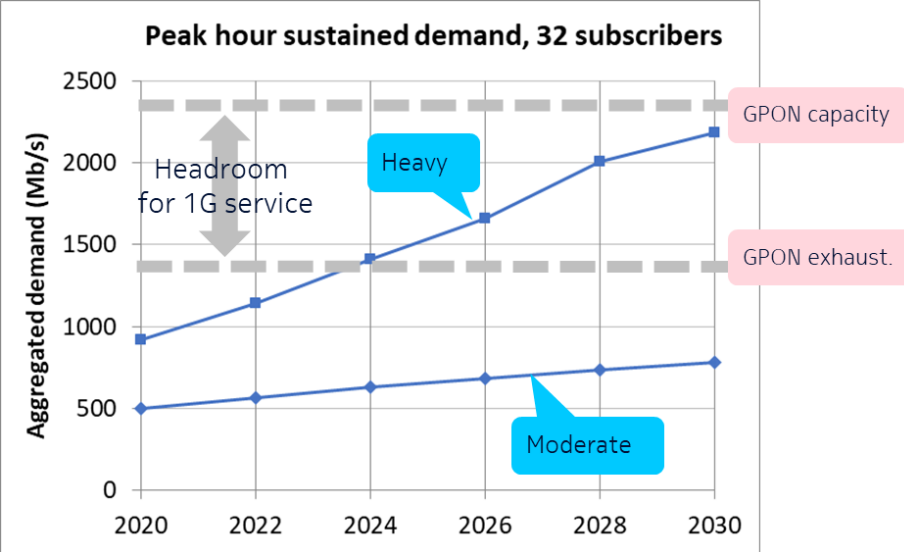
|	Q18 BW estimate	Nokia BW estimate (2020 → 2030)
IPTV 8k	> 150 Mbps (a)	60 → 30 Mbps (c)
Cloud VR 8k	> 360 Mbps (~1G) (b)	120 → 60 Mbps (c)
Cloud VR 16k	> 440 Mbps (~1.5G) (b)	220 → 110 Mbps (c)

(a)   Broadband Development Alliance, WP 2021
(b)   ITU-T SG15 G.9976 UHD video over G.hn,2021
(c)   Bandwidth Demand Forecasting, Harstead & Sharpe based on 12k and 24k Field of View (FOV)

FTTR is not born from desperate BW shortage, but fiber is always an attractive alternative – worth exploring. But first…

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Pause to Look at Existing solutions

Single Wifi

- Wifi6 &6E = **1.2 – 4.8 - 9.6 Gbps** (w 8ch and 160MHz)
  - Wifi7 allows up to 40Gbps
- Challenges
  - Spectrum pollution in dense areas
  - Concrete walls attenuate signal

Single Wifi

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Gateway ONT
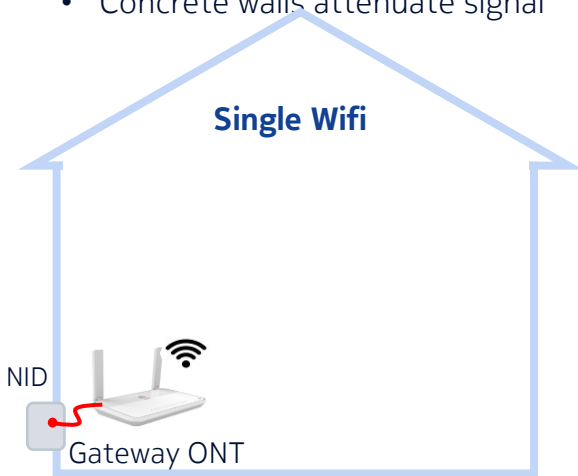
Wifi with extenders

- Wifi6 & 6E = **1.2 – 4.8 - 9.6 Gbps** (w 8ch and 160MHz)
- Significantly overcomes concrete wall *(see next slide)*
- Easy installation

Wifi Extenders

NID

Gateway ONT
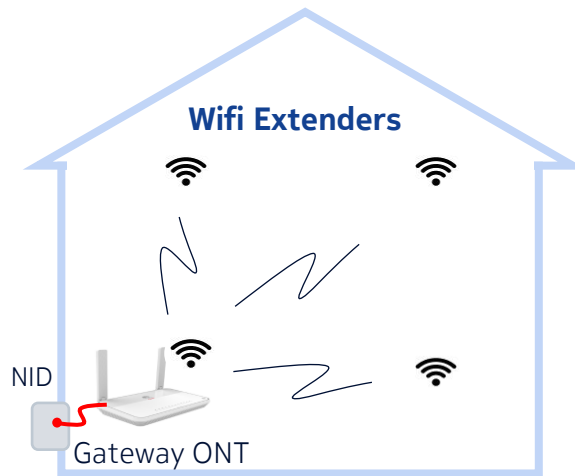
Ethernet Cat 5 to the room

- Cat5e = **1Gbps**
- Cat6a =**10Gbps**
- Installation of wires is a pain
  - We could rightly ask: Why not use fiber instead?

Ethernet Cat 5

AP

wall module

AP

Ethernet cable

NID

Gateway ONT

AP

Capacity of existing solutions (1-10Gbps) exceeds foreseen needs (a few 100 Mbps)

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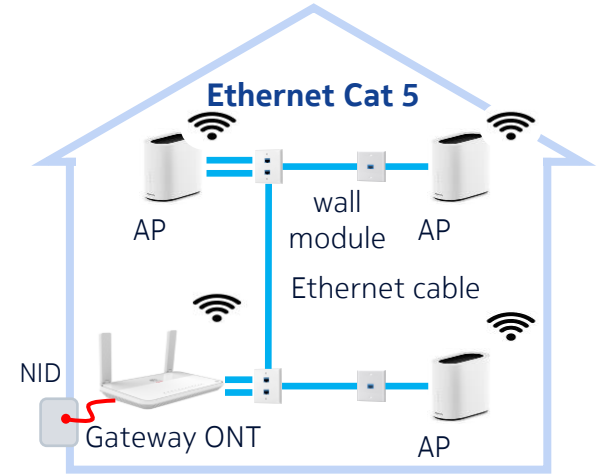
Improving Wifi Bandwidth with Extenders

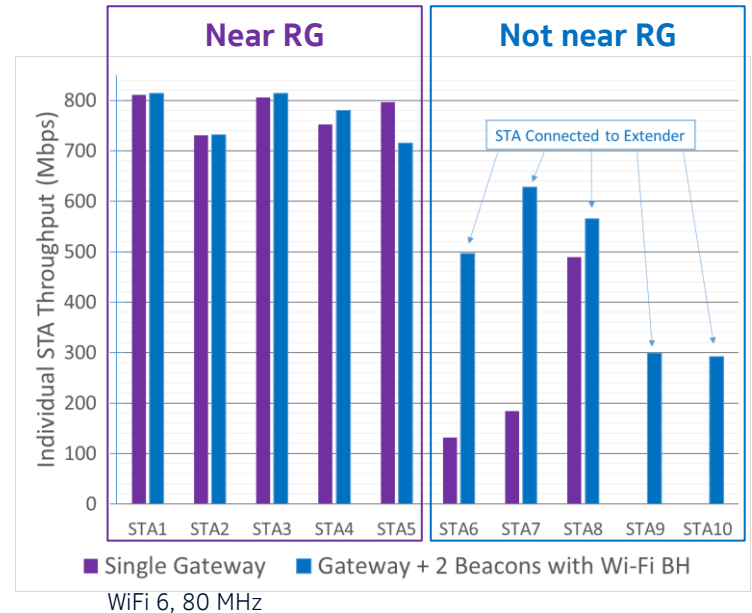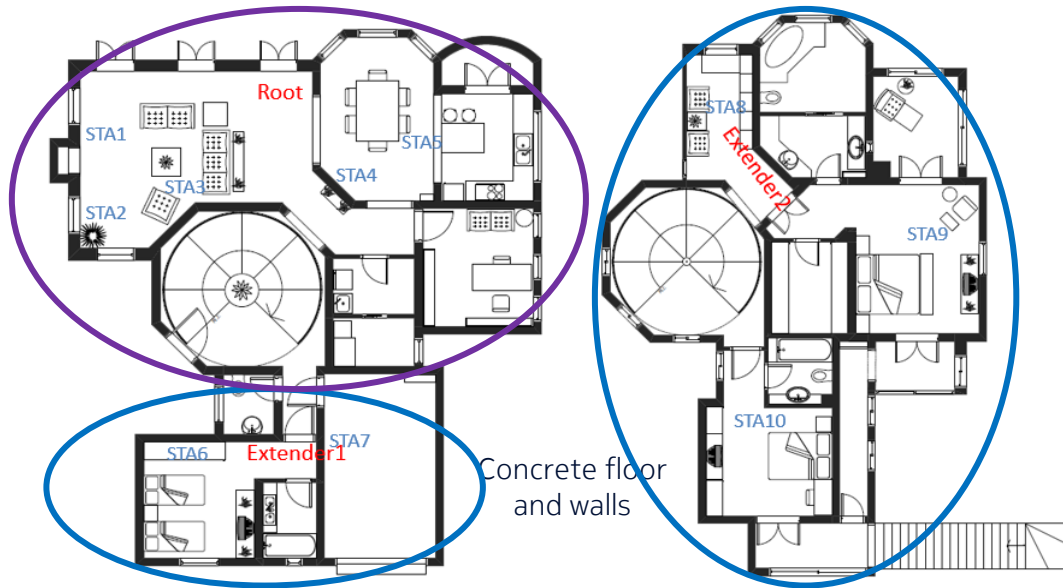- Tests performed in sample Shanghai home
  - Concrete floor and walls
- WiFi 6 with only 80MHz used (could go to 160MHz)
  - i.e. this WiFis is well below what the standard allows

- Single WiFi provides 700-800Mbps nearby
- Adding 2 extenders provides complete coverage
  - Goes from 0 to 300Mbps and 150 to 550Mbps

Root
STA1
STA5
STA3
STA4
STA2
STA6 Extender1 STA7

STA8
Extender2
STA9
STA10
Concrete floor and walls

Near RG   **Not near RG**

STA Connected to Extender

Individual STA Throughput (Mbps)

STA1 STA2 STA3 STA4 STA5 STA6 STA7 STA8 STA9 STA10

■ Single Gateway   ■ Gateway + 2 Beacons with Wi-Fi BH

WiFi 6, 80 MHz

WiFi is an easy solution with plenty of BW headroom....can overcome concrete.

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Potential FTTR Architectures

PON to the Room

- PON promoted by FTTR initiative
- GPON seems insufficient for Wifi 6E & 7 (only **2.5Gbps**)
 - Need XGS to compete w. WiFi (**1-10Gbps**) - more expensive
- Pros: Single port on GW, flex split
- Cons: Complexity of PON MAC, new chips, complication of splitter, no fiber savings due to PON, no daisy-chain, need to adapt to EasyMesh
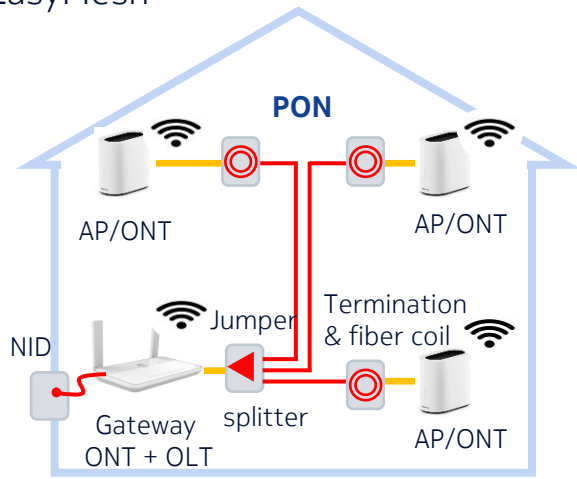
Extending CO-PON into the home – AN IDEA

- In-home PON is an extension of the access PON
  - Add reach extender (amplifier) or electrical split with P2P drops
  - Gateway functions virtualized to the CO-OLT
- Pros: Simpler Gateway, centrally controlled
- Cons: No in-home device-to-device connection PLUS all other PON Cons.
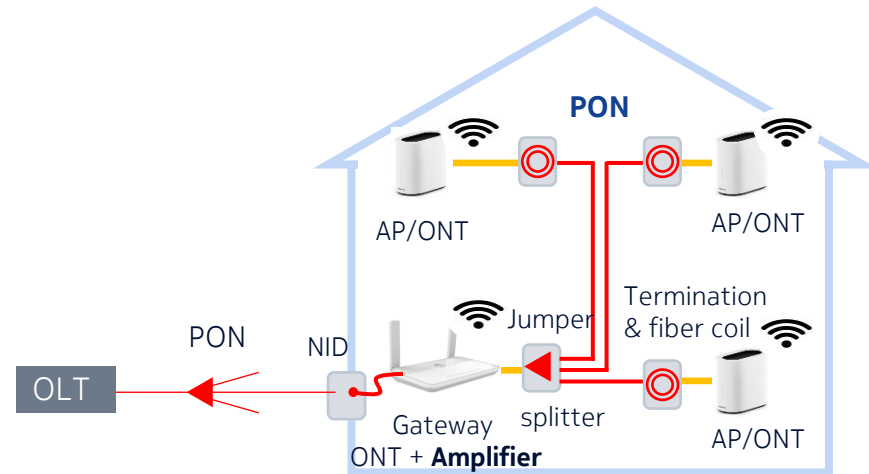
Is PON necessarily the best fiber solution?
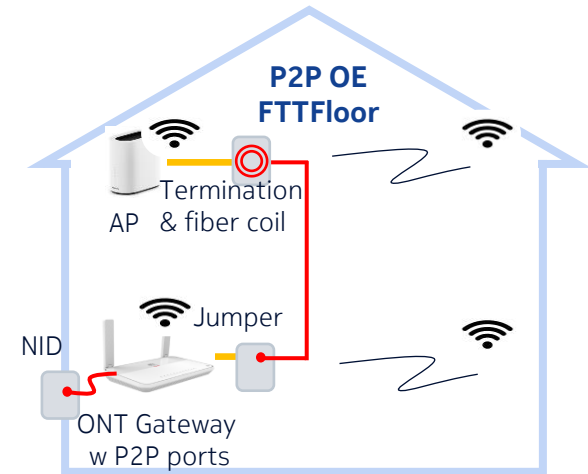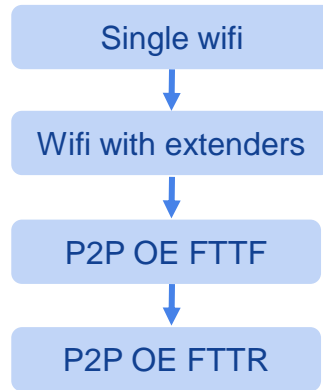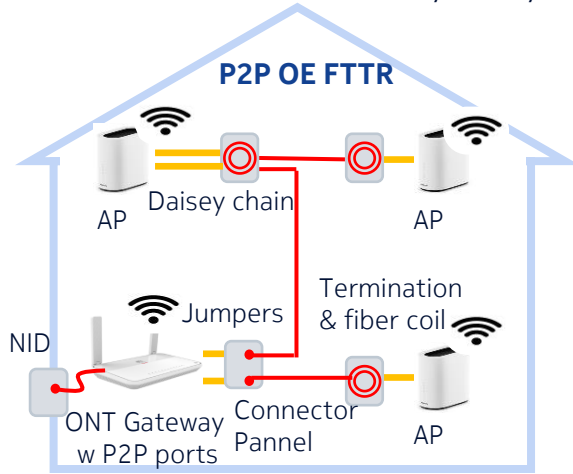
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Potential FTTR Architectures

P2P Optical Ethernet to the Room – AN ALTERNATIVE

- **1Gbps** and **10Gbps** optics readily available

- Pros: simple, minimal change to GW, low cost P2P optics, no external splitters, supports EasyMesh, could easily daisy-chain

- Cons: Multiple ports on GW and some parallel fibers – But both are minimized by daisy-chaining

P2P Optical Ethernet to the Floor – EVEN SIMPLER

- Use point to point fiber only where needed (for different floor or opposite end of house)

- Use wifi extension for the rest

- Provides **1-10Gbps,** can evolve to FTTR as needed

- Pros: Simple, lowest cost, scalable, evolvable

P2P OE FTTR

AP Daisey chain AP

Jumpers Termination & fiber coil

NID

ONT Gateway w P2P ports Connector Pannel AP

Single wifi

↓

Wifi with extenders

↓

P2P OE FTTF

↓

P2P OE FTTR

P2P OE FTTFloor

Termination & fiber coil

AP

Jumper

NID

ONT Gateway w P2P ports

Optical Ethernet appears to be a valid alternative with flexible evolution

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Cost Comparison of Different In-Home Solutions

- Wi-Fi option is the cheapest
  - potential for increase BW with more spectrum
  - Exceeds BW needs of foreseen services

- Fiber seems to be lower cost than Cat5/6

- PON solutions are the most expensive (GPON and XGS)

- Optical Ethernet to-the-floor or to-the-room are the lowest cost solutions for FTTR
  - Could allow a flexible, scalable evolution path from Wifi to FTTFloor to FTTR using daisy-chain as needed

xTTR Cost [bandwidth]

| wifi | Cat5/6 | Optical Ethernet | PON |

Legend: ■ Gateway ONT ■ 3 AP/ONTs ■ Passives ■ Labor
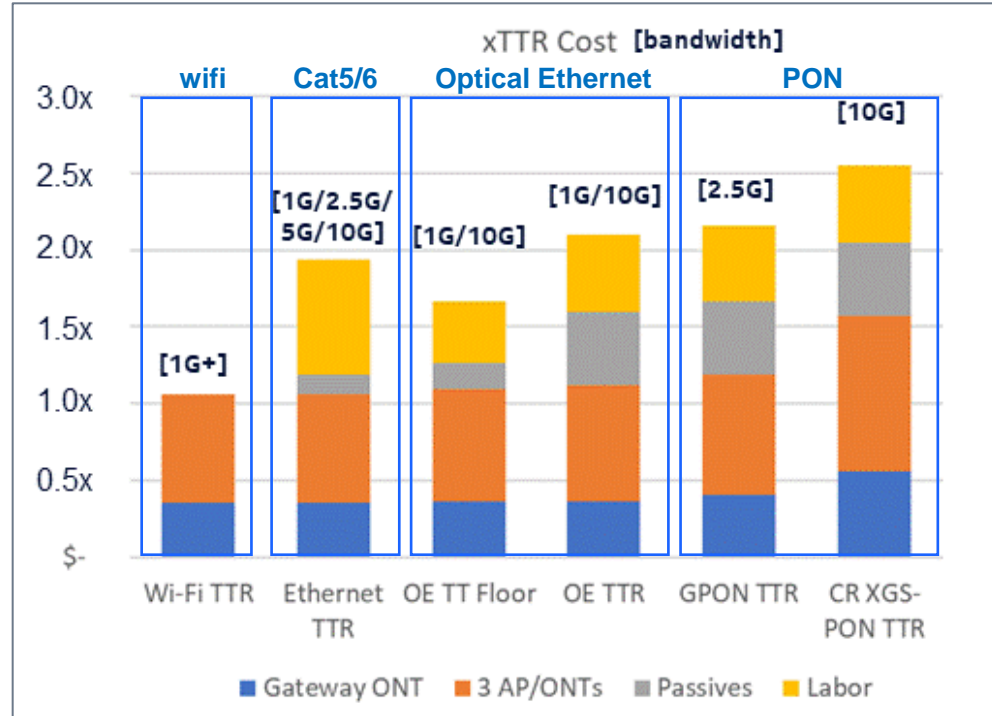
- Labor rate for developed countries.
- Shown for RG + 3 AP/ONTs

Serious consideration should be given to OE as alternative to PON for FTTR

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Conclusions

- Fiber in the Home is not new
  - Low profile indoor fiber and elegant installation techniques exist (for use by technician)

- There is no shortage of BW with existing solutions for future needs
  - WiFi with extenders can provide 1Gbps+ (in theory up to 9.6Gbps w Wifi 6E, more with Wifi 7)
    - No installation required, can overcome concrete walls
  - Individual services seem to be no more than a few 100Mbps, the killer app being the speed test

- Potential motivations for FTTR deal more with perceptions
  - Operators may upsell for a higher perceived value of fiber (e.g. higher speed test)
  - Real estate developers may add perceived value to their homes by pre-fibering

- P2P Optical Ethernet is a low cost alternative to PON for FTTR
  - Already supported by EasyMesh
  - Simple change to existing GW's – swap output ports with existing 1G or 10G Optics

- A natural flexible evolution could be envisioned
  - Single wifi → wifi with extenders → P2P OE fiber to the floor → P2P OE FTTR

QUESTION: Is there anything still needed to allow P2P OE to be used as a standard solution for EasyMesh?

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Thank you

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Estimates of Encoding Gains for Future video

Encoded video bit rate forecasts: heavy (3D)

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