The expected advances in fixed access networks for mobile networks

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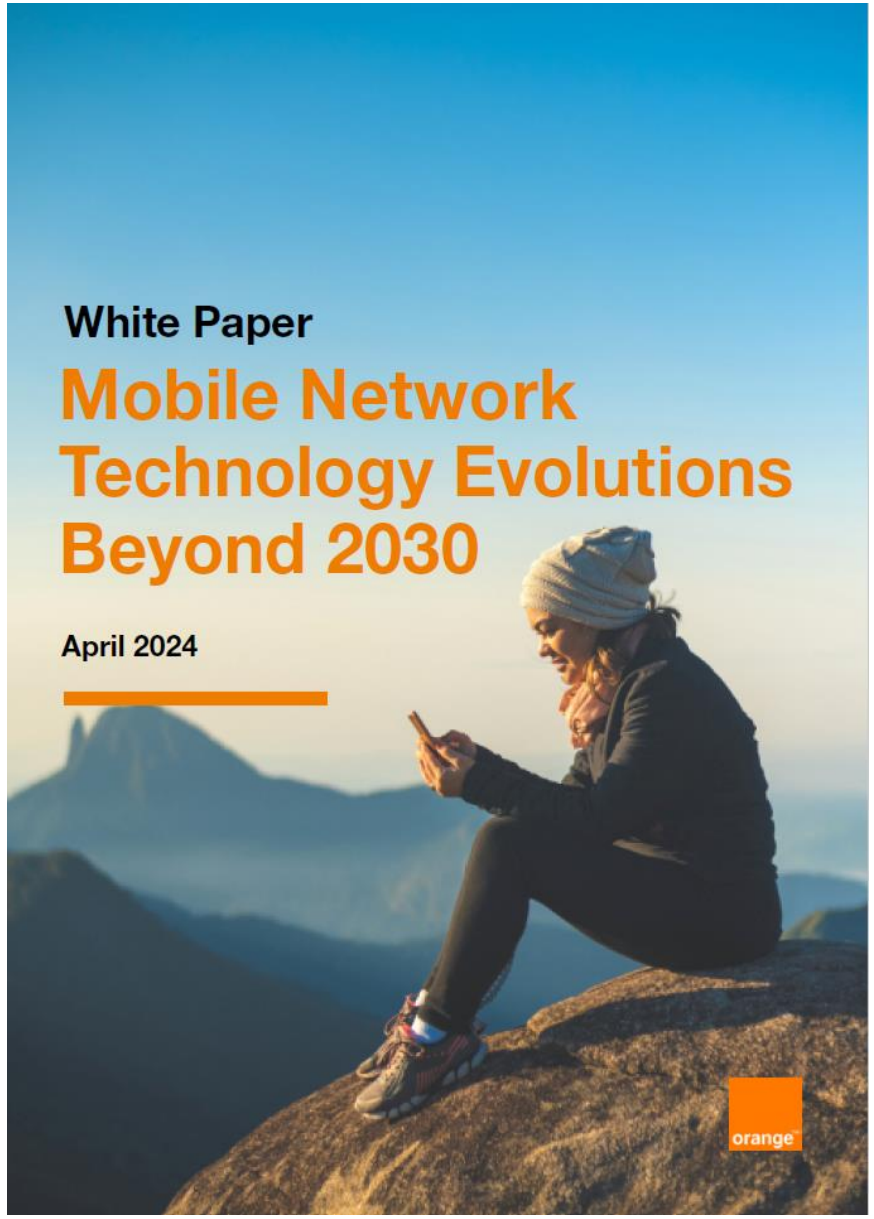
Workshop : Mobile Optics for 6G and Open Cloud RAN: New Concepts or More of the Same?

The Sunday 22th September 2024

Mobile Network Technology Evolutions Beyond 2030



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Key messages : Mobile Network Technology Evolutions Beyond 2030

Beyond "G's", for a new approach of mobile network technologies evolutions

We expect future network technologies to make the high level of 5G performance accessible to a larger number of devices rather than to improve the maximum performance levels as a given.

A new G requires new network equipment, to be added to or to replace the legacy ones, and to change the user terminals, leading to massive cost and environmental impact.

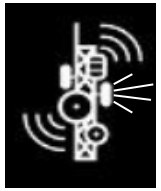
on the possibility to reuse legacy equipment through software upgrade or not…

A right balance should be found between introducing innovative connectivity services and capitalizing on legacy technologies whenever possible.

KPI	Possible extreme value	5G reference [12]	Complement, e.g., target scenario
User experienced data rate (at cell edge)	300 Mbit/s 100 Mbit/s	300 Mbit/s 50 Mbit/s	dense urban other outdoor environments Note: 250 Mbit/s required for immersive experiences. The majority of identified future usages would require less than a hundred of Mb/s.
Area capacity	3 Tb/s/km² 450 Gb/s/km²	750 Gb/s/km² 100 Gb/s/km²	dense urban outdoor & wide area Note: 30% activity factor assumed
Connection density	35 000 / km² 15 000 / km² 1.10^5/ km²	25 000 / km² 10 000 / km² 1.10^5 / km²	mobile broadband – dense urban mobile broadband – urban macro massive IoT
Positioning accuracy	< 10cm < 1m	1m 3m	indoor deployment outdoor & wide area
Energy efficiency	x10 vs. 5G	no quantitive requirement	at least as much as capacity increase, so that the network energy consumption remains stable of decreases
Minimum end-to-end latency	5 ms 0.5 ms (URLLC)	0.5 ms 0.5 ms	in generic deployments, for services that require it for specific services & uses cases associated to specific deployments
Reliability	99.9 % 99.999 %	idem idem	for most of services, typically (mobile broadband for specific services & uses cases associated to specific deployments
Mobility	500 km/h	idem	for specific services (very high speed trains, planes)

Some features under discussions…

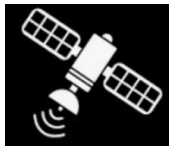
Frequency range FR3 (7.125 to 24.25 GHz) for radio coexistence
but might in conflict with public radio bands



Higher order MIMO and narrower beamforming
→ facilitate multi-user configuration within a cell

Sub-THz bands for deeper radio sensing

Public radio access points in various locations (transport nodes or shopping malls)
Offer local high-speed connectivity
potentially support mm-Wave small cells' backhaul needs



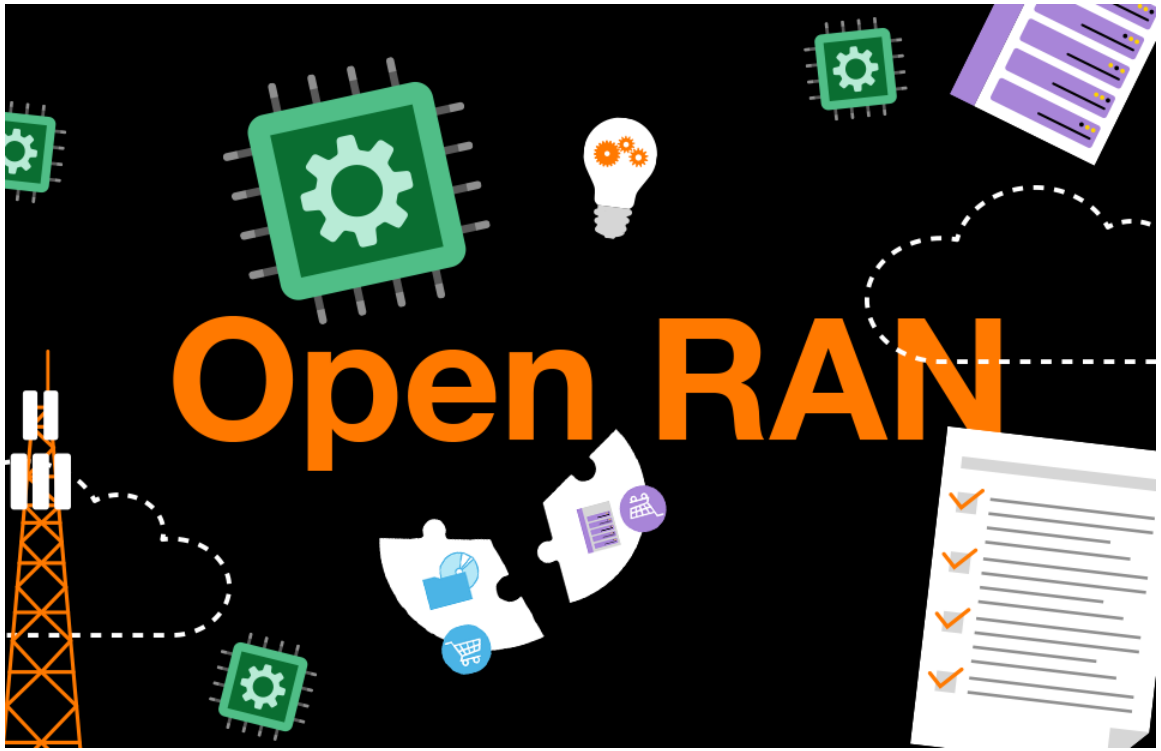
Satellite communication included as Radio Access Network
Specific interconnections to ensure real-time seamless
communication and connect the unconnected

Data-rate capacity x 10

New Applications

Seamless communications

Open RAN Evolutions



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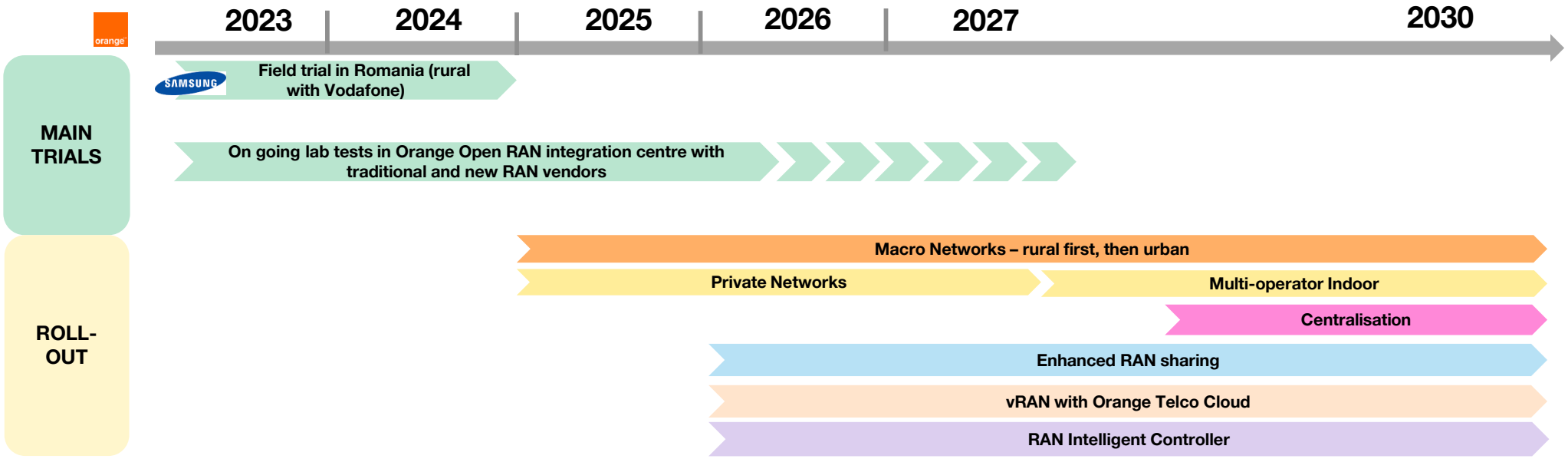
ORANGE Open RAN strategy



Open RAN opportunities

RAN renewal & cybersecurity: further swaps in Europe

RAN sharing extensions: e.g. in urban areas

Open RAN key drivers

Higher automation with virtualization: enabler for zero touch networks, allowing reduced OPEX

Higher efficiency with intelligence: optimized performance & higher operator customization, starting with higher layers, physical layers tbc

Higher operator differentiation with RAN sharing: more flexibility to operate own vRAN SW

Higher competition & flexibility with Open Fronthaul: mix & match of vendors easing swaps

Expectations

Support of v4G + v5G (with optional v2G): support of all technos to allow full swap of legacy

Feature parity with traditional RAN

Lifetime of cloud infra to be similar to BBU (~10y)

Temperature range up to +55°C

Competitive ecosystem for chipset / accelerator: performance, energy efficiency, portability

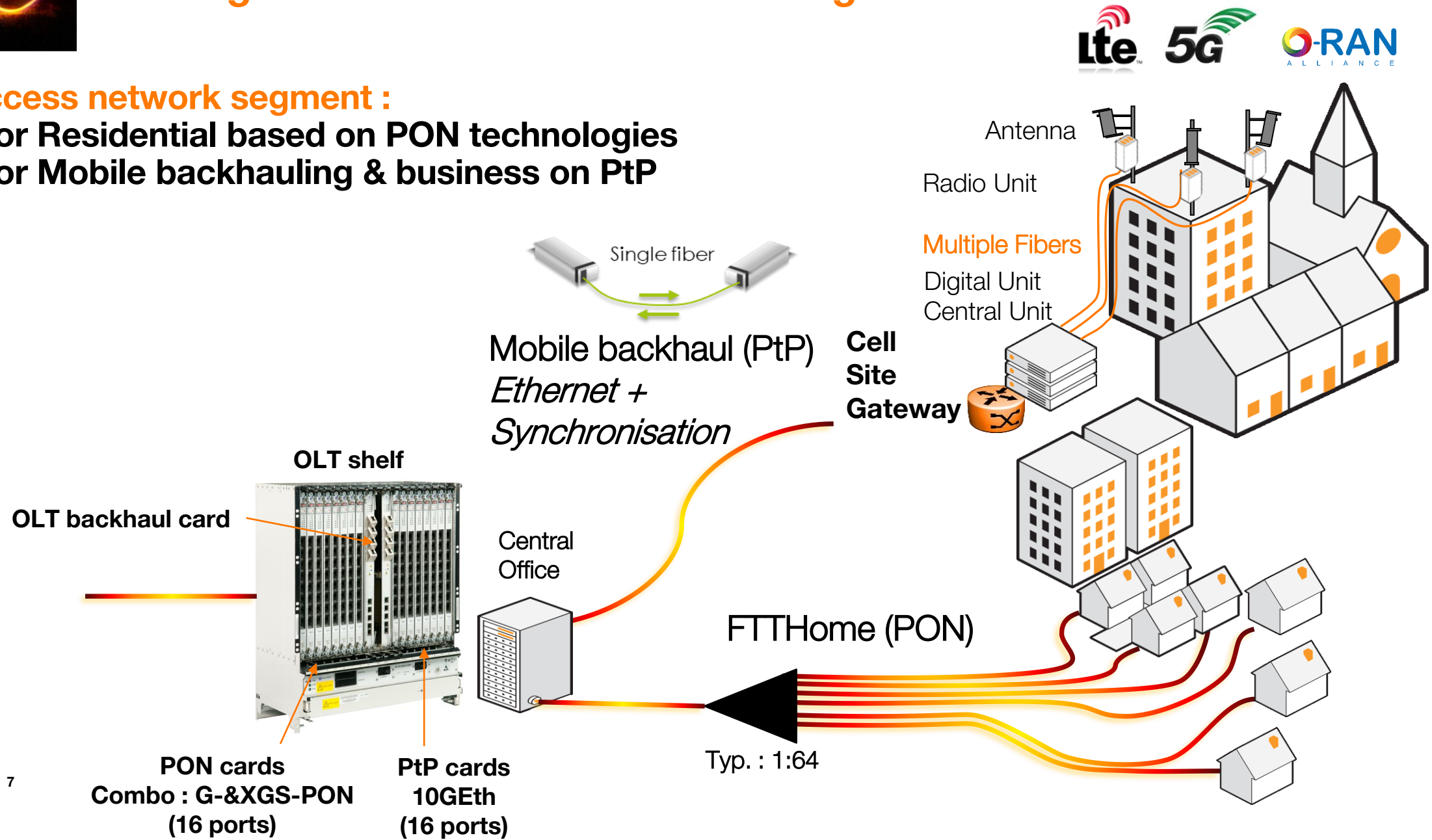
Open Fronthaul support with selected vendors: enabling both FDD & Massive MIMO

Automation framework open to operator custom modules and inter-op with 3rd parties

Orange's access networks technologies

Access network segment :

- for Residential based on PON technologies
- for Mobile backhauling & business on PtP



Orange's access networks technologies

Access infrastructure medium

Medium

Only Copper → Full Fiber → New Fiber?

Hardware

PON technologies

Operational deployment for FTTH

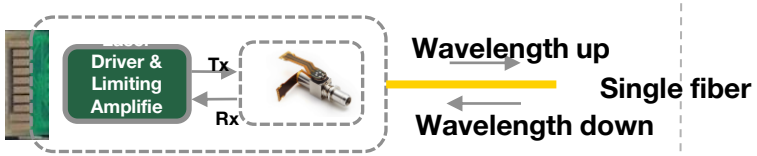
- G-PON — 2,5/1,25 Gbit/s — ?
- XGS-PON — 10 Gbit/s
- HS-PON — 50 Gbit/s — ? Orange considers HS-PON as the next step but no deployment request already identified by Orange
- VHS-PON — 200 Gbit/s — ?

Standard started · Standard finished · Deployment begins · Deployment ends

PtP technologies (FTT Cell Site)

- 100 Mbit/s (G.985)
- 1 Gbit/s (G.986) — ?
- PtP WDM 1.25 2.5, 10 Gbit/s (G.989)
- WDM PON (G.9802)
- 10 Gbit/s, 25 Gbit/s, 50 Gbit/s, 100 Gbit/s (G.9806)
- 200 Gbit/s
- 400 Gbit/s IEEE802.3dk

Operational deployment for FTT Cell Site (mobile backhaul)



2000 2005 2010 2015 2020 2025 2030 2035 2040

PtP optical access to serve 5G and post-5G

OLT shelf

PtP cards
10GEth
(16 ports)

Existing optical access connectivity

- for distributed RAN (in other word no Centralized RAN, no extended reach fronthaul), only Mobile backhaul
- 10GEth PtP is the regular connectivity required for Mobile backhaul (single fiber, bidirectional)
- 25GEth PtP is ready but not purchased
- OLT switching capacity : about 3 to 10Tbit/s

Future optical access connectivity

- 25GEth PtP is ready but could be purchased
- OLT switching capacity evolution : about 100Tbit/s
- 100GEth PtP bidirectional (single fiber) is available (ITU & IEEE specifications in final discussion)
- 200 to 800 Gbit/s (1,6Tbit/s) is under investigation for PtP bidi
- new PtP transceivers include advanced signal processing, new FEC, coherent technology….
- for a tight synchronization, the transceiver parameters must be considered: cf. next slide

PON to serve 5G and post-5G?

Why PON is not massively used for Mobile backhauling?

- No alignment of the roadmaps of FTTH and Mobile backhaul:
  typ. In 2020, 5G cell site required 10GEth, when XGS-PON is launched in 2024
- An existing fiber infrastructure PtP dedicated to each antenna (with dedicated boxes) to decrease unavailability (historic of SDSL vs. ADSL for 2G and 3G)
- Each OLT shelf (up to 16k residential customers) has limited number of antenna site within the coverage area :
  - high density area : up to 20 cell sites (never several antenna sites per ODN)
  - medium density area : <5 cell sites

  So PON is a solution that is not massively replicated (not the same scale)
- Need a specific ONU compatible with synchronization (low volume but fully PON interoperable)
- PON is based on aggregation mechanism, CU&DU is also aggregation based, PON for mobile backhaul is a cascaded of two aggregation mechanisms.
- Fair play aggregation mechanism not at the same scale for OLT PON port:
  - each home is about 4 final users (64 split ratio ≈ 256 final users per OLT port)
  - one cell site is about 2k final users

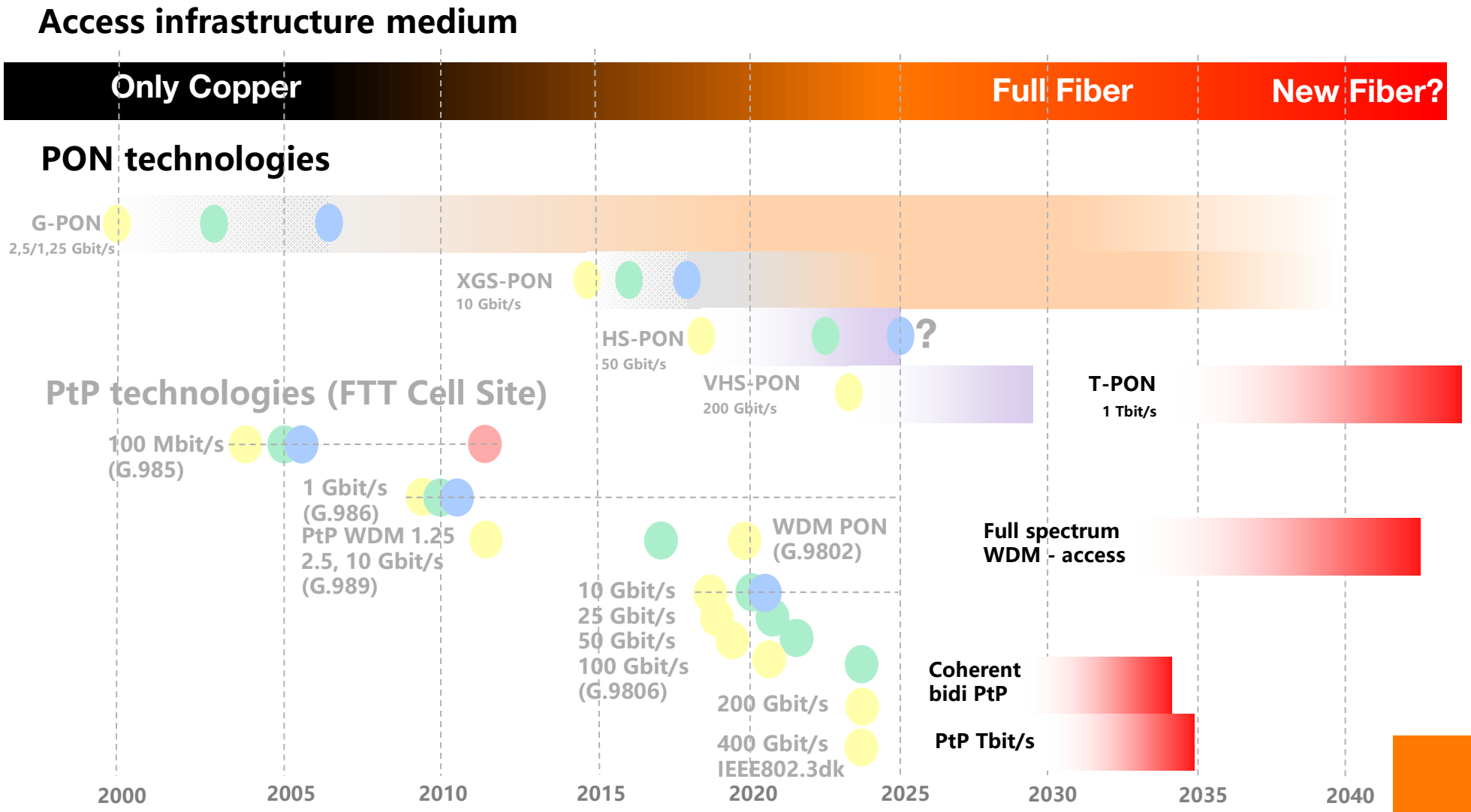
Why PON could be used for Mobile backhauling?

- Decrease the cost of Mobile backhaul price
- Fiber is now everywhere and could be used for new or remodeling cell sites

Photonics in 6G related to Orange's access networks

Medium

Hardware



Related fixed access technologies to serve radio access networks

Medium

Hardware

Software

Access infrastructure medium

Only Copper

Full Fiber

New Fiber?

PON technologies

HS-PON
50 Gbit/s

?

T-PON

VHS-PON
200 Gbit/s

PtP technologies (FTT Cell Site)

100 Gbit/s

200 Gbit/s

400 Gbit/s
IEEE802.3dk

Full spectrum
WDM - access

Coherent
bidi PtP

PtP Tbit/s

Access software

Dedicated hardware &
proprietary manager

Software Defined Access
Network

Autonomous &
intelligent network

2000 2005 2010 2015 2020 2025 2030 2035 2040

Key points for fixed access networks to serve future mobile networks

1. To be ready for a mass market 100Gbit/s PtP bidirectional (single fiber) operation with reach up to 60 km

2. Next generation OLT shelf with several 10's Tbit/s switching capabilities and uplink working at 800 Gbit/s or more

3. Open question : When do we need to add "all photonics" (IOWN) functions at OLT node?

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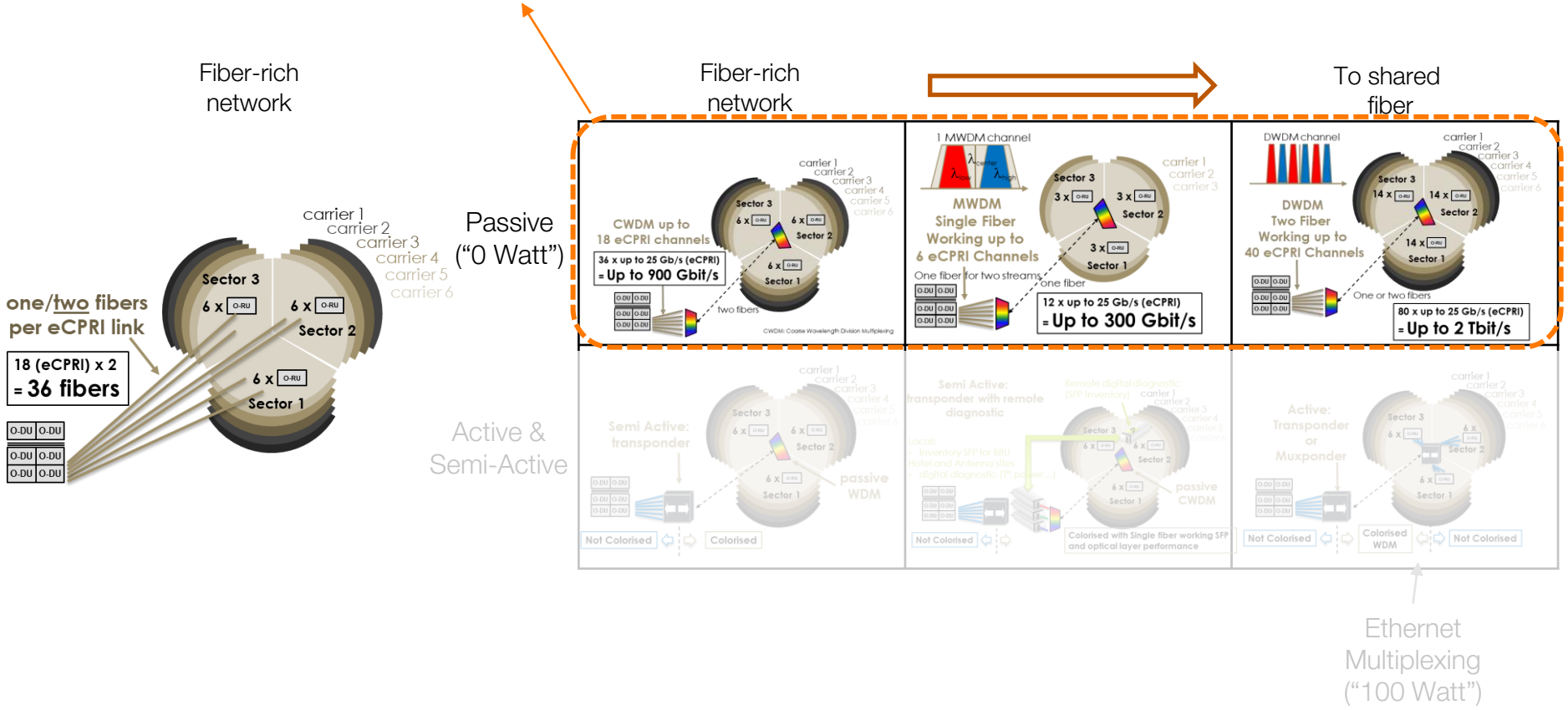
Thank You

Existing passive optical transport solution for outdoor Mobile fronthaul

- "0 Watt" solution (passive) is used to save fiber between cell sites and central office node
- Fiber and wavelength allocation are not line rate dependent
- Potential complex colorized transceiver operation
- No dedicated transport management (passive demarcation point)
- Required dark fiber offers (by wholesale or other)



Existing active optical transport solution for outdoor Mobile fronthaul

- **Active solution (about 100 watt) is used to save fiber between cell sites and central office node**
- **Grey optical transceivers operations (low cost vs. colorized transceivers)**
- **Ports, card & shelf are line rate and protocol dependents (renewal of transport equipment to be planned cyclically)**
- **Interoperability between providers**
- **Potential special features required: time sensitive, slice management,…**
- **Transport management allowing to provide demarcation points with KPI**