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MOPA
Mobile Optical Pluggables Alliance

Mobile Optics (MOPA) for the 6G Era

Show Floor Moderator:
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Mobile Optics (MOPA) for 6G: Operator Requirements for 6G

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Orange Innovation Networks

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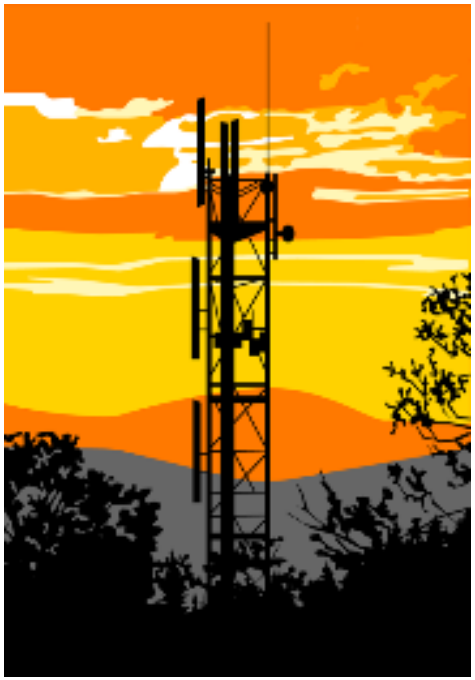


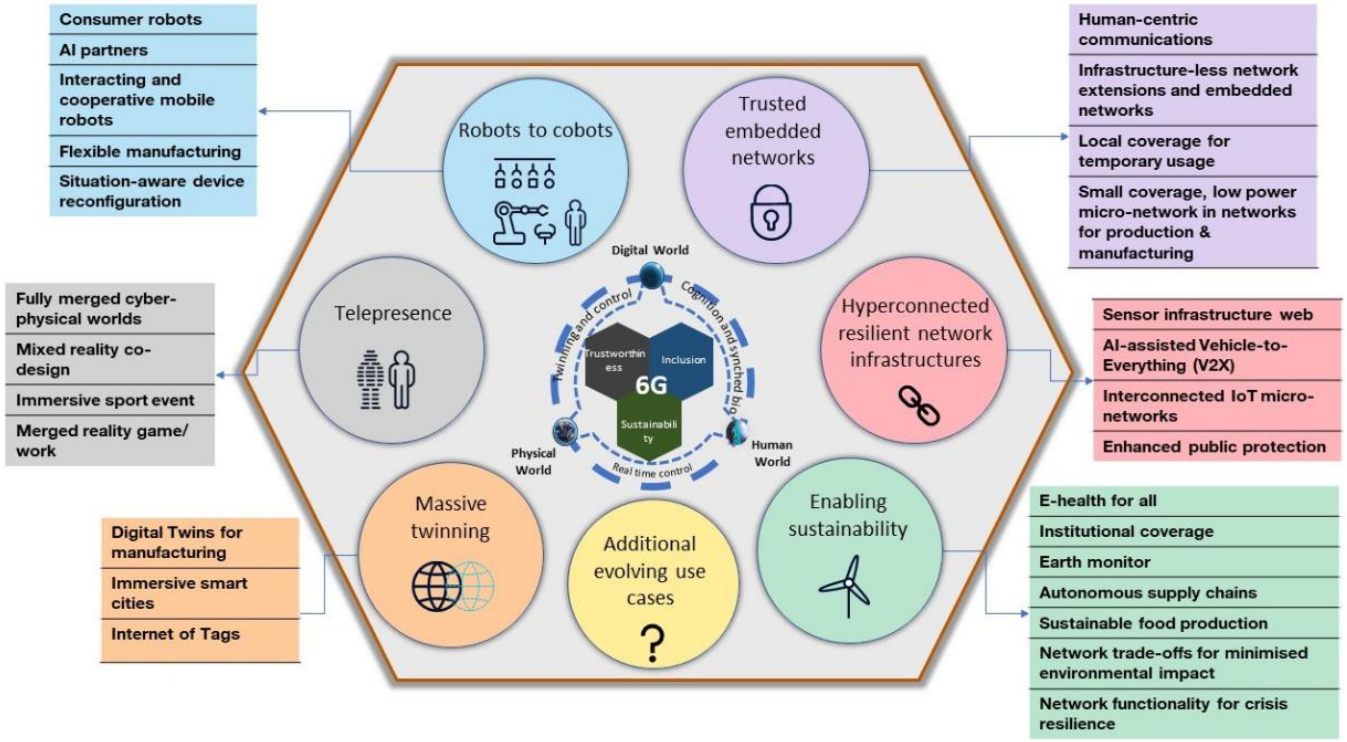
Agenda

1 6G Architecture Landscape

2 Optical access solutions to support xHaul

The 6G Architecture Landscape – European perspective

Families of 6G uses cases



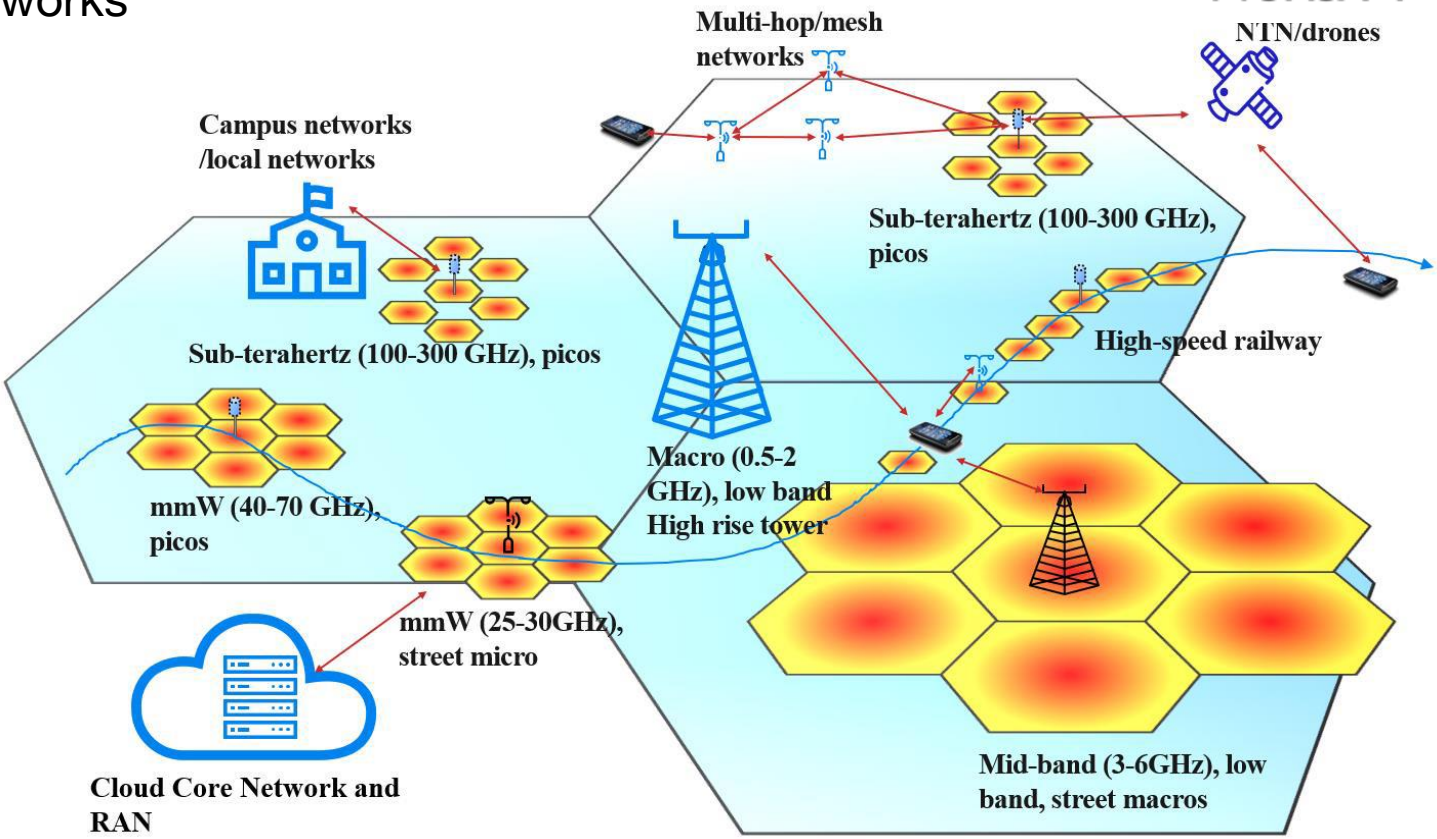
Main performance metrics / KPIs

- Accuracy in position and orientation
- Resolution to separate objects / paths
- Latency to support high mobility applications
- Range to provide coverage
- KPIs defined based on use cases
- KPIs put requirements on bandwidth, array sizes, deployments, etc

Source: Hexa-X project, D1.4 summary slides, available online https://hexa-x.eu/

The 6G Architecture Landscape – European perspective

6G will consist of many sub-networks:
A “network of networks”



Many sub-networks

6G must:
- support L1/L2 mobility
- develop new enhanced multi-connectivity
- develop dynamic spectrum sharing for 5G-6G migration

The 6G Architecture Landscape – European perspective

Research Trends

Channel Modelling

- Modelling near-field and wide bandwidth effects at (sub-)THz
- Small-scale fading over frequency and space due to the multi-paths created by rough surfaces

Radio Architecture and Models for D-MIMO

- Signal processing options
- Functional splits for different purposes
- Use of serialized and wireless fronthaul interfaces, RIS, and network-controlled repeaters
- Exploring the trade-offs between analogue and digital processing and centralized versus distributed processing

Localization and Sensing

- Algorithms for extra-large aperture arrays (in context of D-MIMO and near field localization)
- Reconfigurable intelligent surfaces as low-cost alternative to power-hungry base stations
- Techniques to use ML effectively with limited real-world data and to handle unknown channel models

Signal processing techniques

- D-MIMO
  - Enhanced non-coherent techniques
  - Multi-band operations
  - Multi-antenna UEs
  - Heterogeneous nodes (w.r.t. capabilities and functionalities)
  - Role of reconfigurable intelligent surfaces and network-controlled repeaters for integrated access and backhaul
  - Context-aided communications
- Compensation of hardware impairments
  - Modelling of hardware impairments
  - TX vs. RX side compensation
  - Machine learning frameworks for data, training, monitoring, etc.

Optical Wireless Communications

- Methods for combining THz and OWC to enhance performance in terms of capacity, reliability, and latency

The 6G Architecture Landscape – 6G FLAGSHIP

FLAGSHIP
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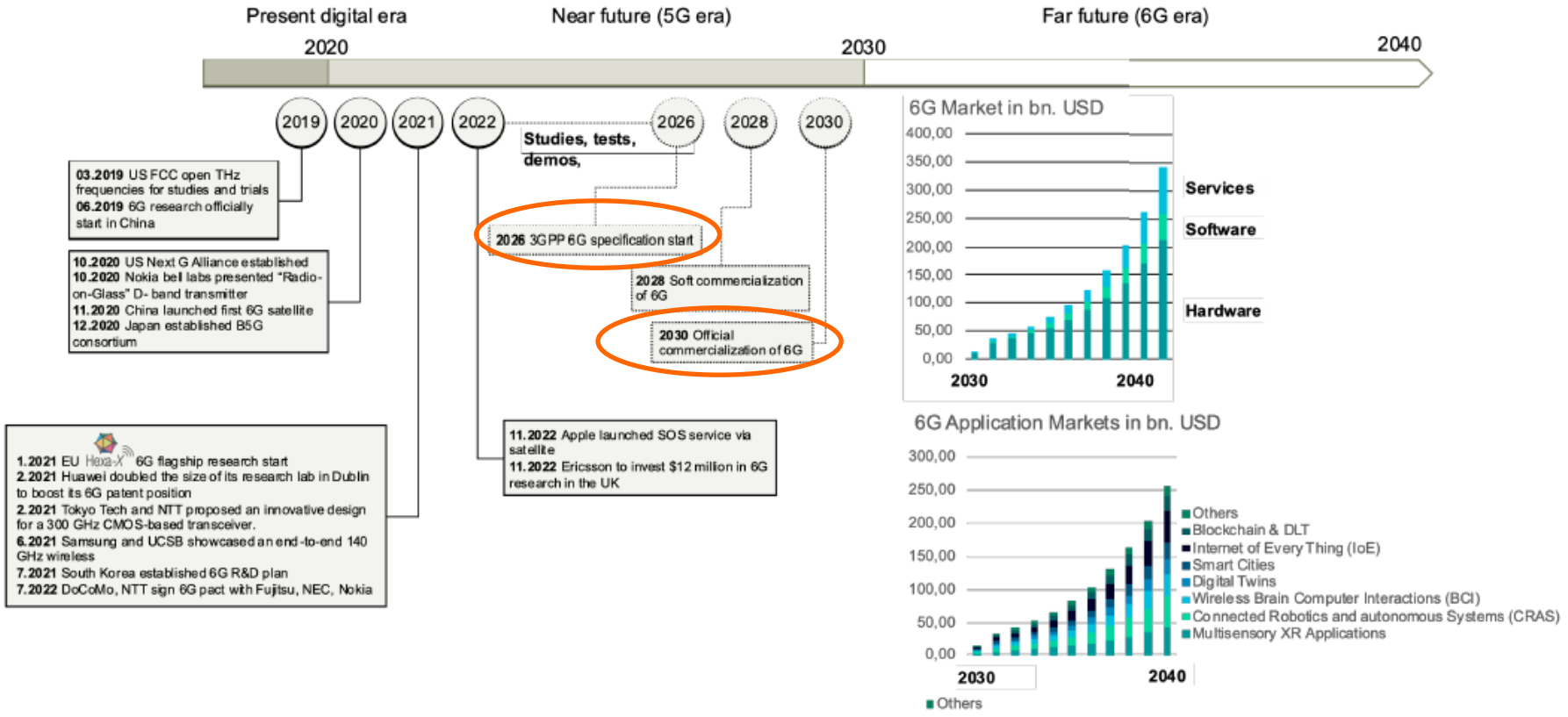
KPI	5G	6G
Peak data rate	20 Gb/s	1 Tb/s
Experienced data rate	0,1 Gb/s	1 Gb/s
Peak spectral efficiency	30 b/s/Hz	60 b/s/Hz
Experienced spectral efficiency	0,3 b/s/Hz	3 b/s/Hz
Maximum bandwidth	1 GHz	100 GHz
Area traffic capacity	10 Mb/s/m^2	1 Gb/s/m^2
Connection density	10^6 devices/km^2	10^7 devices/km^2
Energy efficiency	not specified	1 Tb/J
Latency	1 ms	100 µs
Reliability	$1-10^{-5}$	$1-10^{-9}$
Jitter	not specified	1 µs
Mobility	500 km/h	1000 km/h

Table 1: A comparison of 5G and 6G KPIs [4–6,9].

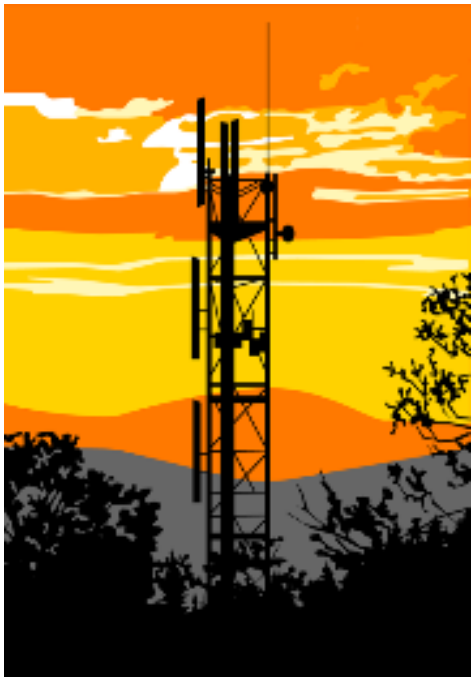
The 6G Architecture Landscape – European perspective

6G Markets Evolution



Based on: IDTechEx, „Where Are We at With 5G, and Where Are We Going With 6G?", 2022

Based on: Market Research Future, "6G Market Research Report", 2023



Agenda

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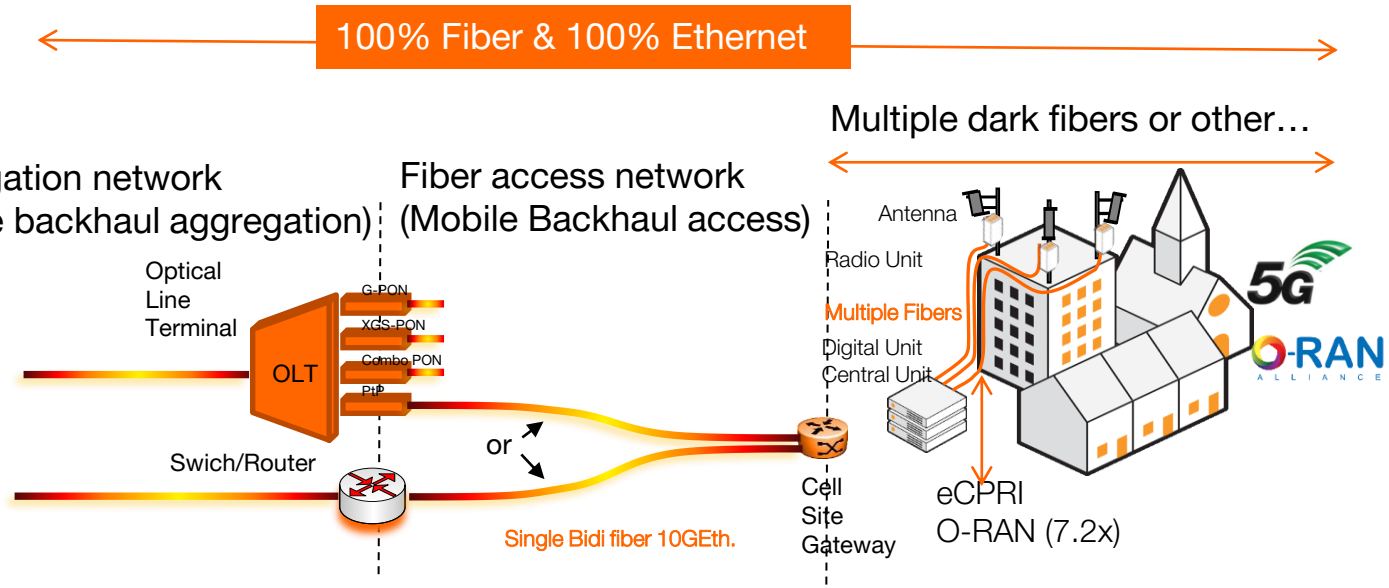
2 Optical access solutions to support xHaul
- Distributed RAN
- Centralized RAN
- Indoor RAN

Optical access solutions to support xHaul

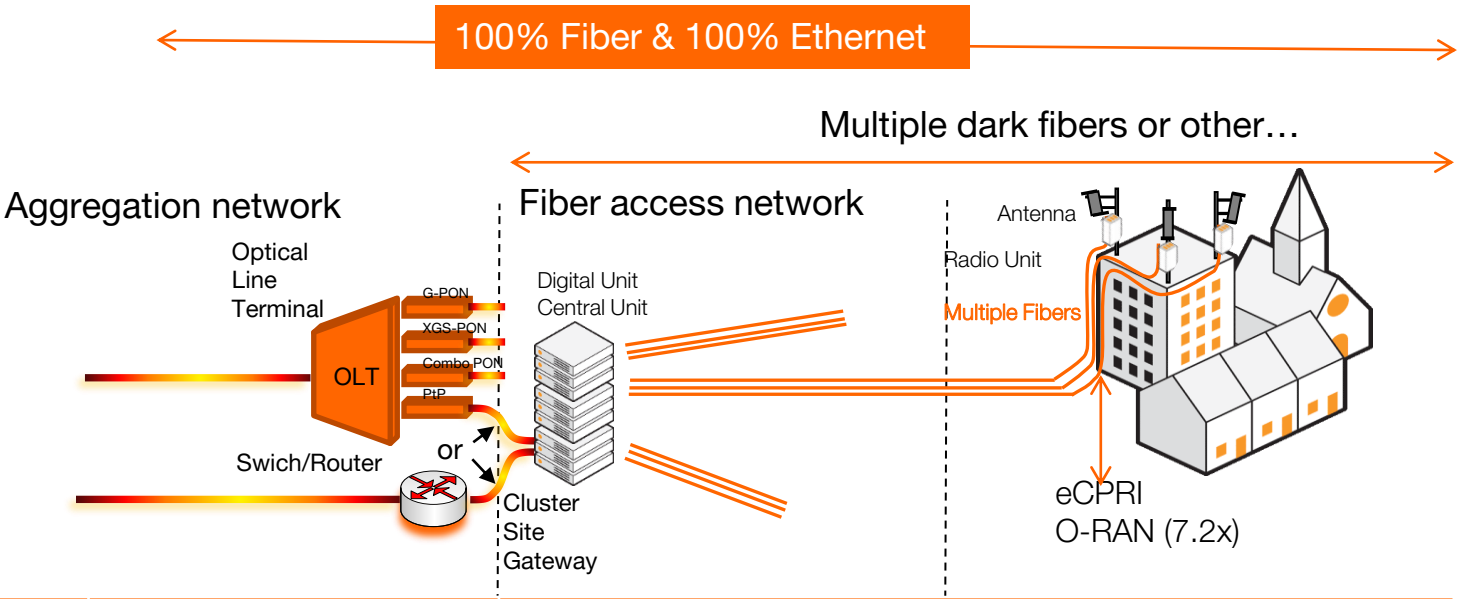
Distributed RAN



	Backhaul aggregation (mesh)	Backhaul access (typ. 10 km) (PtP, option: dual adduction)	Fronthaul (local < 2km) (N x PtP links]
Now	100Gbit/s [bidirectional recently available with limited reach]	Bidirectional 10Gbit/s	N = number of RU interfaces N x 10 or 25 Gbit/s ≈ 100 Gbit/s
Future	200, 400, 800Gbit/s [bidi. not available]	25Gbit/s and 100Gbit/s	RU interface = 100 Gbit/s

Optical access solutions to support xHaul

Centralized RAN



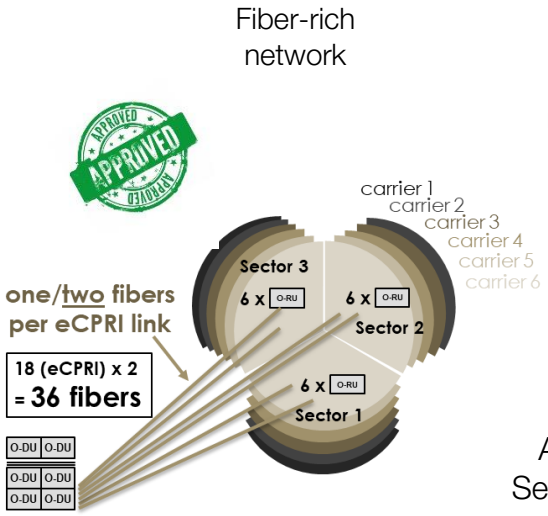
	Backhaul aggregation (mesh)	Fronthaul access and local (typ. 10 km) (PtP, WDM)
Now	Multiple 100Gbit/s	N = number of RU interfaces; P = number of Antenna site N x P x 10 or 25 Gbit/s ≈ 1 Tbit/s
Future	200, 400, 800Gbit/s [bidi. not available]	RU interface = 100 Gbit/s (single fiber, bidirectional?)

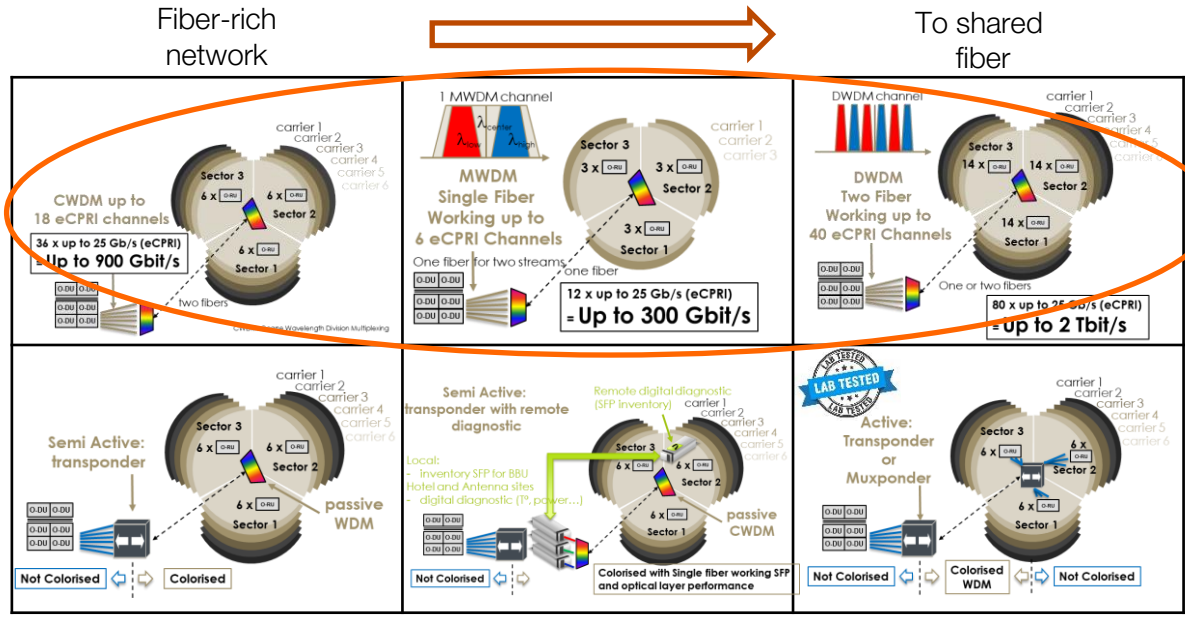
Optical access solutions to support xHaul

Centralized RAN (cont.)

Existing transport solution for outdoor Mobile fronthaul at Orange France

- "0 Watt" solution (passive) is used for niche market of Orange France Centralized RAN (cell site footprint issues)
- Solution integration with RAN vendors Nokia and E///
- Fiber and wavelength allocation are not line rate dependent
- No dedicated transport management
- Existing dark fiber wholesale offers



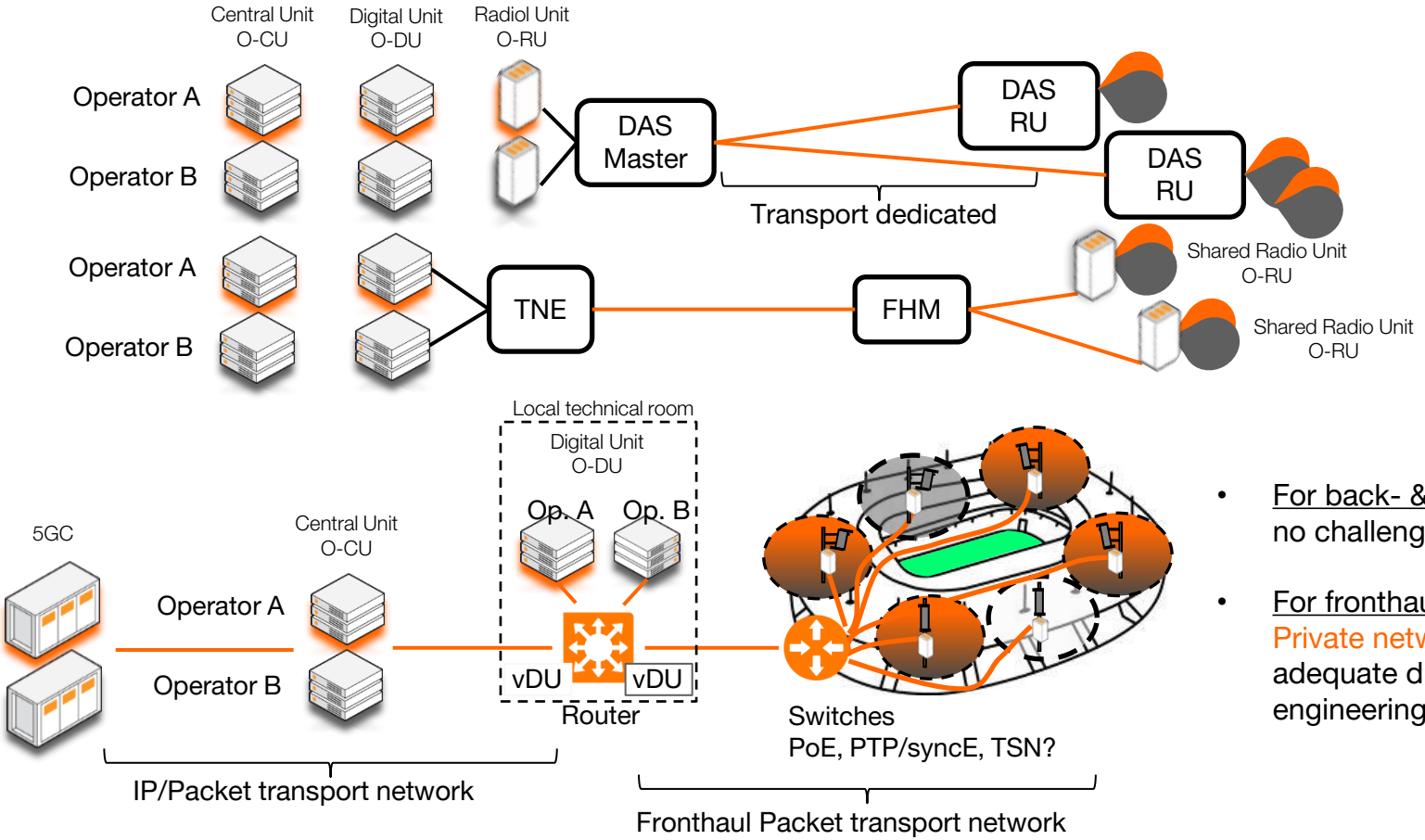


Optical access solutions to support xHaul

- DAS: Distributed Antenna System
- TNE: Transport network equipment
- FHM: fronthaul multiplexer

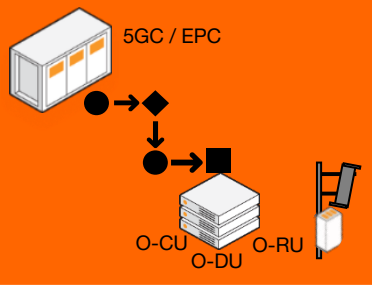
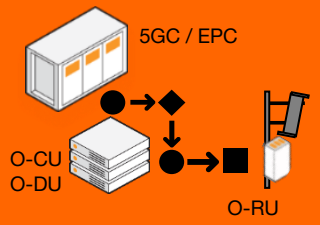
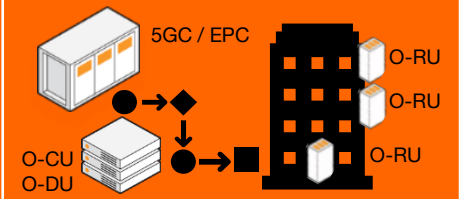
Indoor RAN

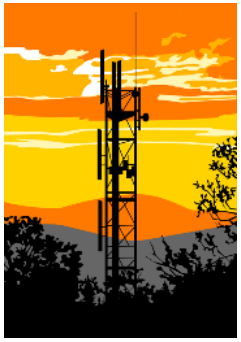
Overview of a transport solution for indoor Mobile



- For back- & mid-haul transport: no challenges
- For fronthaul transport: Private network with the adequate dimensioning and engineering rule.

Optical access solutions to support xHaul

Scenario	Distributed RAN	Centralized RAN	Indoor RAN
			
Back&Mid-haul	- No transport challenges - Medium term : slicing (coordination between FAN & RAN)	- No transport challenges (Central office or Edge node with technical room for Data Center accommodation*) - Medium term: slicing	- No transport challenges - Medium term : slicing (coordination between FAN & RAN)
Fronthaul	- Local fronthaul - Multi-source transceivers compatibility & interoperability	- Active solution: « Rakuten » - Passive solution: 0 Watts (preferred)	- Evolution of DAS (Distributed Antenna Systems) to Ethernet (TSN) or WDM



key points for optical access to support 6G X-haul

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

2 Centralized RAN with extended Fronthaul is :
- niche market for Orange, presently
- country wholesale or fiber operation dependent

3 For indoor RAN, traditional transport equipment could be reused (synergy with Passive Optical LAN and FTTRoom)

4 Challenges for equipment multi-vendor interoperability and combination of several network management and data model.

Thank You

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