6G series workshop by Hexa-X-II

Hexa-X-II Architecture enabler design

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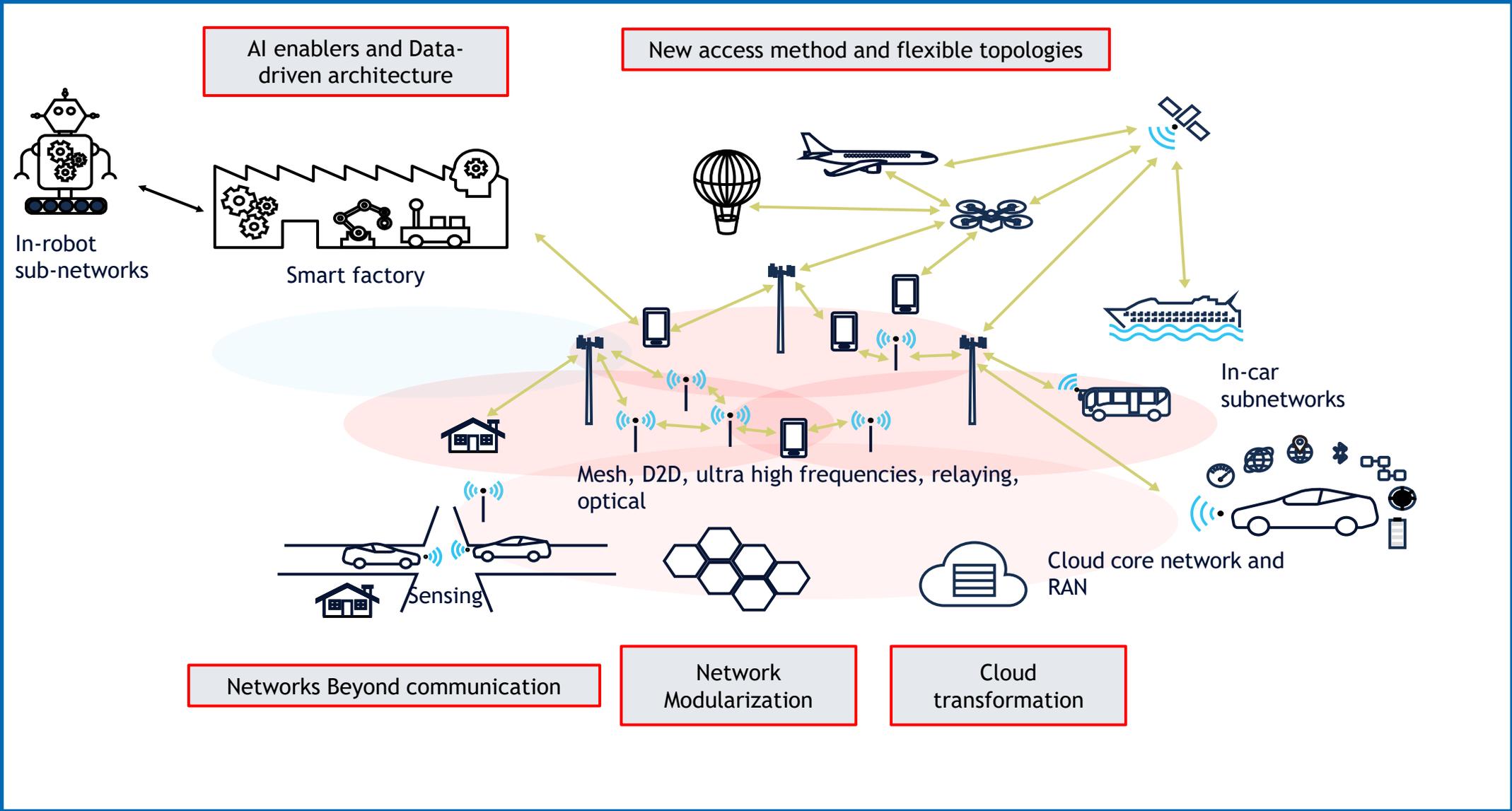
Hexa-X-II

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12.2.2025

6G Architecture enabler overview

AI enablers and Data-driven architecture

New access method and flexible topologies

In-robot sub-networks

Smart factory

Mesh, D2D, ultra high frequencies, relaying, optical

In-car subnetworks

Sensing

Cloud core network and RAN

Networks Beyond communication

Network Modularization

Cloud transformation
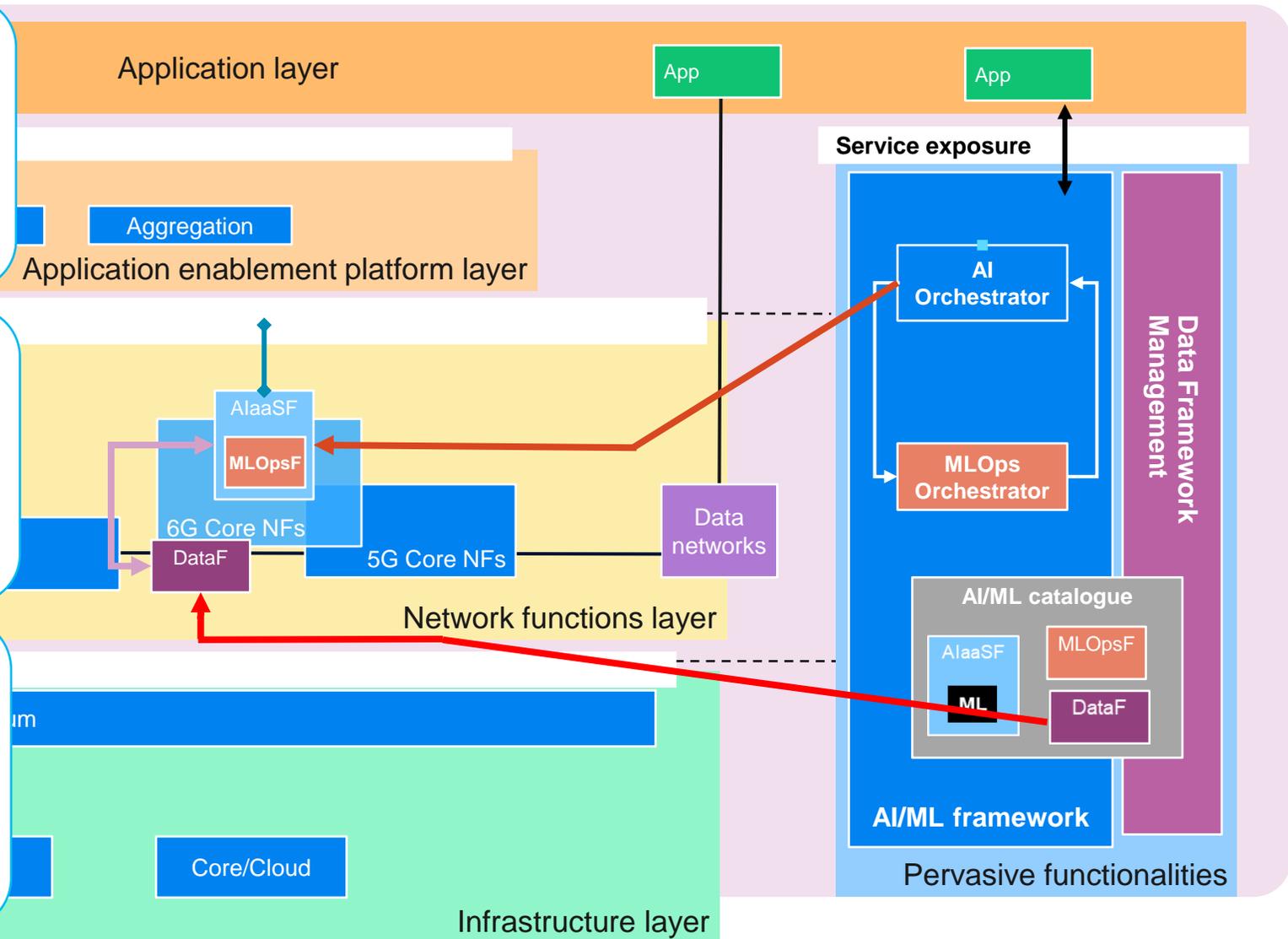
AI enablers

Data driven arcchitecture

AIaaS
AI/ML enablers in the AI/ML framework

- **AIaaS**
  - "one-stop shop" solution to ease the deployment, operation and execution of AI/ML services
  - Exposure through a set of open APIs

- **MLOps:**
  - automate AI/ML models lifecycle management
  - acts as an enabler for AIaaS by optimizing AI services throughout their lifecycle.

- **DataOps:**
  - to efficiently distribute and manage data for AI services

- MLOps and DataOps work in synergy to streamline AL/ML lifecycle.

Application layer

App

App

Service exposure

Aggregation

Application enablement platform layer

AI Orchestrator

AIaaSF

MLOpsF

6G Core NFs

DataF

5G Core NFs

Data networks

MLOps Orchestrator

Data Framework Management

Beyond Communications functions

Network functions layer

AI/ML catalogue

AIaaSF

MLOpsF

ML

DataF

Core/Cloud

AI/ML framework

Pervasive functionalities

Infrastructure layer

DataOps

- **Streamlined Data Management:**
  - DataOps integrates collection, processing, and exposure of data across 6G networks

- **Some key findings:**
  - **Privacy-Preserving Architecture:**
    - NWDAF acts as the **collector** and AFs manage aggregation
    - Ensures privacy in data collection and analysis by the network
  - **5G Core Observability Platform:** The Failure Prediction Machine Learning module was being implemented in order to improve the 5G Core reliability
    - Results show that allows to achieve high failure detection accuracy

DataOps: 5G Core Observability Platform architecture: detect or predict a failure (risk of losing service continuity)

MLOps
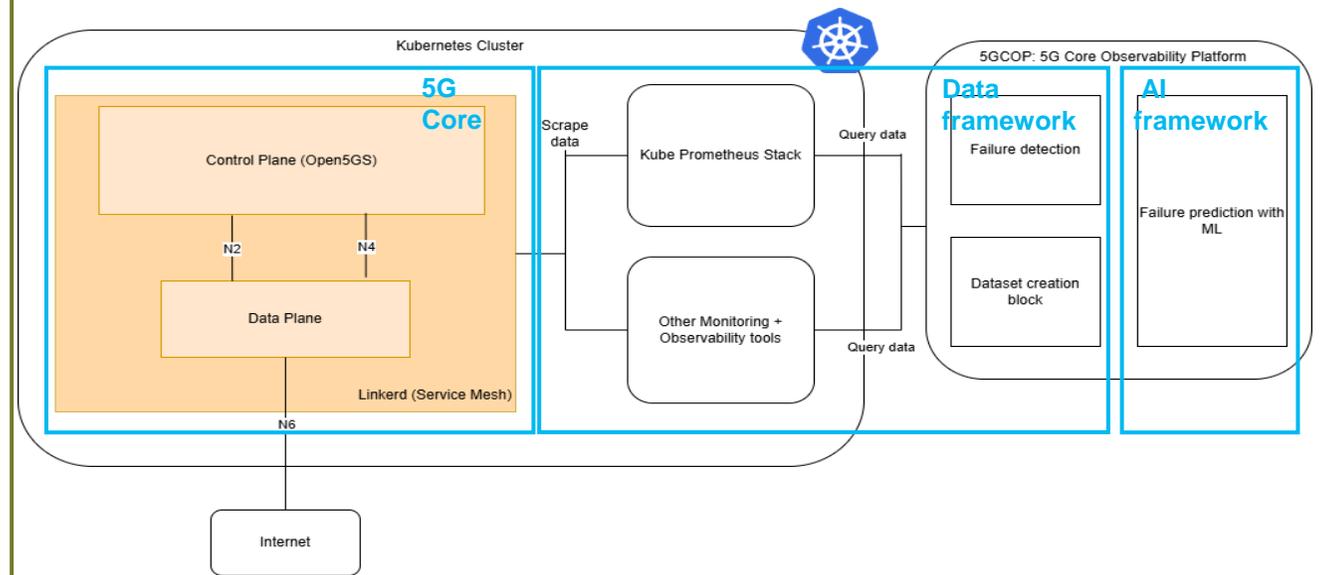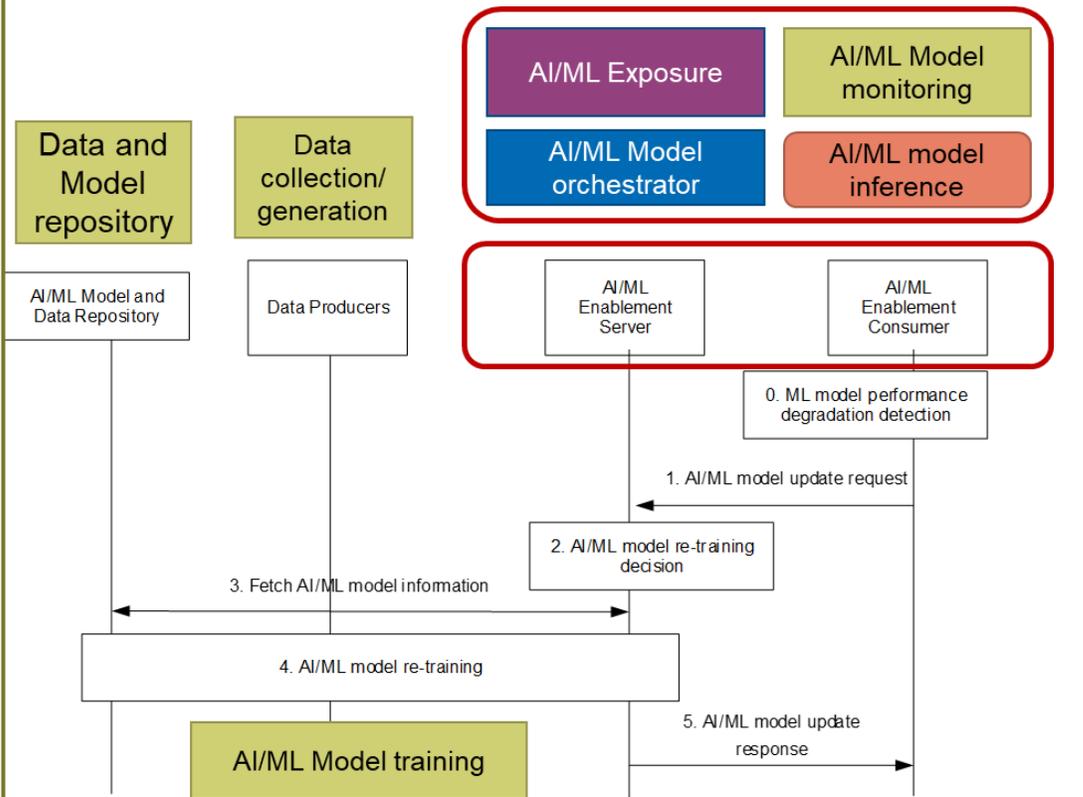
ML lifecycle

Fig.2: Support for AI/ML model lifecycle management in 3GPP (ref. TR 23.700-82)

Illustration of communication and computation optimization in wireless Federated Learning (FL) networks
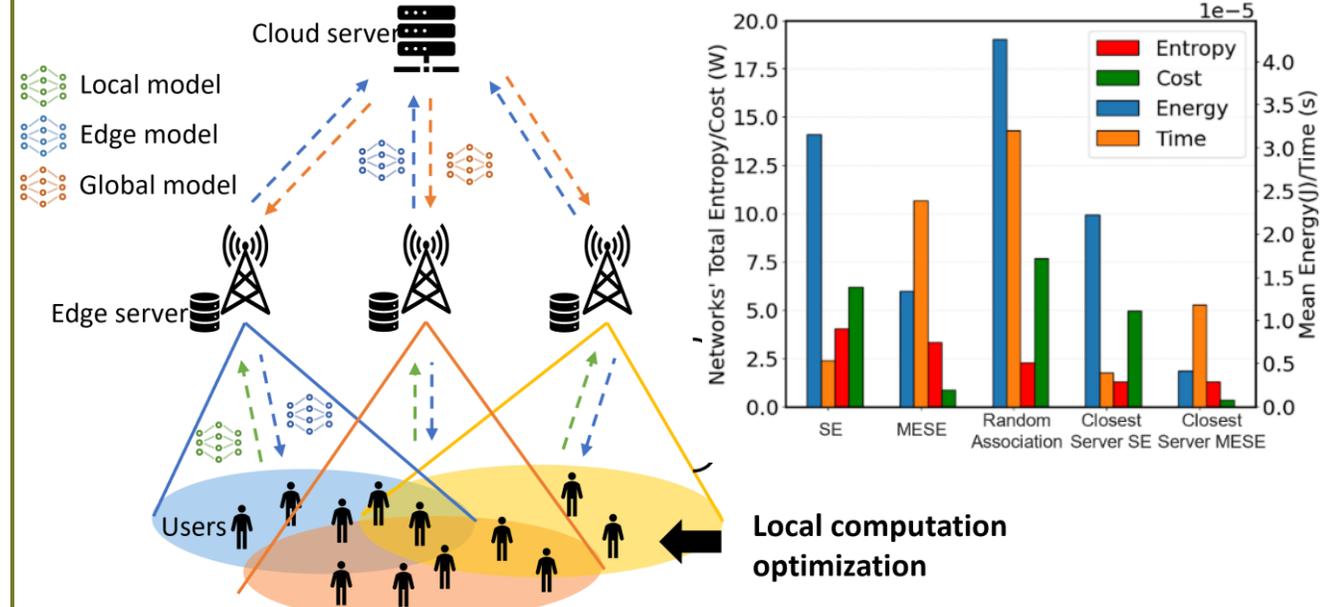

Illustration of communication and computation optimization in wireless Federated Learning (FL) networks

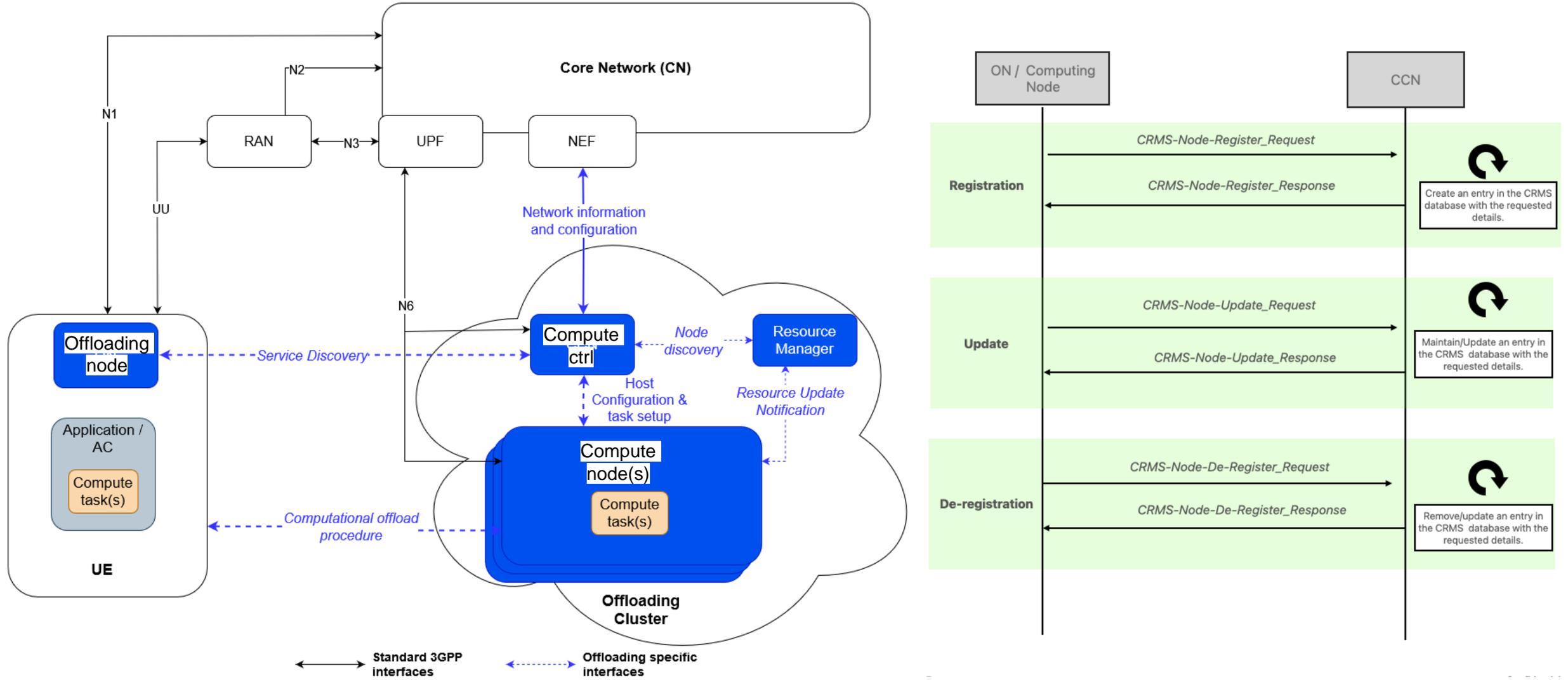# Compute offloading framework

Compute offload architecture framework

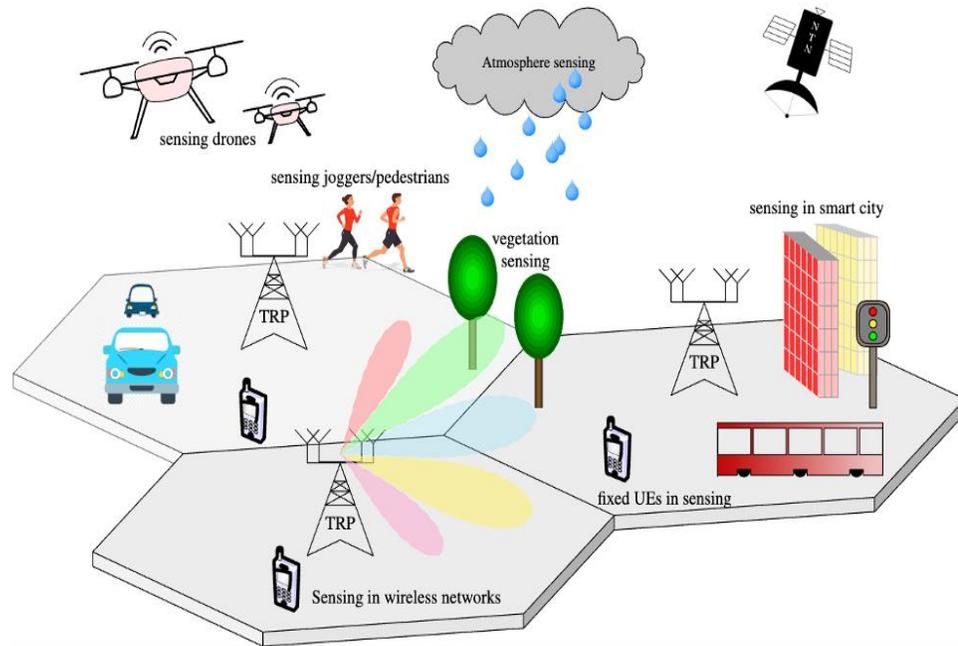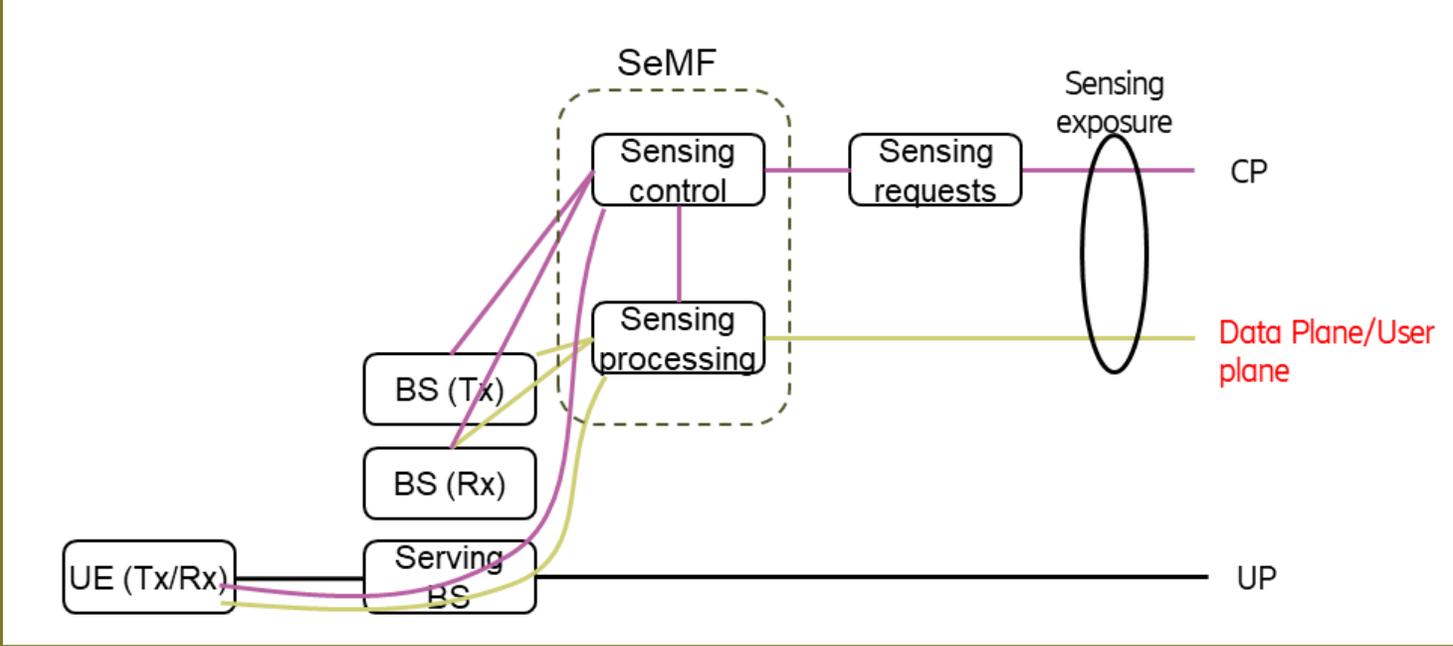Fig. 1: Draft architecture: offloading components interacting with the network
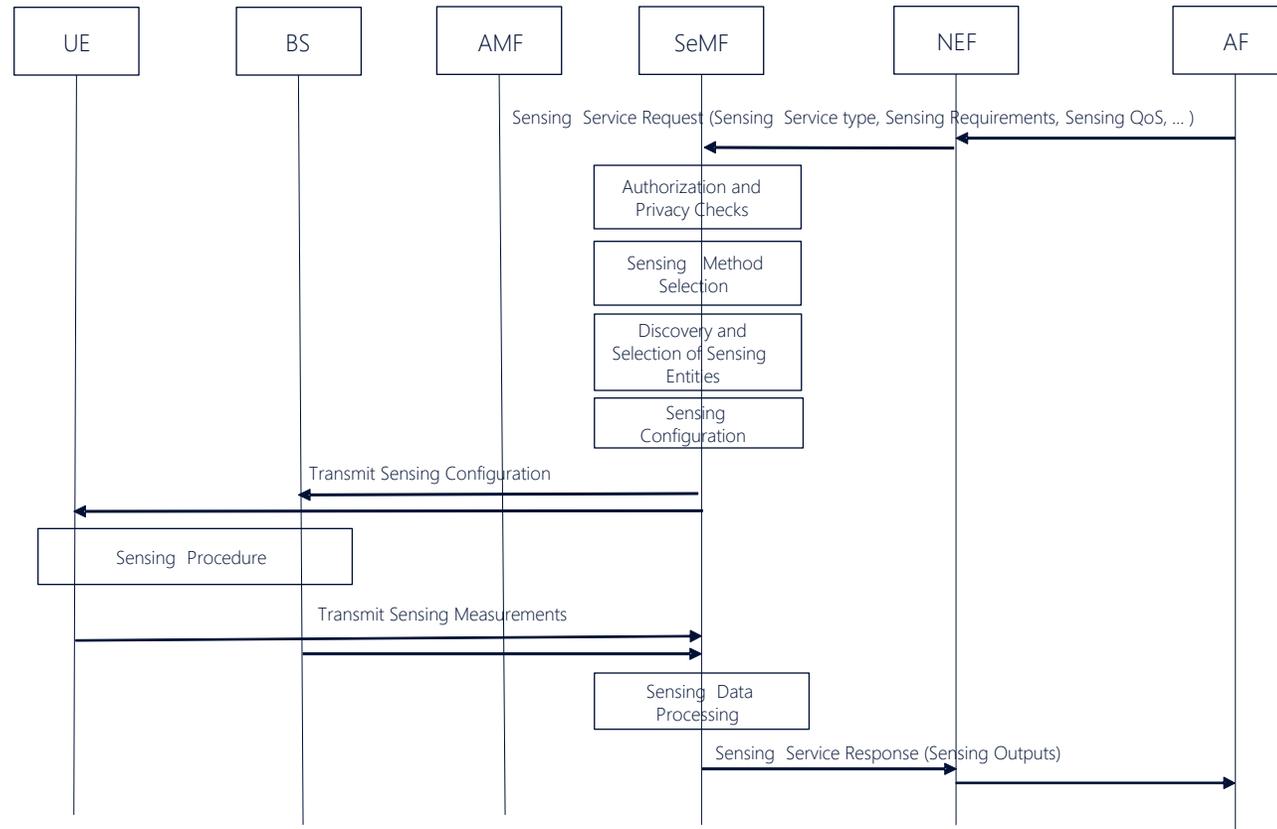
Sensing framework

Sensing functional view

Sensing functional architecture
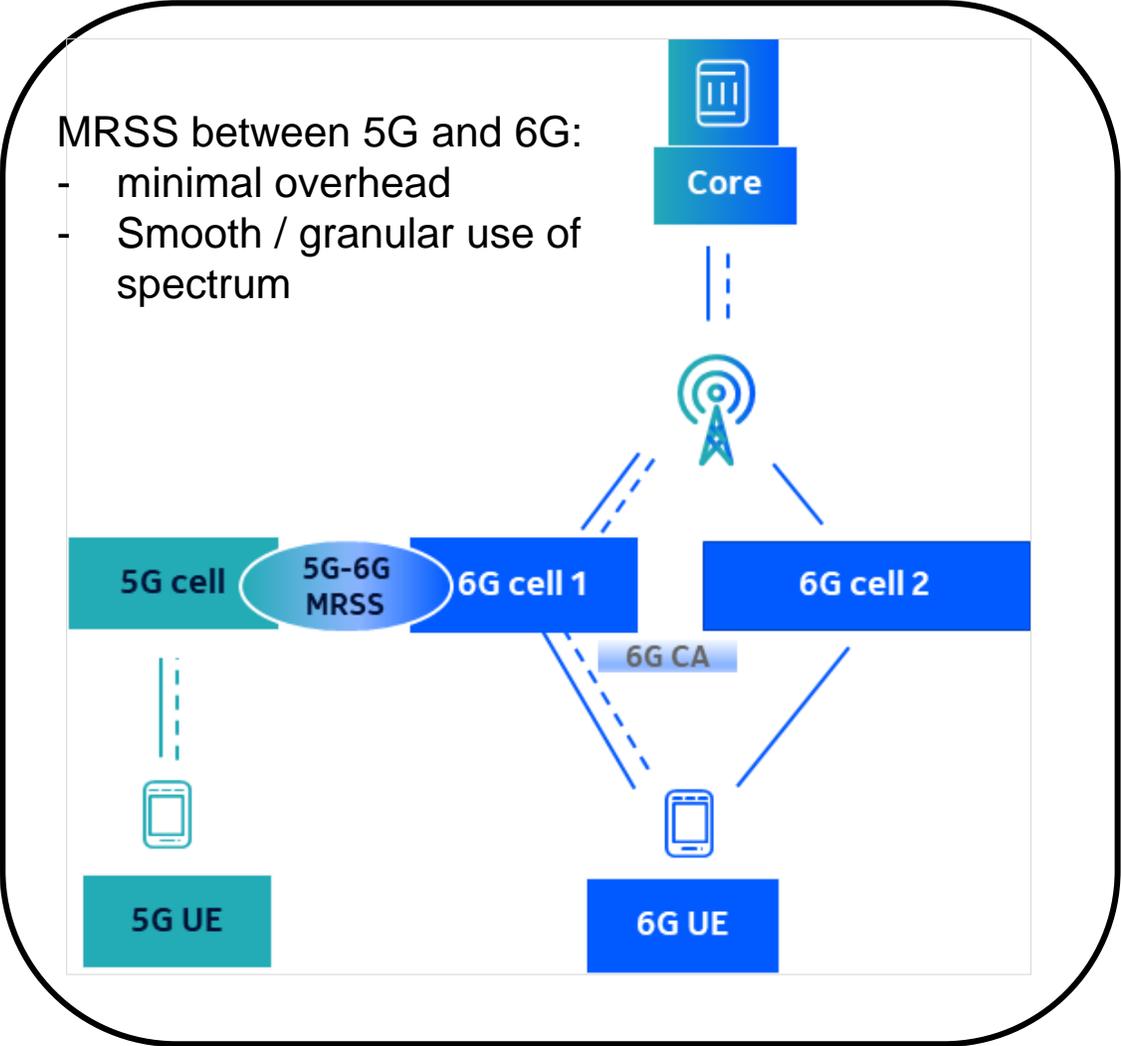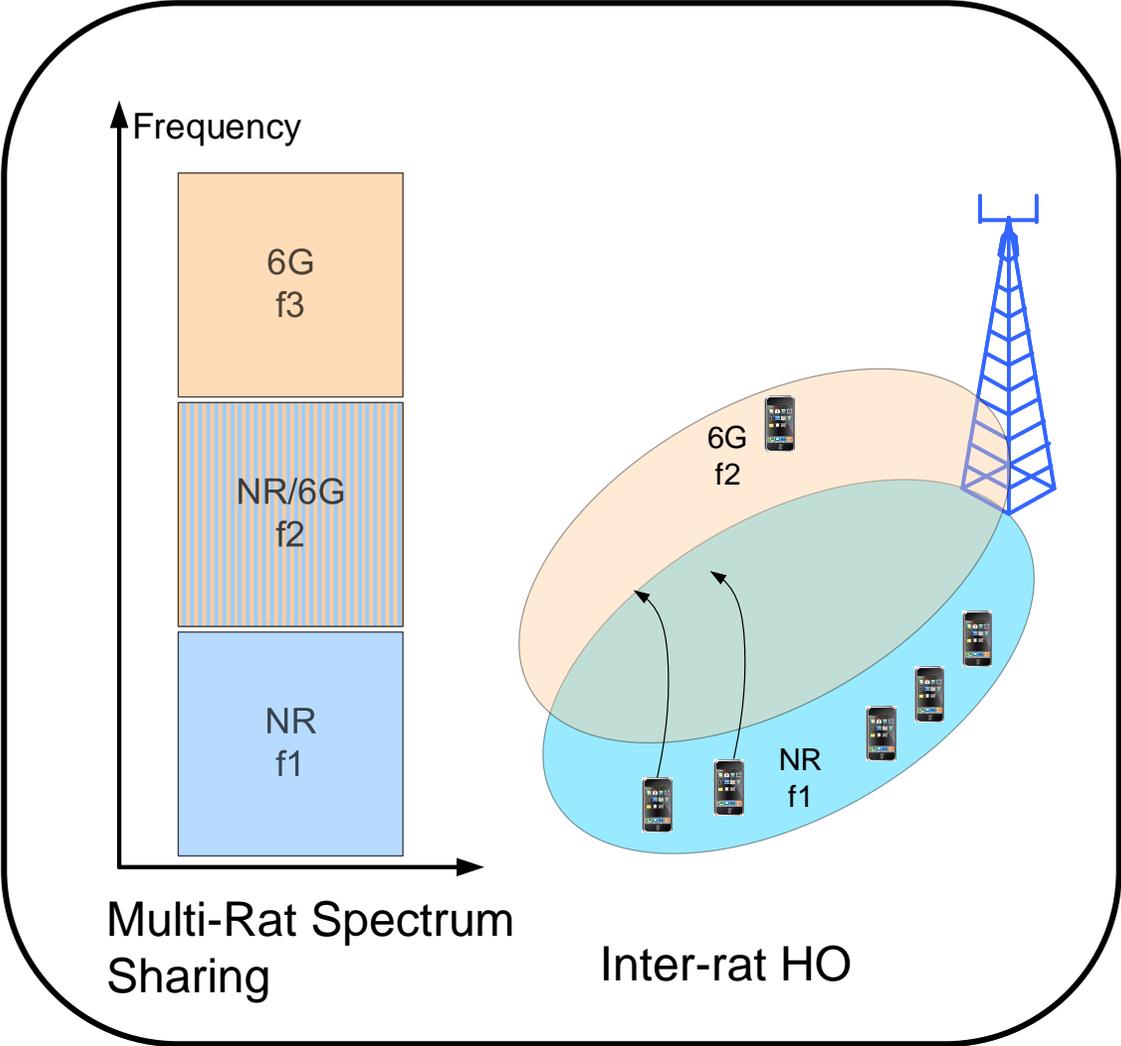
Sensing signaling

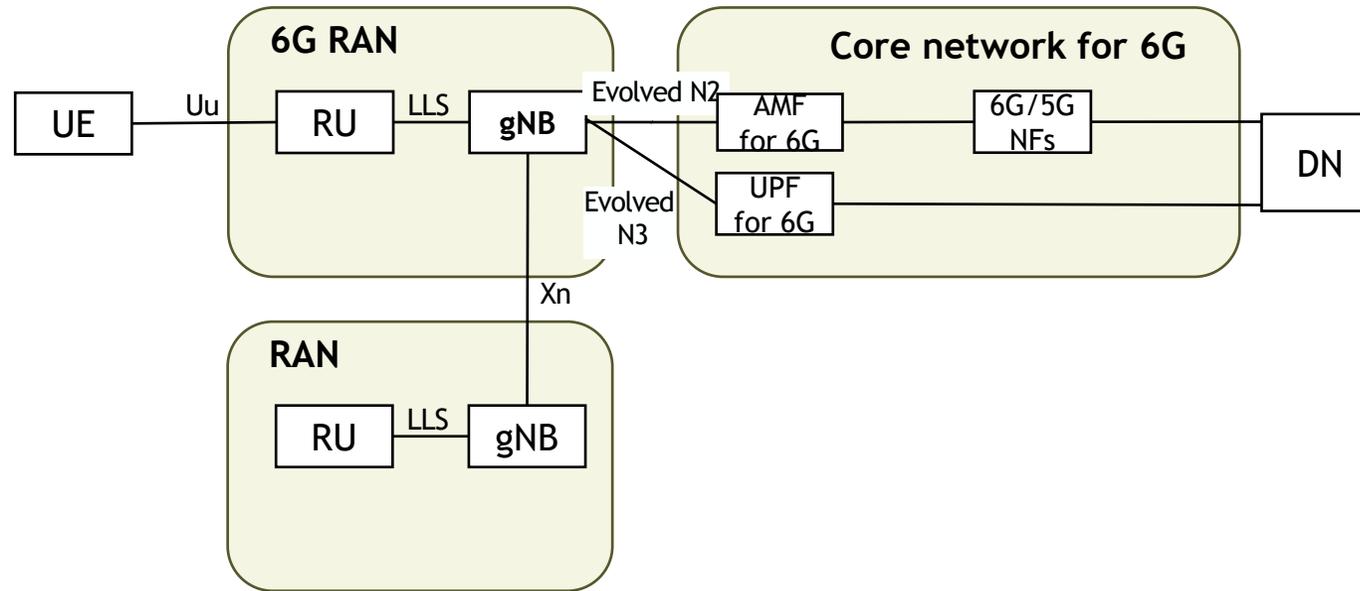## Sensing protocol overview

Network modularization

including 5G to 6G migration aspects

5G-6G interworking methods

Multi-Rat Spectrum Sharing

Inter-rat HO

6G
f3

NR/6G
f2

NR
f1

Frequency

6G
f2

NR
f1

MRSS between 5G and 6G:
- minimal overhead
- Smooth / granular use of spectrum
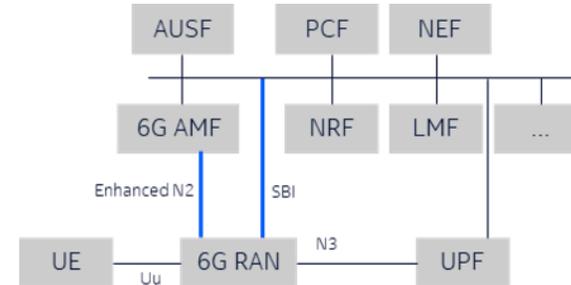
Core

5G cell

5G-6G
MRSS

6G cell 1

6G cell 2

6G CA

5G UE

6G UE

RAN and CN interfaces

6G RAN CN interface options

Option A: Enhancing NGAP

Option B: RAN-CN Control Plane SBI

Option C: RAN-CN Control Plane SBI+NGAP
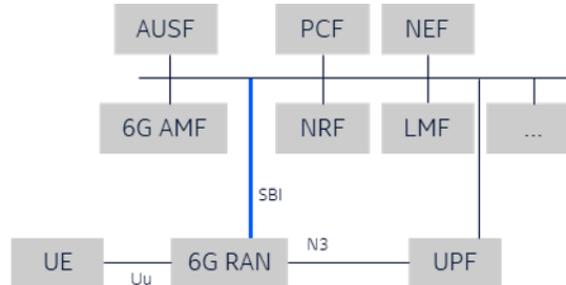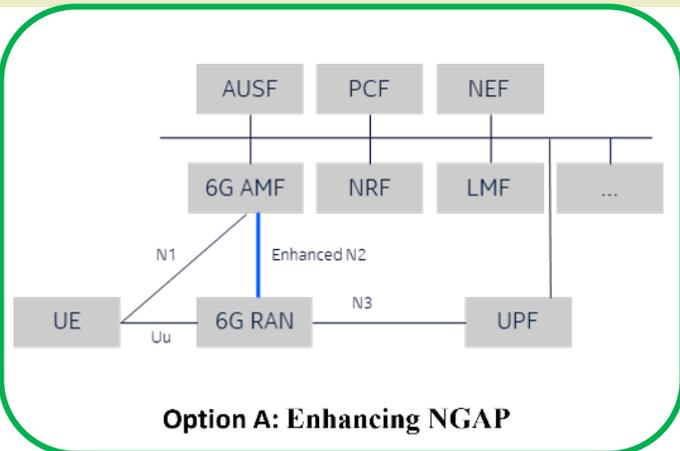
Flexible topologies

Flexible Topologies

Subnetworks configuration procedures

Legend

F-RRC	Full RRC-Reconfig ← →
L-RRC	Lean RRC-Reconfig ← - · - →

Server

BS

F-RRC

Step#1: Default Configuration Logic (Cell-Common, Subnetwork-Common, UE Specific)

Step#4: Confirm

MgtN

F-RRC
L-RRC

Step#3: Confirm

Step#2: RRC-Reconfig (Default Config)

UE1

L-RRC

Step#2: RRC-Reconfig (Default Config)

Step#3: Confirm

UE2

F-RRC
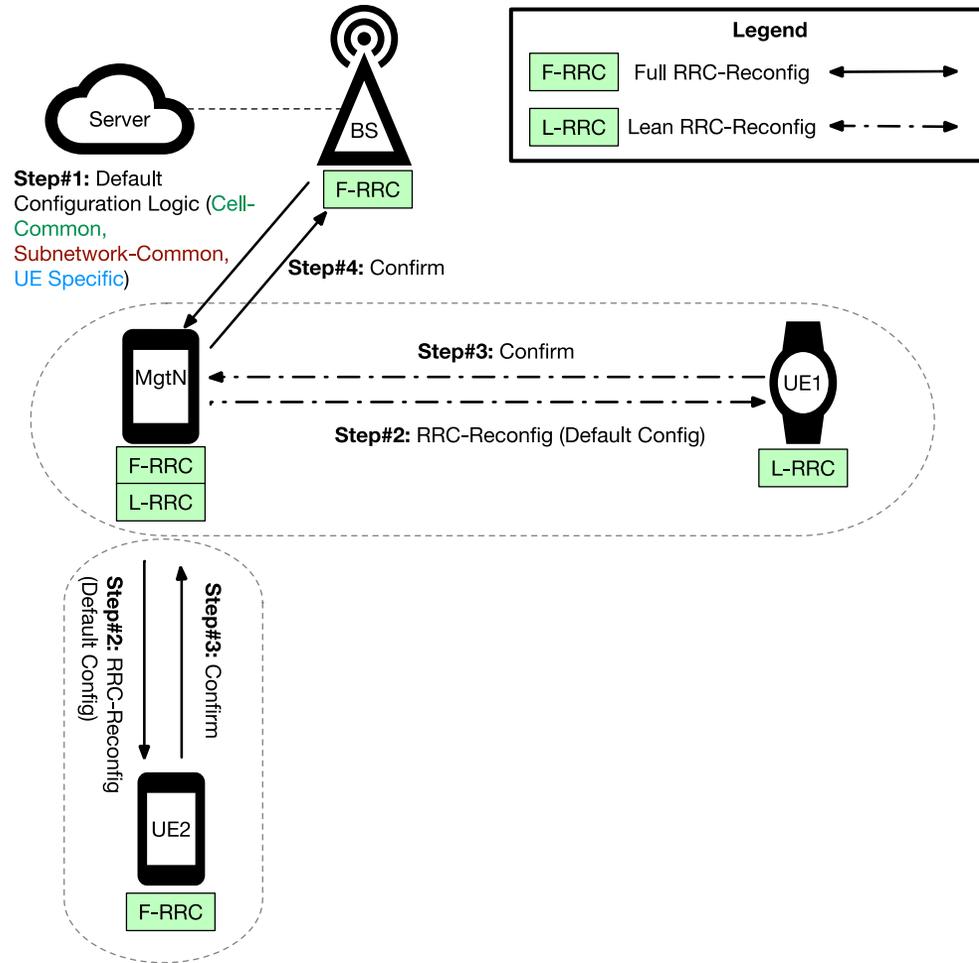
UAV assisted subnetwork
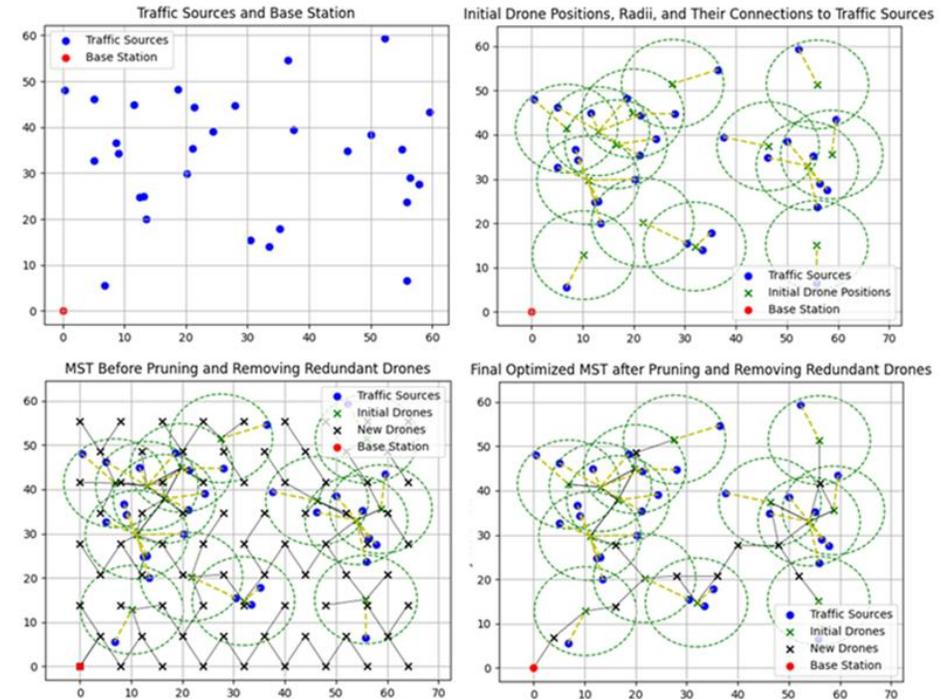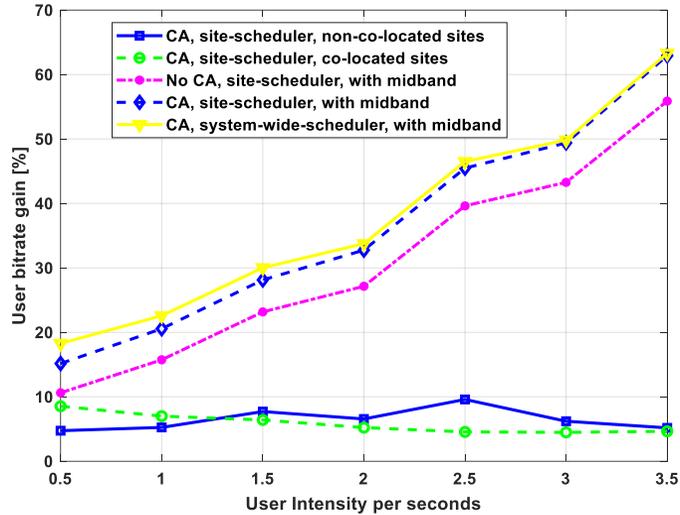

- *UAV control and management systems*
- *Integrated with existing network infrastructure*
- *Dynamic deployment and real-time optimization of UAV-assisted topologies.*
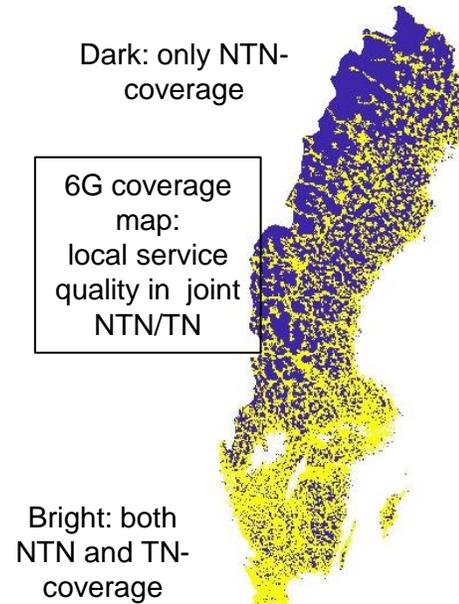
Flexible Topologies

Carrier aggregation evalutions for 6G

Legend:
- CA, site-scheduler, non-co-located sites
- CA, site-scheduler, co-located sites
- No CA, site-scheduler, with midband
- CA, site-scheduler, with midband
- CA, system-wide-scheduler, with midband

X-axis: User Intensity per seconds
Y-axis: User bitrate gain [%]

Carrier aggregation user throughput gains depends:
- *Carriers need to be similar in terms of coverage, capacity and bandwidth*
- *Traffic model e.g. size of packet to download*

NTN/TN coverage maps

Dark: only NTN-coverage

6G coverage map: local service quality in joint NTN/TN

Bright: both NTN and TN-coverage

A *new coverage inequality index* measure reflects for an NTN/TN-served large-scale region the rural-urban service fairness
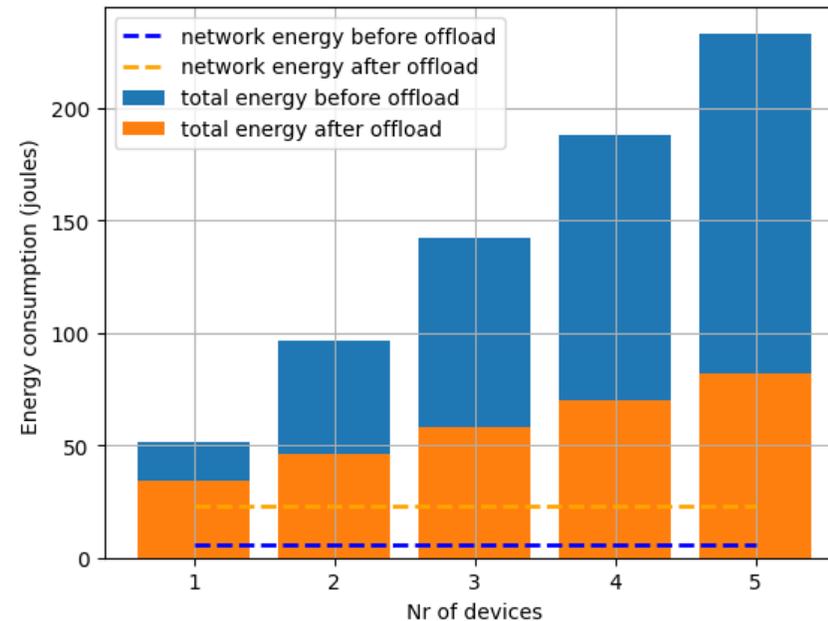
Optimal placement

- Optimal placements methods show 35% and 50% latency improvements, and 55% lower power consumption

- Split learning and model layer offloading shows up to 70% EE savings
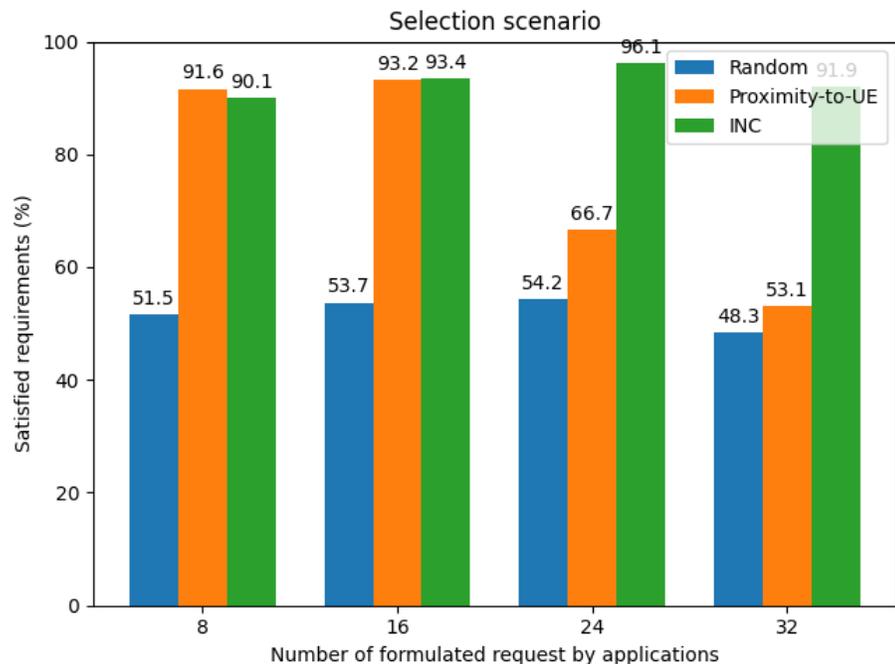
**Optimal placement
Integration of Network and Compute (INC)**

**Offloading model layers from application
to the network**

Cloud transformation

Multi-domain/multi-cloud Federation
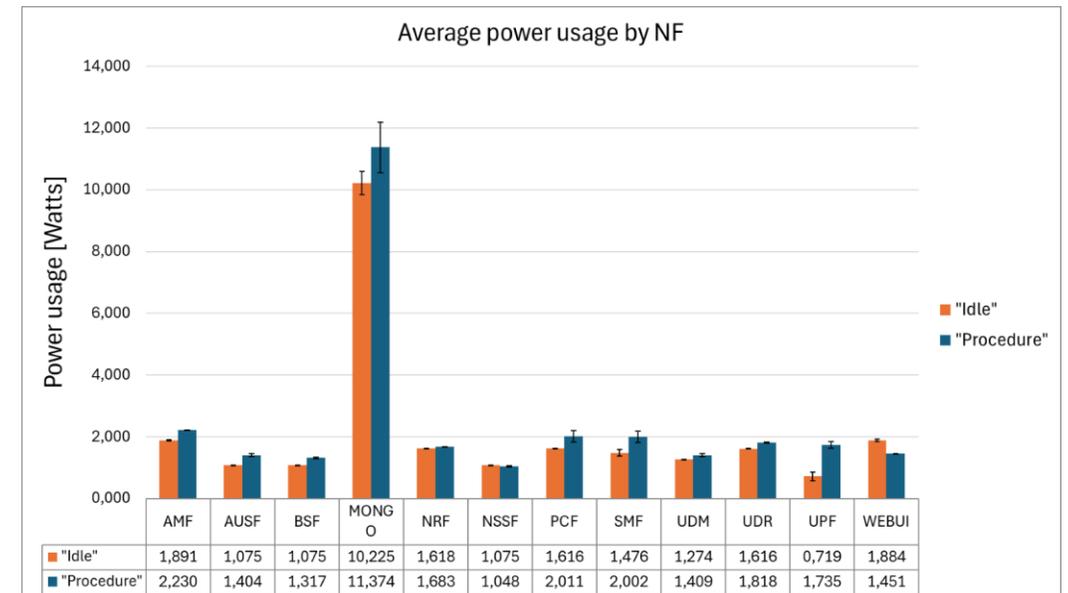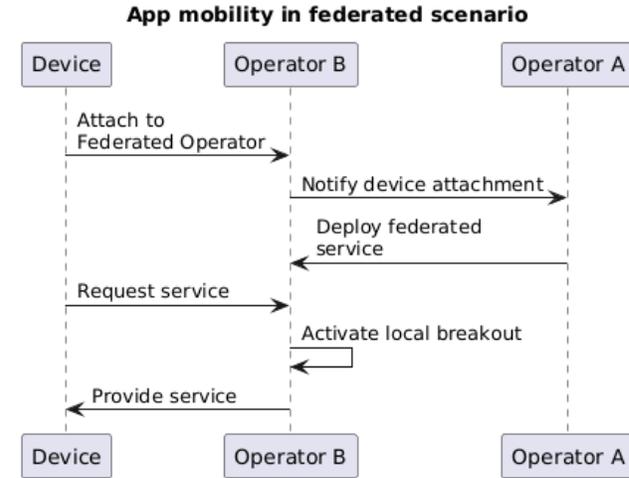
Multi-domain/multi-cloud Federation - Key take-away

Benefits and key take-away

A Multi-domain framework allows for the management of multiple cloud service providers, providing the following benefits:

- Seamless user experience in all EU territory

- Applications work as in the home country

- Access to more cloud resources

- Improved flexibility of services that can be made available

- A central management unit can deploy services using the best choice of resources available at the time

Experimental results:

- Resource (CPU, Memory) and Energy usage per network function per deployment for single infrastructure provider

App mobility in federated scenario

Average power usage by NF

	AMF	AUSF	BSF	MONGO	NRF	NSSF	PCF	SMF	UDM	UDR	UPF	WEBUI
"Idle"	1,891	1,075	1,075	10,225	1,618	1,075	1,616	1,476	1,274	1,616	0,719	1,884
"Procedure"	2,230	1,404	1,317	11,374	1,683	1,048	2,011	2,002	1,409	1,818	1,735	1,451

6G Architecture enabler summary

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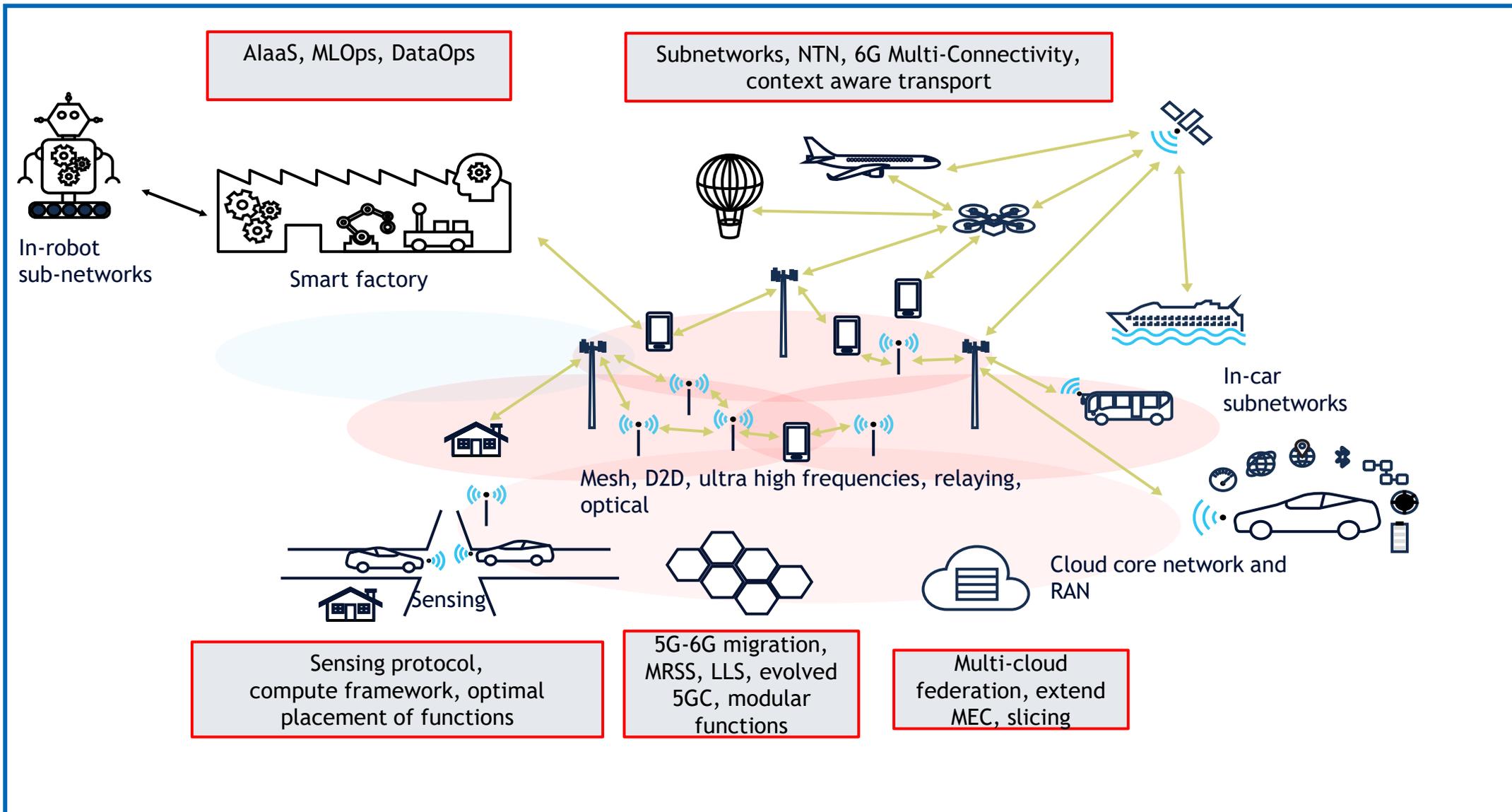
AIaaS, MLOps, DataOps

Subnetworks, NTN, 6G Multi-Connectivity, context aware transport

In-robot sub-networks

Smart factory

Mesh, D2D, ultra high frequencies, relaying, optical

In-car subnetworks

Cloud core network and RAN

Sensing

Sensing protocol, compute framework, optimal placement of functions

5G-6G migration, MRSS, LLS, evolved 5GC, modular functions

Multi-cloud federation, extend MEC, slicing

More details

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Co-funded by the European Union

6GSNS