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

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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

- 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
• 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
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
5GTANGO Key Contributions

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

- **Public Catalogues**
  - NFV-enabled SDK
  - Developer’s V&V and Service Platform
  - VIM/WIM/infrastructure emulator
  - Vendor 3rd party developer
  - VnV platform
  - Qualification Service Platform
  - VIM/WIM/infrastructure emulator
  - Qualification Infrastructure
  - External V&V

- **Operational Service Platform**
  - OSS
  - VIM
  - SD-WAN
  - Actual Infrastructure
  - Operator

**Vendor**

- 3rd party developer

**External V&V**

**Qualification Service Platform**

**Public Catalogues**

**Operational Service Platform**
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 виде-conference services with different QoS
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:

CTTC
Atos
• 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
5G-TRANSFORMER: Architecture

**Architecture components**

- **M(V)NO**
- **Vertical**
- **OSS/BSS**

**Vertical Slicer** (5GT-VS)

- **Service Or orchestrator (5GT-SO)**
  - Service/Resource Orchestration and Federation

- **Mobile Transport and Computing Platform (5GT-MTP)**
  - Technology Domain 1
  - Technology Domain 2
  - Technology Domain 3

**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)
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 5GCRDCO
5GCAR Use Cases

- Lane merge
- See-through
- Network assisted vulnerable pedestrian protection
- High definition local map acquisition
- Remote driving for automated parking

Document name
5G V2X System and Architecture
Network Slicing

Service Platform (NFV-O+VNFM)

SDN controller

RAN

Edge cloud

Central Cloud

Slice: Mobile broadband / Tenant: Operator
Slice: Coperative perception
Tenant: Coop. Perception
Slice: Remote maintenance / Tenant: Automaker
Slice: Remote driving / Tenant: Automaker
MWC18 Demonstration

Service Orchestrator

Cloud Controller

SDN Controller

Edge Controller

Video Analytics

Cooperative Perception

Cooperative Maneuver

OVS Bridge

Client
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?

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