MARSAL

Machine Learning-Based, Networking and Computing Infrastructure Resource Management of 5G and Beyond Intelligent Networks

Overall Vision, Use Cases and Requirements

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Outline

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❑ **Title:** *Machine Learning-based, Networking and Computing Infrastructure Resource Management of 5G and Beyond Intelligent Networks*

❑ **European Call:** H2020-ICT-2020-2

❑ **Grant Agreement (GA) No.:** 101017171

❑ **Topic:** 5G PPP – Smart Connectivity beyond 5G (ICT-52-2020)

❑ **Duration: 36 months** *(January 2021 – December 2023)*

❑ **Overall budget (requested grant)** of ~**6.126 Million Euro**

❑ **Consortium members:** 14 partners (from 9 EU member states)

❑ **Project Coordinator: Iquadrat Informatica S.L. (ES)**

Expertise \ Partner	CTCC	IQU	KUL	ICCS	NEC	MLNX	OTE	ICOM	EBOS	ORANGE	UNIMI	ACC	ISW	PT
5G Network Architecture	✓	✓		✓	✓		✓	✓		✓				
Network Management	✓	✓		✓	✓		✓				✓	✓		
Network Security	✓	✓		✓	✓	✓	✓		✓		✓			
Cell-Free Networks			✓					✓				✓	✓	✓
5G Experimental Platforms	✓	✓				✓	✓				✓	✓		
Machine Learning	✓			✓		✓					✓			
Standardization	✓	✓			✓	✓	✓			✓		✓	✓	✓

Motivation
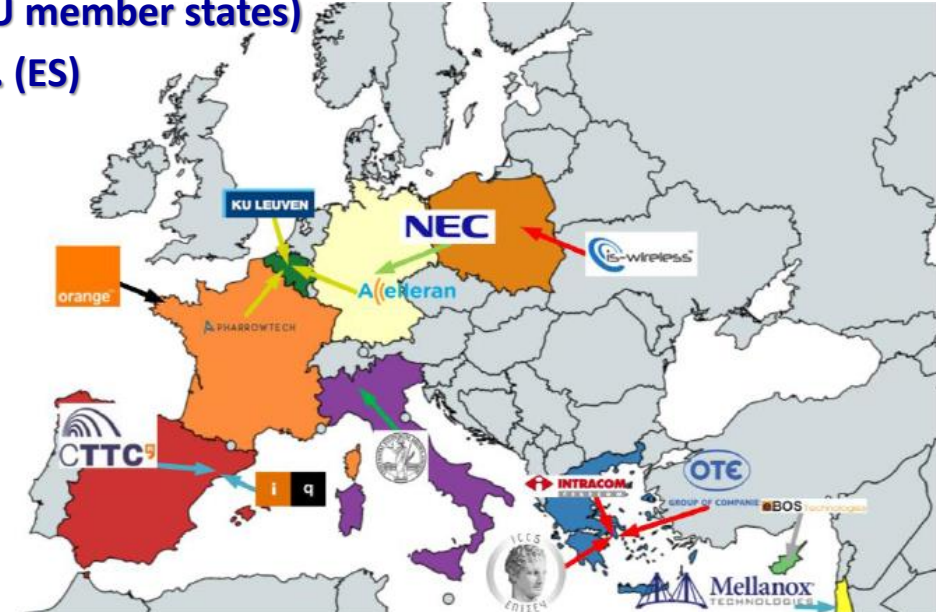
- 5G mobile networks will be soon available to handle **all types of applications** and to provide service to *massive numbers of users*.

- In this complex and dynamic network ecosystem, an ***end-to-end performance analysis*** and ***optimization*** will be the key features, in order to effectively manage the diverse requirements imposed by ***multiple vertical industries over the same shared infrastructure***.

Objectives

Objective One

Design and demonstrate scalable, distributed cell-free massive-MIMO networks supporting massive AP deployments.

Objective Two

Design and implement a cell-free vRAN for B5G, aligned with the O-RAN Alliance architecture.

Objective Three

Architect a disaggregated, SDN control plane towards Fixed-Mobile Convergence.

Objective Four

Deployment of an Elastic Edge Computing paradigm with Cloud-Native technologies.

Objective Five

Policy-driven security, privacy and trust in multi-tenant infrastructures.

Objective Six

Deliver a Self-driven infrastructure with pervasive, ML-driven control.

Objective Seven

Implementation and proof-of-concept of the MARSAL solutions.

Objective Eight

Dissemination, standardization and exploitation of MARSAL.

Technical Objectives

- **Providing the set of specifications of the MARSAL architecture in accordance with the with the O-RAN Alliance.**

- **Providing a 3-layer network architecture**, *by introducing the requirements and specifications of the different RAN components* (e.g., vCU (*virtual Centralized Unit*), vDU (*virtual Distributed Unit*), RU (*Radio Unit*)), *and their interfaces, as well as the reference points of the MEC system with the 3GPP network*.

- **Interfaces among the MARSAL entities**, and the required modifications to add cell-free support.

- **Functional requirements of MARSAL's Fronthauling technologies and the definition of new interfaces for DU coordination**.

- **Identifying and specifying the functional and non-functional specifications for each of the levels of its envisaged virtual elastic infrastructure** *(i.e., MEC system, SDN control framework towards FMC, and ML-driven automation).*

- **Defining the functional requirements of the MEC platform**, *focusing on host-level and system-level components, existing cloud-native frameworks, and detailing the required extensions to support the vision of an Elastic Edge.*

- **Detailed specifications and functional requirements for the Analytic and Decision engines** and **for software components.**

- **The specifications of the ML and blockchain technologies for trust-less multi-tenant slicing will be introduced,** as well as the requirements for the fragmentation strategies and policy-driven data sharing pipeline, to ensure the data confidentiality & data integrity in environments with multiple tenants.
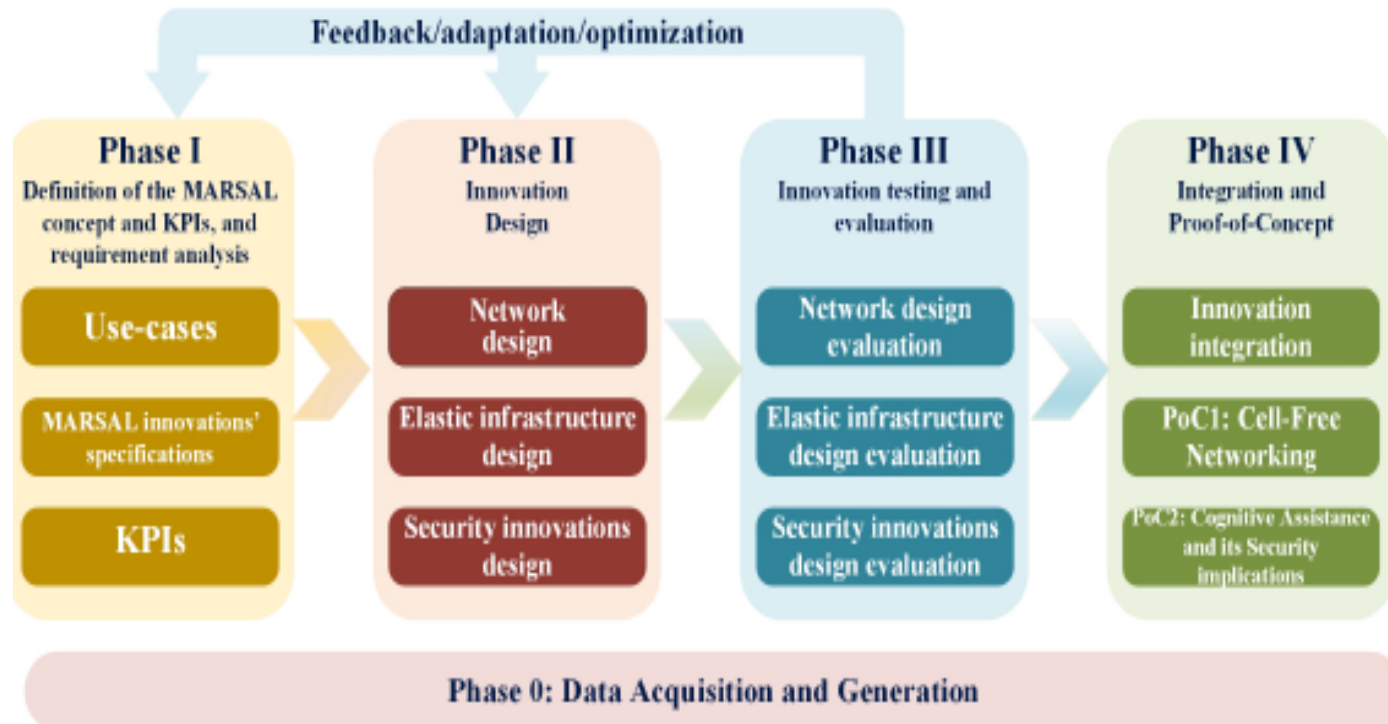
Methodology

MARSAL Methodology

Major Innovations (1)

Definition of requirements, specifications, KPIs and test scenarios for the following MARSAL PoCs

- **PoC1:** Cell-free networking in dense and ultra-dense hotspot areas
  - *Experimentation Scenario 1.1: Dense User-Generated Content distribution with mmWave Fronthauling.*
  - *Experimentation Scenario 1.2: Ultra-dense video traffic delivery in a converged Fixed-Mobile network.*

- **PoC2:** Cognitive assistance and its security and privacy implications
  - *Experimentation Scenario 2.1: Cognitive Assistance and Smart Connectivity for next-generation sightseeing.*
  - *Experimentation Scenario 2.2: Data security and privacy in multi-tenant infrastructures.*

Major Innovations (2)

Functional and non-functional specification of the Virtual Elastic Infrastructures

- Computing (edge & cloud) and networking (Fixed Access - FAN and Radio Access Network) infrastructures
- Optical Mid-haul supporting Fixed-Mobile Convergence
  - *PON controller that provides inventory & service creation capabilities*
  - *White-box OLTs based on pluggable OLT*
- MEC management for 5G/6G networks
  - *Coordinated resource allocation for MEC applications and 5G/6G Network functions*
  - *Support the disaggregation of application functions both horizontally (i.e., across Edge sites) and vertically (i.e., from the cell site towards the core cloud)*
  - *Manage cell-free resources through a cloud-native approach*
- Advanced algorithms
  - *Virtual network embedding*
  - *Inter-DC load balancing*
  - *Resource optimization on converge infrastructures*
  - *Analytic mechanisms*

Major Innovations (3)

Definition of interfaces, functional and non functional requirements for Security, privacy and trust in multi-tenant environments

- Decentralized framework for confidentiality and direct contracts in B5G networks
  - *Smart contract platform*
  - *Privacy preserving representations*

- Policy-driven secure collaborative computations and distributed storage in multi-tenant infrastructures
  - *Release/sharing data policies*

- *ML-assisted, hardware accelerated slice security mechanisms*
  - *Advanced network telemetry system*
  - *Users security with network representation*

➢ **Dense User-Generated Content distribution with mmWave Fronthauling**

- *Deploying cell-free networking in 6G networks with massive AP deployments.*
  - Distributed processing, with clusters of APs and DUs coordinating via fronthaul links and inter-DU coordination effect in spectral efficiency.
  - Dynamic adaptability of AP-DU and DU-DU coordination & data-driven clustering algorithm.
  - Design of cell-free enable vO-DU, cell-free MAC scheduler, PHY sub-layer.
  - Modification of the CP protocols and O-RAN specified interfaces for practical cell-free operation and fully distributed processing.
  - Hybrid MIMO fronthaul solution leveraged for O-RUs and O-DUs interconnection.
  - Represent indoor/outdoor event with high users' and APs density. UGC streamed by spectators / local real-time consumptions, using a video streaming MEC app deployed at the edge.
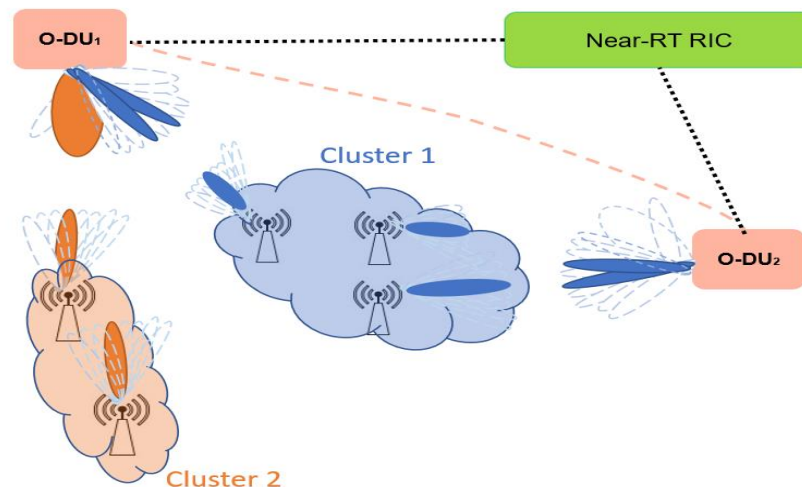
➢ **Ultra-dense video traffic delivery in a converged Fixed-Mobile network**

- *Fixed-mobile convergence in an ultra-dense indoors context*

  Two fixed networks segment dedicated to xhaul:
  - *fronthaul based WDM transmission technologies,*
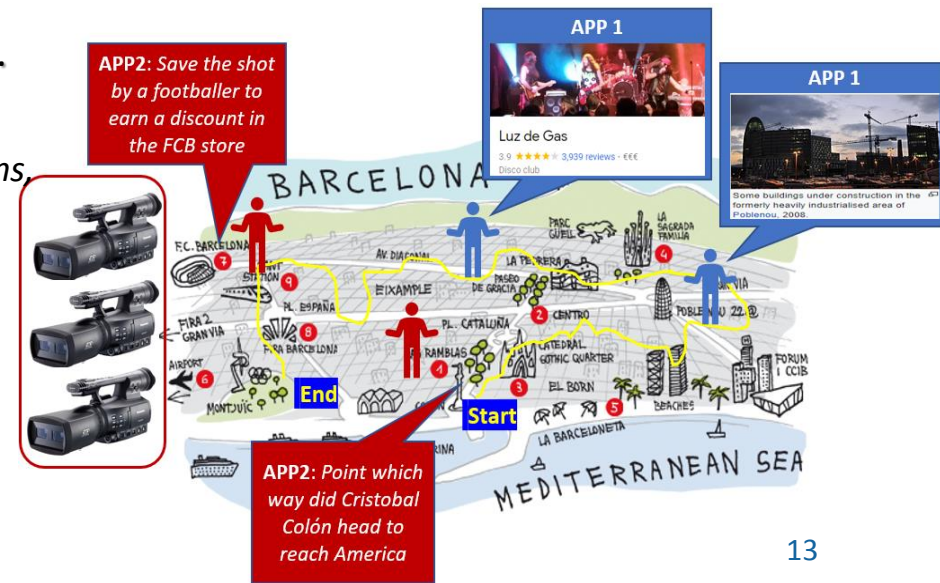 - *back-/mid-haul based on PtP and PtMP technologies.*

- *Distributed cell-free RAN RU deployed based on a serial fronthaul topology.*

- *Representation of an indoor/outdoor event: Users connected to real time videos. Fixed clients will be served by the same infrastructure via PtMP (PON) links sharing capacity with the Radio Edge node.*
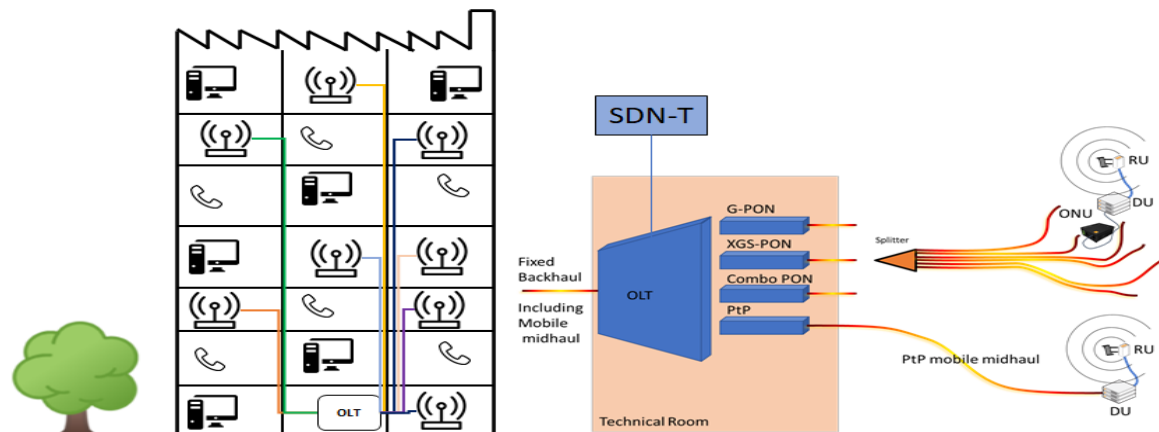
➢ **Cognitive Assistance and Smart Connectivity for next-generation sightseeing**

- *High-level definition of two real-time, interactive, cloud-native AR applications for 6G outdoors sightseeing, supporting human-centered interaction via 3D cameras, equipped with untethered AR glasses.*

  ✓ **APP1**: *real-time video analytics, visual guidance*

  ✓ **APP2**: *cognitive assistance, virtual representation of an artefact projected at AR glasses*

  - Provide a *flexible network architecture* capable of adapting to fulfil applications performance requirements.

  - Cope with the *challenging applications requirements*, while keeping the *SLAs* of the rest running apps.

  - *Load balancing* according to *priority services*.

  - *MEC* approaches:

    - *lighten the network burden of the AR applications,*

    - *leverage the use of edge computing nodes.*

APP2: *Save the shot by a footballer to earn a discount in the FCB store*

APP 1

Luz de Gas
3.9 ★★★★ 3,939 reviews · €€€
Disco club

APP 1

Some buildings under construction in the formerly heavily industrialised area of Poblenou, 2008.

BARCELONA

End

Start

APP2: *Point which way did Cristobal Colón head to reach America*

MEDITERRANEAN SEA

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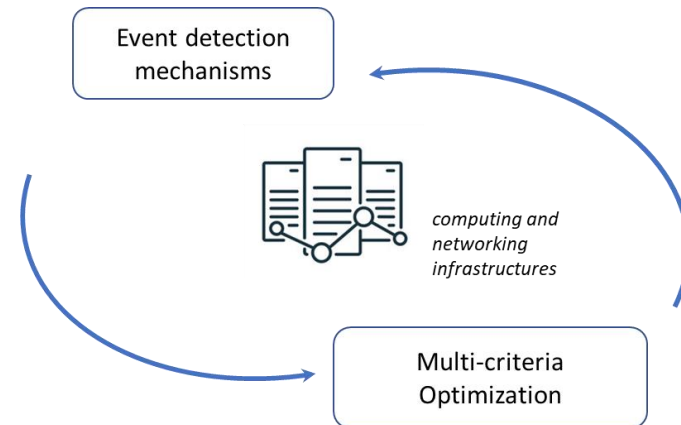➤ **Data security and privacy in multi-tenant infrastructures**

- *Demonstrate and evaluate MARSAL's privacy and security mechanisms.*
  - Guarantee slice isolation & ensure collaboration of participants in multi-tenant 6G infrastructures, without assuming trust.
  - Evaluation of mechanisms w.r.t. mitigate the increased privacy risks of NGI applications that process Personally Identifiable Information (PII).
  - Application of security and privacy mechanisms in different layers:
    - *secure and private sharing of information among tenants,*
    - *legal security using smart contracts,*
    - *security of the data stored in the cloud,*
    - *security of the final users.*
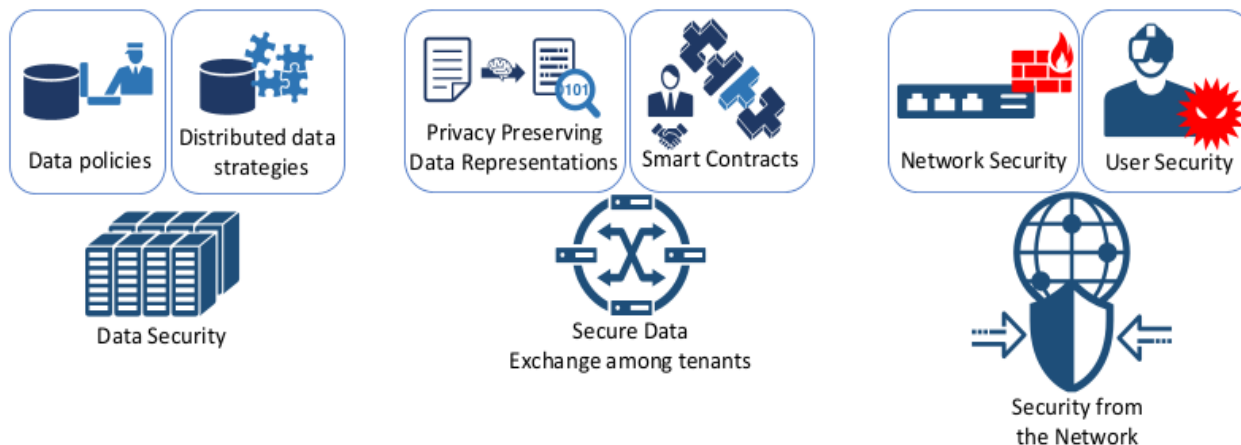
- ***Analysis of existing technologies***
  - Software-Defined control plane towards Fixed Mobile Convergence
  - "Multi-access Edge Computing" (MEC) platforms
  - Multi-Objective Optimization

- ***Definition of functional requirements***
  - Transport network management
  - MEC resources management
  - Algorithms & engines

- **Definition of non-functional requirements**
  - Performance, scalability, power consumption, etc.

- **Preliminary definition of interfaces to other MARSAL components**

Selected functional requirements:

- *Event detection mechanisms*
- *Multi-criteria optimization mechanisms*
- *Decision & analytic engines*

Event detection
mechanisms

computing and
networking
infrastructures

Multi-criteria
Optimization

Data security and privacy in multi-tenant infrastructures – *requirements*

➤ **Data security and privacy in multi-tenant infrastructures**

- ***Analysis of existing technology and possibility***

- ***Definition of functional requirements***
    - How does it work?

- ***Definition of non-functional requirements***
    - Performance, scalability, power consumption, etc.

- ***Preliminary definition of interfaces to other MARSAL components***

Selected functional requirements:
- *Availability of the Smart contracts*
- *Atomicity of the Smart contracts*
- *Data ownership added to the Smart contracts*
- *Data generated is encoded but directly useful for ML tasks*
- *The Privacy Preserving data representations should support different formats*
- *The size of the output should be configurable*

Smart Contracts — Secure Data Exchange among tenants — Privacy Preserving Data Representations

Data security and privacy in multi-tenant infrastructures – *requirements*

Data policies — Data Security

Network Security — Security from the Network — User Security

Selected functional requirements:

- *Data Authorities must maintain control over their data when relying on external nodes*
- *Support fine-grained Access restrictions*
- *Data stored outside the premises of a trusted party must be encrypted*

Selected functional requirements:

- *Advanced telemetry should not impact network performance*
- *Ability to collect and block data in real time*
- *The system learns from the users' sessions*
- *The system can detect harmful connections before they happen*

Questions?