Vodafone Vision for FTTR

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Overview

SITUATION TODAY

- Speed/capacity requirements
- Customer requirements for extended WiFi coverage
- What we have learned: How to improve the FTTR solution

LOOKING FORWARD

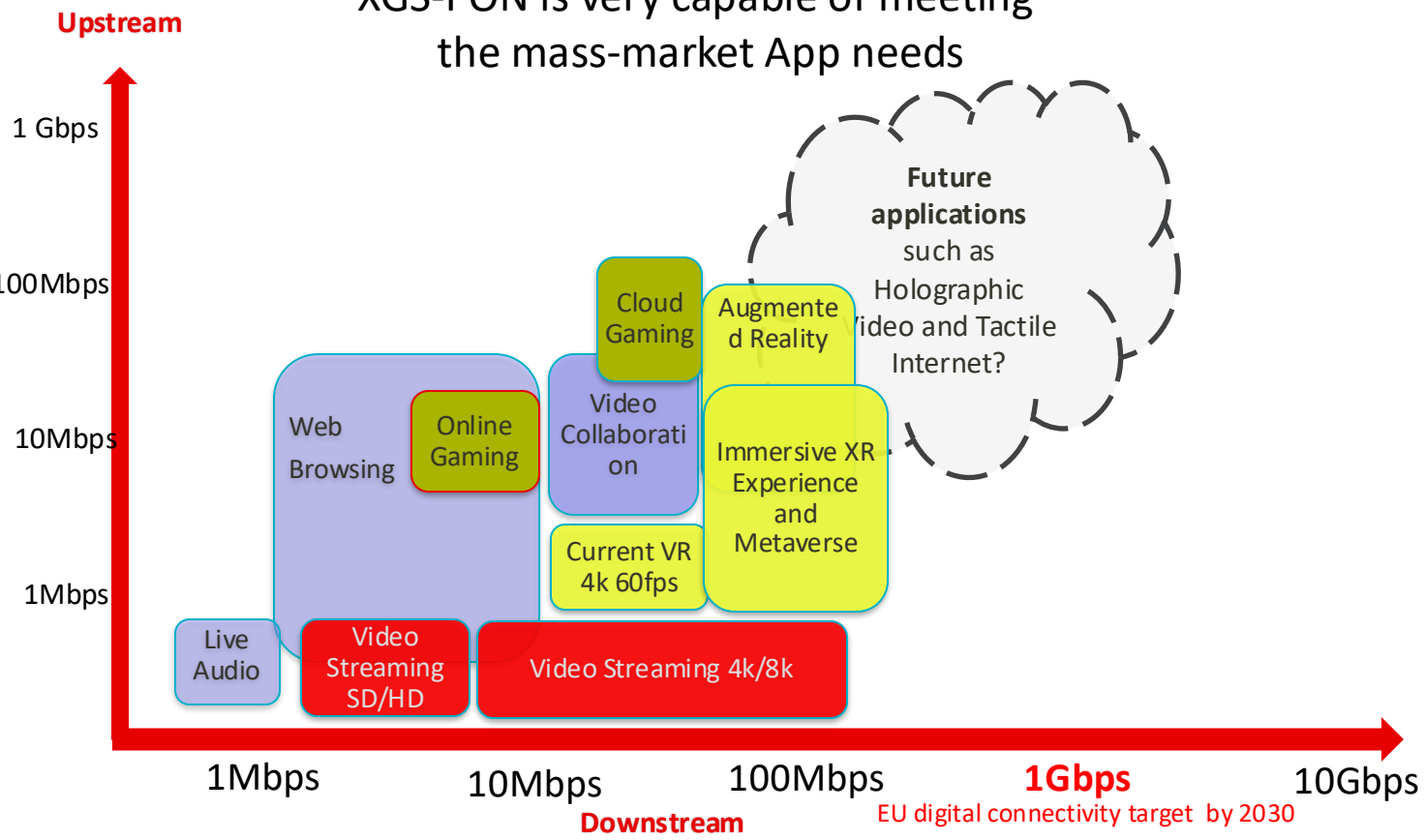
- WiFi/FTTH systems capacity alignment
- The complimentary nature of FTTR with mmWave WiFi8

Situation TODAY

Application Requirements & FTTH Capacity TODAY

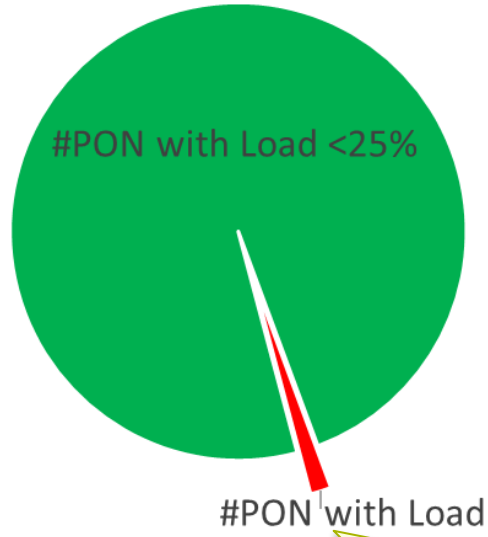
Speed is not a problem for consumers

XGS-PON is very capable of meeting the mass-market App needs



Capacity is not a problem

Even our GPON networks today are not fully utilized



Of thousands of active GPONs, only1% are loaded more than 25% in downstream (12% in upstream)

The top loaded PONs have an average utilization of ~30%

Virtually no residential customers even burst beyond 500Mbps today, apart from when running a speedtest or doing a software update. Bit rates for business services may be much higher.

WiFi Coverage: Extender Use (2 example countries)

Country A:

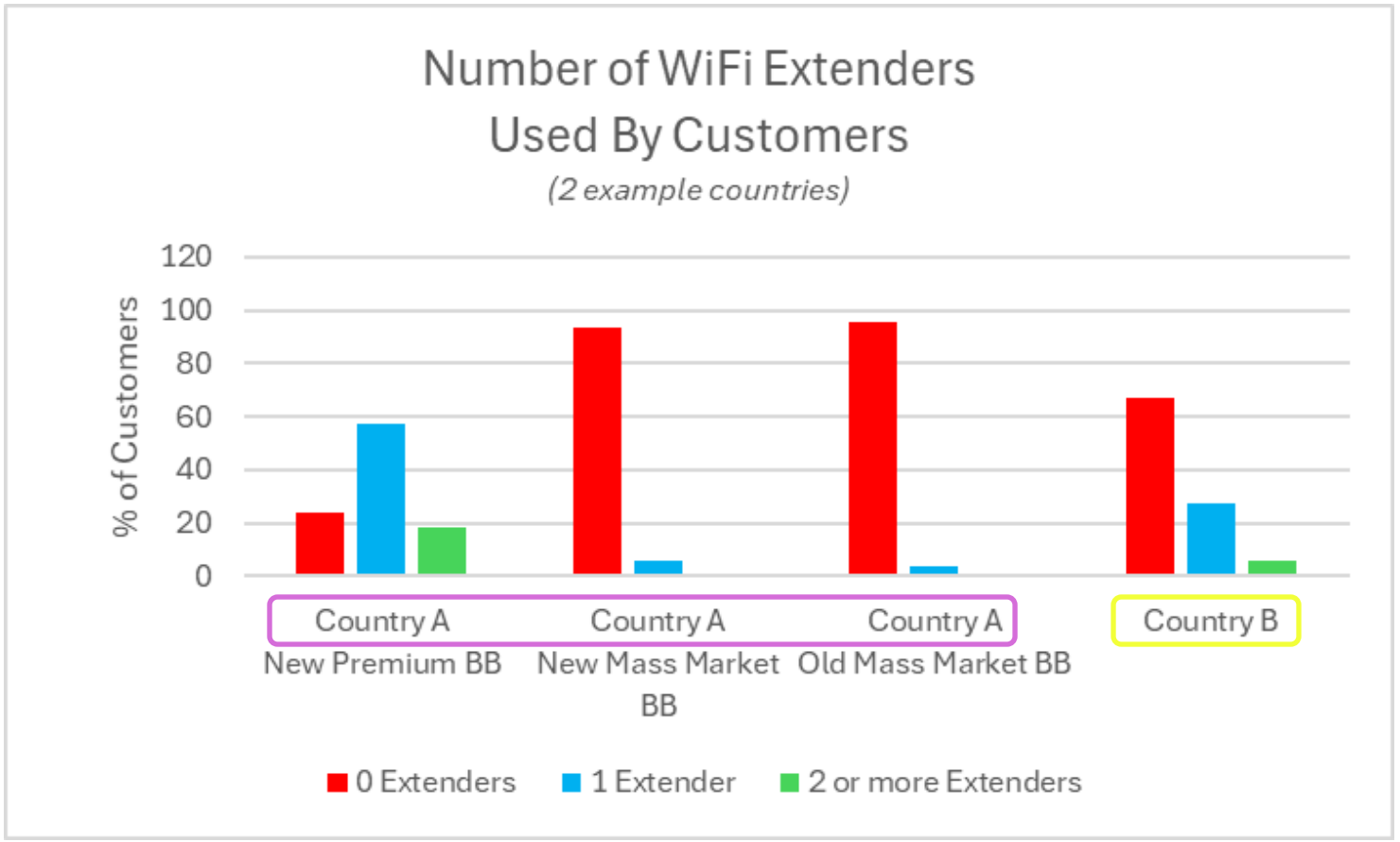
Primarily Houses

- *Premium Broadband (BB) bundle:* Includes 1 'free' extender. Others available (for free) on request if measurements show its necessary.
- *Mass Market Broadband products* Incur incremental cost per extender.

Country B:

Apartments in cities, houses in rural areas

- Customers can get an extender sent if telemetry shows poor coverage.
- For other customers, it is an incremental cost



- **Some customers are reluctant to add extender(s) to improve coverage if its not already in their Broadband bundle**
  - **Hence extender use is more prevalent in those taking premium bundles**
  - **Today <10% of customer devices connecting to our WiFi hubs/extenders are even capable of using the 6GHz band**
  - **Emphasises the fact that FTTR to improve WiFi coverage/performance likely to be niche in the near-term**

Comparison of FTTR vs WiFi with Extenders

Fibre To The Room (FTTR)

- ✓ **Consistent ultra fast speed and low latency** across all rooms – removing the need to depend on WiFi capacity
- ✓ **Potentially cost effective to offer to MDUs** vs. gaining permission to lay FTTH fibre in building/apartment

- ✗ **High installation** (compared to Wifi extenders) **and lifecycle management costs**
- ✗ **Niche customer appeal:**
  - **Limited take-up where we have launched FTTR** (P2MP variant)
  - Particularly challenging in price sensitive markets

Broadband Hub + WiFi extenders

- ✓ Latest generations of WiFi technology e.g. WiFi 7, will **reduce performance gap** vs. FTTR
- ✓ **Signal degradation** away from the main router is **typically not noticeable for most customers**
- ✓ **Wide device compatibility;** Our latest CPE devices are Matter-ready to enable the connected home
- ✓ **Cost-effective deployment** and **easy to install**

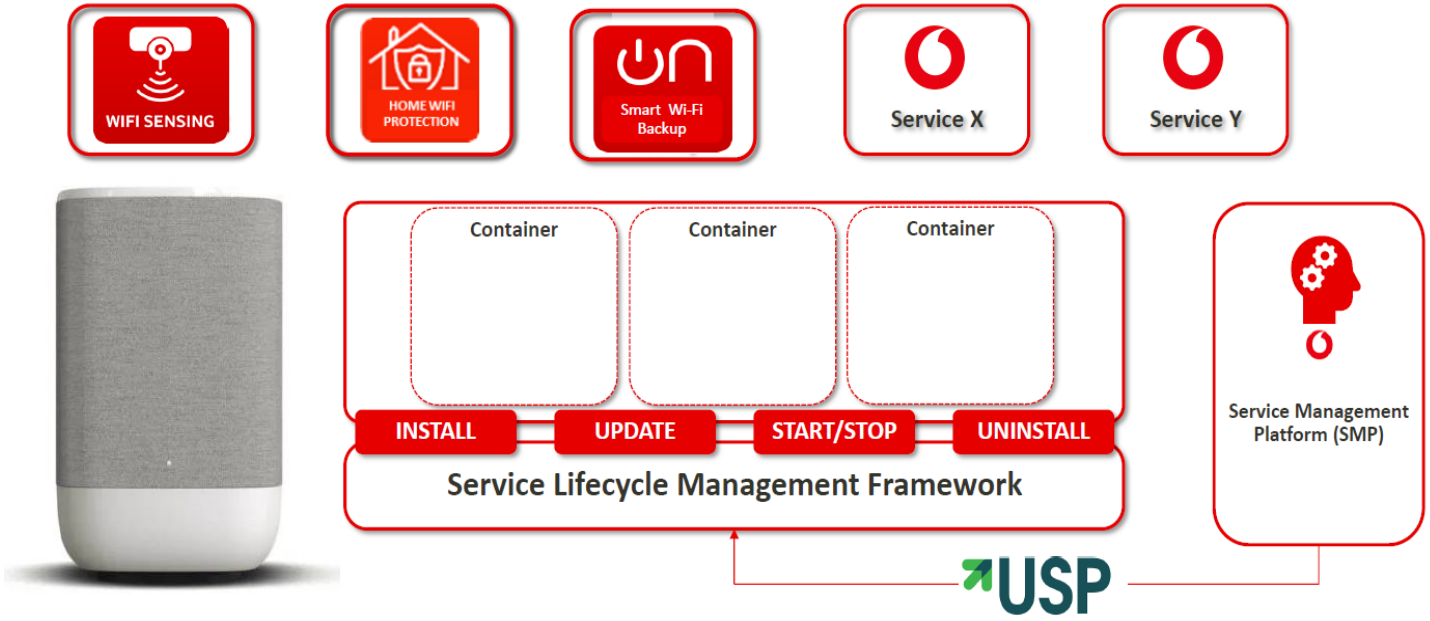
- ✗ **Inconsistent performance** as coverage and speed can vary depending on wall materials, interference, and extender placement

Sources: World Broadband Association 'Beyond Broadband: Revolutionizing CPN Connectivity', Interviews

CPE Architecture in Vodafone

Agile Service Delivery Platform based on Global/Open standards

- **RDK-B** for Service Delivery Platform (SDP)
- **BBF** for Broadband Hub & WiFi Extender management (i.e. USP/TR-369)
- **BBF** for Data Model (TR-181, inc. WiFi Data Elements with WiFi Alliance & CableLabs)
- **Prpl Foundation** for Lifecycle Management (LCM)



PLUS

- **TMF** (& **CAMARA**) for Northbound APIs

- **Enables rapid deployment and Time-To-Market (TTM) of new services**
- **New services pushed to customers via USP and use prpl LCM**
- **The new functionality is instantiated in containers**
  - **Enables instant enablement, no CPE reboot**
  - **Faster integration & test of service-enabling client SW from partners**

What have we learned, how can we improve the FTTR solution?

1. **Increasing broadband speed has reached a point of diminishing returns in terms of customer benefits**
   - Multiple 4k UHD video streams don't look any better on a 2Gbps fibre bearer than on 1Gbps!
   - Reduced latency is not an easy sell – Gamers get it, but it can be challenging to market better "responsiveness" to average consumers

2. **Customers are increasingly attracted by convenient value-added services**
   - These address key issues around home security, family protection, connected home device control, energy management …

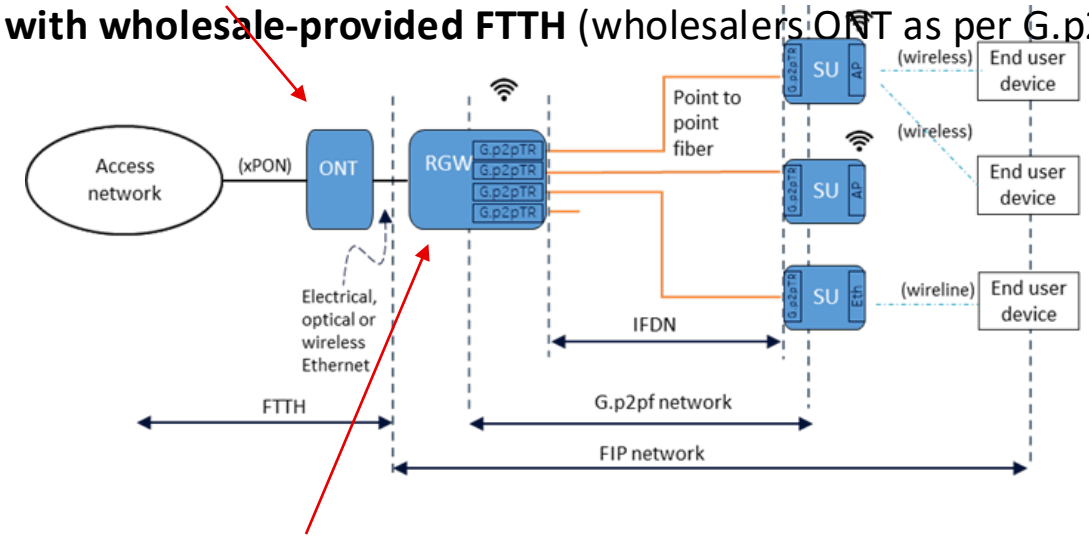
3. **The installation time/cost (plus appointment scheduling of an engineer if not self-install) is a hassle for some customers when compared to WiFi extender self-install and hence is a barrier**
   (as it was with ADSL splitters in the late 1990s, before the advent of self-install microfilters)

4. **The solution needs to also work where we use wholesale FTTH instead of self-build**
   - Ideally, avoid an excessive number of boxes (>2) requiring additional space & power outlets

In order to address these issues, we need to modify the FTTR modularity & form-factor

How could FTTR solutions better meet our requirements?

- **Topology options**
  - **P2MP can have a role in some MDU scenarios**, to reduce the cost of fibre runs (with an incremental cost of splitters). This P2P connectivity could also be based on existing PON standards.
  - **We also need a simple, self-installable P2P solution** (as per G.p2pf) which will suffice for many homes
    - Often, improved WiFi coverage and fastest speed is only required in 1 or 2 rooms. Star & daisy-chain topologies should be viable options
  - Simple **compatibility with wholesale-provided FTTH** (wholesalers ONT as per G.p2pf option) is essential for national market coverage



- **Service Delivery**
  - Any FTTR solution **must fit with our CPE services delivery architecture & devices** so that we have homogeneity across all home routers and WiFi Apps/extenders (rather than a ring-fenced variant just for FTTR customers, which increases service development complexity)
  - This facilitates alignment with the global standards we use for the broadband services layer (RDK-B, BBF, prpl Foundation, TMF,

Options for Connecting FTTR transceivers to Hub & extenders

1. Use a simple media converter (10G electrical Ethernet to Ethernet over fibre)

✓ Already demonstrated in an operator's deployment in Spain

✓ Zero impact on existing Broadband Hub and extender hardware

✗ Extra box(es) for the customer to power

2. Integrate the FTTR transceiver into the Hub *(1 for P2MP, 2 for P2P)*

✓ This is similar to the integrated ONT WAN option which we have already deployed in some self-build Local Markets

✗ However, for FTTR, it is only justified with proven very high-volume take-up.
(This appears to be unlikely in the near-term for Europe, as our P2MP FTTR deployment has shown)

3. Have SFP+ cages/LAN port(s) on the Hub that an SFP+ FTTR transceiver could plug into

✓ Less cost on the Broadband Hub & extenders than option 2 and less boxes than option 1.

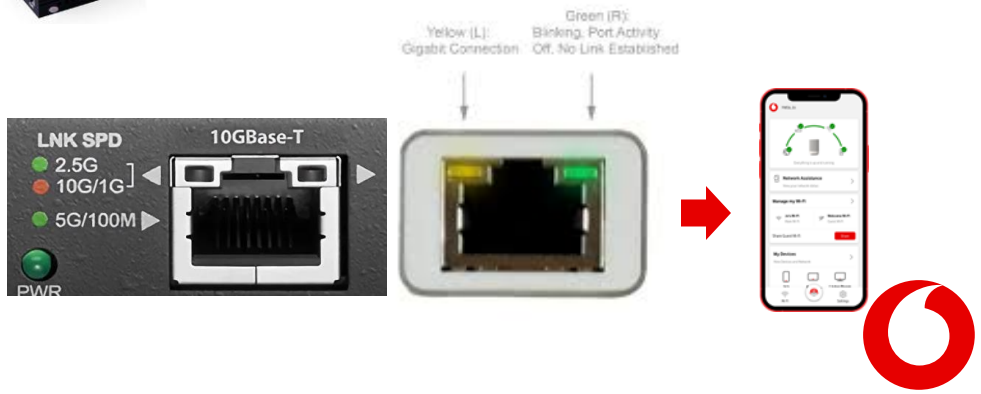
✗ Would need 1 cage for P2MP, preferably at least 2 for P2P FTTR (simple Ethernet over fibre)

Potential components in a modular FTTR solution

- **Invisible fibre** self installable
  - Needs to pass local fire safety & security regulations (especially in MDUs)
  - Include a slack fibre storage module

- **Pluggable FTTR optics** (Pre-connectorised, that can plug directly into a Broadband router* and WiFi extenders to leverage our value-added services via a “1-box” solution
  - This makes the solution more like the add-on Powerline in-home networking products which many customers used a few years ago
  - An Ethernet media converter option can help with legacy CPE

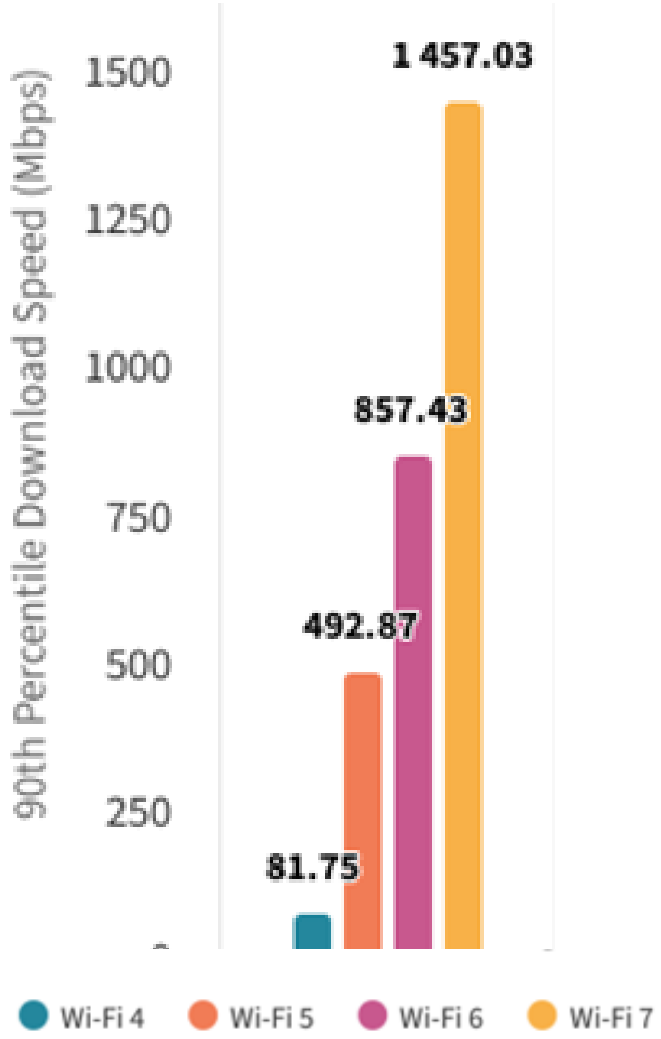
- **Diagnostics**: Even very simple telemetry functionality (equivalent to Ethernet link light) should ideally be accessible via BBF USP (inc. standardised data model) for integration with existing back-end analytics and customer-facing broadband App etc.



The picture shows SFP WAN port, but 1 or 2 SFP+ 10G LAN ports for pluggable FTTR optics could be added

Looking Forward

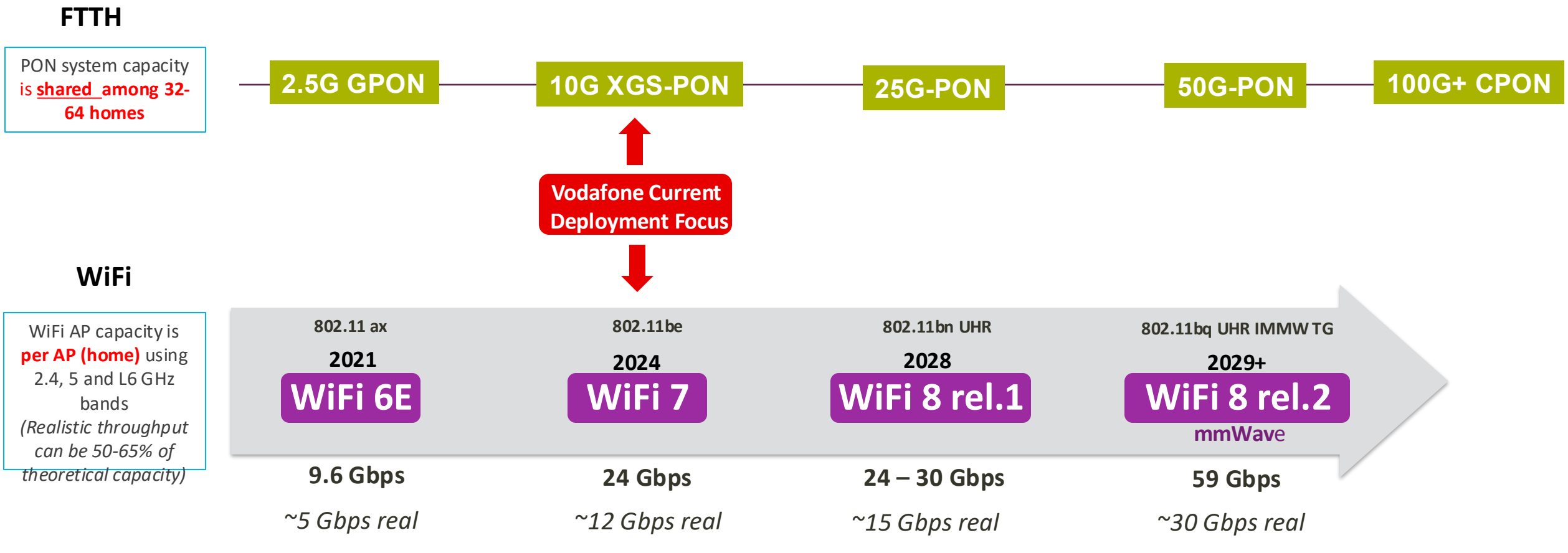
WiFi7 is required for FTTH to reach Gigabit speed



Source: Fiber-Rich, Wi-Fi Poor: Spain Exemplifies the Scourge of Outdated Wi-Fi | Rica en fibra y pobre en Wi-Fi: España ejemplifica la 'enfermedad' del Wi-Fi obsoleto

WiFi evolution can leverage the capacity of faster PON

Comparison between shared capacity in Wi-Fi and PON



WiFi and PON technology speed/capacity evolution is well aligned

mmWave will dramatically expand WiFi Capacity

- Suitable for high capacity, short-range environments (but won't go through walls!)
- mmWave WiFi also facilitates more accurate WiFi sensing capabilities*
- Previously, the mmWave RF transmission was proven in the WiGig protocol 802.11ad/ay
  - WiGig provided 8 Gbps on Single carrier 2160 MHz Channel, up to 40 Gbps capacity @60GHz mmWave (LoS) per AP
  - Bandwidth depended on available spectru nsmission techniques

mmWave will be enhanced for wider applicability in WiFi 8 rel.2

(802.11bq UHR IMMW TG)

mmWave Wifi is a Perfect complement for Fibre-To-The-Room (FTTR)

* https://www.technologyreview.com/2024/02/27/1088154/wifi-sensing-tracking-movements/

SUMMARY

- FTTR prospects of successful deployment in our European markets requires products better aligned to our CPE and home technology architecture requirements:
  - Modular solution with topology options (inc P2P) to adapt to customer segment and their dwelling situation (MDU vs house etc.)
  - Complementary “add-on” to our unified Hub/WiFi Service Delivery Platform architecture (which is standards based, not Vodafone-specific)

- FTTR is a natural compliment to mmWave WiFi
  - The combined capabilities of these 2 technologies warrants further analysis to assess its potential to be the “ultimate in in-home connectivity”

Back-Up Slides

CPE Architecture in Vodafone *(more detail)*

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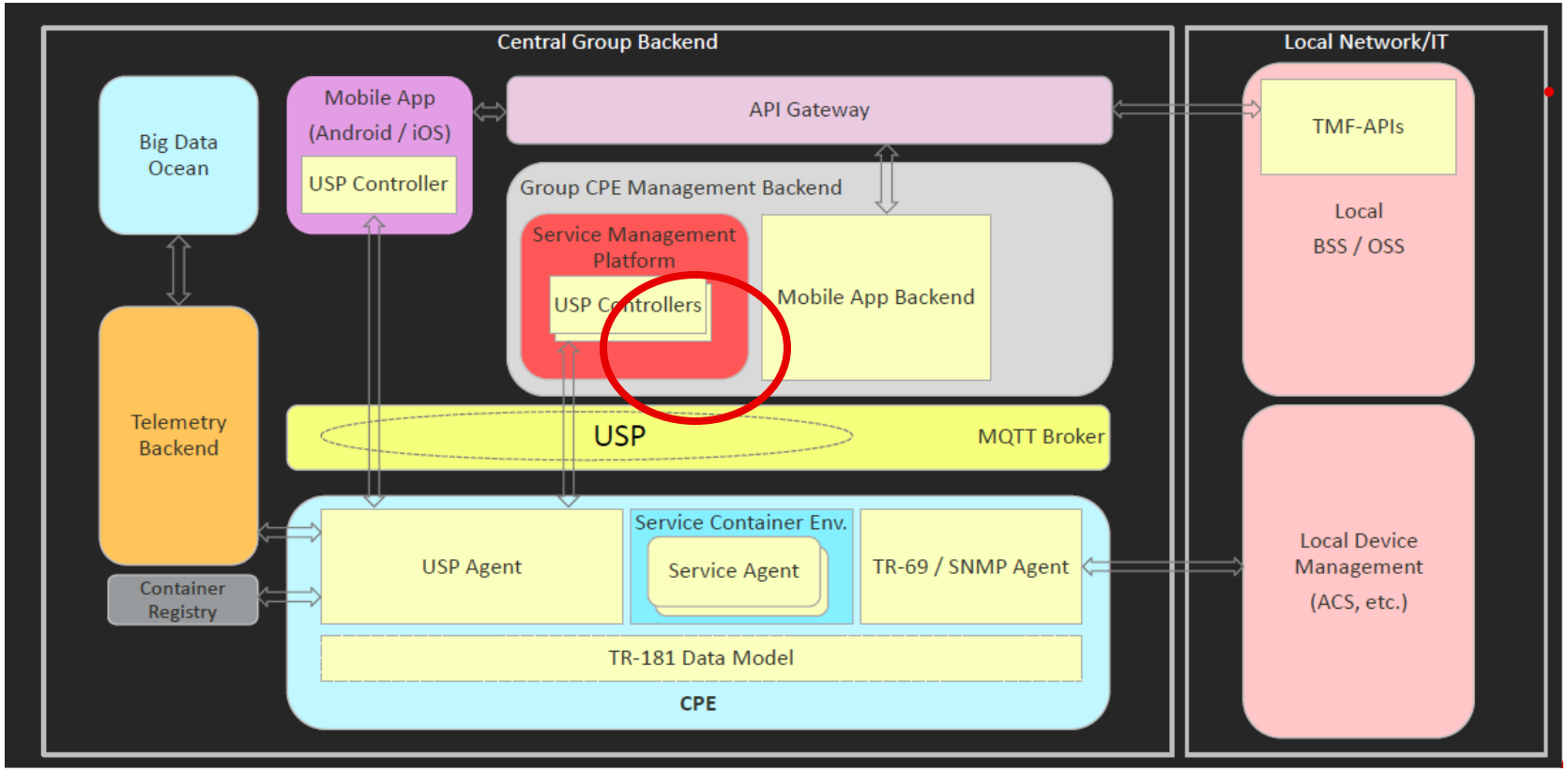

PLUS
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for Northbound APIs

WiFi capacity Roadmap

WiFi emerging capabilities fulfil todays and emerging applications (using only 2.4, 5 & lower 6GHz WiFi bands)

2021	2024	2028	2030 (?)
WiFi 6E	**WiFi 7**	**WiFi 8 rel.1**	**WiFi 8 rel.2 (9)**
802.11 ax	802.11be	802.11bn UHR	802.11bq UHR IMMW TG
Max capacity per AP	**9.6 Gbps** (1)	**24 Gbps** (3)	**24 - 30 Gbps** (11)	**59 Gbps** (10)
	•Bands 2.4, 5 GHz and lower 6GHz •1k QAM •160 MHz channel • MU-MIMO (up to 8 Spatial Streams) (12)	•From 160 to 320 MHz channel (x2) •4k QAM (+20%) •Multi-Link Operation (bonding channels) (5) •Puncturing •Enhanced Target Wake Time •Advanced MU-MIMO •Multiple RUs (14)	•Multi-AP Coordination (6) •Possible 8k QAM will increase +8.33% (7) •Lower Latency	• Add mmW 42.5 and 71 GHz (LoS) and possible 7GHz

- ✓ **Significantly increased throughput with 2.4GHz, 5GHz and Lower 6GHz (& with less variation)**
- ✓ **Reduced latency**
- ✓ **Much improved spectral efficiency allowing high crowded served area**
- ✓ **Robustness against interference (via MLO & puncturing)**

- ✓ **Suitable for high capacity, short-range environments (Factories, school classrooms, venues, offices,…)**
- ✓ **Perfect complement for Fibre-To-The-Room (FTTR) in homes (ITU standard now available)**
- ✓ **Previously the mmWave was proven in the WiGig protocol 802.11ad/ay**

Note on figures: Bit/rates are theoretical. Actual speeds depend on environment, interferences, distances etc. All Bit/rates are calculated considering only 6GHz lower band (5925 – 6425 MHz) Footnote are n backup slides.

WiFi Roadmap – Access Point & Handset

Max bit-rate and new features on each upgrade

	2021	2024	2028	2030 (?)
	WiFi 6E 802.11 ax	**WiFi 7** 802.11be	**WiFi 8 rel.1** 802.11bn UHR	**WiFi 8 rel.2** (9) 802.11bq UHR IMMW TG
Max capacity per AP 	9.6 Gbps (1) •Bands 2.4, 5 GHz and lower 6GHz • MU-MIMO (up to 8 Spatial Streams) (12)	24 Gbps (3) •4k QAM (+20%) •From 160 to 320 MHz channel (x2) •Multiple RUs (14)	24 - 30 Gbps (11) •Multi-AP Coordination (6)	59 Gbps (10) • Add mmW 42.5 and 71 GHz (LoS) and possible 7GHz
Expected max User speed 	1.2 Gbps (2) •1k QAM •160 MHz channel	3.6 - 9.3 Gbps (4) •Multi-Link Operation (bonding channels) (5)	9.3 Gbps(8) •Possible 8k QAM will increase +8.33% (7) •Lower Latency	9.3 Gbps (13)

mmWave

- Suitable for short haul and indoor environment like within rooms
- Already exploited in WiGig protocol 802.11ad/ay (11)
- Not best fit for mobile networks (dense antennas and rain attenuation)
- It is expected to be exploited by WiFi 8 rel.2 (9)

Note on figures: Bit/rates are theoretical. Actual speeds depend on environment, interferences, distances etc.
All Bit/rates are calculated considering only 6GHz lower band (5925 – 6425 MHz).