5G Backhauling_

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5G System Requirements and Architecture

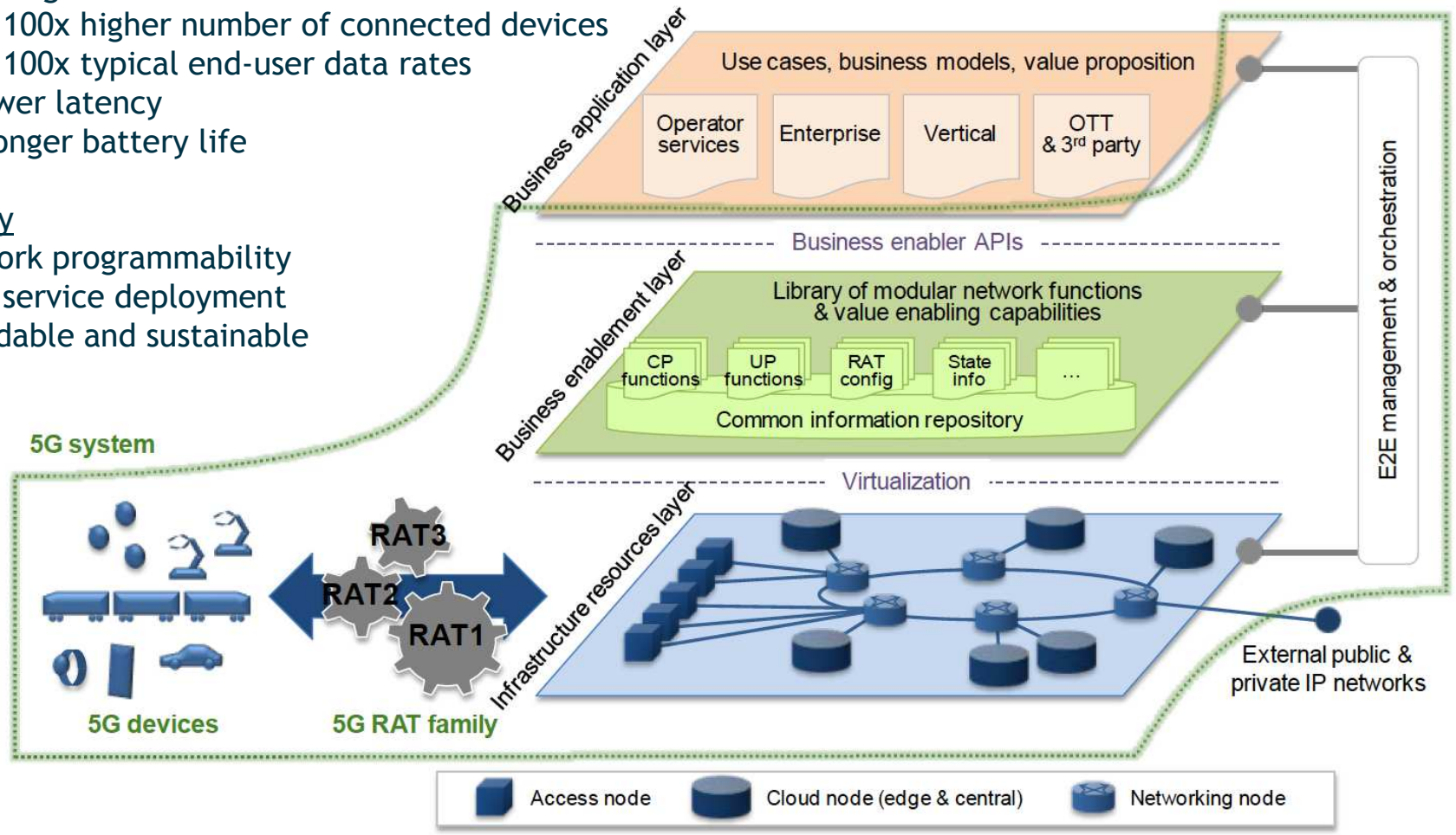
Performance

- 1000x higher mobile data volumes
- 10x – 100x higher number of connected devices
- 10x – 100x typical end-user data rates
- 5x lower latency
- 10x longer battery life

Flexibility

- Network programmability
- Agile service deployment
- Affordable and sustainable

5G Architecture from NGMN White Paper



5G Use cases

4 White papers 5G scenarios are covering massive IoT, low latency, high reliability, flexibility, cost-efficiency, etc

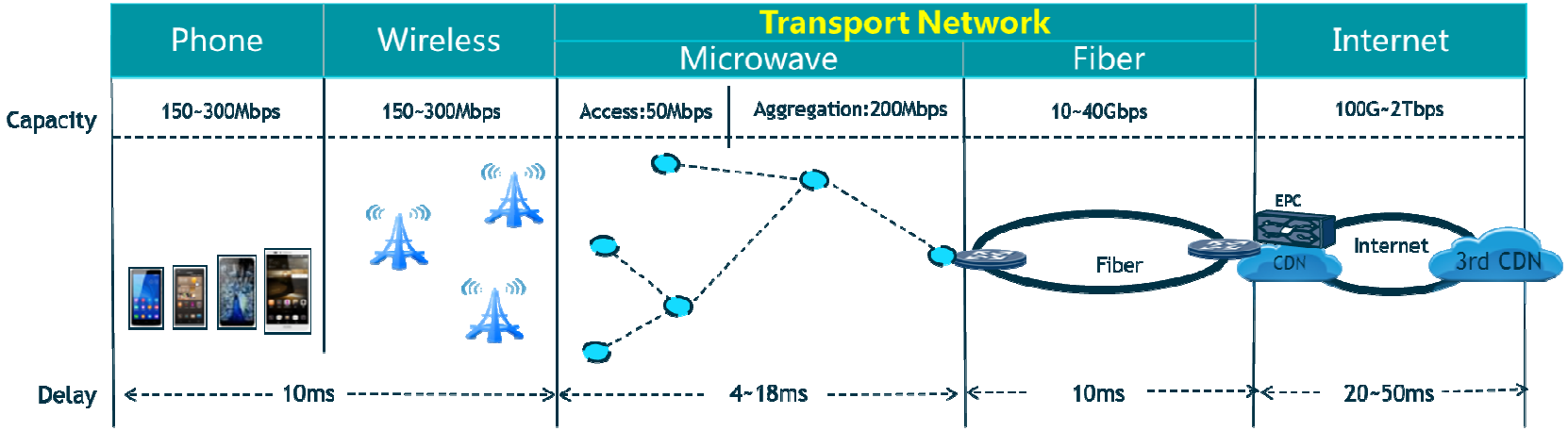
IMT-2020 whitepaper - 4 scenarios
- Seamless wide-area coverage
- High-capacity hot-spot
- Low-power massive-connections
- Low-latency high-reliability

3GPP whitepaper - 6 scenarios
- Ultra-reliable
- Mobile broadband
- Flexible and scalable
- Wide-area
- Virtural presence
- Real-time

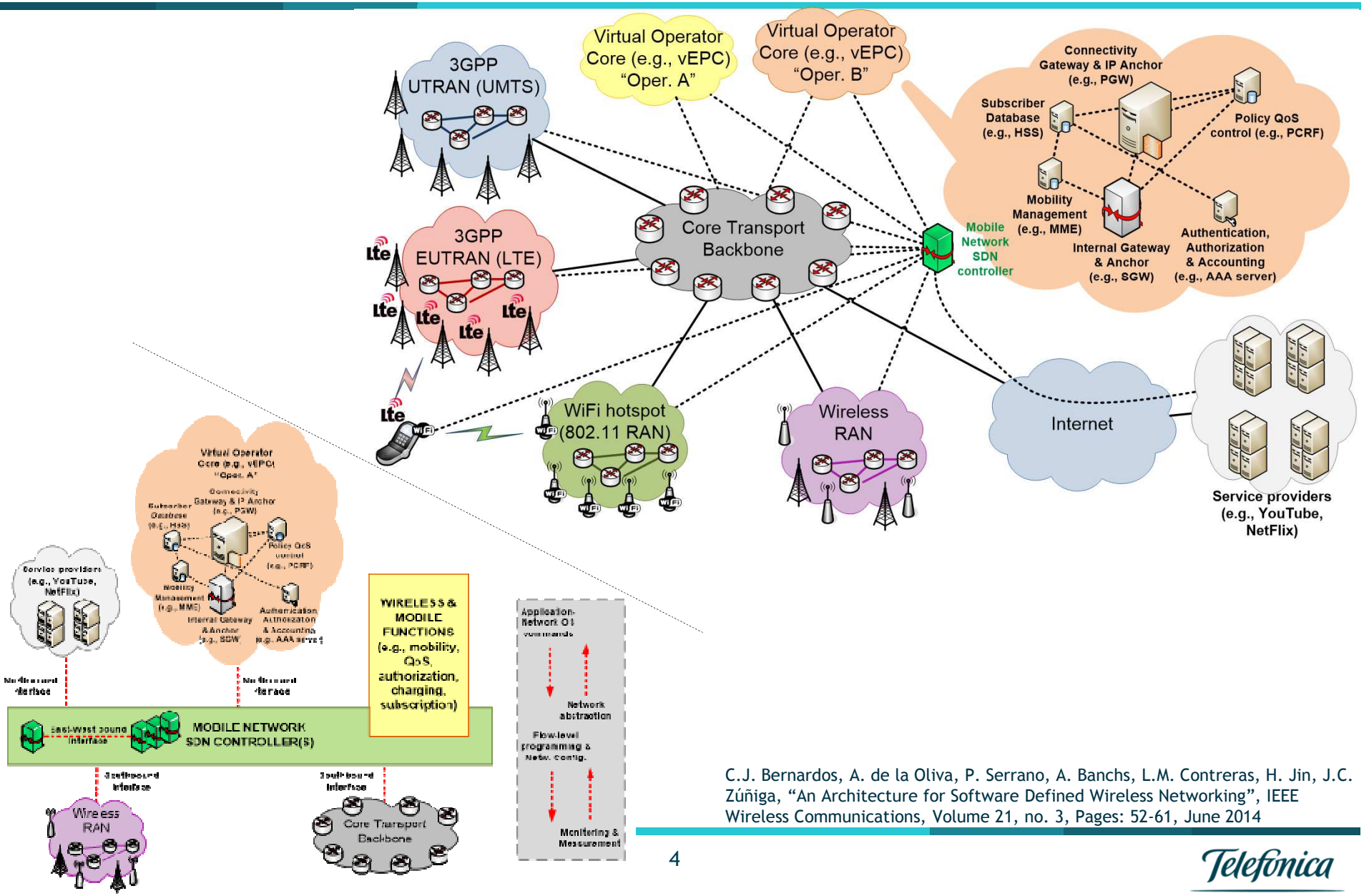
NGMN whitepaper - 8 scenarios
- Broadband access in dense areas
- Broadband access everywhere
- Higher user mobility
- Massive internet of things
- Extreme real-time communications
- Lifeline communications
- Ultra-reliable communications
- Broadcast-like services

IMT-2020 whitepaper - 3 scenarios
- Enhanced mobile broadband
- Ultra-reliable and low latency communications
- Massive machine type communications

Very distinct use cases with different requirements to be supported over the same BH infrastrcuture



Software Defined Wireless Network concept



C.J. Bernardos, A. de la Oliva, P. Serrano, A. Banchs, L.M. Contreras, H. Jin, J.C. Zúñiga, "An Architecture for Software Defined Wireless Networking", IEEE Wireless Communications, Volume 21, no. 3, Pages: 52-61, June 2014

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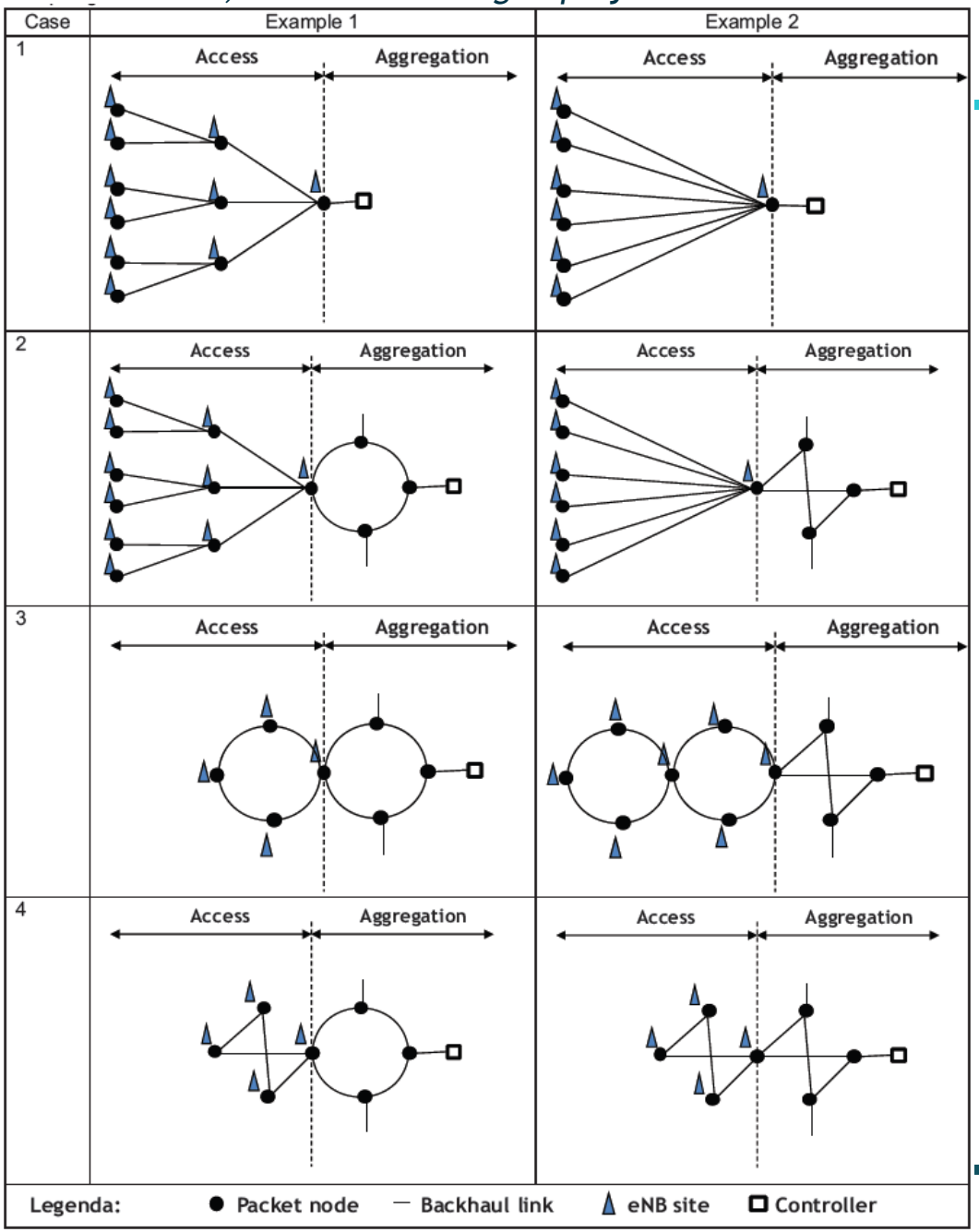
Mobile backhaul

Mobile service provided over

- Multi-technology network
  - ✓ Optical, microwave, Ethernet
- Multi-topology architecture
  - ✓ Ring, star

Source: NGMN, *"LTE Backhauling Deployment Scenarios"*



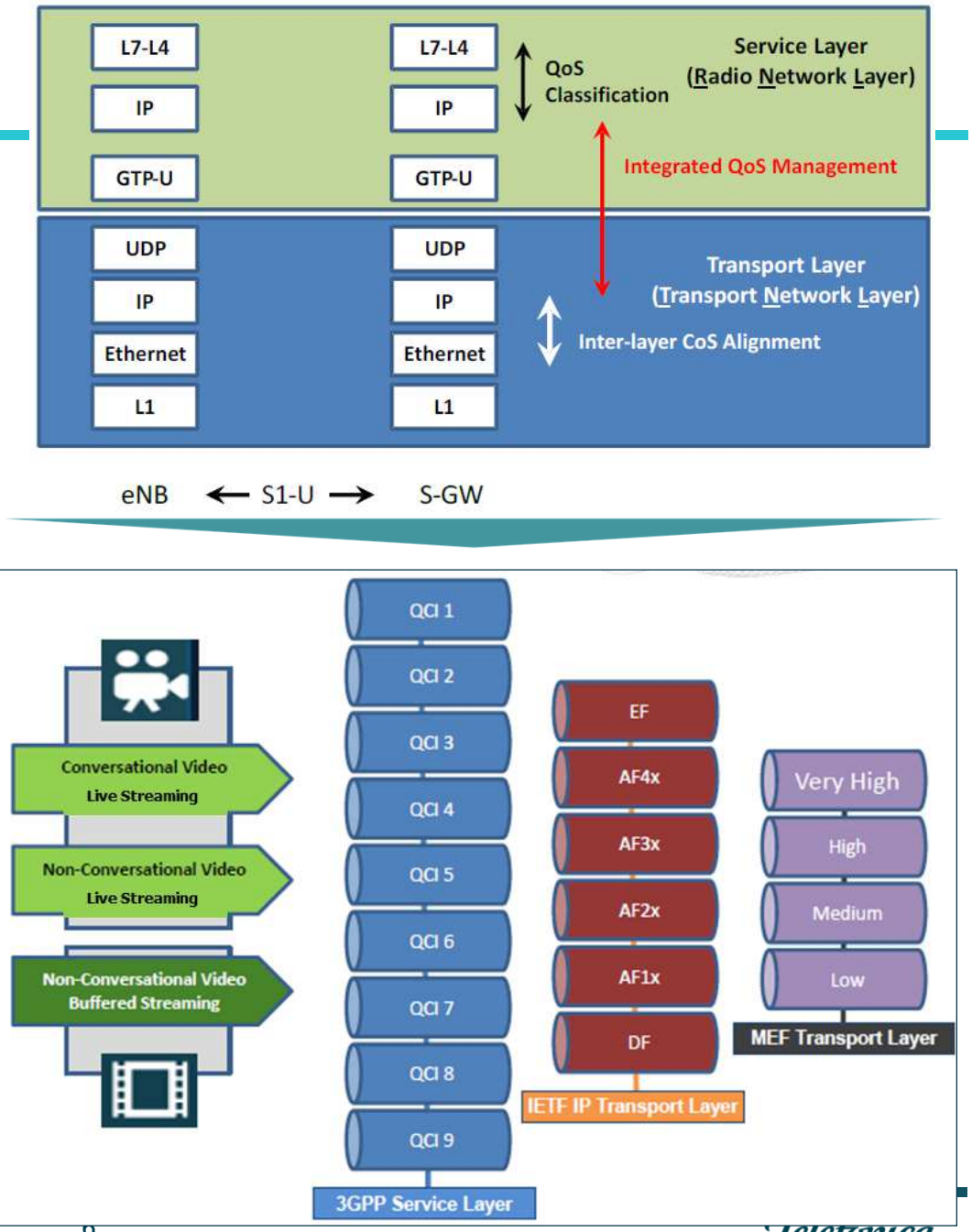
Mobile backhaul

<u>Exemplary case – QoS</u>

Need for providing homogeneous QoS over heterogeneous transport networks

Need for dynamically controlling network resources according to radio conditions

- ✓ For instance, adaptive modulation in a wireless backhaul path could impact the network resources for a flow both in the radio access and the aggregation switches in backhaul



Source: NGMN, *"Integrated QoS Management"*

Software Networks and Economic Efficiency

Some other cases

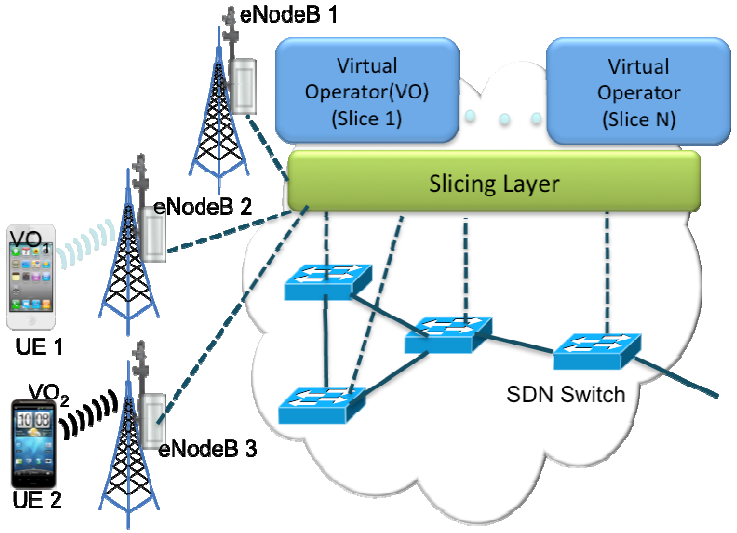
Network Sharing

- The higher granularity of the access networks make them subject of higher investments
- Sharing network infrastructures with other operators reduce that investments
- Agile and flexible mechanisms for sharing network resources are needed

Traffic offloading / steering

- Variations on traffic load, network status, or service node location could lead to flow redirection over vacant infrastructure

- New models for network resource management (including sharing)
  - Multi-tenancy at any level
- Reducing CAPEX and OPEX
  - Help building the case for addressing 5G
- Address the long tail when and wherever necessary
  - Following the users
- A new converged architecture
  - The “last yard” rather than the “last mile”



Mobile backhaul

SDN control will allow the orchestration of the network resources

Separate, independent layers do not allow overall optimization

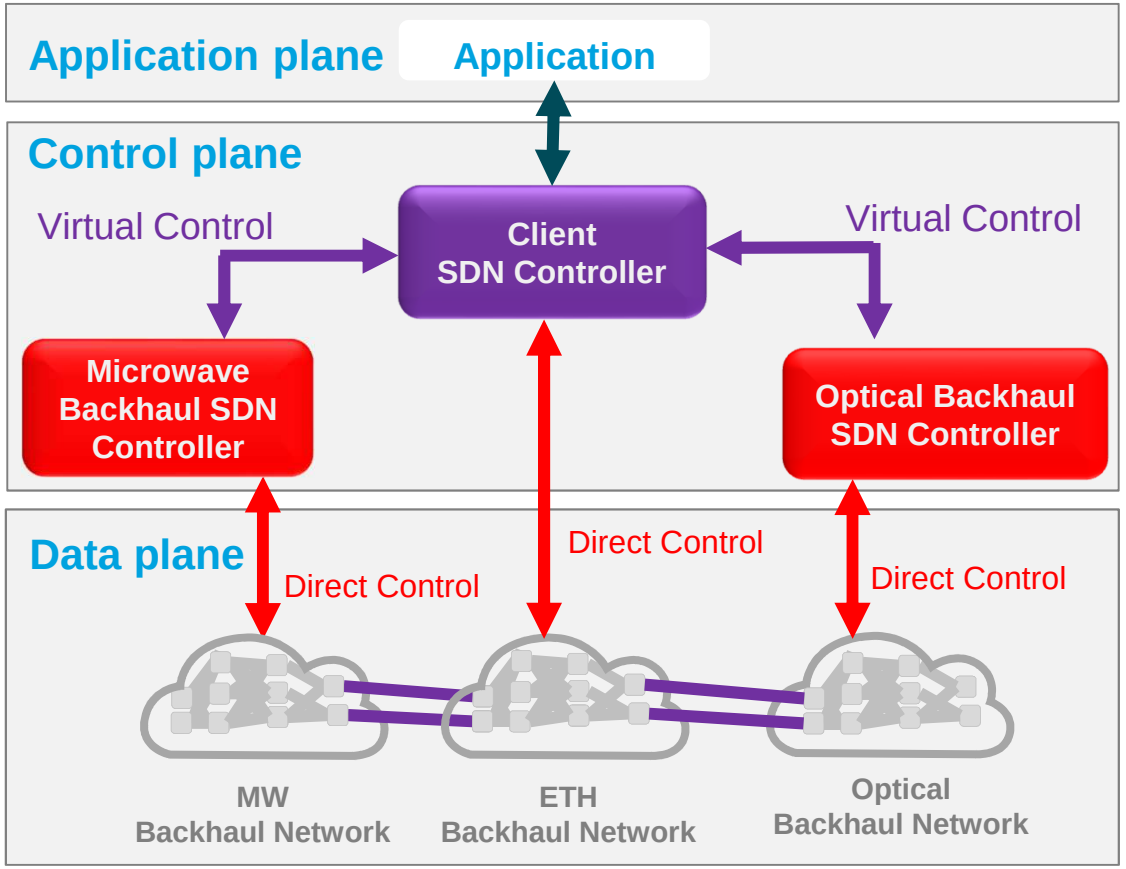
- Multilayer approach for performing combined optimization

Separated domains complicate the service provisioning and network adaptation

- Interconnection of controllers for e2e optimization

Separated control and management mechanisms require multiple interventions

- Standard interfaces simplify heterogeneous device management



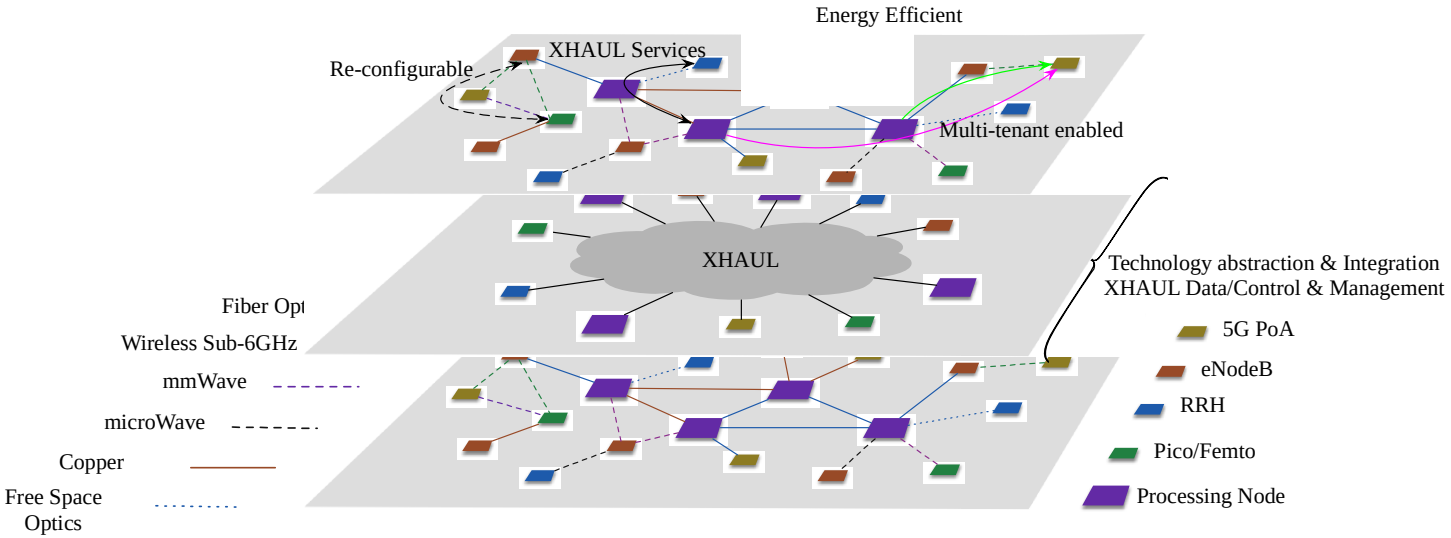
SDN challenges for 5G

Fine-grained management of network flows	▪ New possibilities arise for a richer management of traffic flows to provide advanced functionalities (e.g., offloading, caching, etc.) ▪ Opportunity for achieving a better network utilization ▪ Fixed/Mobile mix of traffics with distinct QoS and different impact in terms of network costs and revenue
SDN-based control mechanisms	▪ Scalability of the decoupled control elements ▪ Reliability of a logically centralized system
Co-existence with fixed and mobile legacy infrastructure	▪ Put in value the control plane in current network equipment already deployed e.g. E2E MPLS (integration vs. substitution) ▪ Interoperability with conventional equipment in the field (IP routing, MPLS signaling, OAM mechanisms, etc.)
Enabler for network virtualized functions	▪ Rapid programmatic re-configuration to support de-localized network functions from fixed and mobile (even moving network functions to the cloud)
New forms of operating the network	▪ Organizational changes and new skills are required

Taking Action – Xhaul(*) project

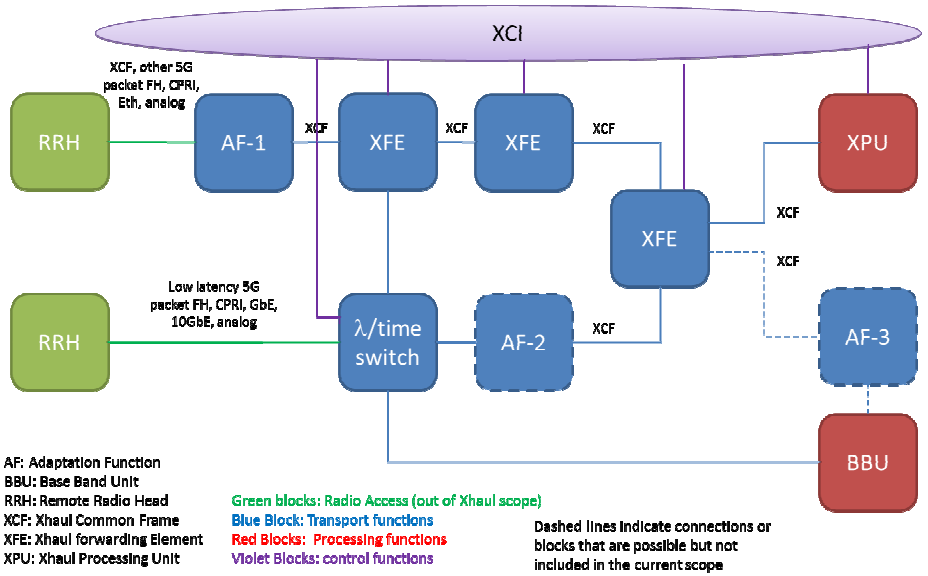
- Xhaul aims at developing an adaptive, sharable, cost-efficient 5G transport network solution integrating the fronthaul and backhaul segments of the network.
- This transport network will flexibly interconnect distributed 5G radio access and core network functions, hosted on in-network cloud nodes, through the implementation of novel building blocks:
  - A control infrastructure using a unified, abstract network model for control plane integration (Xhaul Control Infrastructure, XCI);
  - A unified data plane encompassing innovative high-capacity transmission technologies and novel deterministic-latency switch architectures (Xhaul Packet Forwarding Element, XFE).
  - A set of computing capabilities distributed accross the network (Xhaul Processing Units, XPUs)
- Xhaul will greatly simplify network operations despite growing technological diversity. It will hence enable system-wide optimisation of Quality of Service (QoS) and energy usage as well as network-aware application development.

Taking Action – Xhaul(*) project



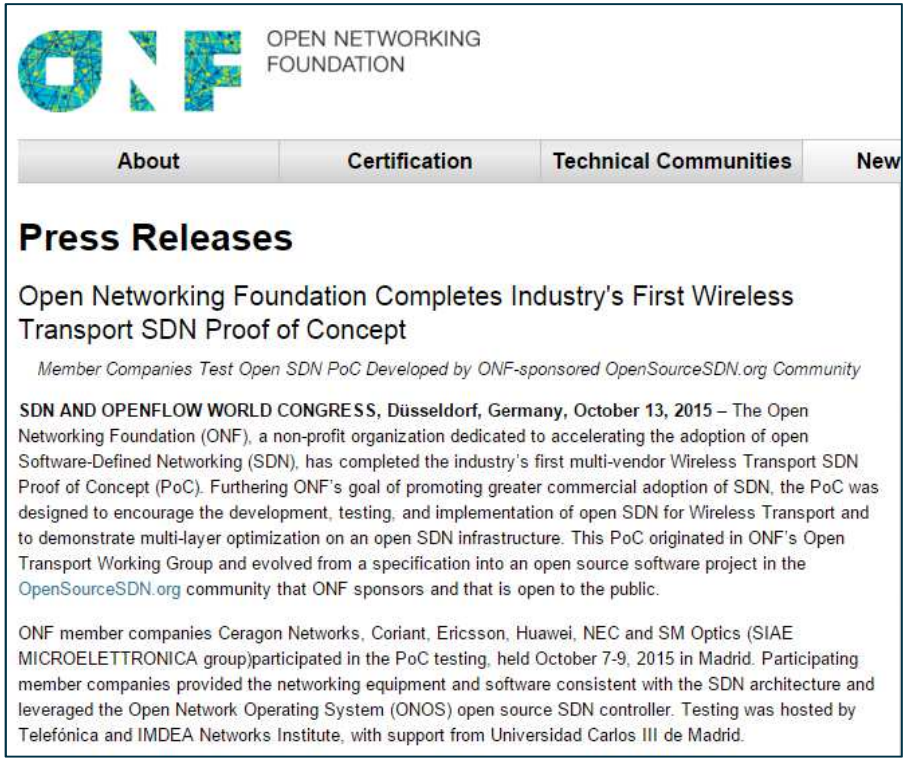
The middle layer represents one of the key concepts associated to Xhaul: the integration of the different technologies (including **fronthaul and backhaul**) in a common packet network based on **technology abstraction, unified framing and common data, control and management planes.**

Finally, the upper layer presents a selection of the features offered by the Xhaul infrastructure



Taking Action – First-ever SDN PoC for MW

Wireless Transport SDN PoC White Paper
https://www.opennetworking.org/images/stories/downloads/sdn-resources/white-papers/ONF_Microwave_SDN_PoC_White_Paper%20v1.0.pdf



OPEN NETWORKING FOUNDATION

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Press Releases

Open Networking Foundation Completes Industry's First Wireless Transport SDN Proof of Concept

Member Companies Test Open SDN PoC Developed by ONF-sponsored OpenSourceSDN.org Community

SDN AND OPENFLOW WORLD CONGRESS, Düsseldorf, Germany, October 13, 2015 – The Open Networking Foundation (ONF), a non-profit organization dedicated to accelerating the adoption of open Software-Defined Networking (SDN), has completed the industry's first multi-vendor Wireless Transport SDN Proof of Concept (PoC). Furthering ONF's goal of promoting greater commercial adoption of SDN, the PoC was designed to encourage the development, testing, and implementation of open SDN for Wireless Transport and to demonstrate multi-layer optimization on an open SDN infrastructure. This PoC originated in ONF's Open Transport Working Group and evolved from a specification into an open source software project in the OpenSourceSDN.org community that ONF sponsors and that is open to the public.

ONF member companies Ceragon Networks, Coriant, Ericsson, Huawei, NEC and SM Optics (SIAE MICROELETTRONICA group)participated in the PoC testing, held October 7-9, 2015 in Madrid. Participating member companies provided the networking equipment and software consistent with the SDN architecture and leveraged the Open Network Operating System (ONOS) open source SDN controller. Testing was hosted by Telefónica and IMDEA Networks Institute, with support from Universidad Carlos III de Madrid.

Use cases tested

- capacity-driven air interface: network's ability to adapt to traffic demand and to efficiently optimize wireless resources for a more energy efficient operation of the transport network
- flow-based shaping: network's ability to adapt and respond to changing conditions such as the weather impacting wireless transport networks.

- Motivation
  - ✓ No common way of controlling and managing Wireless Transport Networks (e.g., Microwaves)
    - Road to simplification
  - ✓ No advance control plane features for rich functionalities nor multilayer coordination (SDN as an enabler)
    - Road to automation
- Framework
  - ✓ OpenFlow extensions defined within Wireless Transport Project within Open Networking Foundation (ONF)
  - ✓ First attempt to define a (unified and standard) control plane for Microwave systems
  - ✓ Multi-vendor interworking, multi-layer control, network-wide coordination

Taking Action - 5TONIC

- 5TONIC is an open research and innovation ecosystem in the area of 5G Products and Services
  - Based on the direct collaboration between Telefónica and IMDEA Networks
  - Make industry and academia come together
  - Boost technology and innovative business models
- With the goal of becoming a central hub for knowledge sharing and industry collaboration in the area of 5G technologies
  - Across Europe, associated with the European 5G initiatives
  - Across the global Telefónica footprint
- Initially focused on two main technology areas
  - 5G Virtual Software Network Area
  - 5G Wireless System Area

Telefónica

PRESS RELEASE

Madrid, October 29, 2015

TELEFÓNICA AND IMDEA NETWORKS ANNOUNCE OPENING OF 5TONIC: SPAIN'S FIRST LABORATORY OF 5G EXCELLENCE

http://saladeprensa.telefonica.es/documentos/nprensa/5TONIC_TEF_EN29_10_2015_DEF.pdf

Main challenges

Key Benefits	Key Challenges
Easier deployment of new services	Specification of the interfaces
Reduced management and operational costs of heterogeneous technologies	Need to integrate scheduled-based and contention-based systems
Efficient operation of multi-vendor infrastructures	Harmonization of the standardization efforts
Increased accountability and service differentiation	Verifiable security and privacy architecture
Continuous and transparent enhancement of network operation	Operation and management of wireless networks is more complex

This work has been (partially) funded by the EU H2020 Xhaul Project (grant no. 671598)

Xhaul: the 5G Integrated fronthaul/backhaul

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High level setup – SDN PoC for MW