MARSAL

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

Ioannis Chochliouros, Alexandros Kostopoulos (OTE)

5GPPP KPIs WG – TMV Webinar

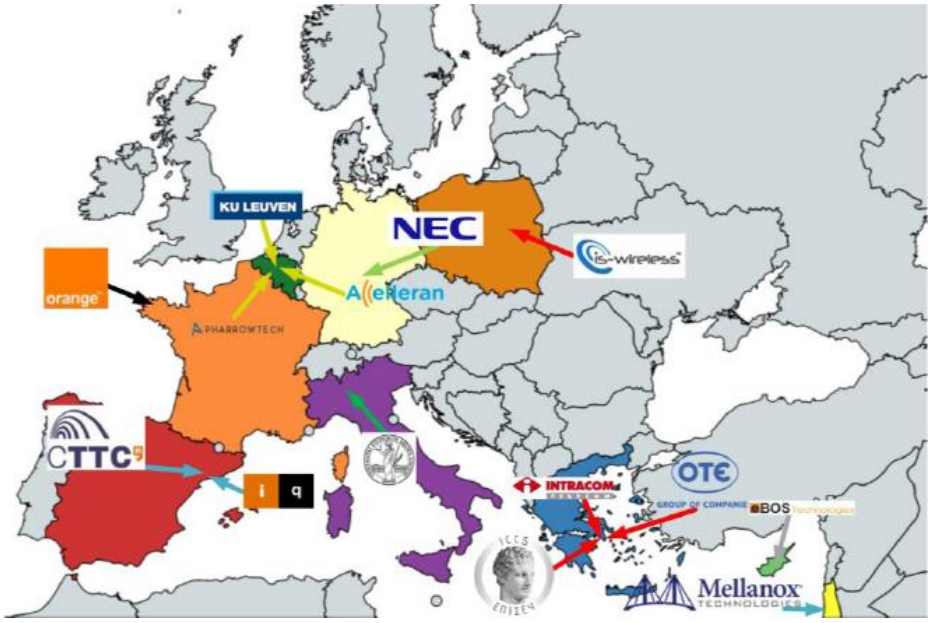
28th September 2022

This Project has received funding from the European Union´s Horizon 2020 research and innovation programme under Grant Agreement No. 101017171

MARSAL at a glance

- 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 (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 changes the landscape of mobile networks in a profound way**, *with an evolved architecture* supporting unprecedented capacity, spectral efficiency, and increased flexibility.
- Moreover, **5G adopts Edge computing as a key paradigm**, evolving from centralized architectures (e.g., based on C-RAN) towards multiple tiers of Edge nodes and a virtualized RAN (vRAN).
- **Open RAN initiatives such as O-RAN have a key role in this evolution**, complementing the 3GPP 5G standards with a foundation of vRAN network elements.

- *However, these technologies have been developed in isolation between them, making difficult to fully exploit their capabilities in an integrated, end-to-end and secure manner.*
- *Algorithms do not only run in the cloud, and optical and wireless links cannot be abstracted in the same way.*

- When going to cell-free networking concepts, more nodes and links will be interconnected, serving local and global secure applications and, *consequently*, **it is essential to rethink the architecture and algorithms running elastically at the scale of a city or building level.**

Positioning

Application traffic flows from (and towards) end-users and end-devices, served by multiple levels of storage and computing entities from the edge to the cloud, while utilizing a diverse set of wireless and optical technologies *in the fronthaul, midhaul and backhaul network segments.*

These ***variable infrastructure resources***

- *belong to different administrative domains,*
- *operate in parallel in the same network area(s) and*
- *are usually shared between competing flows, computations and data in static and/or statically multiplexed manner.*

Targeted innovation activities need to take place to fully exploit key technological developments, towards structuring a disaggregated infrastructure model

- ***where technological infrastructure blocks can be transparently and flexibly replaced by others,***
- ***while offering similar networking and/or computing offerings and control, together with monitoring capabilities.***

Challenges

***Key advances are required* both in the network design and network/service orchestration levels:**

- ***The network infrastructure should be able to support multiple distributed edge nodes and a huge number of Access Points**, which are coordinated and orchestrated by entities in a low-cost and near-zero latency manner.*
- ***A unified and hierarchical infrastructure is essential in order to provide an intelligent management of communication, computation and storage resources**, which can be further enhanced by incorporating efficient Machine-Learning (ML) algorithms.*
- ***The support of multiple tenants should be followed by the application of mechanisms being able to guarantee data and information security and integrity, especially in multi-tenant environments**, which would play a vital role in enabling various use-cases and industry verticals targeted in 5G and Beyond (B5G) systems.*

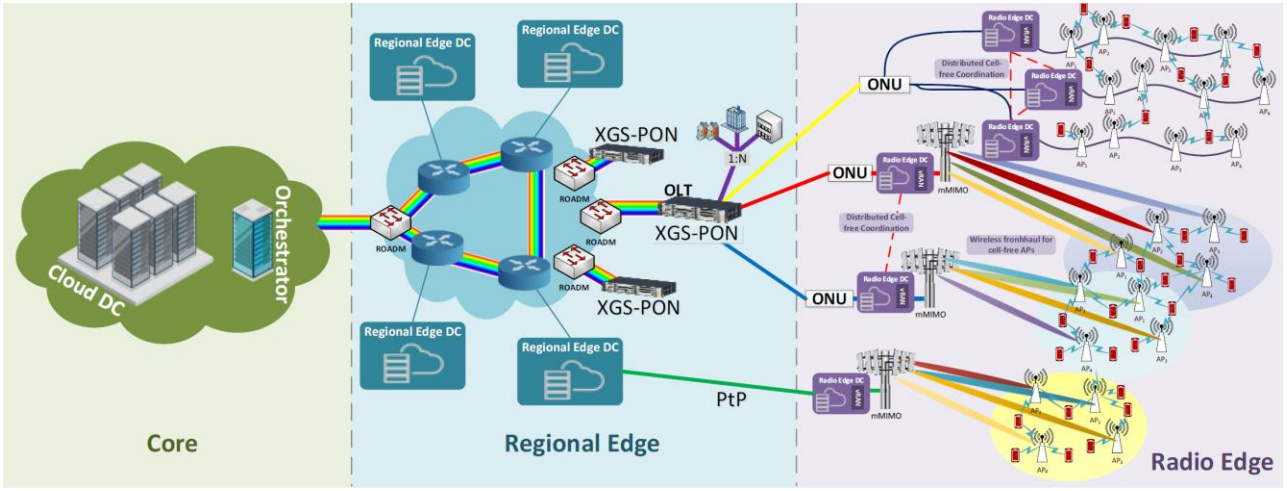
Aims

MARSAL proposes a new paradigm of elastic virtual infrastructures

- ***that integrate in a transparent manner*** *a variety of novel radio access, networking, management and security technologies,*
- ***which will be developed under the project framework*** *in order to deliver end-to-end transfer, processing and storage services in an* ***efficient and secured way.***

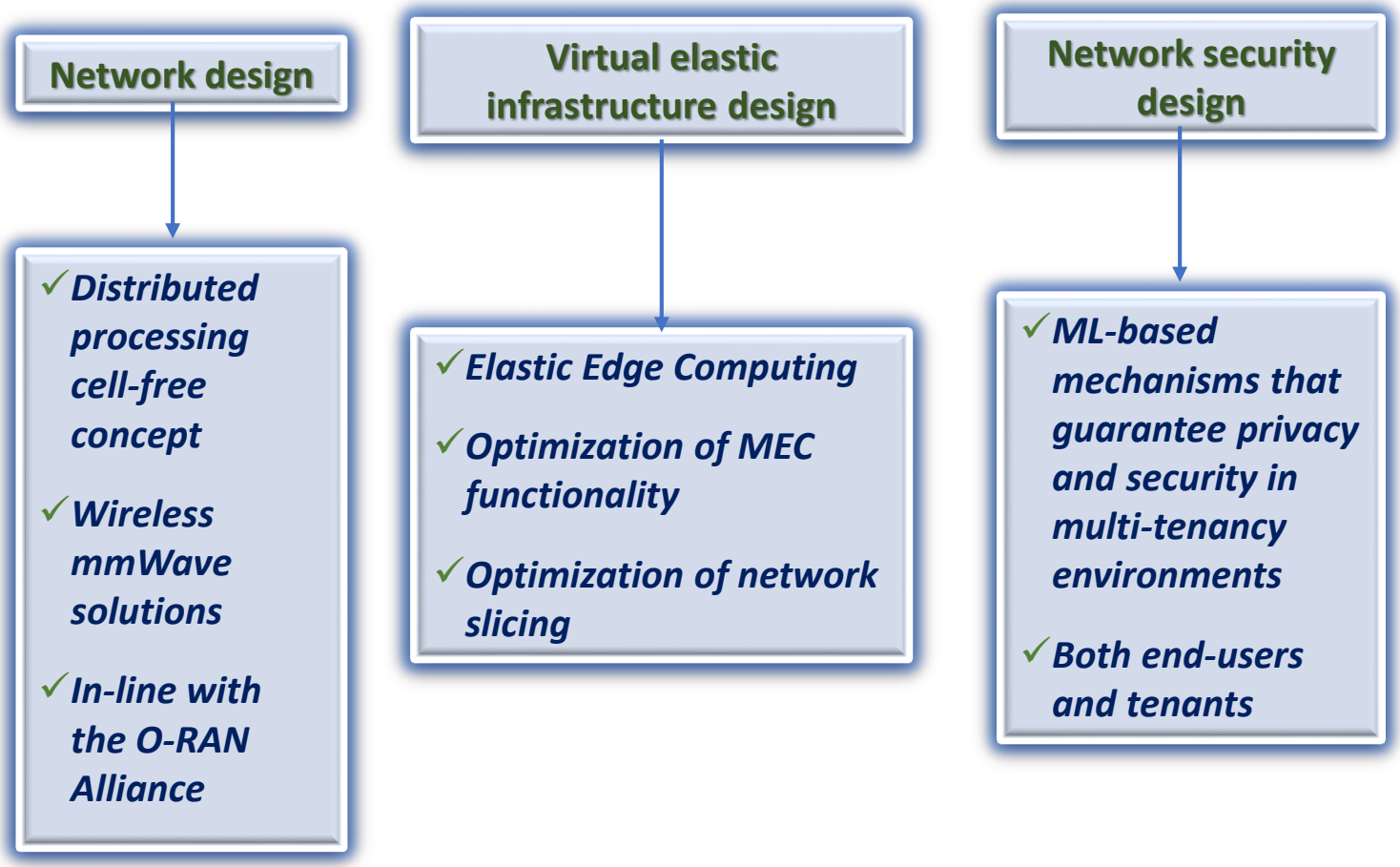
MARSAL aims to provide an evolved architecture towards B5G, offering:

- ***Unprecedented degrees of flexibility*** *and* ***closed-loop autonomy at all tiers of the infrastructure,***
- *and* ***significantly improved Spectral Efficiency, via Cell-Free Networking.***



Concept

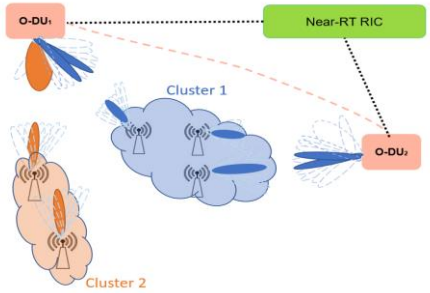
MARSAL focuses on three pillars to enable a new generation of ultra-dense, cost-efficient, flexible and secure networks

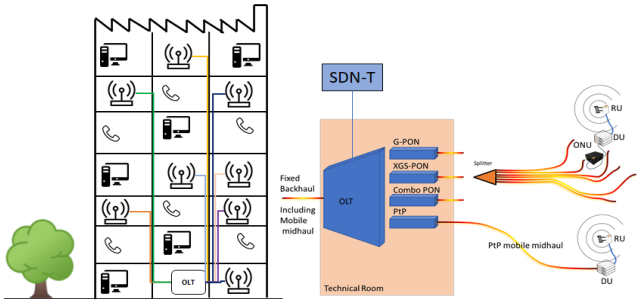


PoCs & Scenarios

PoC1: Cell-free networking in dense and ultra-dense hotspot areas

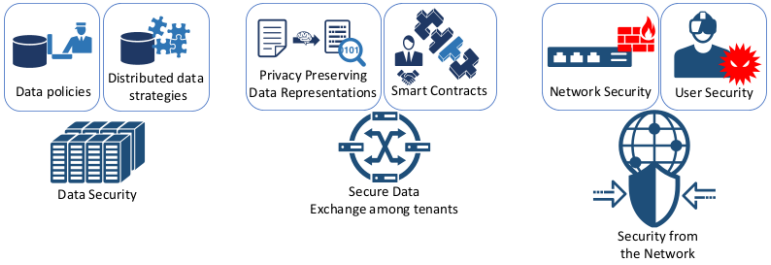
- *Experimentation Scenario 1.1: Dense User-Generated Content distribution with mmWave Fronthauling.*
- *Experimentation Scenario 1.2: Ultra-dense video traffic delivery in a converged Fixed-Mobile network.*





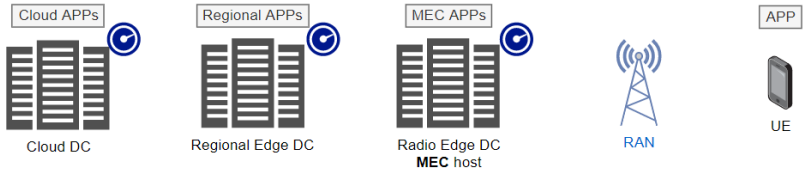
PoC2: Cognitive assistance and its security and privacy implications

- *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.*

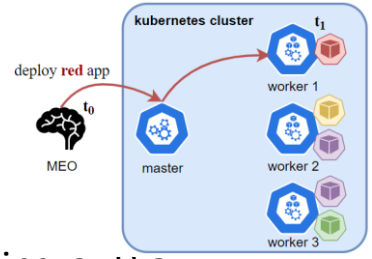


MARSAL KPIs (1)

- Resource utilization
  - *Resource utilization of hosts and data-centres across the different domains (cloud, regional, and edge).*
    - The resource utilization is expressed in terms of computing, storage, and networking, of the hosts and data-centres across the network domains.
    - It is efficient for high-demanding use cases where it is convenient to share efforts among different hosts including MEC. *The goal is to avoid the overall network underutilization of available resources, while diminishing overutilization of certain hosts.*
    - It is measured in the physical, virtualized, and containerized functions across the different network domains.



- Scale-out latency
  - *Scale-out of containerized application functions.*
    - It refers to the time it takes from submitting the order of creating (or scaling-out) a containerized function to the actual deployment of such function.
    - Aims to provide imperceptible latency for time-critical use cases, *like untethered AR apps.*
    - Investigates how to achieve optimal latency budgets through the MEC orchestrator (MEO) *to derive the optimal placement of the containerized application functions at the Radio Edge or Regional Edge data-centres.*
    - It is measured from the master node of the cluster managing the containerized functions (e.g., Kubernetes).



MARSAL KPIs (2)

- Computing resource utilization
  - ***Increased Virtual Elastic infrastructure resource utilization via load balancing.***
    - It is the percentage of the available processing and storage Virtual Elastic resources, *that are consumed by MEC applications.*
    - Unbalanced demands will be emulated in the coverage area of certain Regional Edge nodes, *and the ability of the MEC system to uniformly re-direct traffic within the Virtual Elastic DC will be showcased.*
    - Investigates how the utilization of the Virtual Elastic DC resources can be increased through extensions to the MEC system *to facilitate the disaggregation of Cloud-Native MEC applications both horizontally (across may tiers of Edge nodes) and vertically (i.e., across the same tier).*
    - It is measured by computing resources placed at the edge nodes.

- Communication network efficiency
  - ***Increased network efficiency in terms of communication resource utilization and latency.***
    - It refers to the utilization of the active communication resources and the introduced latency.
    - Unbalanced demands will be emulated in the coverage area of certain Regional Edge nodes, *and the ability to re-direct traffic increasing the network resource utilization will be showcased while keeping the latency for time critical applications below 1 ms.*
    - It is measured by using communication resources available at the access and transport part of the network.

MARSAL KPIs (3)

- Spectral efficiency
  - *Per user spectral efficiency, System spectral efficiency.*
    - The spectral efficiency can be measured as the information rate that can be transmitted over given physical resource blocks of the considered cell-free mMIMO networks at the radio edge.
    - It investigates how the spectral efficiency can be maximized while optimizing the radio resources at the radio edge.
    - In the radio edge, the APs will be interconnected with O-DU nodes serving the users in a coordinated manner and we evaluate the performance via a pre-recorded video content *that will be uploaded and downloaded by UEs to/from a video streaming MEC app deployed at the Regional Edge node, to emulate dense user-generated streaming both in the uplink and in the downlink direction.*
    - It is measured by using radio resources and CF mMIMO APs, available at the radio edge of the overall MARSAL architecture.

- Frame loss
  - *Forwarding rate of interface / Traffic configuration for **back-, mid- and front-haul***
    - It investigates how the frame loss in the Transport Network Equipment (TNE) can be lowered to a strict minimum.
    - Checks the forwarding rate of interface to be under 100% of load for various frame lengths of the TNE.
    - Traffic configuration is considered for for back-haul, mid-haul and front-haul.
    - It is measured at the transport network equipment, using a traffic generator and analyzer.

MARSAL KPIs (4)

- Data Privacy
  - *Tenant data privacy.*
    - It is the amount of confidential information shared between the tenants and the infrastructure owner.
    - Consideration of multi tenant scenarios, where the information from tenants is required to optimize the performance of the whole system.
    - *It aims to develop Privacy Preserving functions able to anonymize the data while keeping value for learning.*
  - *Smart contract latency.*
    - The latency between issuing a transaction and the time to receive a response.
    - It relates to real time network resources negotiations.
    - *For evaluation purposes, latency needs to be smaller than 10 s.*
  - *Smart contracts throughput.*
    - The average number of transactions process per second.
    - Number of smart contracts created for network slicing.
    - *For evaluation purposes, throughput needs to be larger than 100MB/s.*

MARSAL

Thank You!!!

Questions?

Contract Information:

Dr. Ioannis Chochliouros & Dr. Alexandros Kostopoulos

Fixed Network R&D Programs Section
R&D Department, Fixed & Mobile
Hellenic Telecommunications Organization S.A. (OTE)

Email: ichochliouros@oteresearch.gr; alexkosto@oteresearch.gr;
Tel.: (+30)-210 6114651

This Project has received funding from the European Union´s Horizon 2020 research and innovation programme under Grant Agreement No. 101017171