

An Experimental View on 5G Research Projects: From the Lab to the Field

Raul Muñoz, Ramon Casellas, Ricard Vilalta, Ricardo Martínez

Centre Tecnològic de Telecomunicacions de Catalunya (CTTC/CERCA), Castelldefels, Spain.

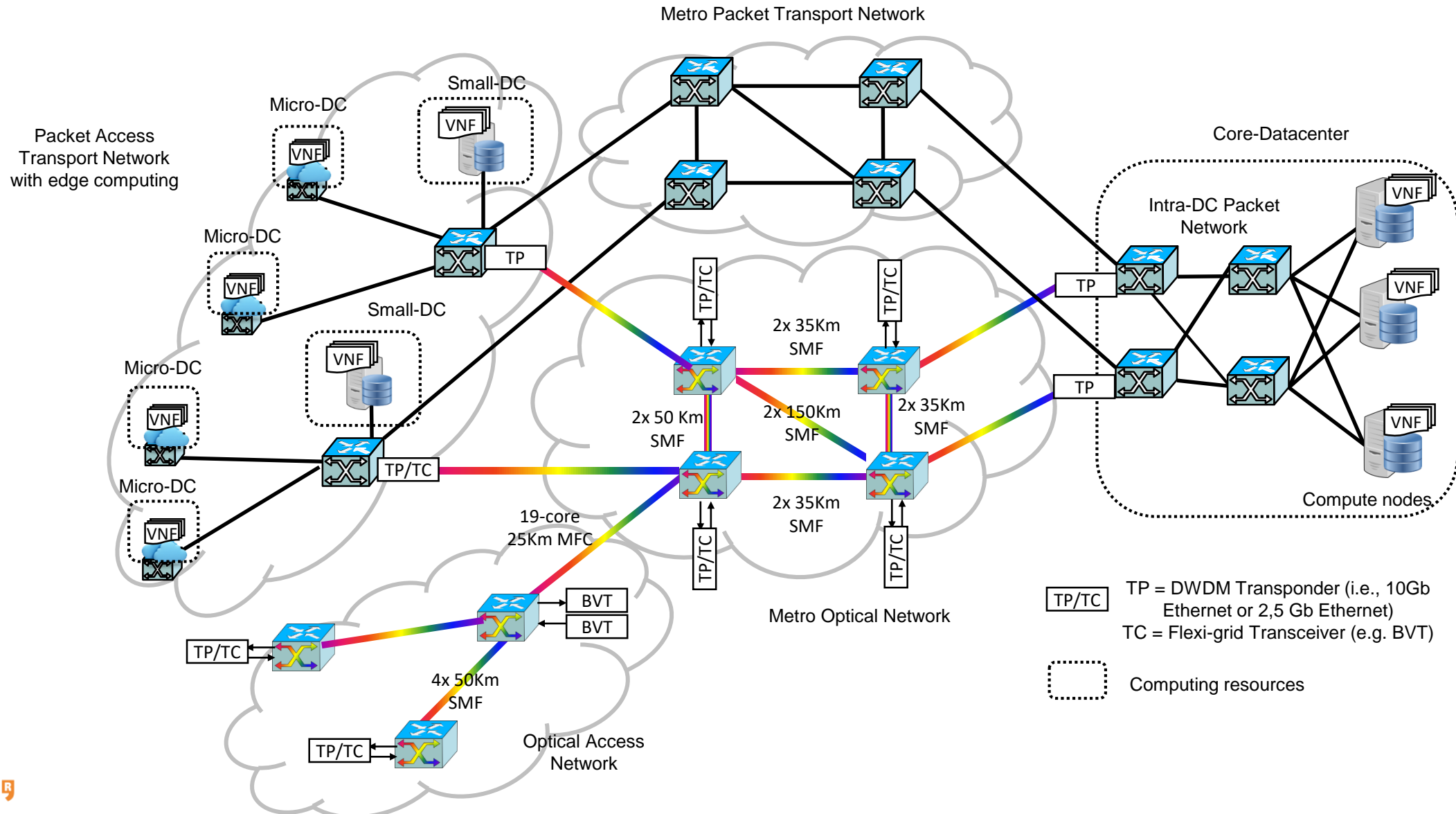
IEEE Future networks: 5G Technology Workshop

February, 28 2019

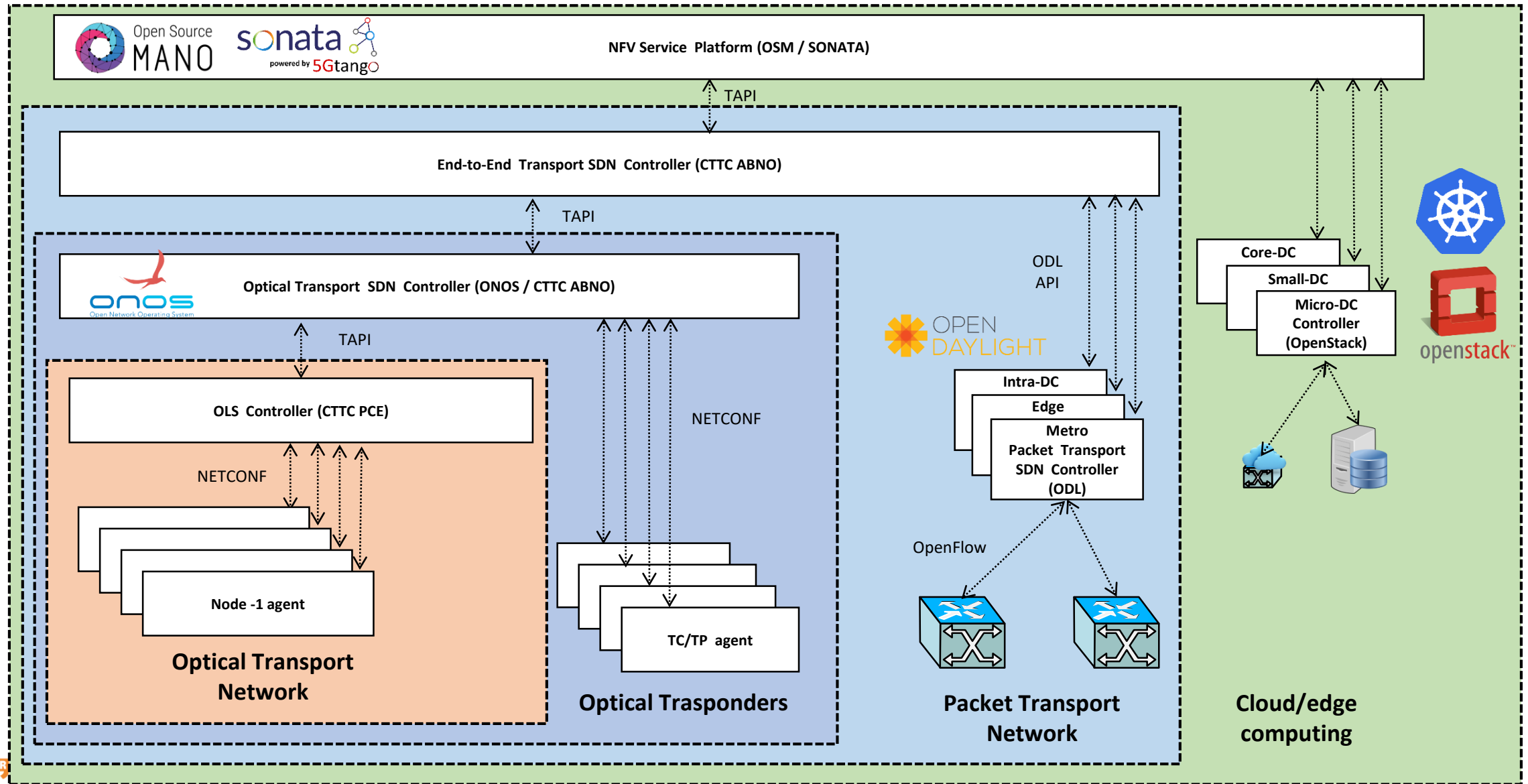
Agenda

- The CTTC ADRENALINE Testbed
- Overview on the on-going 5G-PPP projects:
 - blueSPACE
 - Metro-haul
 - 5GTransformer
 - 5GTANGO
 - 5GCAR
 - 5GCroco
- Conclusions

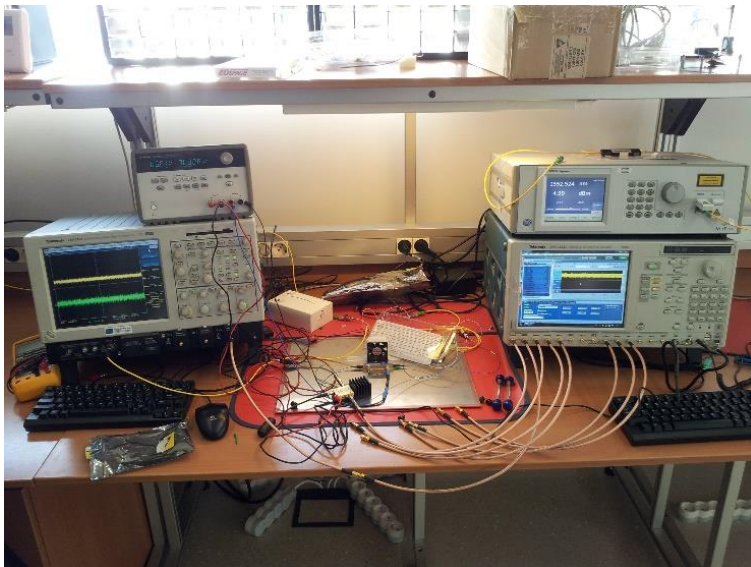
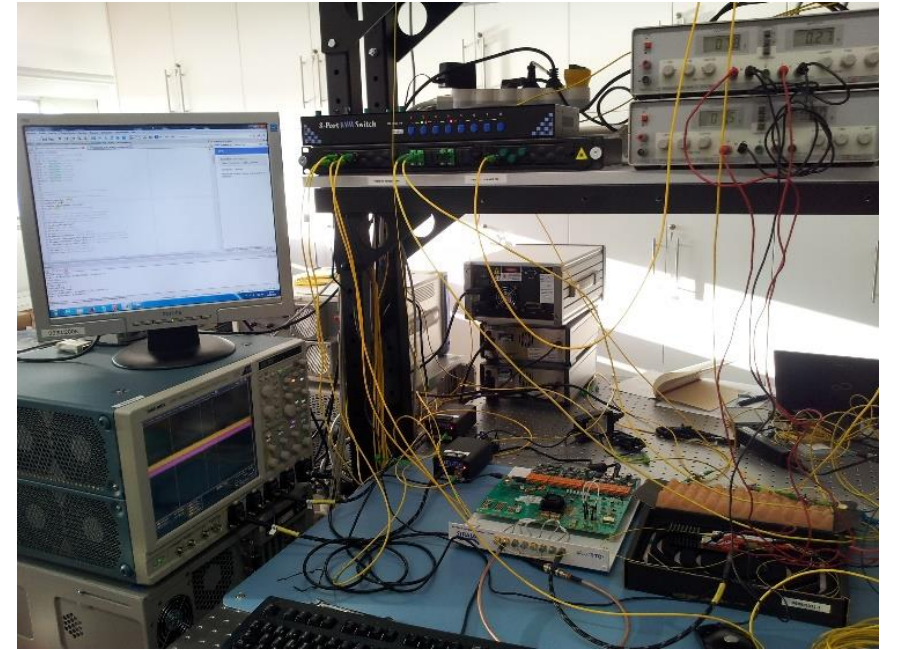
ADRENALINE's end-to-end transport and cloud infrastructure



ADRENALINE's control and orchestration



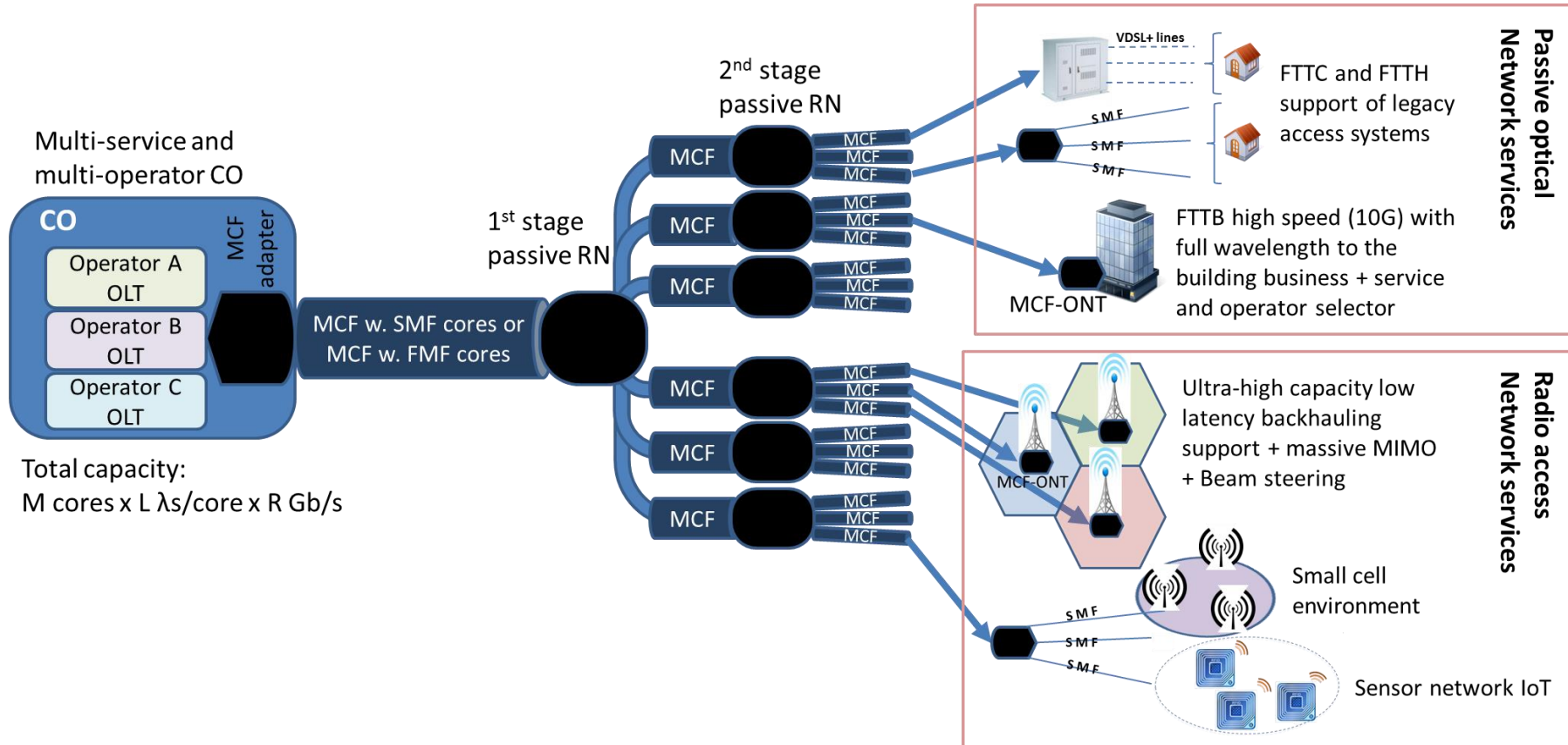
CTTC ADRENALINE testbed view



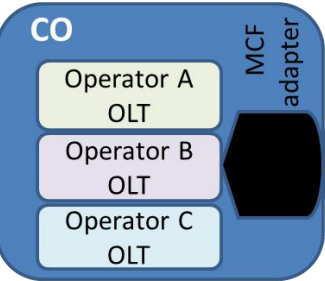
THE OPTICAL PROJECTS: BLUESPACE AND METRO-HAUL



blueSPACE Optical Distribution Network



Multi-service and multi-operator CO



Total capacity:
M cores x L λs/core x R Gb/s

» Optical SDM introduced to the network

- » Many parallel (independent) channels
- » Bundles of SMF or MCF => upgrade paths

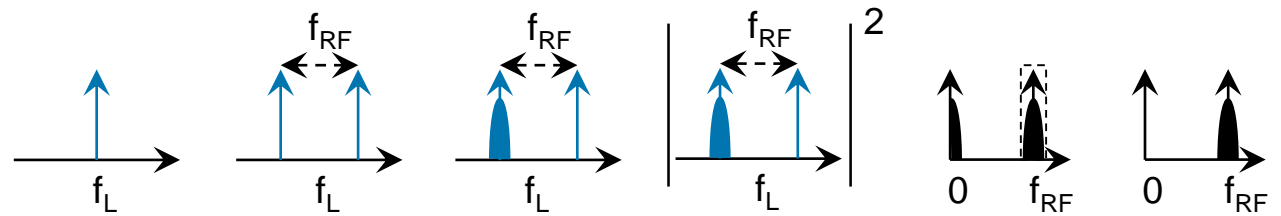
» Shared fiber infrastructure

- » Services (RAN, PON etc.)
- » Operators

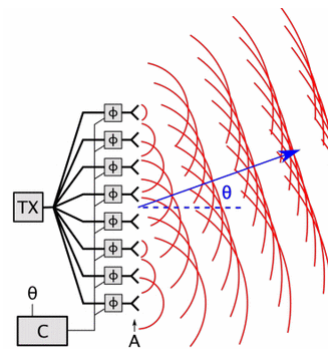
ARoF Fronthaul and Optical Beamforming

- » Analog radio over fiber (ARoF)
 - » Use photonics to directly generate mm-wave signals

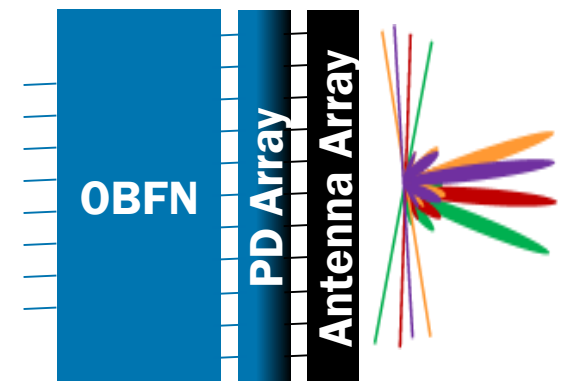
All processing/complexity at CO
 Low modulation BW in optics
 Co-propagation of CW tone
 Beating on photodiode produces mm-wave signal



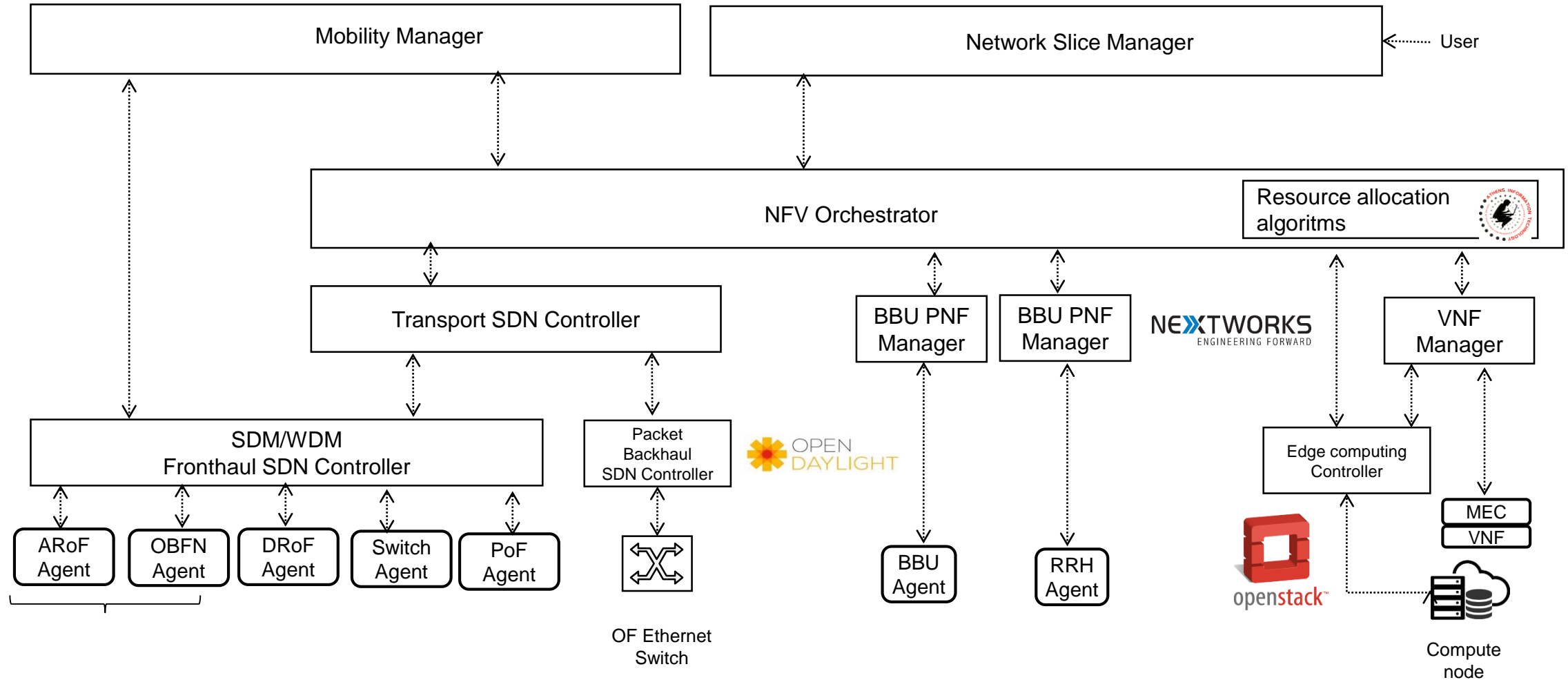
- » Optical beamforming
 - » Beamforming requires differential phase shifts between signal copies
 - Can be achieved in electronics or optics



- » Optical beamforming
 - Reduced power consumption
 - Naturally supports multi-beam transmission
 - Full Blass matrix can be realized



BlueSPACE SDN/NFV MANO architecture



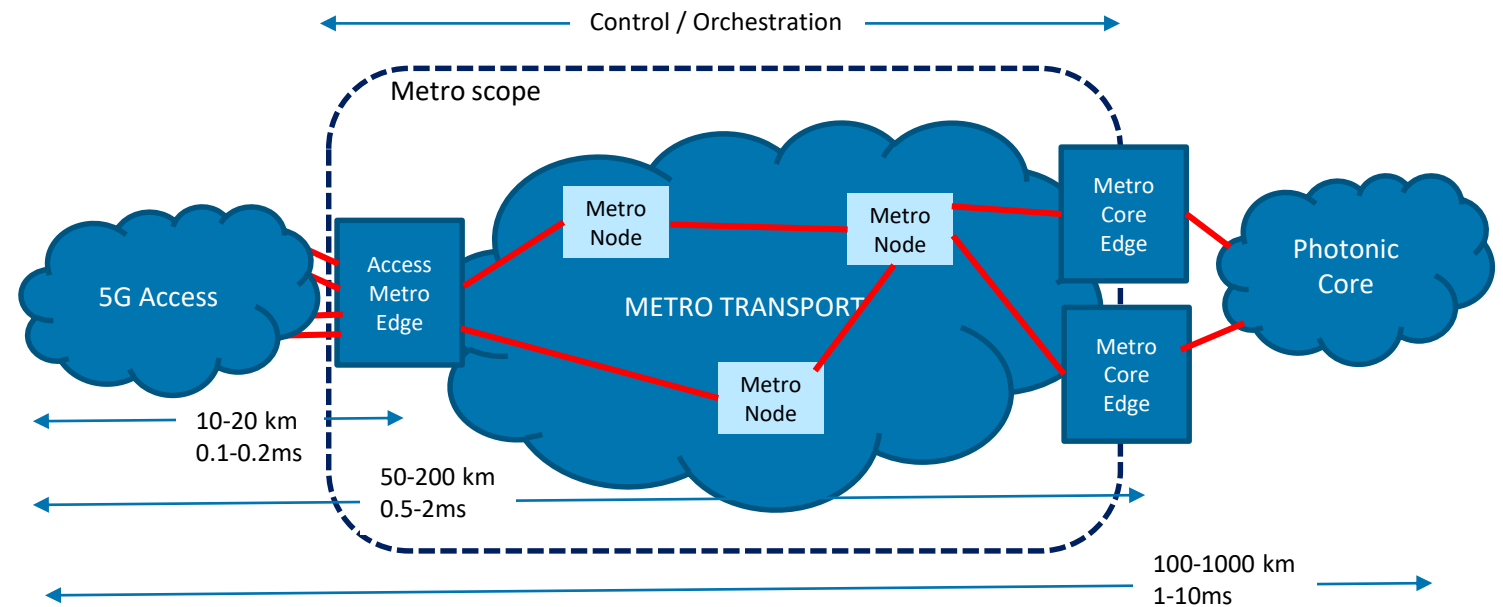
Metro-Haul overview



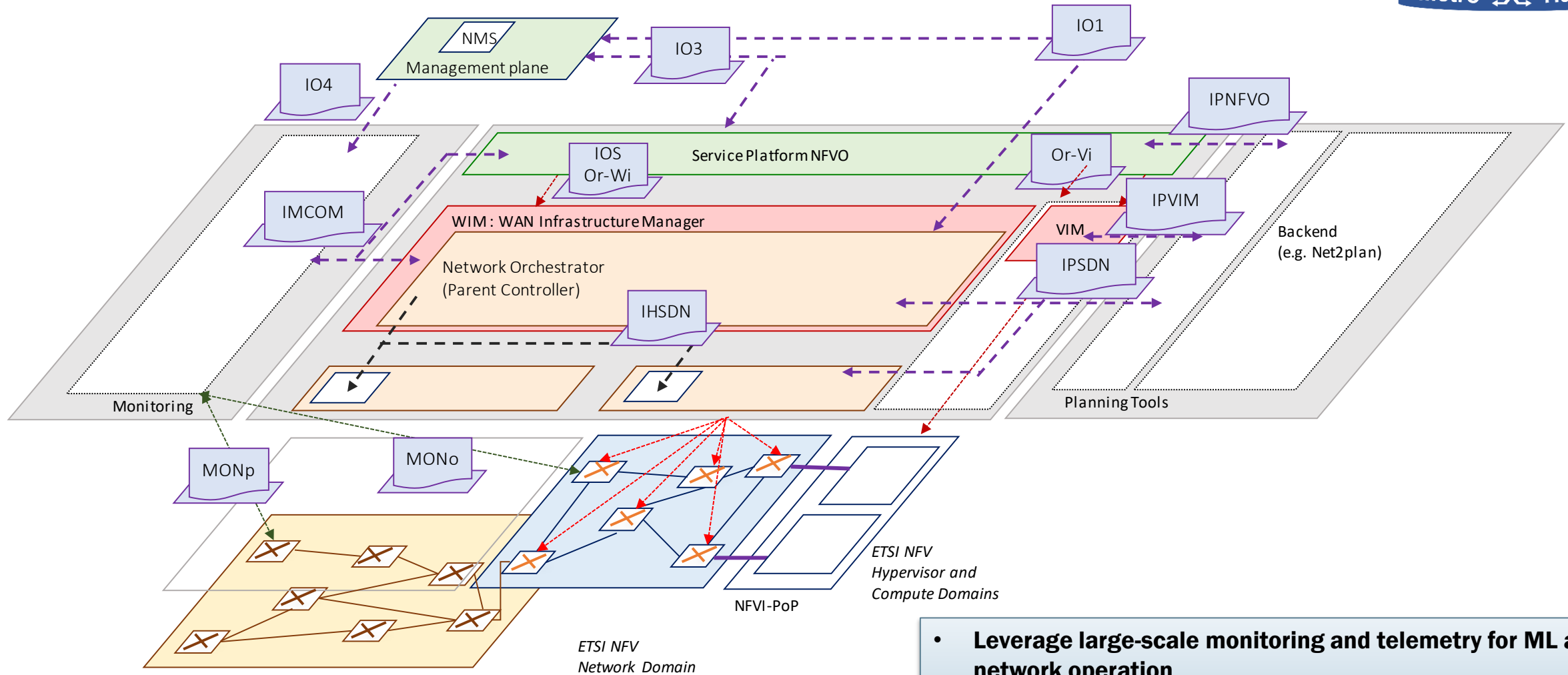
- **Architect and design cost-effective, energy-efficient, agile and programmable metro networks**
 - Scalable for 5G access and future requirements
 - Design of all-optical metro nodes (including full compute and storage capabilities)
 - Interface with both 5G access and multi-Tbit/s elastic core networks.

- **Main Use Cases and demonstrations**

- Video Security for Smart Cities
- Crowdsourced Video Streaming

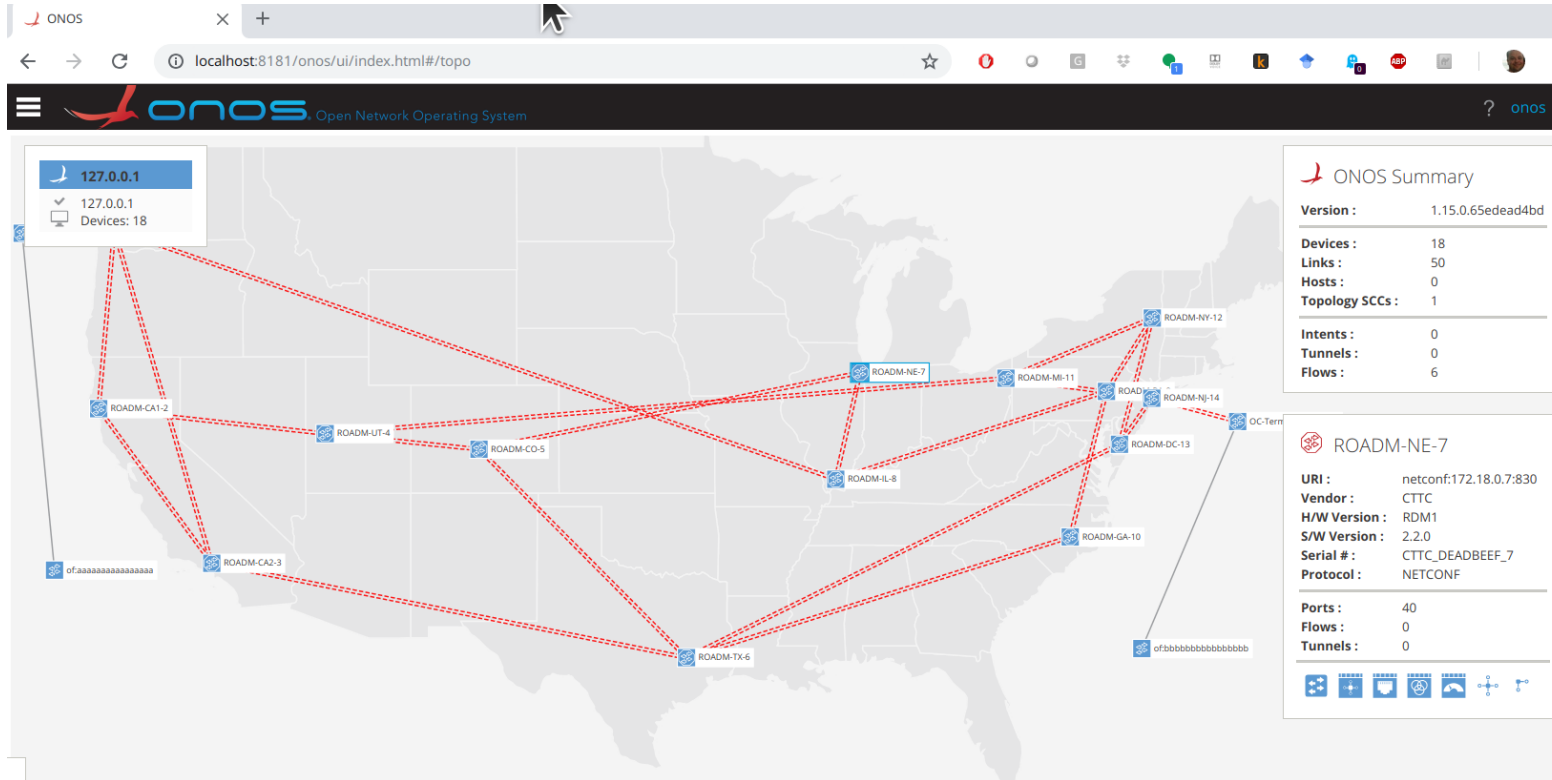


Metro-haul Service Platform



- Leverage large-scale monitoring and telemetry for ML assisted network operation
- Enable advanced planning (e.g. placement) algorithms
- Provide Connectivity to multiple nodes across a network

SDN Controller for the Disaggregated Optical Network



TAPI NBI

Application Logic

OpenConfig Terminal Device Drivers

OpenROADM Device Drivers

Open Source Contributions -- ONOS/ODTN – Open Disaggregated Transport Networks

<https://www.opennetworking.org/solutions/odtn/>

Operator-led initiative to build data center interconnects using disaggregated optical equipment, open and common standards, and open source software

THE SOFTWARE NETWORKS PROJECTS: 5GTANGO AND 5GTRANSFORMER

1

- An NFV-enabled Service Development Kit (SDK) with enriched functionalities for NS developers.

2

- A Validation and Verification (VnV) Platform with advanced mechanisms for VNFs/Network Services qualification (including 3rd party contributions).

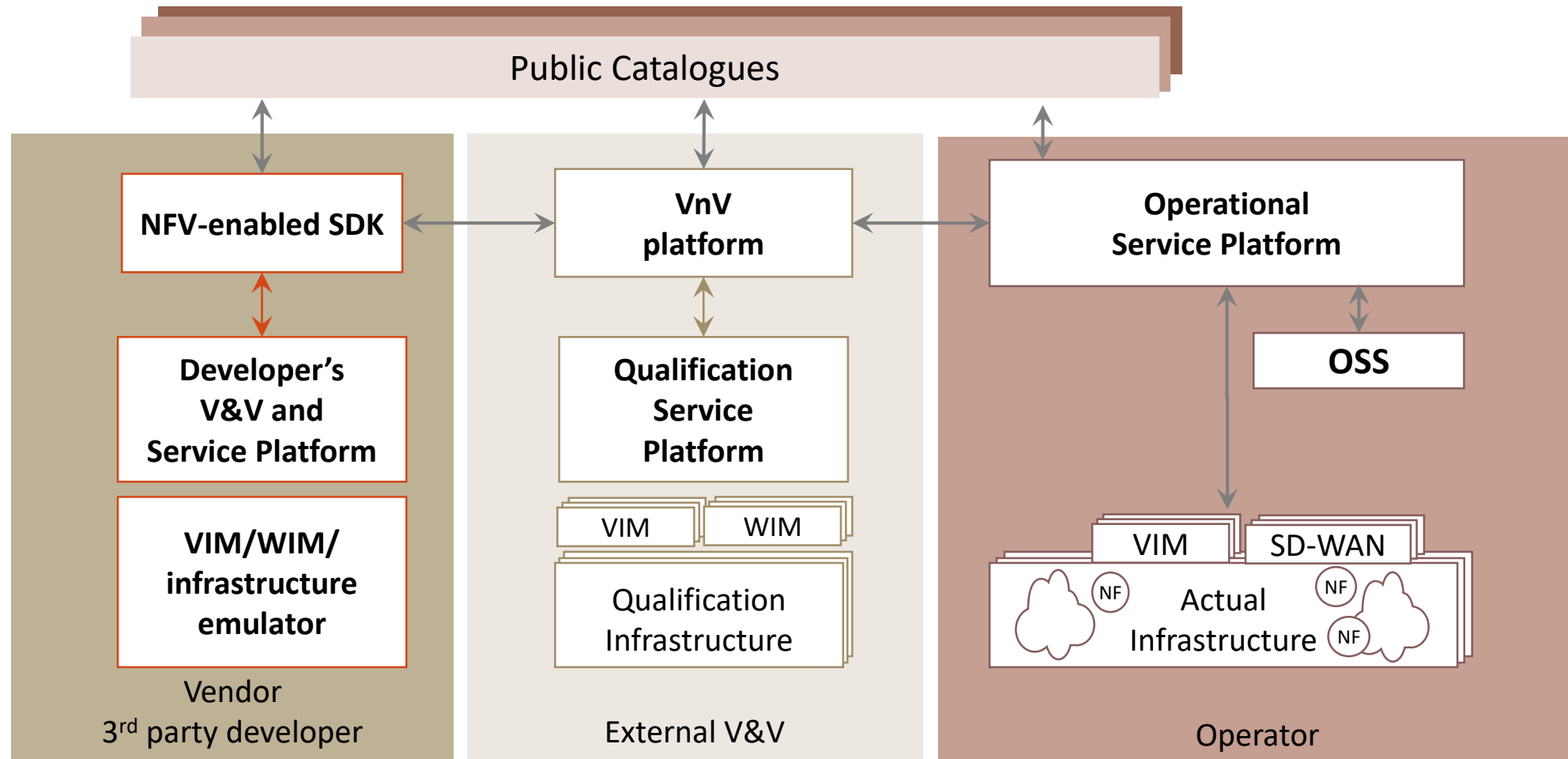
3

- A modular Service Platform with an innovative orchestrator with control and slicing capabilities in order to bridge the gap between business needs and network operational management systems.

4

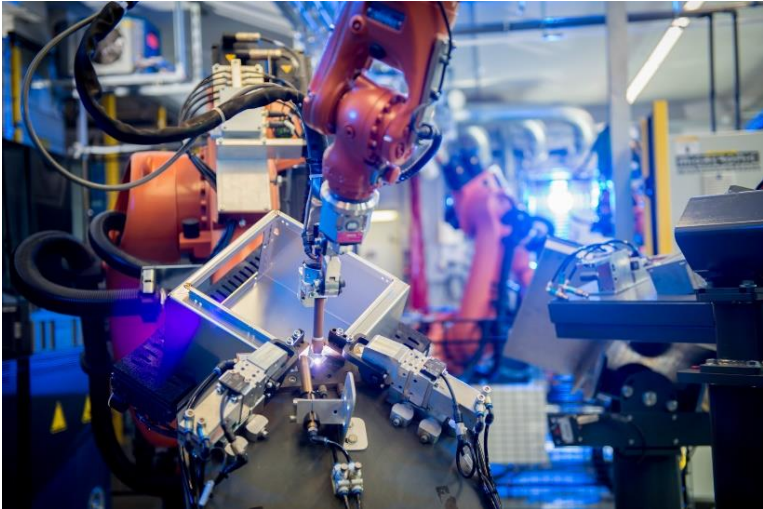
- Methodology and tools to implement an extended DevOps workflow with a multi-organizational design.

5GTANGO High Level Architecture



5GTANGO Pilots

 SMART MANUFACTURING



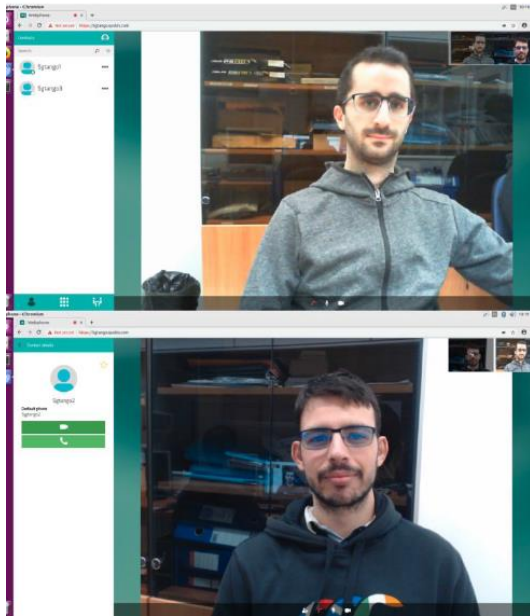
 IMMERSIVE MEDIA



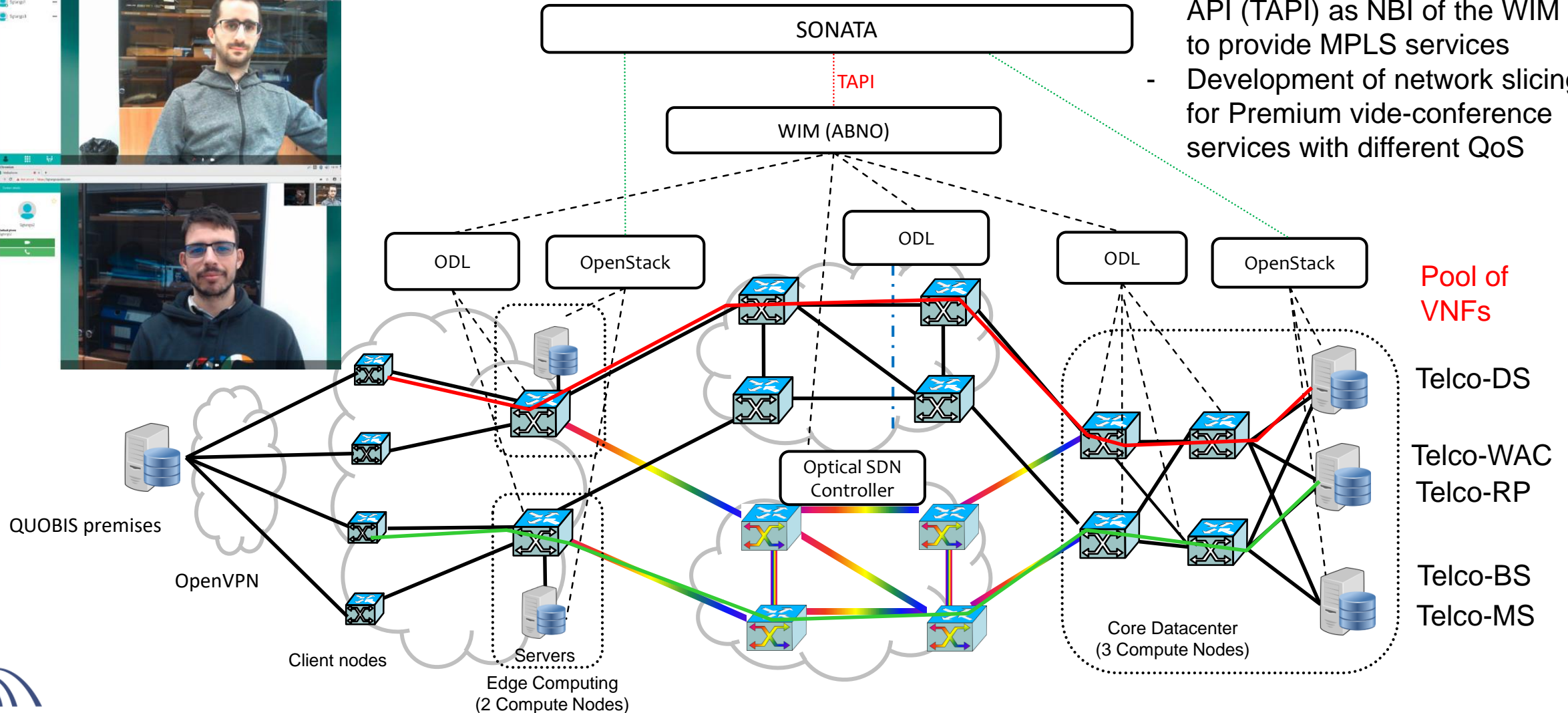
 REAL TIME COMMUNICATIONS



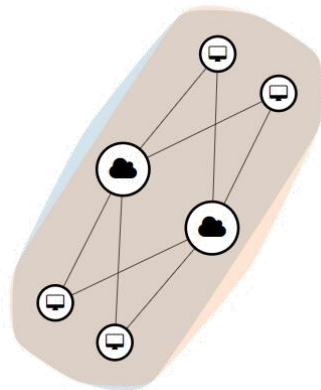
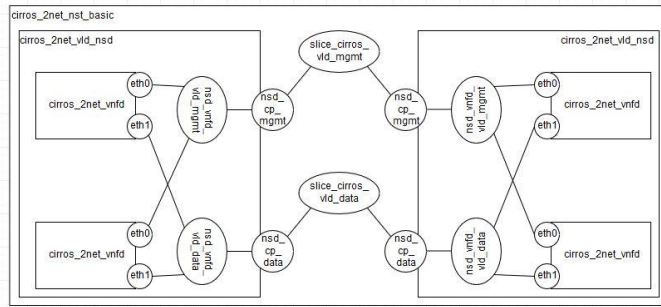
Deployment of real-time communications pilot in ADERNALINE



- Development of the Transport API (TAPI) as NBI of the WIM to provide MPLS services
- Development of network slicing for Premium vide-conference services with different QoS



Development of Network Slicing with ETSI OpenSource MANO



Open source contribution for ETSI OpenSource MANO (OSM) release 5.

The contribution was to prepare OSM to be 5G-ready including 3GPP network slices. Novel data models and lifecycle management have been addressed.

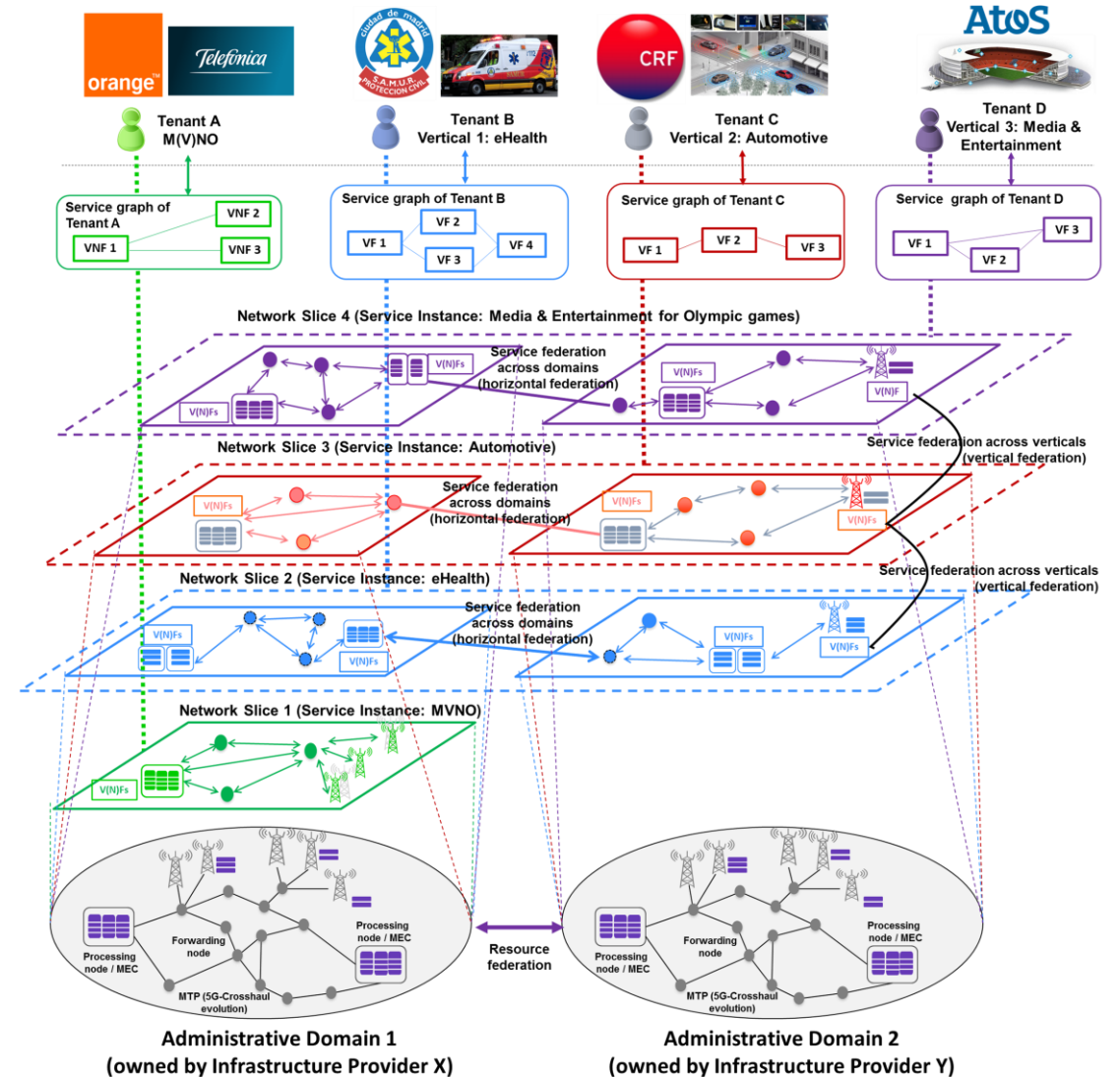
Joint development between:



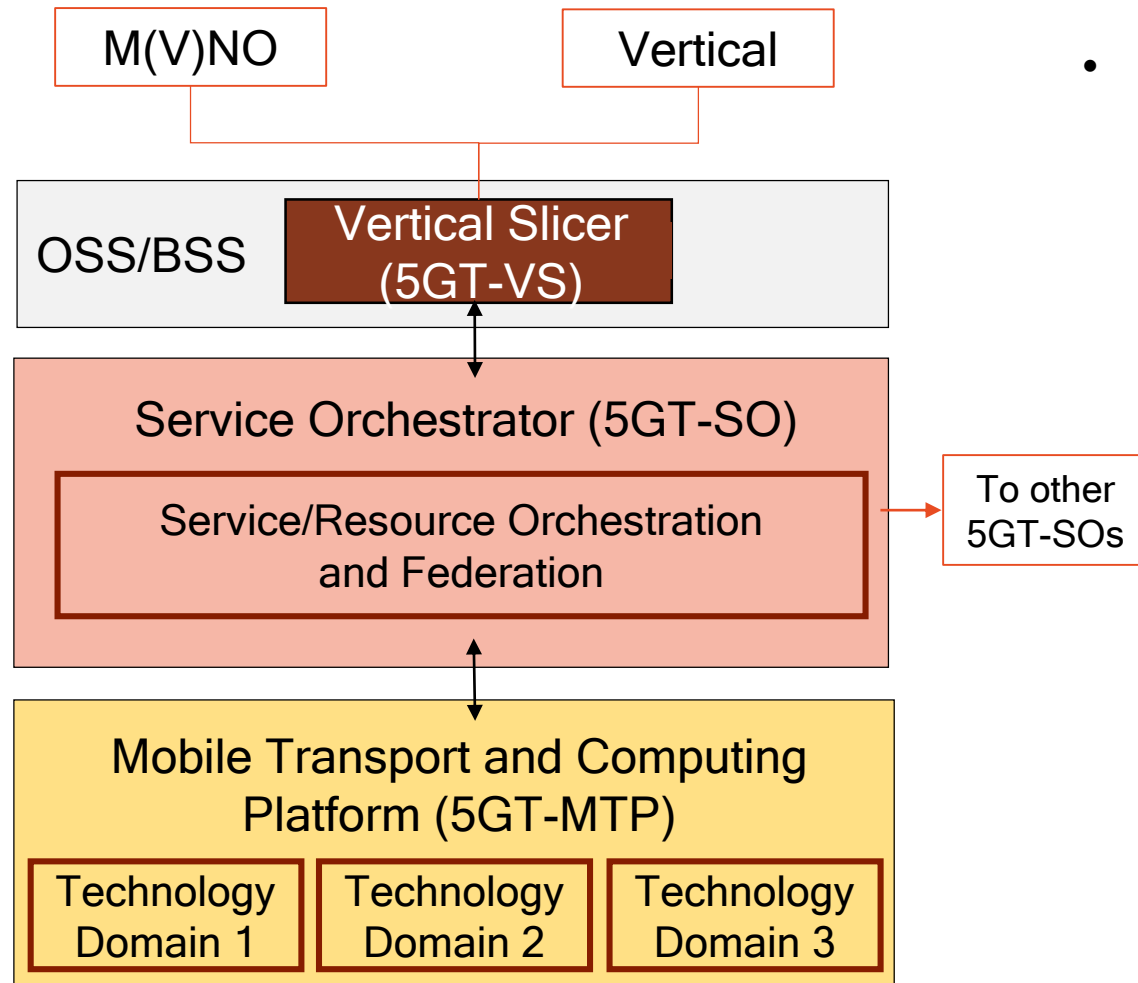
5G-T TRANSFORMER: General View



- **Design the 5G-T reference architecture**
 - Analysis of vertical use cases and their service requirements
 - Analysis of stakeholders and ecosystem
- Derive 5G-T system requirements
- Provide a baseline architecture
- Analysis of the market and economic benefits and costs of the 5G-T platform for vertical industries deployments



Architecture components



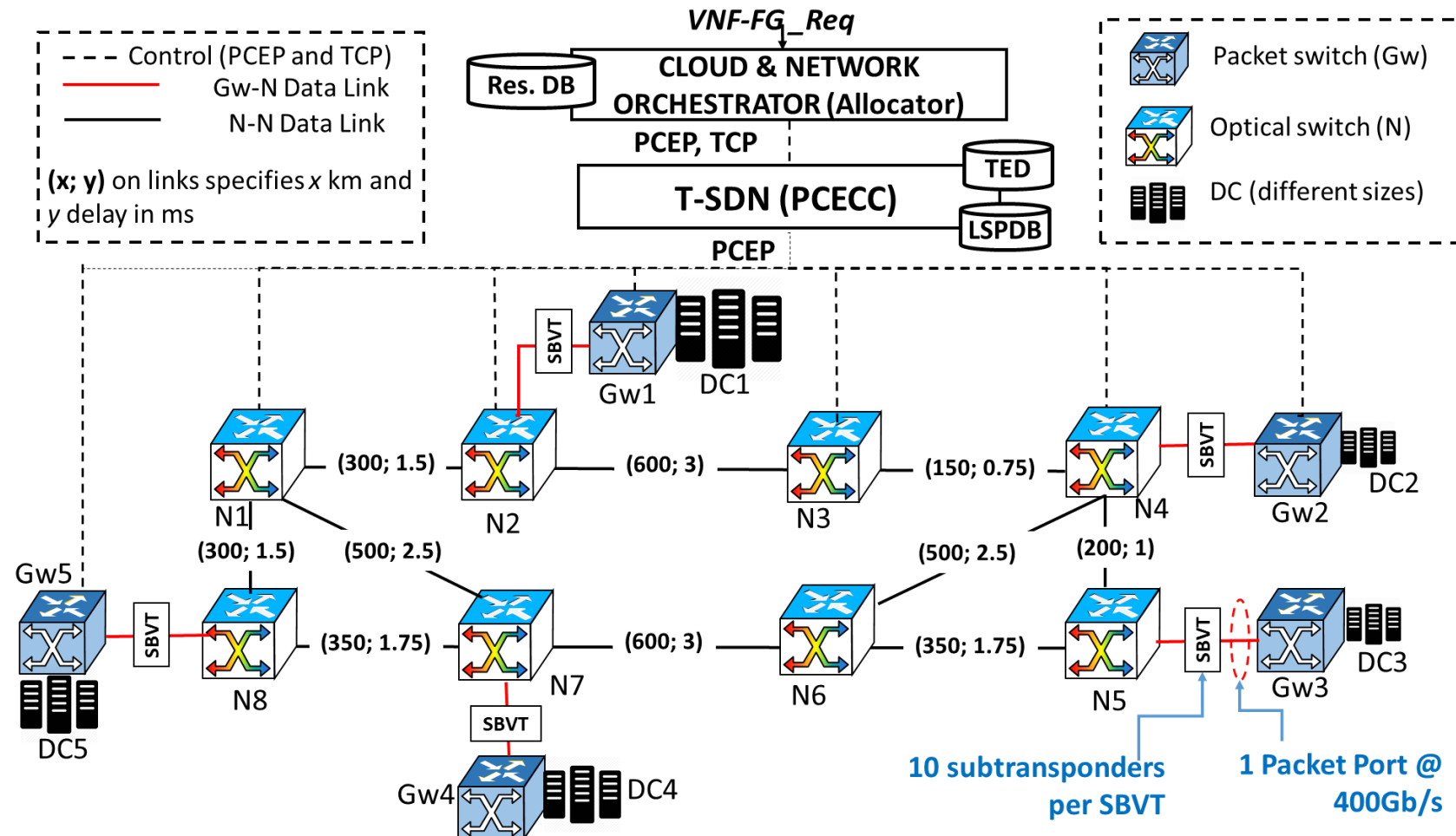
- **Vertical Use cases:** eHealth, Automotive, Robotics and media
- **Vertical Slicer:** Definition and description of the derived vertical services (i.e., VSD and NSD)
- **5GT-SO** orchestrates incoming NSDs selecting and coordinating cloud and network resources
 - Executes a Placement Algorithm for selecting NFVI-PoPs clouds resources and Virtual Links (i.e., network) for intra- and inter-NFVI-PoPs connectivity
- **5GT-MTP** handles the cloud and networking resources for deploying dynamically network services
 - Single platform coordinating multi-domain and multi-technology resources (i.e., cloud, RAN, packet and optical)

5G-TRANSFORMER: CTTC/SSSA joint collaboration



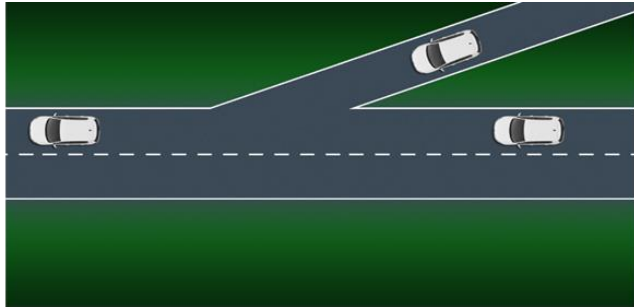
- **Objective:** definition of on-line Cloud/Network Resource Orchestration Algorithms for deploying VNFFGs among multiple NFVI-PoPs

- NFVI-PoPs (with different sizes) interconnected over a MLN (packet/flexi-grid optical network)

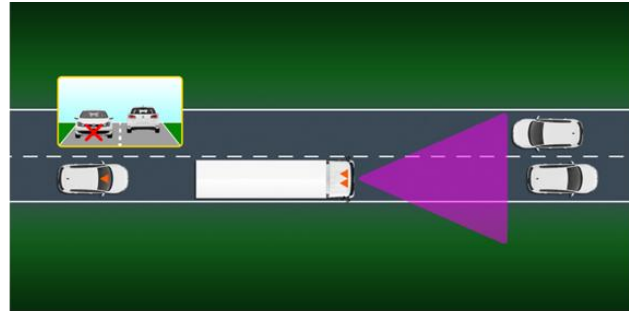


THE CONNECTED CAR PROJECTS: 5GCAR AND 5GCROCO

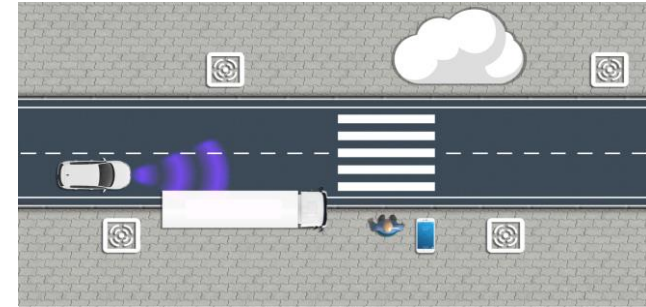
5GCAR Use Cases



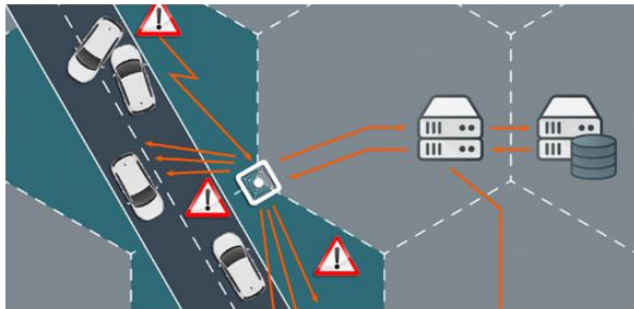
Lane merge



See-through



Network assisted vulnerable pedestrian protection

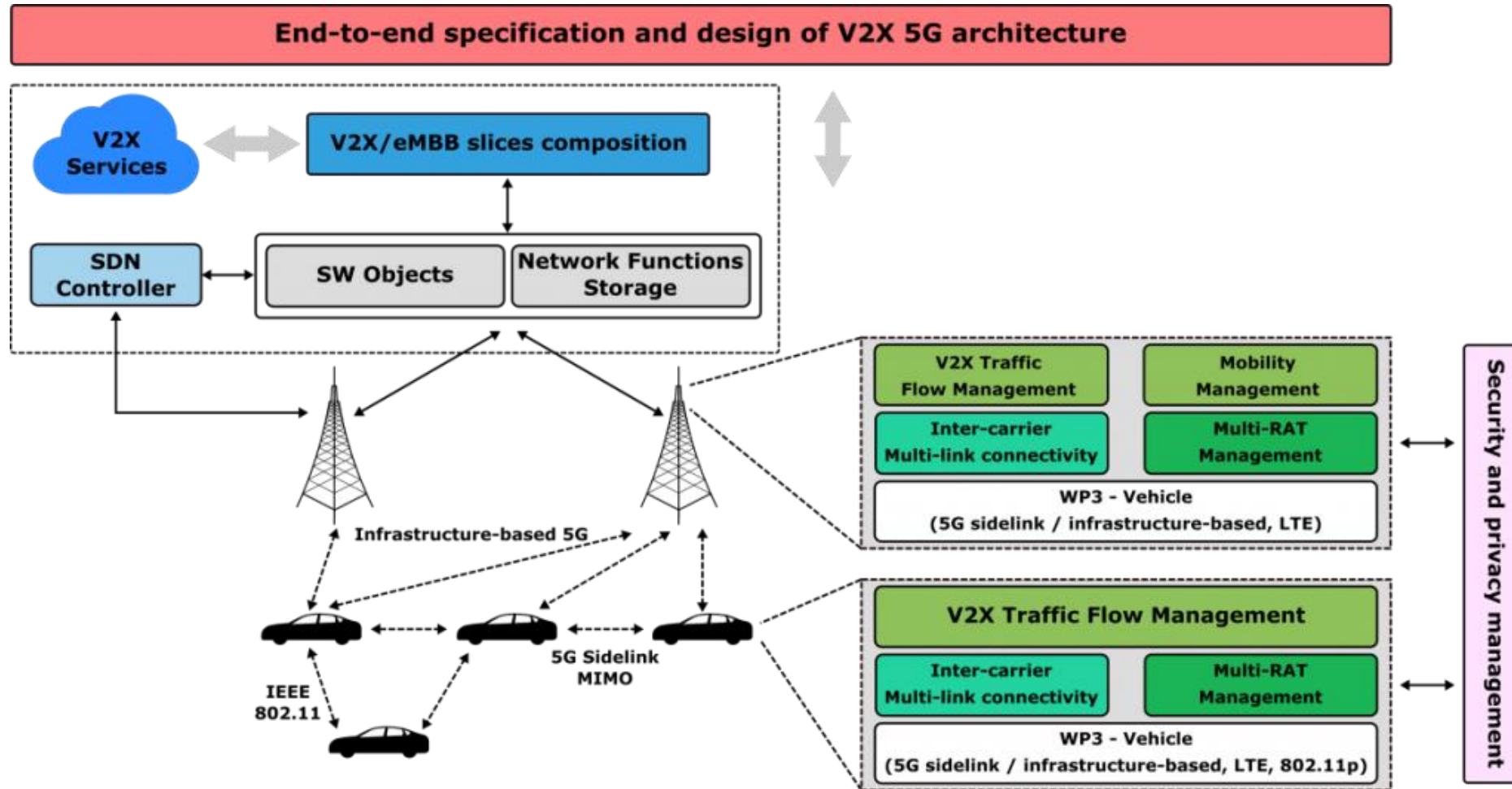


High definition local map acquisition

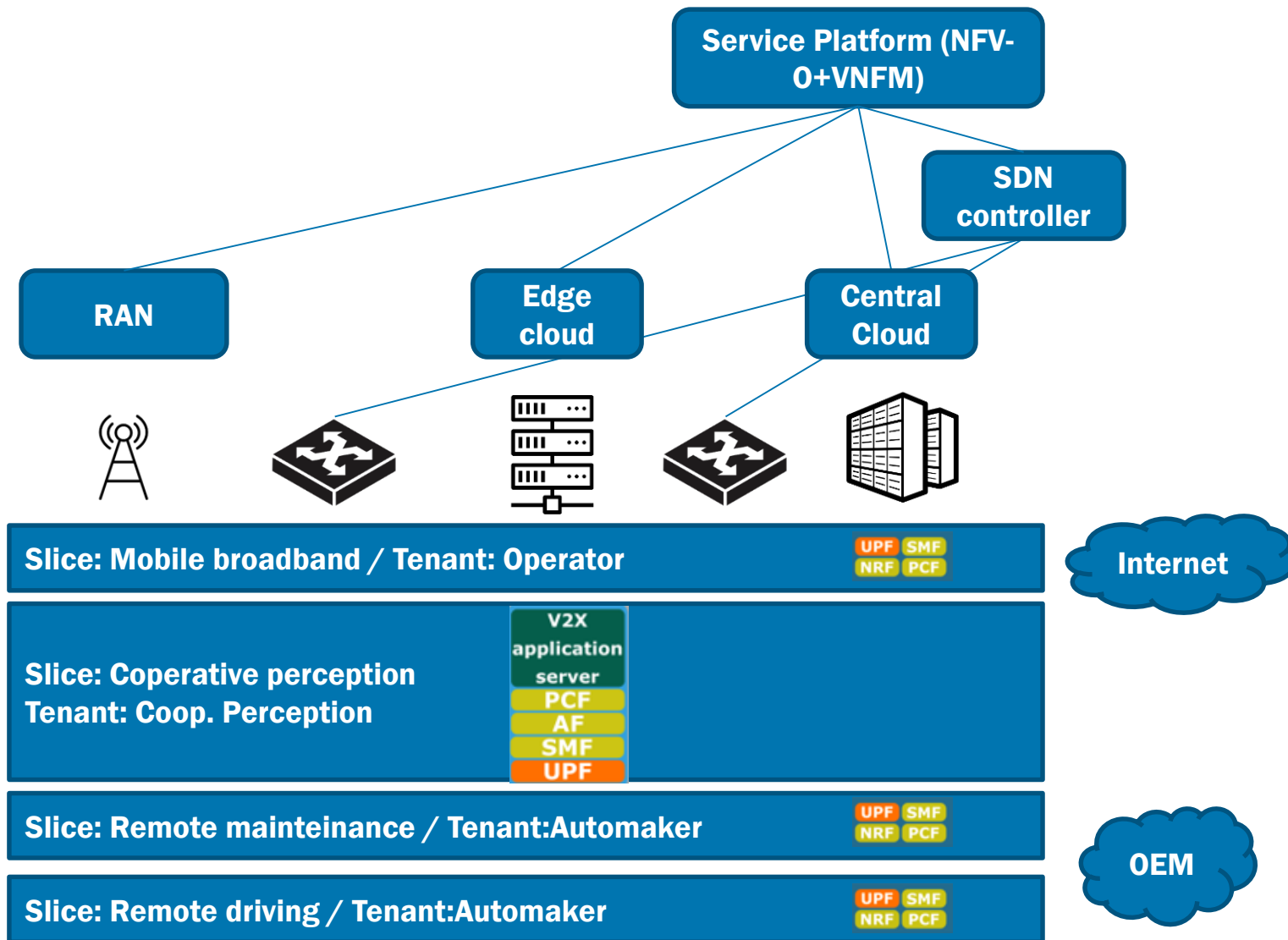


Remote driving for automated parking

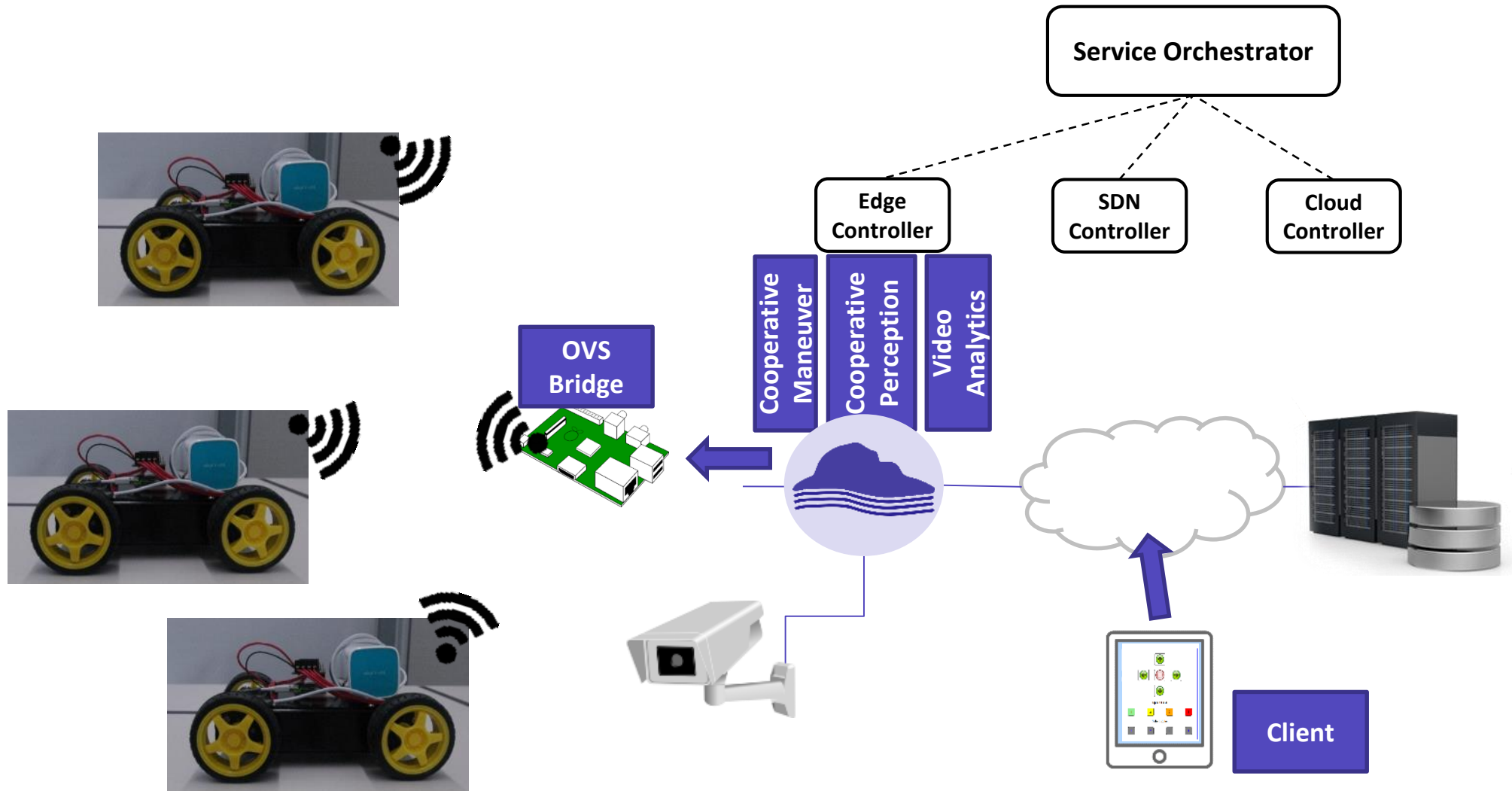
5G V2X System and Architecture



Network Slicing



MWCI8 Demonstration



5GCroCo: 5G cross-border corridor

- CTTC is the coordinator of the ICT18 project and of the Barcelona small-scale pilot.



**Large-scale validation of 5G
along France, Germany, and Luxembourg**

Focus of the innovation

- **5G Technology** features
 - Cross-border/MNO/vendor/generation Operation
 - Distributed Computing enabled by Mobile Edge Computing (MEC)
 - New Radio
 - Network Slicing
 - Predictive QoS
 - Improved Positioning
- Recommendations for **Regulation** and **Spectrum**
- Identification of **new business model** opportunities
- Impact on **standardization** (3GPP, ISO, ETSI, SAE, ...)

Conclusions

- Optical technology is key for the development of 5G fronthaul and backhaul networks.
- SDN Programmability of optical fronthaul/backhaul networks requires common data models and protocols.
- NFV Service platform are not fully integrated with SDN controllers. Need to further develop a common API.
- Network slicing is a key enabler for the verticals, but many projects are proposing proprietary solutions.
- MEC is key for the deployment of connected car, but it has to be integrated with SDN, NFV and cloud to guarantee end-to-end performance.

Thank you! Questions?

Raul Muñoz

Raul.munoz@cttc.es

Work supported by

