



A 5G Convergent Virtualized Radio Access Network Living at the Edge

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5G-CORAL in a Nutshell

A joint EU-Taiwan bid to the Research and Innovation Action H2020 ICT-08-2017, addressing 5G Convergent Technologies with focus on Access Convergence.



Europe



Taiwan



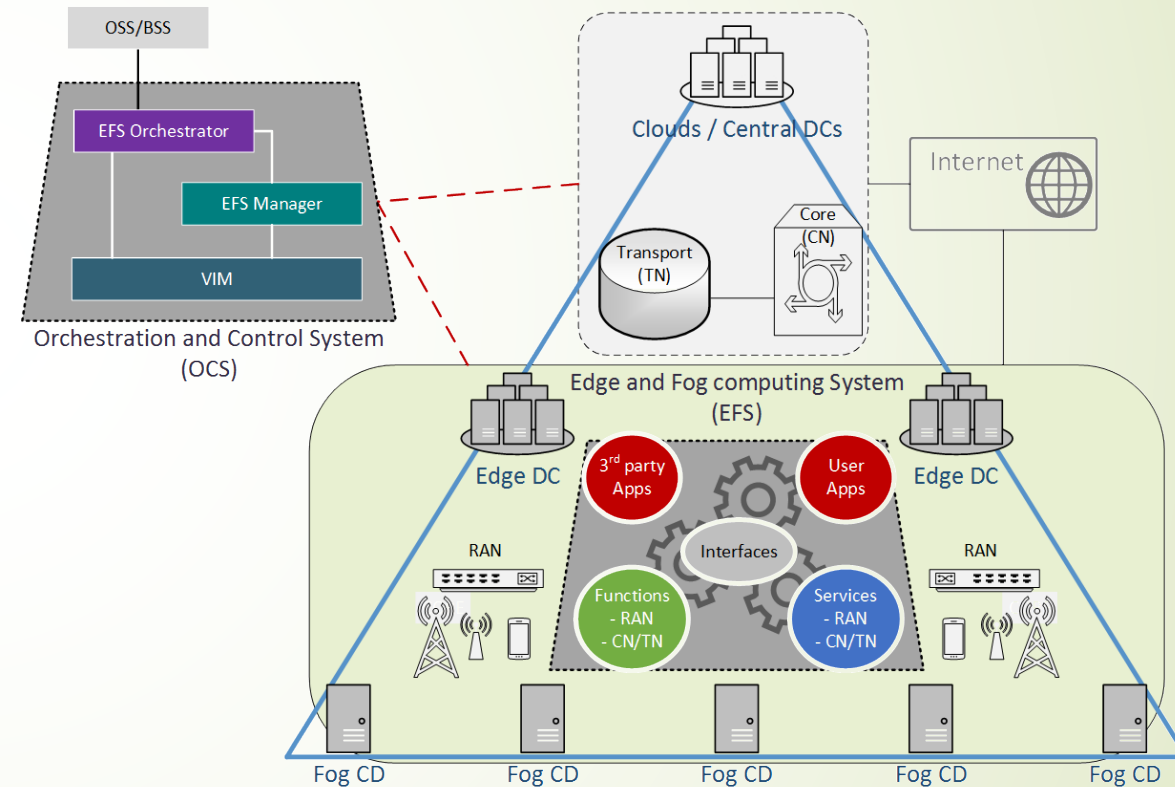
Elevator Pitch

Goal: Deliver a convergent 5G multi-RAT access through an integrated virtualized edge and fog solution that is flexible, scalable, and interoperable with other domains including transport (fronthaul, backhaul), core and clouds.

Target products: Access nodes, terminal devices, controllers and clouds

Virtualization framework

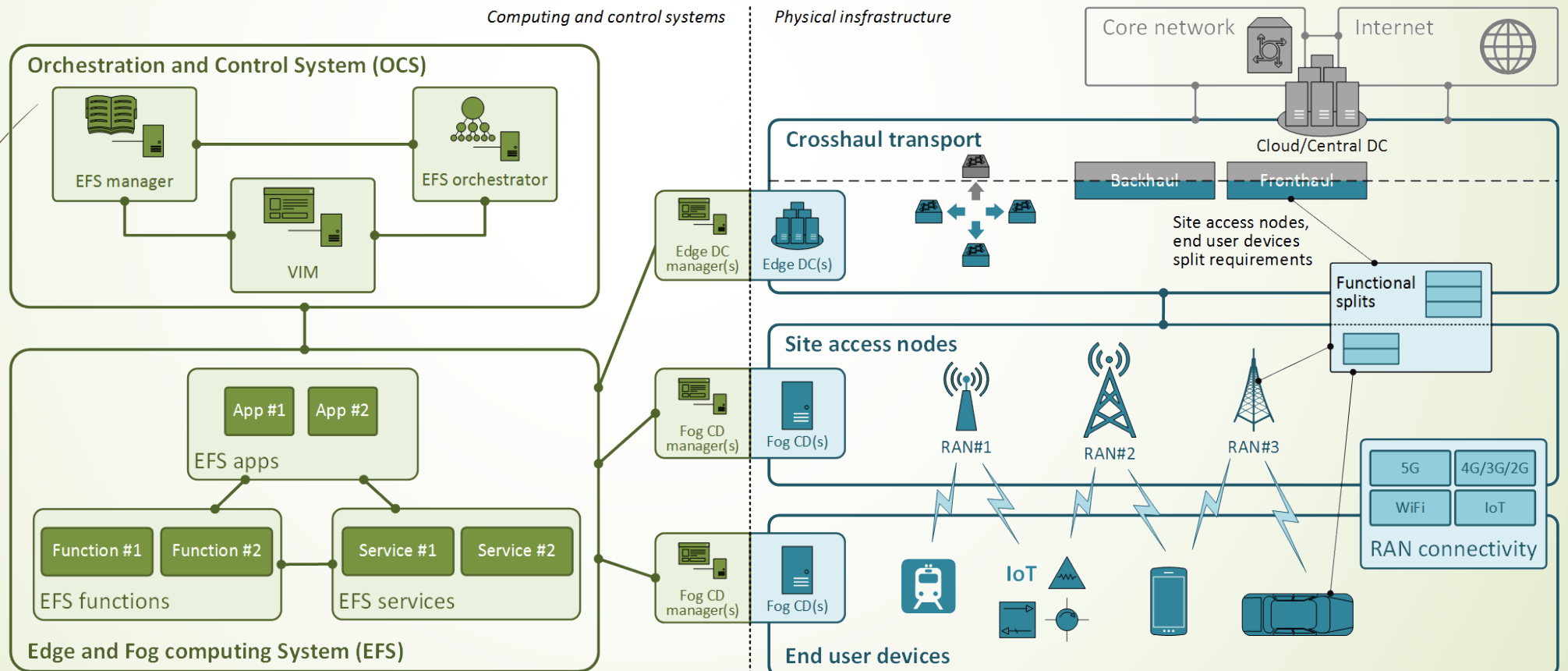
- A hierarchical multi-tier computing infrastructure, from clouds and central data centers (DCs) on top, down to edge data centers (Edge DCs), and further distributed down into fog computing devices (Fog CDs)
- Mobile (non-stationary) Fog CDs are also considered, for example when hosted on moving devices (e.g., car, train, mobile user).
- **The focus is on the edge and fog tiers of the distributed computing infrastructure, along with their interaction with the distant tiers.**



Solution Building Blocks

(1) EFS: hosting all proposed virtualized functions, services, and applications

(2) OCS: managing and controlling the EFS, and its interworking with other domains



EFS – Edge and Fog computing System

Offers hosting in the edge and fog of the following blocks:

- Context information services from multiple RATs in the RAN and other services that can be provided by the Transport and Core networks
- Applications (user and third-party) both inside and outside the EFS subscribing to EFS services through APIs
- Functions subscribing to EFS services for context-aware optimization of network performance in a given local access area
- Virtualized C-RAN functions for access nodes and possibly end user devices, as well as VNFs from the Transport and Core networks

OCS – Orchestration and Control System

Leverage on the extended SDN, NFV and MEC tools to:

- Build and maintain the EFS, by enabling automatic discovery of resources, integrating and federating them into a unified hosting environment, despite their heterogeneity, multiple owners and volatility
- Manage the lifecycle of the EFS functions and applications, by performing their instantiation, live migration and scaling to adapt to changing requirements
- Monitor and measure running functions, applications, and available resources (at physical and virtual level) to guarantee the negotiated service level.

Advancements beyond the SoA (1)

- ▶ A new paradigm for VNFs from the RAN, TN, and CN where the virtualization resources are distributed and may be volatile, compared to today's centralized and fixed paradigm.
- ▶ New forms of access convergence between multiple RATs enabled through a low latency common platform for the RATs to exchange data and support cross-RAT context-aware optimizations.
- ▶ Innovative applications for end users and third-parties that enhance the quality of experience and quality of service by leveraging on the information-rich low latency EFS environment.

Advancements beyond the SoA (2)

- ▶ Extended NFVI, MEC and fog frameworks to support automated and secure integration and federation of distributed resources which may be mobile, and owned by multiple owners.
- ▶ Advanced MANO mechanisms that can cope with the dynamicity and heterogeneity of the EFS environment for the placement and migration of functions and applications.
- ▶ Advances to current SDN-based control through hierarchical multi-layer approaches supporting different roles in the control task and dynamic delegation of task between controllers.

Major Objectives

1

Develop a system model inc. use cases, requirements, architecture, and business models to design and validate 5G-CORAL solution

WP1

2

Design virtualized RAN functions, services, and applications for hosting in the 5G-CORAL Edge and Fog computing System (EFS)

WP2

3

Design an Orchestration and Control system (OCS) for dynamic federation and optimized allocation of EFS resources

WP3

4

Integrate and demonstrate technologies in large-scale testbeds making use of facilities offered by Taiwan, and measure their KPIs

WP4

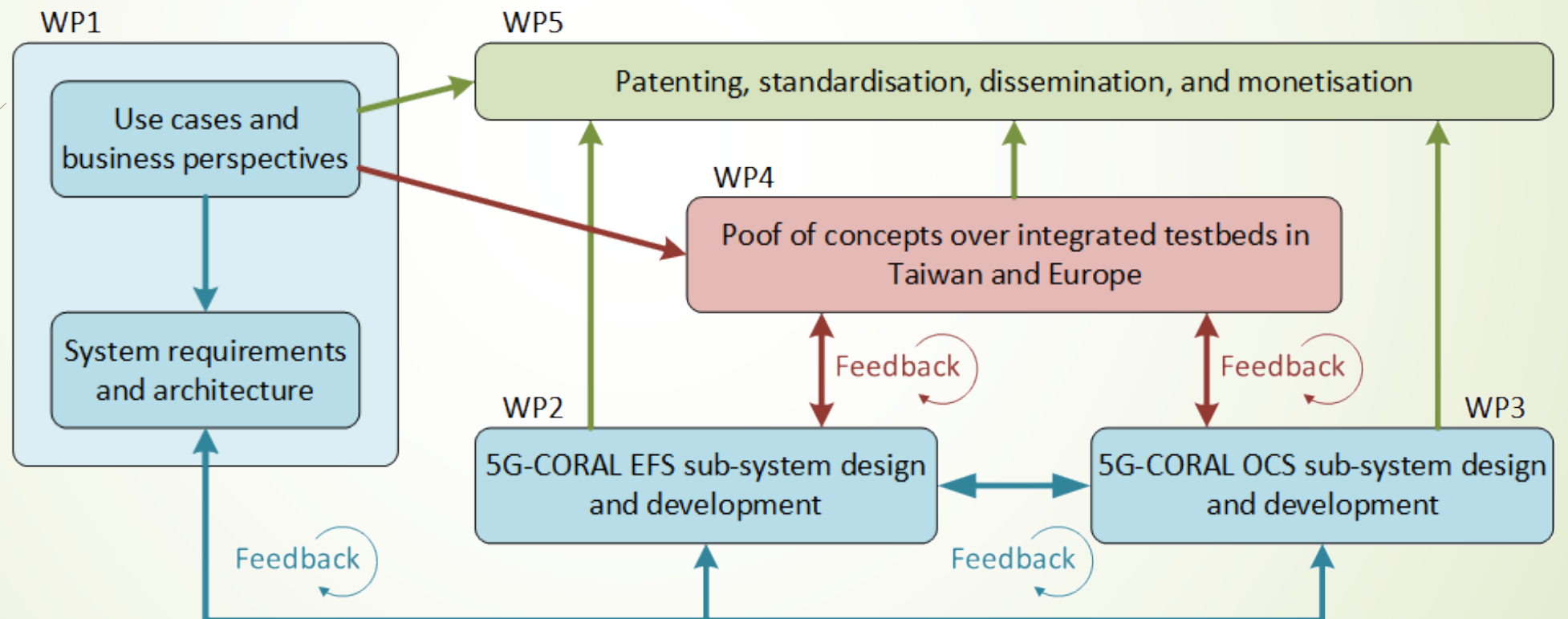
5

Disseminate and contribute results into international research and innovation venues to pave the way for their successful exploitation

WP5

Work Structure

5 Work Packages, in addition to the management WP. Each WP addresses one major objective (cf. previous slide)



WP1 (Lead – Telecom Italia)

- Identify and prioritize use cases, deployment scenarios, and requirements for the design and demonstration of the 5G-CORAL solution.
- Develop business models involving all stakeholders of the 5G-CORAL value chain, such as operators, vendors, service/application/cloud providers, end users.
- Develop the 5G-CORAL architecture leveraging on existing industrial frameworks for NFV, SDN, MEC, and fog computing.
- Develop the 5G-CORAL system framework for supporting convergence between the multiple RATs envisioned.
- Define step-based procedures and techniques for enabling incremental deployment of 5G-CORAL solution into existing networks.

WP2 (Lead – InterDigital)

- Explore the virtualization of RAN functions in the EFS for multiple RATs, develop their requirements, and assess their merits from an access convergence viewpoint.
- Develop EFS functions using EFS services from multiple RATs and the transport and core networks in support of access convergence.
- Specify EFS services for collection, aggregation, publishing, and use of radio and network context information applications and possibly virtualized functions.
- Develop EFS applications using EFS services from multiple RATs and the transport and core networks to improve network KPIs and user QoE.

WP3 (Lead – Foxconn)

- Develop federation mechanisms for EFS resources belonging to multiple owners and subject to different requirements, technical, business, and administrative.
- Develop interfaces for automated deployment of EFS functions and applications.
- Extend existing frameworks for NFV, MEC, and fog to best suit dynamic environments where EFS resources are volatile.
- Integrate the EFS with central clouds to enable instantiation and migration of virtual functions and applications between the EFS and central clouds.
- Develop orchestration and control algorithms for elastic placement and migration of EFS functions, and optimized allocation of EFS resources

WP4 (Lead – ITRI)

- Customize existing testbeds in Taiwan to meet the needs of 5G-CORAL proof-of-concept in large-scale deployments.
- Integrate and validate EFS and OCS in large-scale testbeds, such as shopping mall, high-speed train, and connected cars.
- Demonstrate and trial multi-RAT access convergence and low latency applications, such as augmented reality and car safety, in real-world scenarios involving real users.
- Evaluate the performance of 5G-CORAL solution in the field through measurement of relevant KPIs on data rates and latency in low and high mobility environments.

Trials @ Large-Scale Test beds in Taiwan



Trials – Shopping Mall

- **Shopping mall trial** will showcase network and computing offloading in a multi-RAT environment with the active involvement of EFS and OCS.
- For instance, network-assisted D2D mechanisms, local ads, and AR will benefit from EFS services of localisation and multi-RAT context information.
- In addition, IoT gateway and AR applications will take advantage of the vicinity of computing resources for offloading heavy processing tasks from end user devices/sensors to the Fog CDs/Edge DCs while leveraging the low latency communication offered by 5G-CORAL.

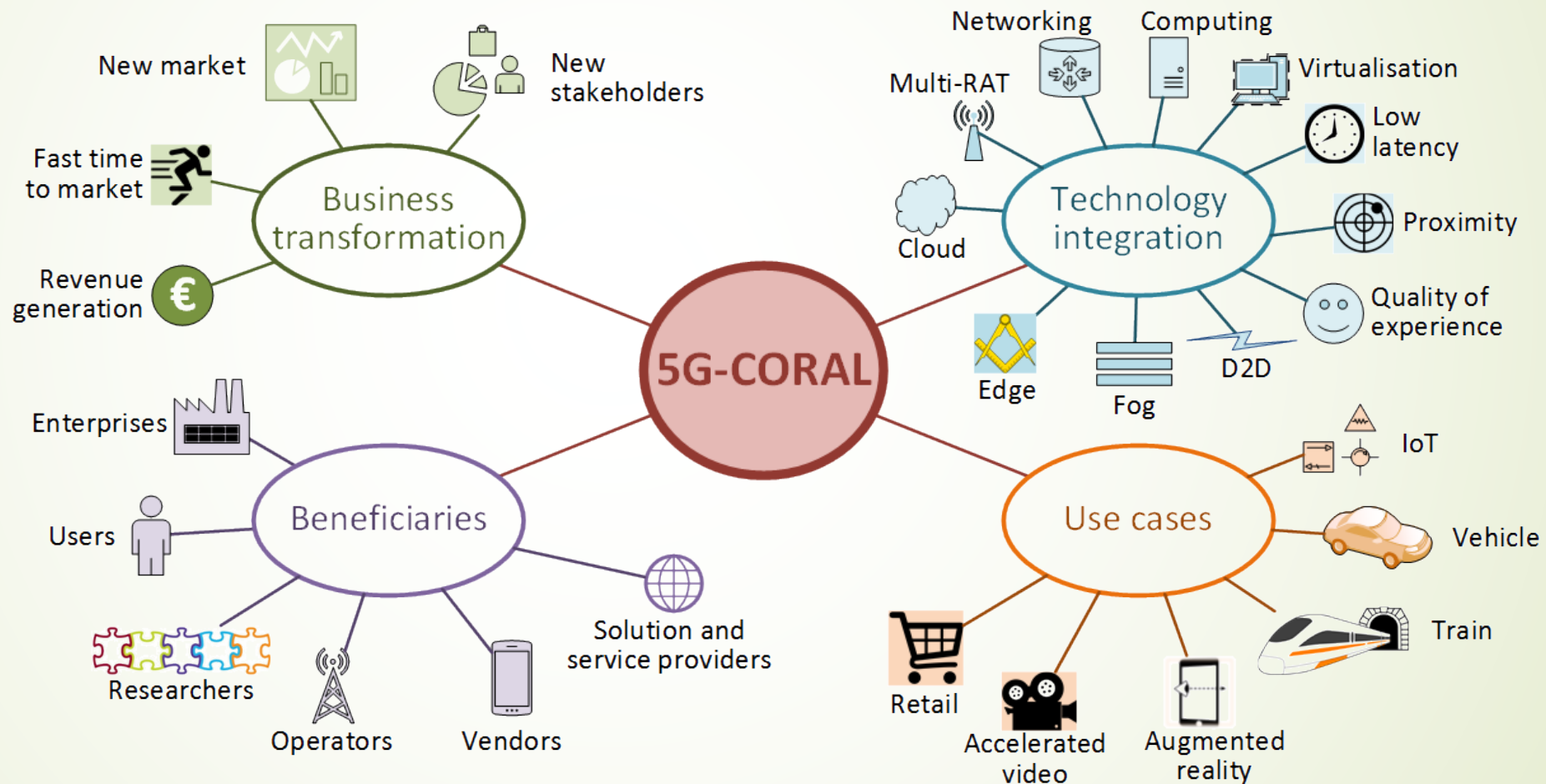
Trials – High-speed train

- **High-speed train trial** will focus on the specific use case of mobility scenarios where massive signaling from frequent handovers are expected due to the large number of end users and sensors on-board the train.
- Therefore, local virtual MMEs will be deployed on the Fog CDs as part of the EFS to cope with the huge amount of signaling envisioned at such a high-speed.
- Such CDs are deployed on-board the train and can also be used to host some specific core functions, such as local breakouts, to enable the storage and consumption of contents locally without the need of going through the train's backhaul connection.

Trials – Connected car

- ▶ **Connected car trial** will showcase the specific latency-sensitive scenarios of car vicinity alert, or any other kind of alert which can be based on EFS localization service (i.e., based on GPS information).
- ▶ An additional scenario is the offloading of V2X and X2V computation-intensive applications (e.g., real-time surveillance, video analytics) to the EFS.
- ▶ Commercially available LTE connections do not offer the required latency for car safety applications. Therefore, ad-hoc small cells and associated network infrastructure will be leveraged to guarantee such latency requirements.

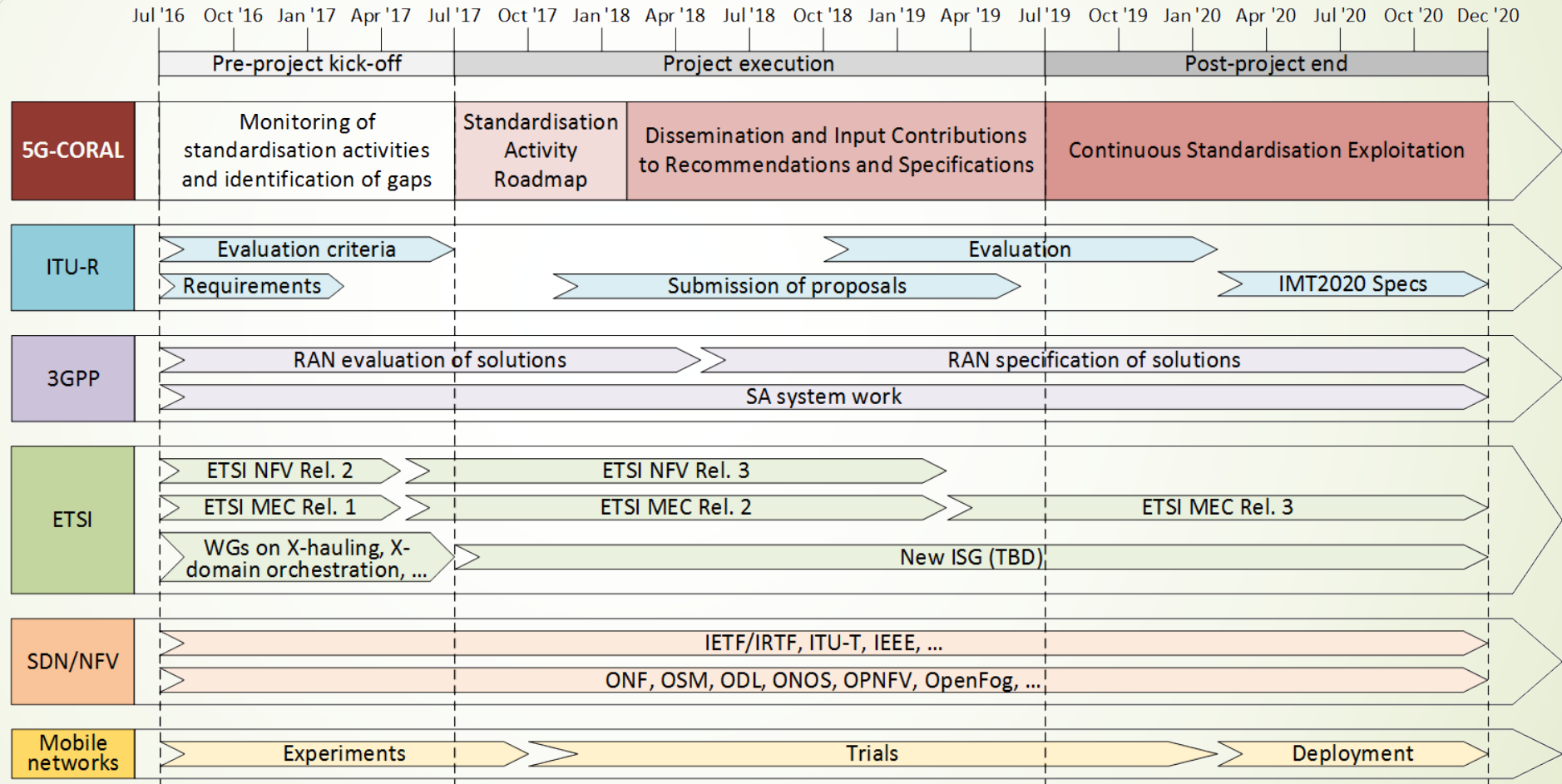
Impact on the Market



Benefits for Stakeholders

- ▶ **Operators:** 5G-CORAL reduces network CAPEX and OPEX through the usage of commodity hardware and virtualization, and creates new revenue streams for operators through novel federation and services creation mechanisms.
- ▶ **Vendors:** 5G-CORAL accelerates the market adoption of products based on standard interfaces for virtualization and federation since the network providers can effectively integrate them in their network.
- ▶ **Solution providers:** Solution providers can offer tailored solutions to enterprise customers on the edge and fog federated system, thus eliminating the need of deploying a dedicated private infrastructure.
- ▶ **Researchers:** Research Community and Academia will be able to go beyond the SoA, thus creating opportunities to transfer the theoretical know-how in practice to industrials and students.
- ▶ **End users:** 5G-CORAL innovations will enhance the quality of experience of the end users.

Standardization Plan



Leadership Team

Role	Leader
Project Coordinator	UC3M
Technical Manager	ITRI
Innovation Manager	Ericsson
WP1 Manager	Telecom Italia
WP2 Manager	InterDigital
WP3 Manager	Foxconn
WP4 Manager	ITRI
WP5 Manager	NCTU



Thank You

Q&A