Telcaria Presentation

WE TRANSFORM HARDWARE-BASED COMPANIES INTO SOFTWARE-BASED COMPANIES

1. Telcaria Expertise

Overview

A **Network Virtualization**

- Network Function Virtualization
- Cloud-based Network Services
- Software Defined Networking
- Protocol-less networking

B **Compute & Cloud**

- Software Architecture
- Private, public & hybrid cloud solutions
- DevOps & CI/CD

C **Wireless and 5G Networks**

- 5G networks
- Advanced MAC protocols
- Energy-efficient networks

2. Ecosystem

Edge-core certified Reseller

Member of OpenDaylight's training ecosystem – as well as former ambassador

5TONIC partnership – Partner on the open research and innovation laboratory for 5G technologies, founded by Telefónica and IMDEA Networks

4. Projects and customers

Other Customers and partners

Goals

Understand 5G and Edge Computing:

- What advantages & opportunities they offer – how they are different
- how they can add value, transform current services or create new revenue channels
- Use case examples

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Change of paradigm in 5G

5G is that it promises to **solve problems of the future**, as compared with other evolutionary technologies in telecommunication, which have all tried to solve existing problems.

5G has taken a **Service Oriented** approach -> create a Virtual Network for a specific Service to deliver the best user experience to customers.

New key concepts:

- **Configurable networks** – customize shared network to your needs (using virtual slices)
- **Edge Computing** – instantiate compute resources inside the network on demand

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Configurable Networks

- Normally networks are **designed with certain purpose** in mind - optimize for the specific requirements
  - Radio frequencies, antenna, encoding, access sharing, messages exchanged…
- Examples:
  - SigFox – radio antennas with very wide coverage, energy efficient (at a cost of lower rates) & support many devices
  - WiFi – optimized for small (normally indoor) coverage areas, optimized for throughput, no focus on reliability nor latency guarantee
- To achieve this, they make a set of fixed implementation decisions
  - Once a specific network standard has been designed it is **difficult to adapt to other requirements**…

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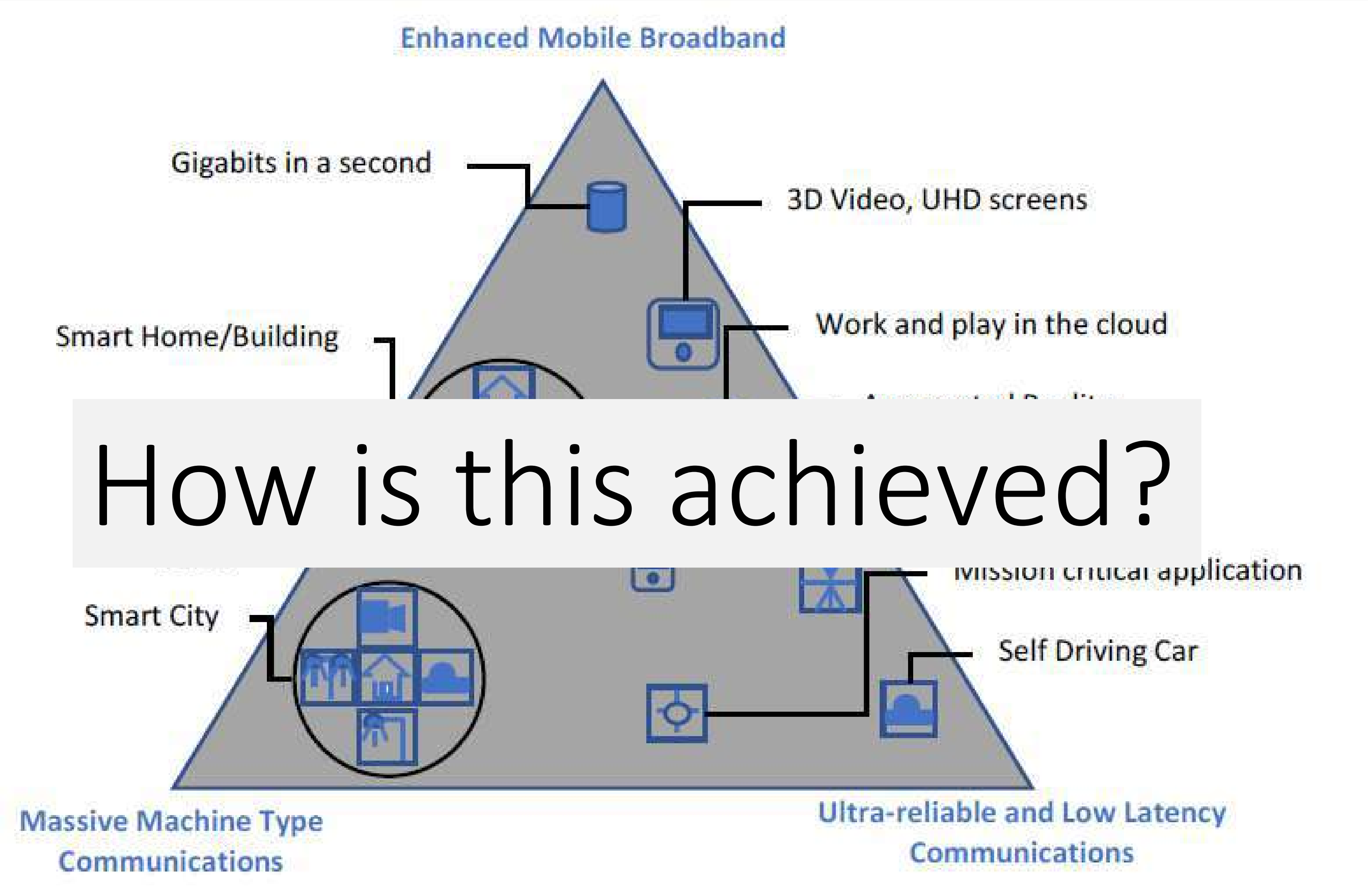
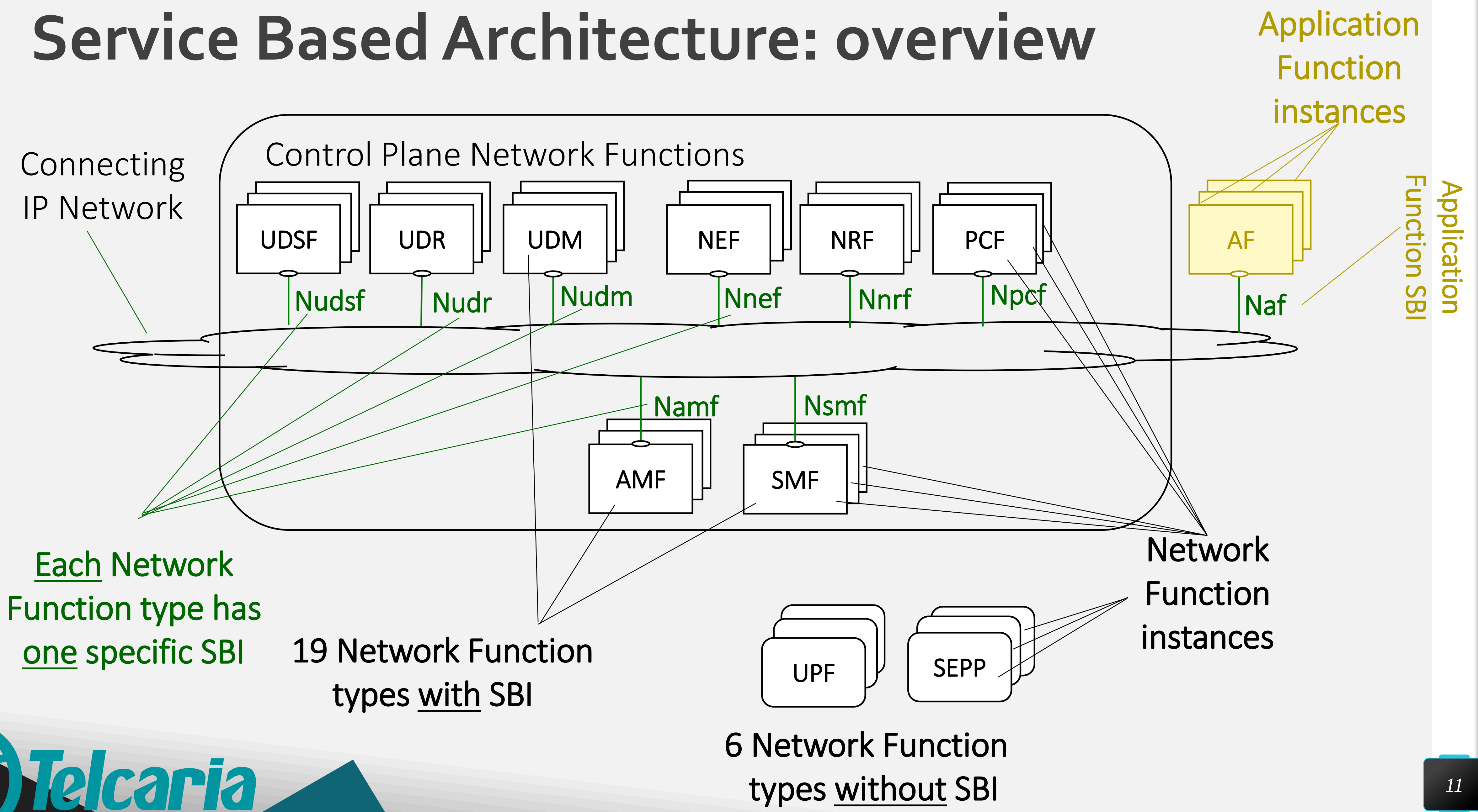
Configurable Networks – Use Cases

…But … lapt to the requi…



How is this achieved?

Service Based Architecture: overview

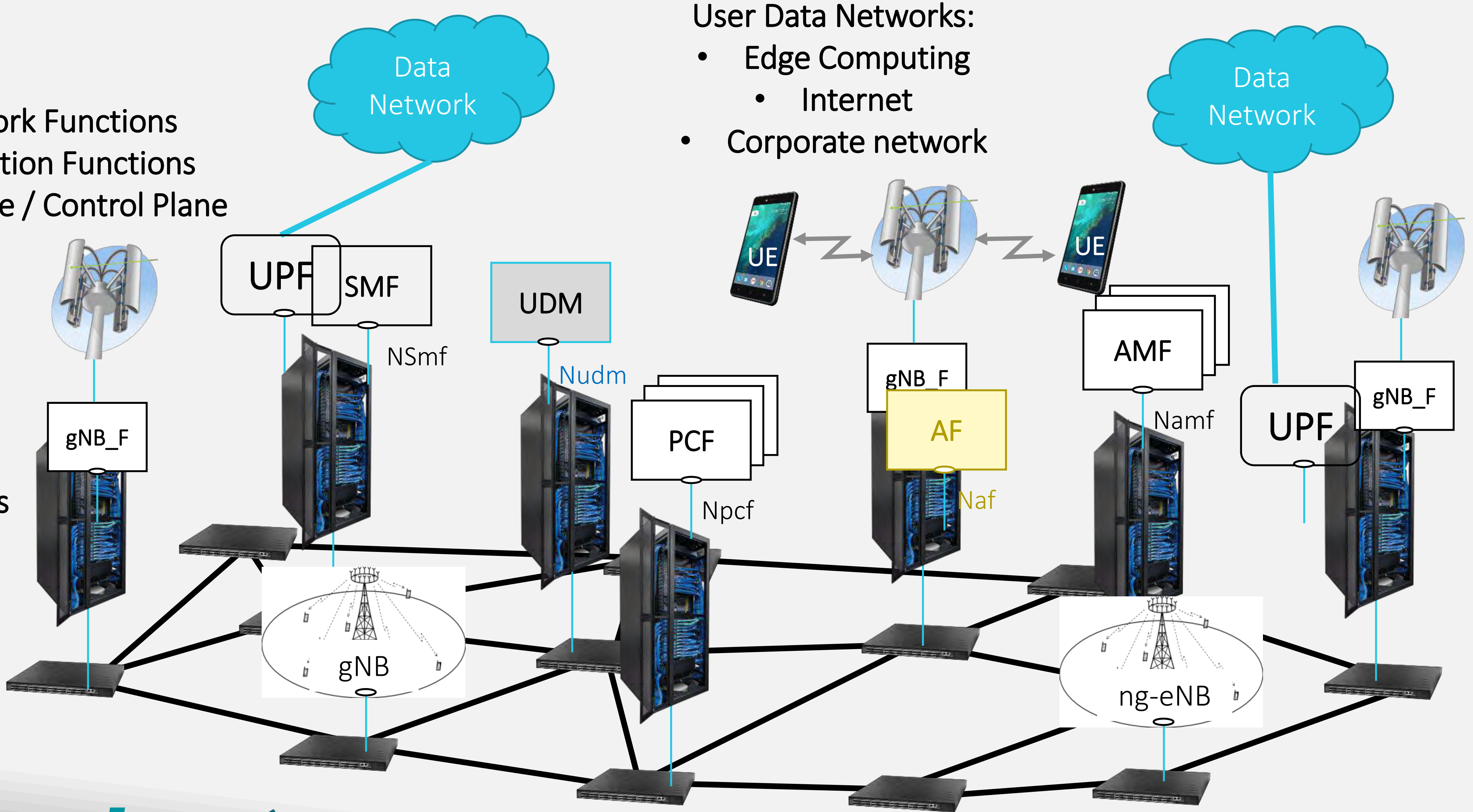


Introduction – 5G Overview

Physical or
Virtual Base
Stations

Internal
Virtual machines
and Servers

Internal
Switched
Network
IP/SDN



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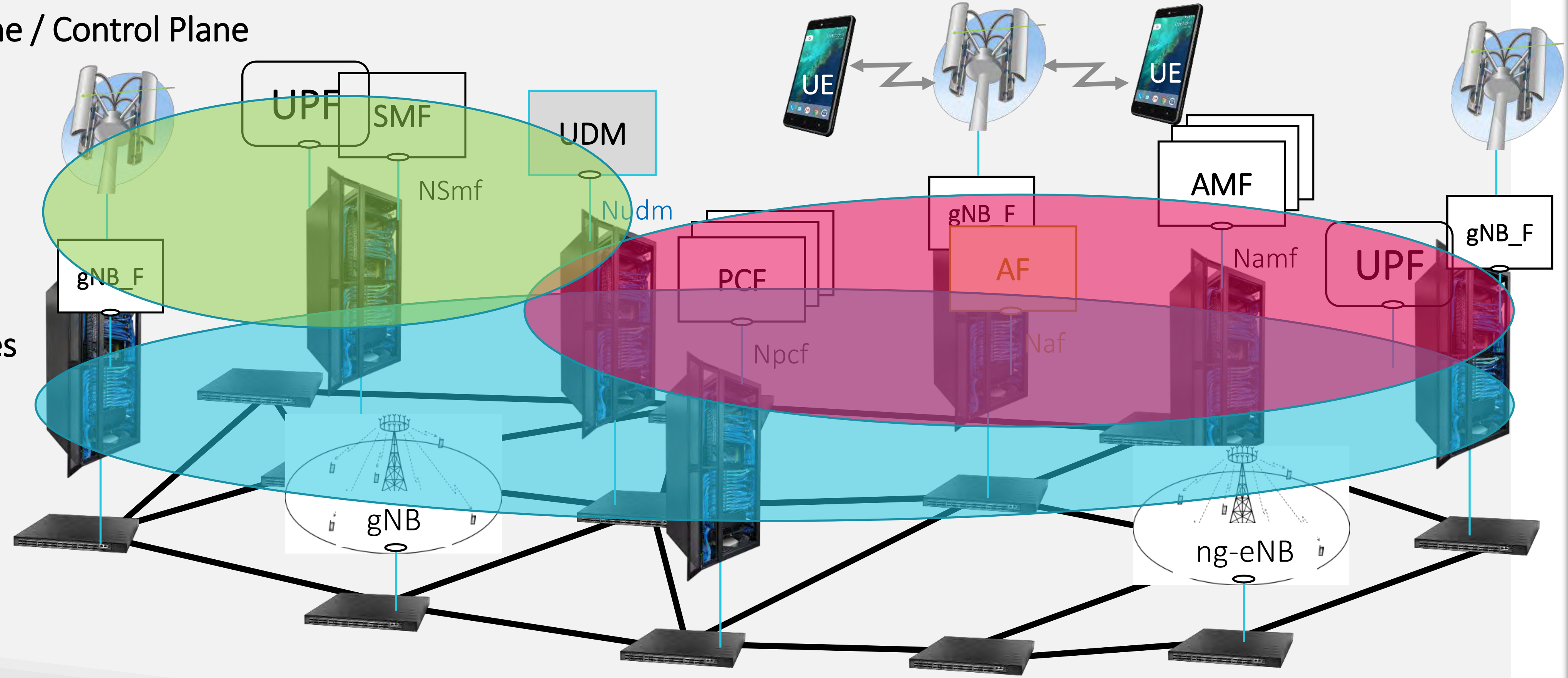
Slices: logical networks over the 5G infrastructure

Network Functions
Application Functions
User Plane / Control Plane

Physical or Virtual Base Stations

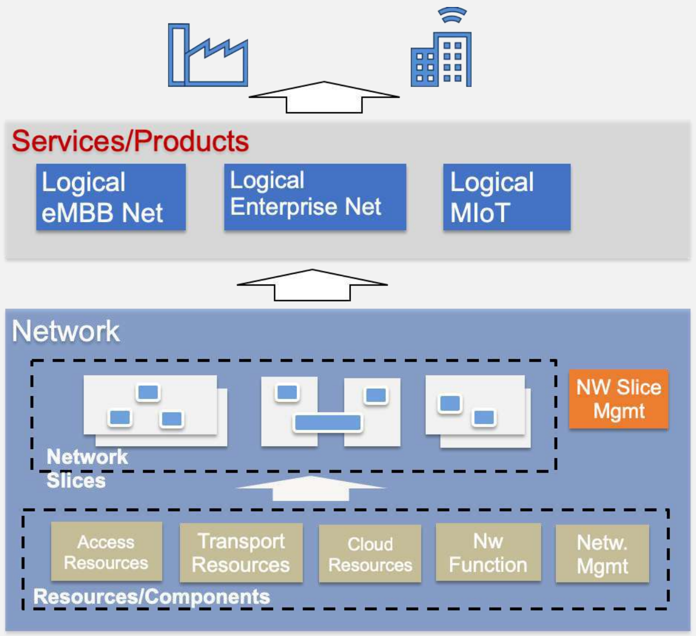
Internal
Virtual machines and Servers

Internal
Switched Network
IP/SDN



Network Slicing Concept

- A <u>Network Slice</u> is a **logical network** dedicated to a specific **business purpose**
- Each slice has its **own network and computing resources**
- Slices are **independent** and **isolated** (but may share resources)



Conclusion: the same physical network can run multiple virtual network with different business purposes each

Contents

Relevance of 5G Edge Computing

DEFINITION

The delivery of computing capabilities to the logical extremes of a network in order to improve the performance, operating cost and reliability of applications and services

Relevance of 5G Edge Computing

- Since 1850 (electrical telegraph), all network technologies have been end-to-end data transport

- Edge computing makes 5G networks ICT service factories: terminals, in addition to communicate among them, communicate with the network itself!!!

  1. Delay bounds for hard-real (impossible end-to-end): drones, cars, robots, games, cyber-physical, IoT, ...

  2. Data Volume: face recognition, ...

  3. Local Metadata: radio info, location tracing, ...

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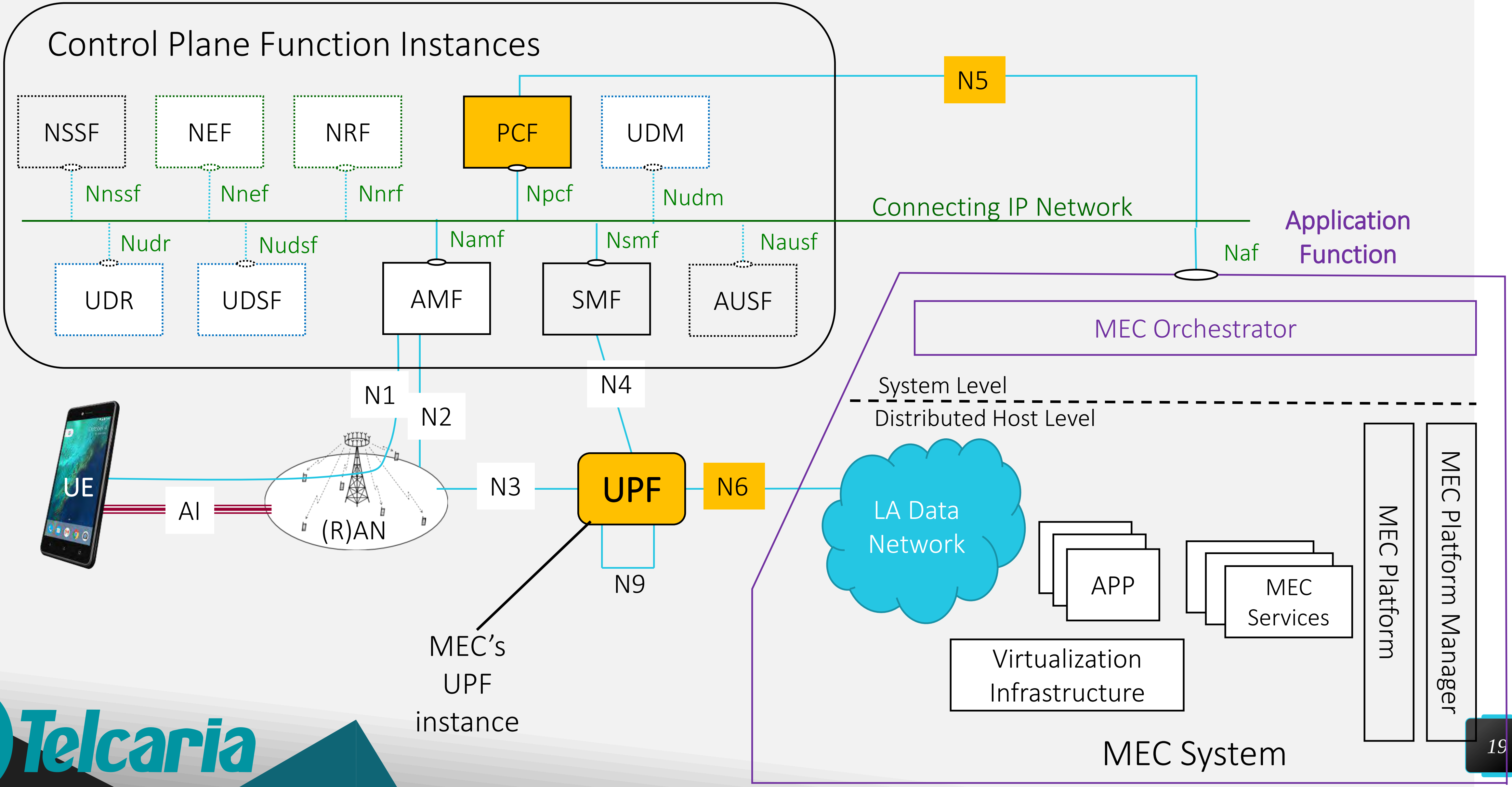
5G System Architecture and MEC



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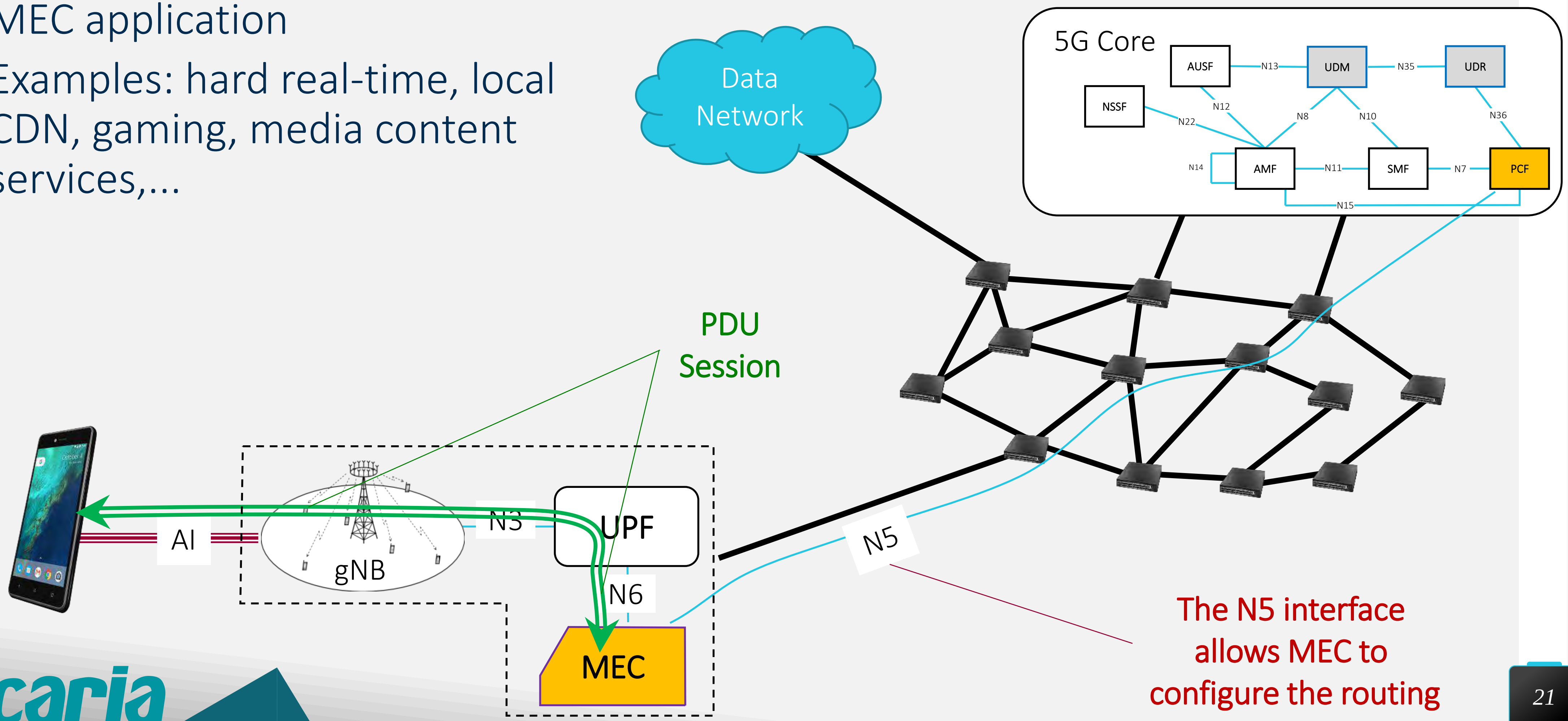
5G System Architecture and MEC

Two configuration parameters:

1. Routing: how traffic flows to the Edge
   - Breakout, in-line, tap, independent
2. Physical location: where the instance is located
   - Base Station, transmission mode, aggregation, core

MEC Routing Options for Packet Data Units (I)

- Breakout mode
  - Session is established with the MEC application
  - Examples: hard real-time, local CDN, gaming, media content services,...



The N5 interface allows MEC to configure the routing

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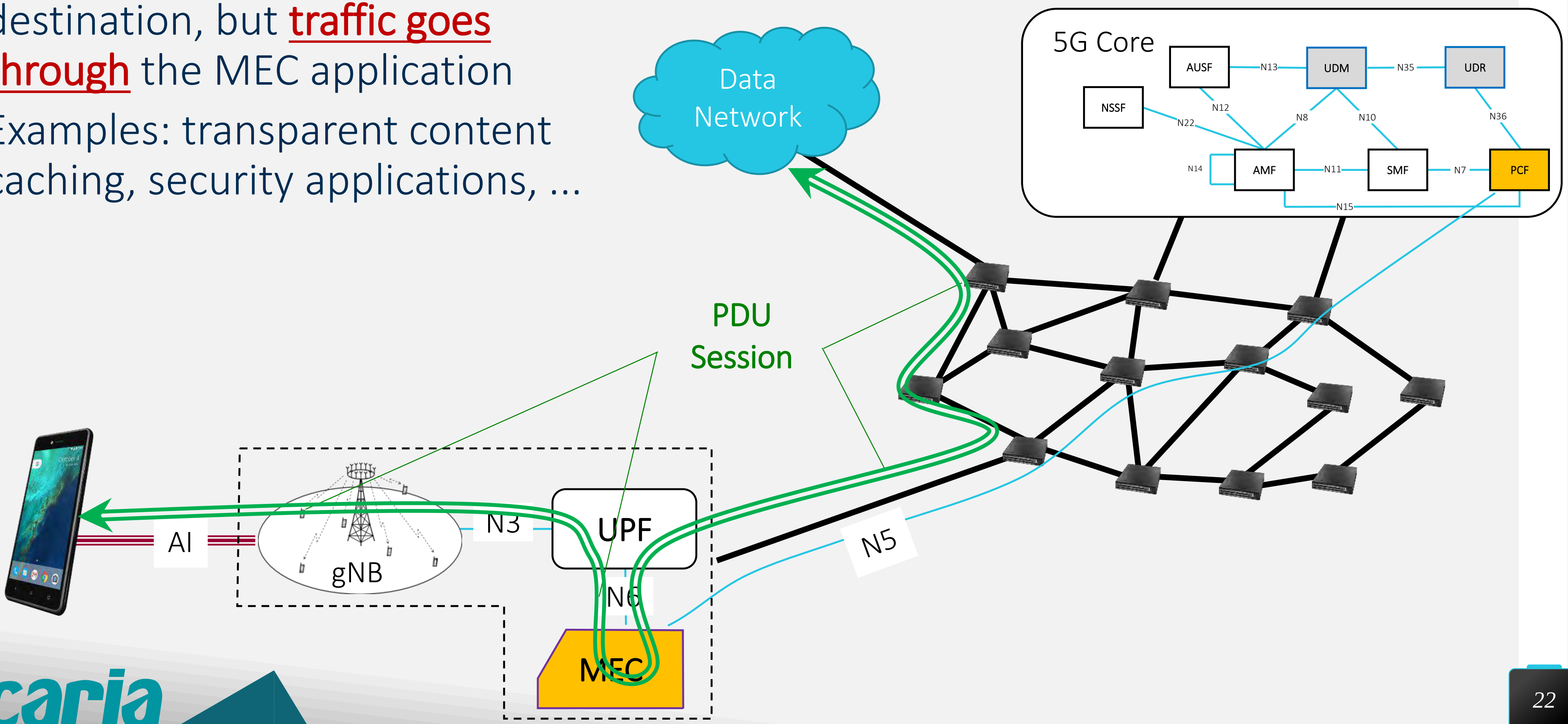
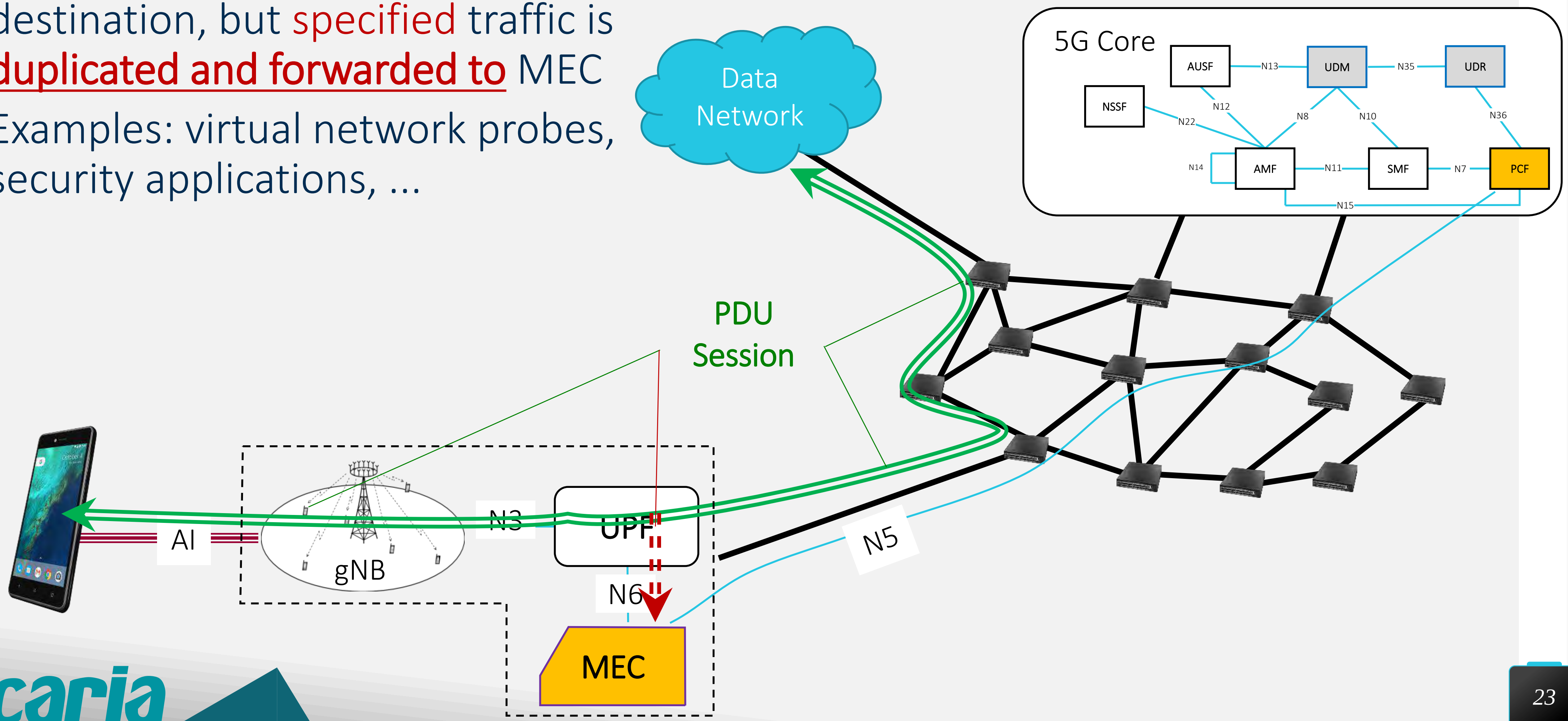
MEC Routing Options for Packet Data Units (II)

- In-line mode
  - Session is established with a destination, but traffic goes through the MEC application
  - Examples: transparent content caching, security applications, ...



MEC Routing Options for Packet Data Units (III)

- Tap mode
  - Session is established with a destination, but specified traffic is <u>duplicated and forwarded to</u> MEC
  - Examples: virtual network probes, security applications, ...



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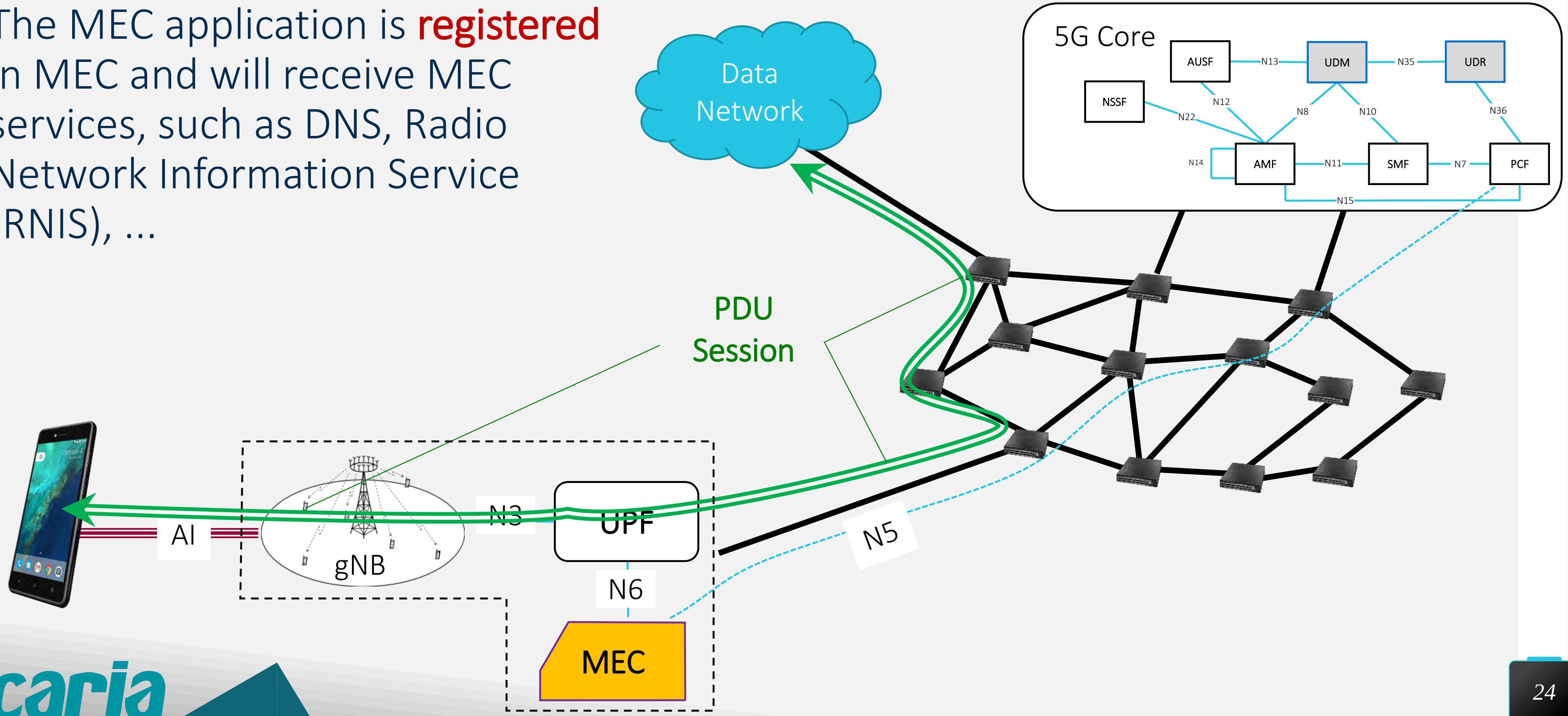
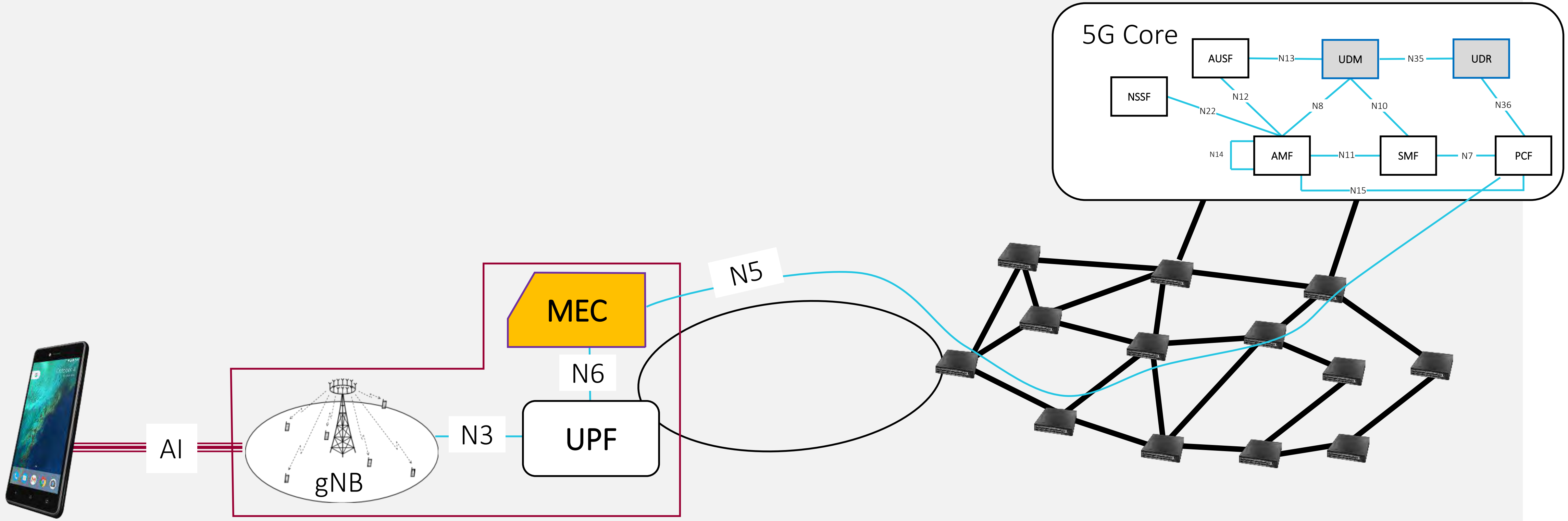
MEC Routing Options for Packet Data Units (IV)

- Independent mode
  - No traffic rerouting,
  - The MEC application is **registered** in MEC and will receive MEC services, such as DNS, Radio Network Information Service (RNIS), ...



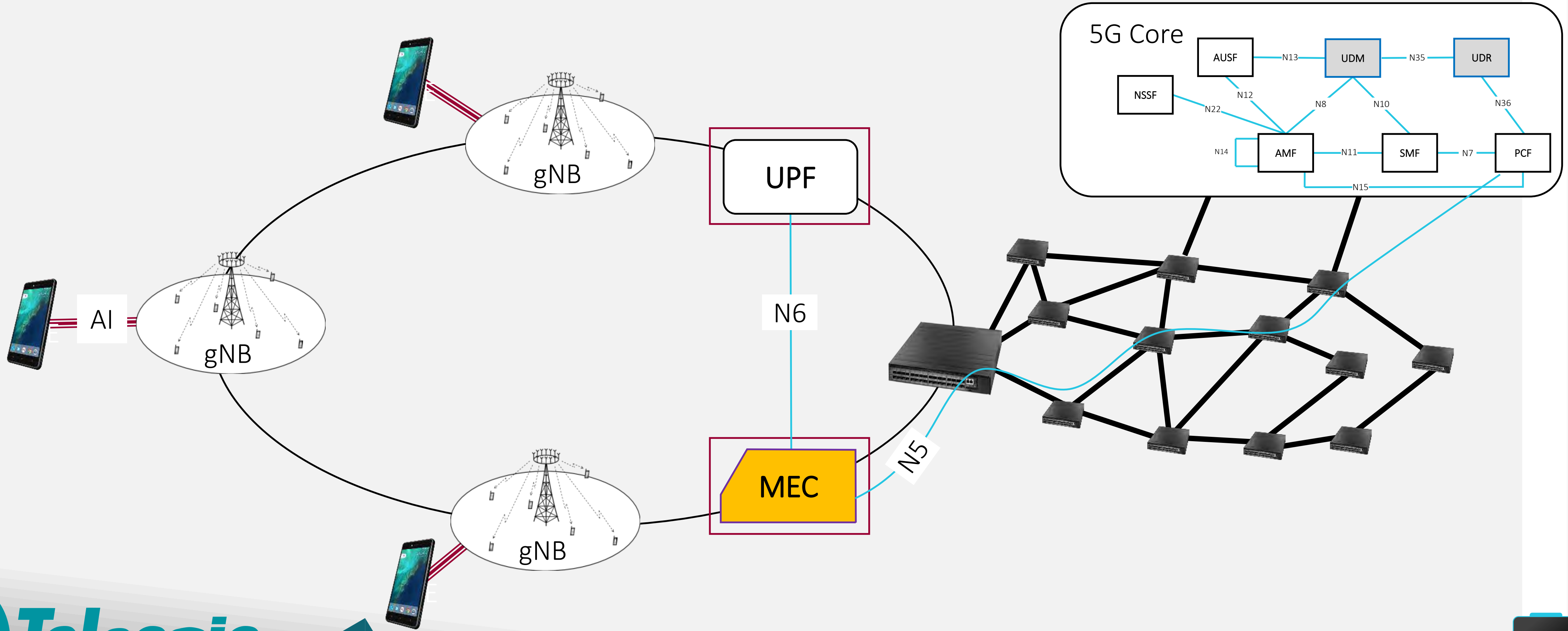
MEC Physical Deployment Options (I)

- MEC and local UPF at the Base Station



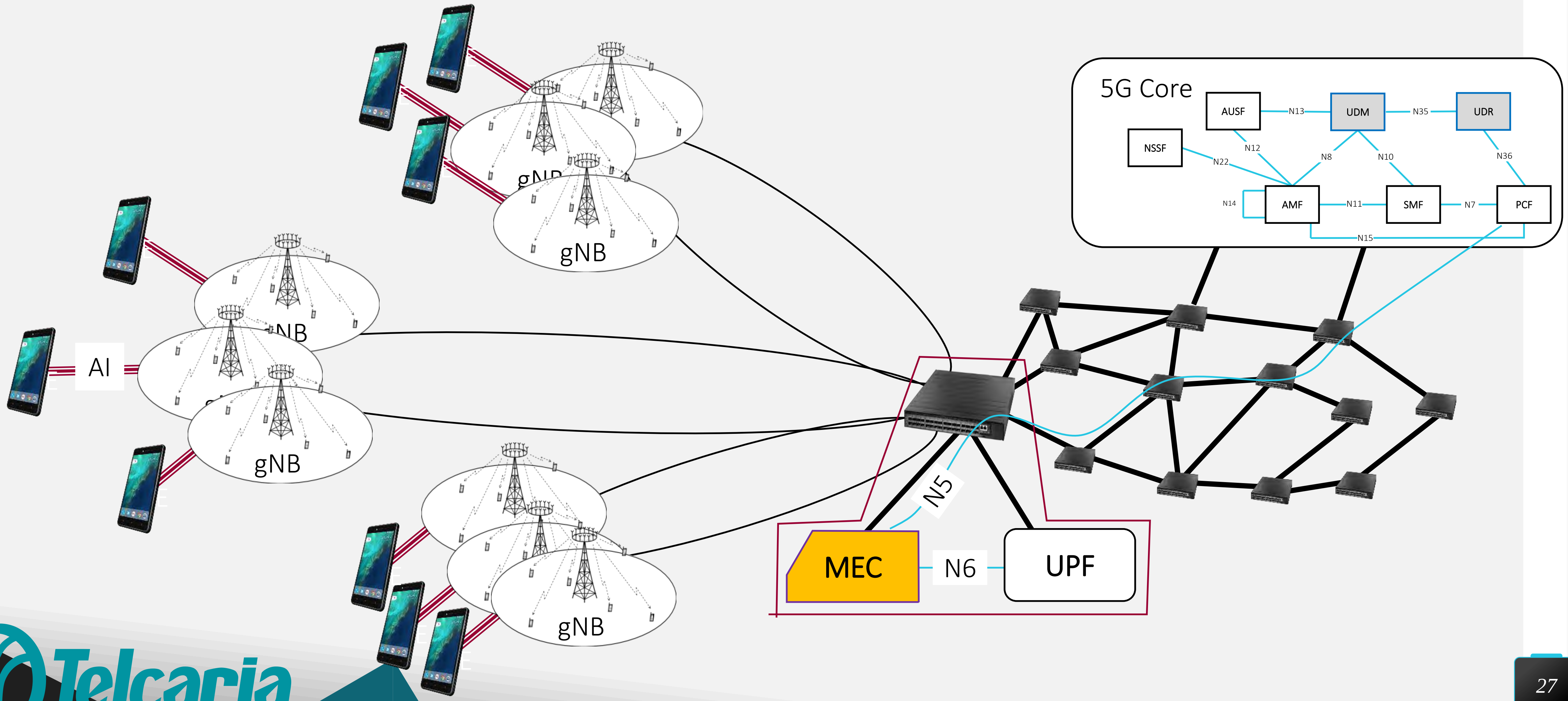
MEC Physical Deployment Options (II)

- MEC at a transmission node (usually with a local UPF)



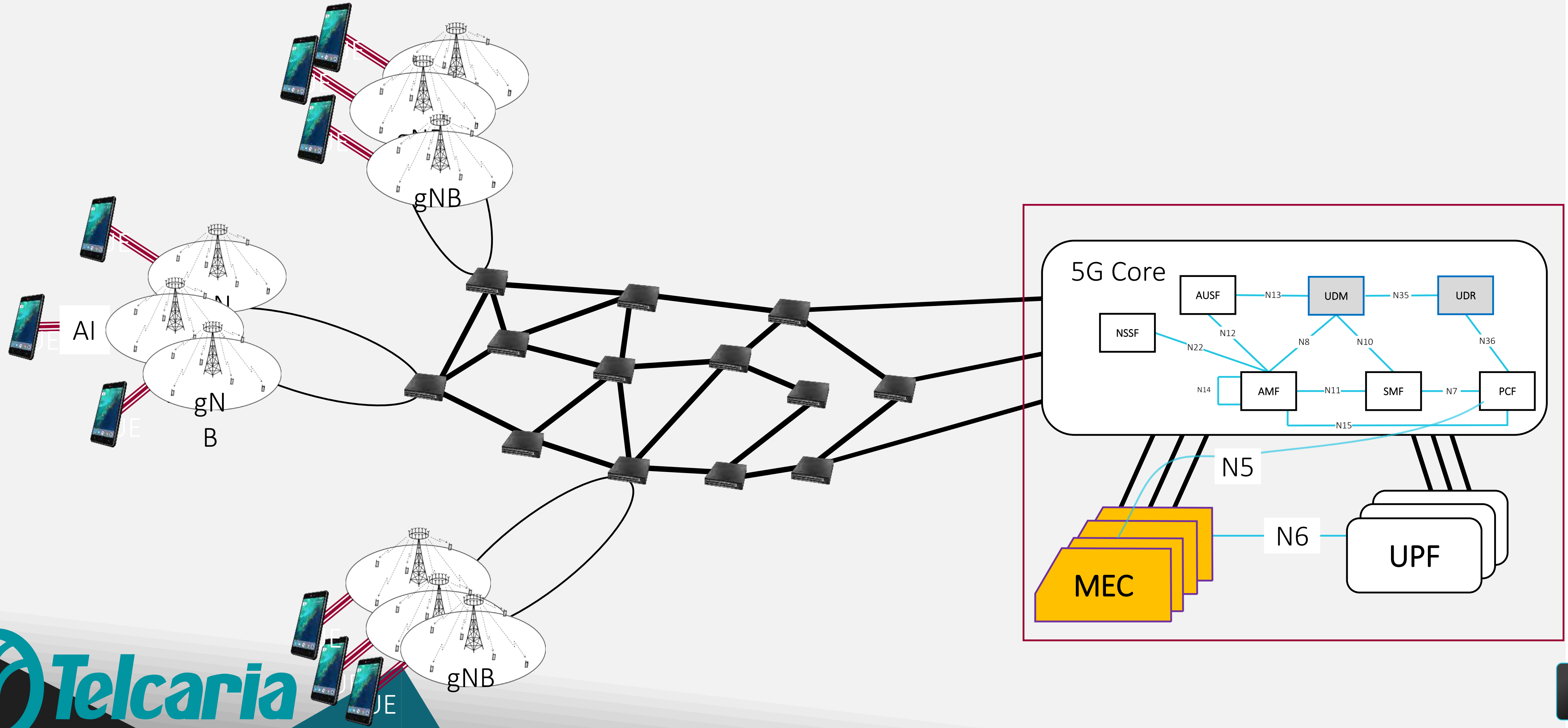
MEC Physical Deployment Options (III)

- MEC and local UPF at a network aggregation point



MEC Physical Deployment Options (IV)

- MEC at Core Network data center



Contents

Comparison

- Comparison of current technologies & architectures vs MEC
- 4+1 comparisons:
  - 1) 5G vs other provider access technologies – no MEC*
  - 2) Cloud vs Edge
  - 3) Local vs Edge
  - 4) Self-managed Edge vs 5G Edge

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1) 5G vs other provider access technologies

sigfox

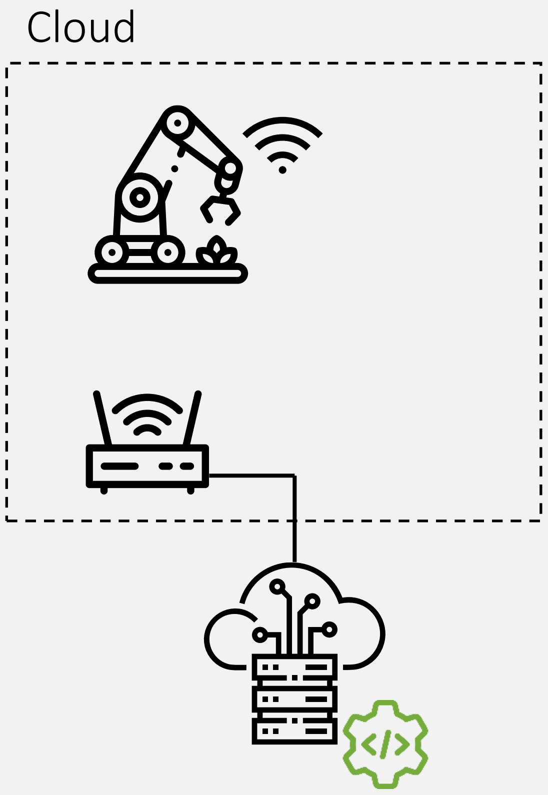
- Different use-case
- Use small messages (12 bytes uplink and 8 bytes downlink) with up to 140 messages per day
- Best option for small data volume IoT (low power + cheap + good coverage)

LoRa™

- Unlicensed narrowband technology (increased range)
- Highly power-efficient
- 5G -> bandwidth-intensive IoT deployments
- LoRa -> agriculture, oil and gas, utilities and transportation industries.

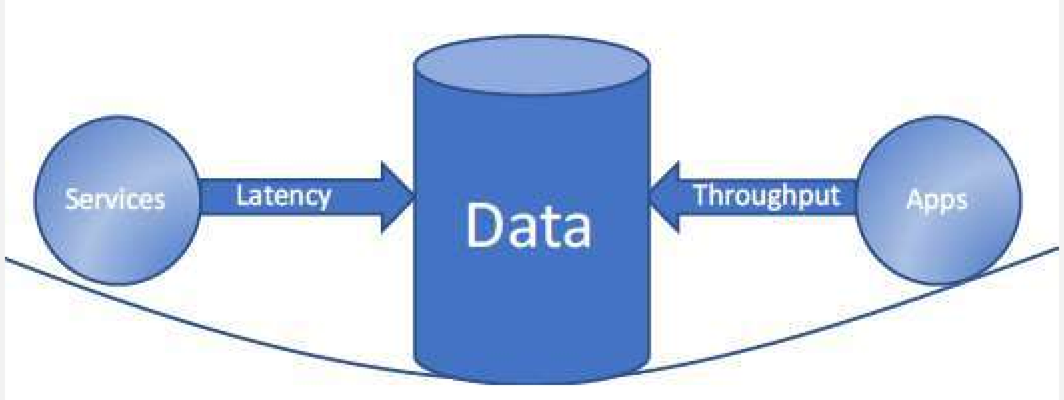
2) Cloud vs Edge

- Delay bounds for hard-real (impossible end-to-end): drones, cars, robots, games, cyber-physical, IoT, ...
- QoS (jitter)
- Data Volume: face recognition, ...
- Data security – data & software stay local



2) Cloud vs Edge – Data Gravity

- The more the data set grows, the more difficult is to move the data



- The idea is that **data and applications are attracted** to each other
  - similar to the attraction between objects in the Law of Gravity
- Apps and data are far away
  - Links get congested, impossible to guarantee QoS or thoughput

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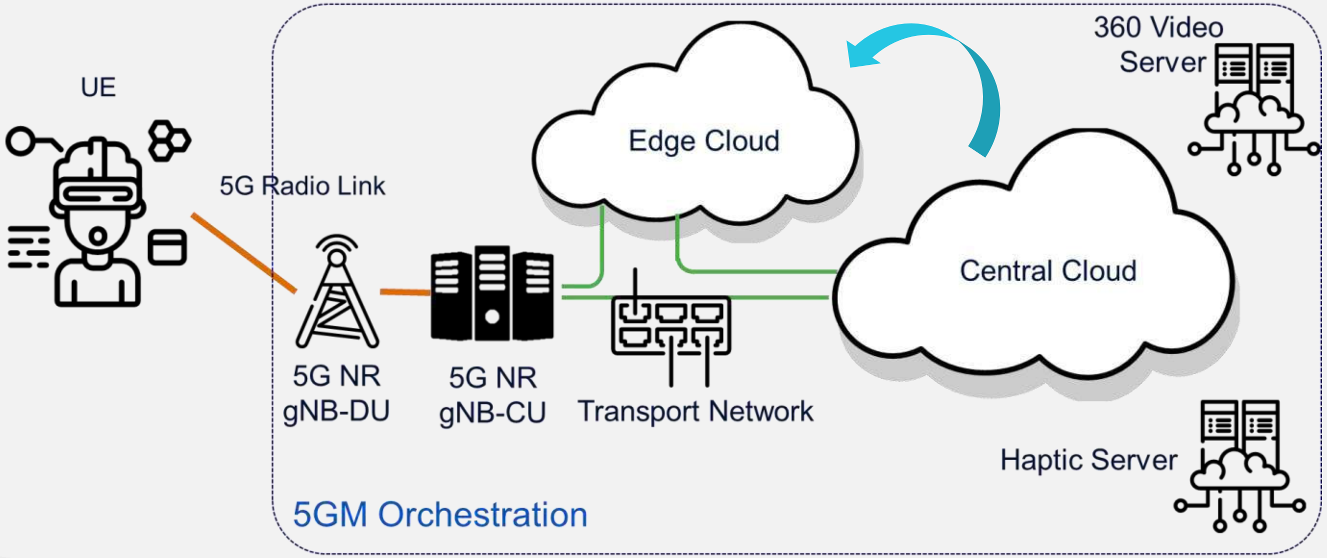
2) Cloud vs Edge – Example I

VR – from cloud to Edge

- VR set connected to 5G
- User interaction sent to instance in the cloud
  - Processing of image updates and user interaction in the cloud



2) Cloud vs Edge – Example I

VR – from cloud to Edge

- Some operation need very fast updates
- Upon detection of increased latency, system migrates processing instance from the cloud to the edge
  - Learning algorithms to optimize resource utilization and monetization

2) Cloud vs Edge – Example I

VR – additional use cases

- Use RAN analytics to estimate the throughput likely to be available at the radio downlink for the user
  - Use packet headers to convey this information to the video server to adapt its stream accordingly
  - Faster alternative to TCP

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2) Cloud vs Edge – Example II

Phase 1 – Cloud

- Robots are remote-controlled and all the operations logic are instructed via the network*
  - The robots are only acting as **sensors and actuators**
  - The robots receive commands from the **brain** which resides in the cloud
- Compute facilities are located far away from the robots
  - Hard to enforce SLAs (even with multiple providers)
  - High latency
- **Limited functionality**:
  - No coordination
  - Collision avoidance

2) Cloud vs Edge – Example II

Phase 2 – Moving to the Edge

- Compute facilities are moved to the Edge – the **brain is now close**
- Better latency and QoS
  - Improved coordination due to low latency and access to context information available in the Edge
- More advanced functionalities
  - Cooperative delivery of large items with fog-assisted robots
  - Latency-sensitive task

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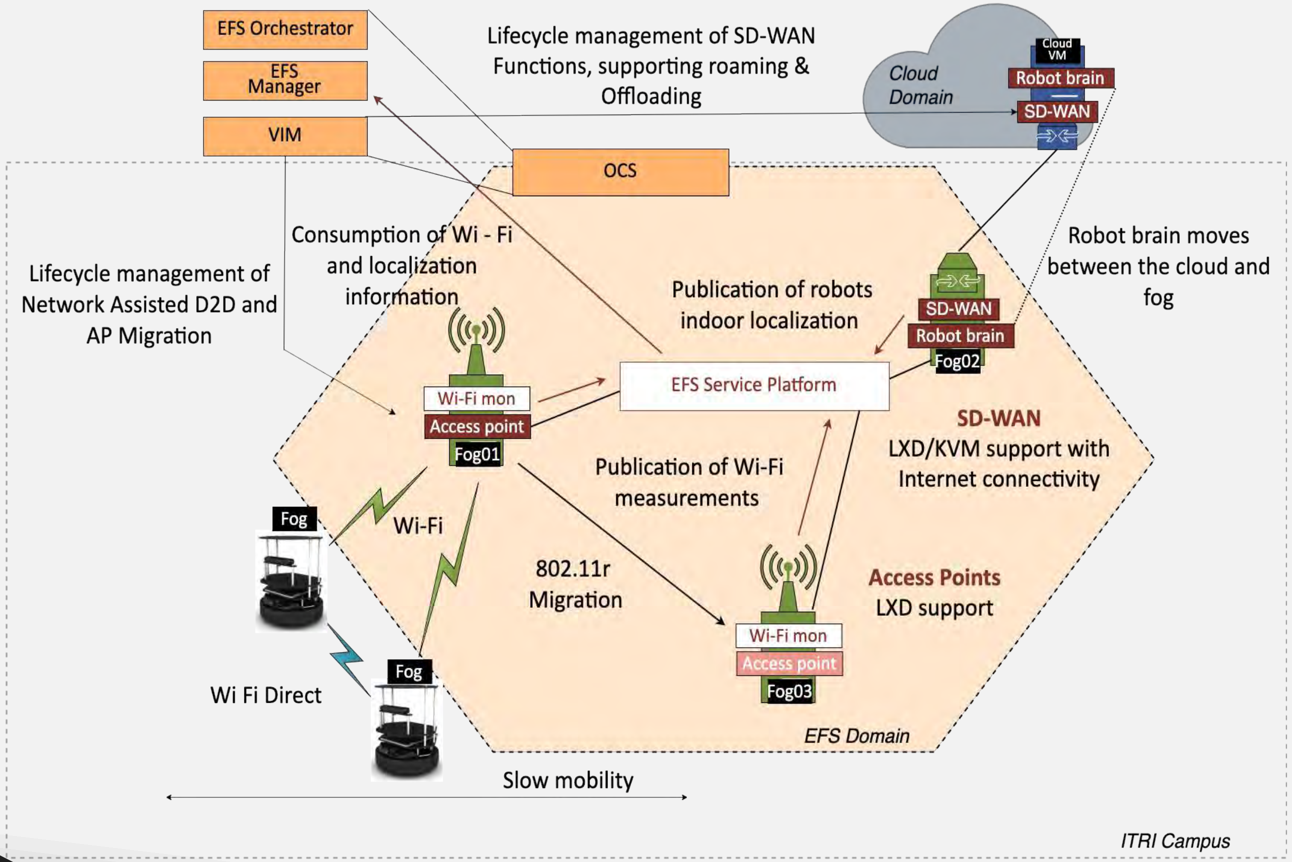
2) Cloud vs Edge – Example II

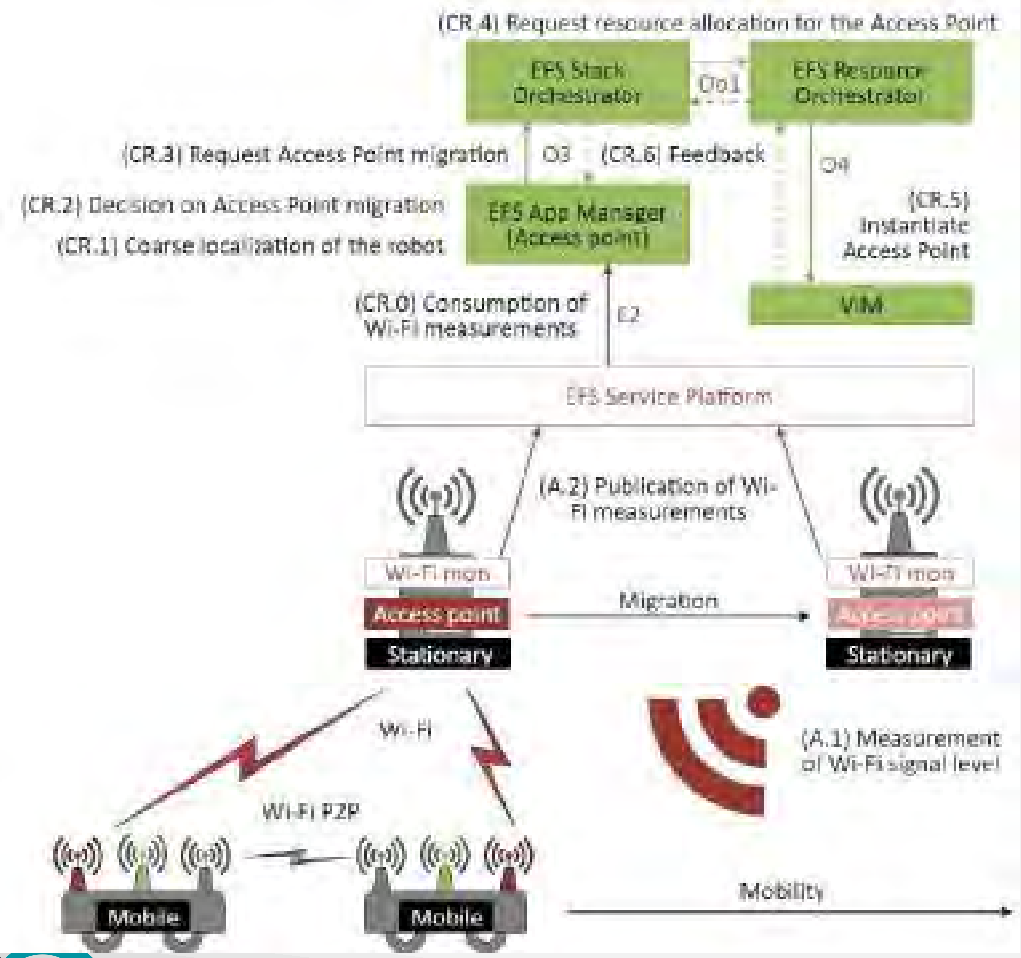
Technologies



- **Kobuki** - low-cost robotics mobile base platform
- Robot Operating System (**ROS**) as software framework for robotics software development
- **fogØ5** as a framework to provision virtual machines, containers, and native applications
  - Robotics applications are provided in form of **LXD** containers, **KVM** VMs, and **ROS** apps
- **SD-WAN** as cloud-to-things continuum provider and offloading assistant.
- Live monitoring of the signal level of the robots via a **Wi-Fi Network Information Service** (WNIS)
- Robots estimated 2D position via a **Localization Service**.

2) Cloud vs Edge – Example II

Edge mobility

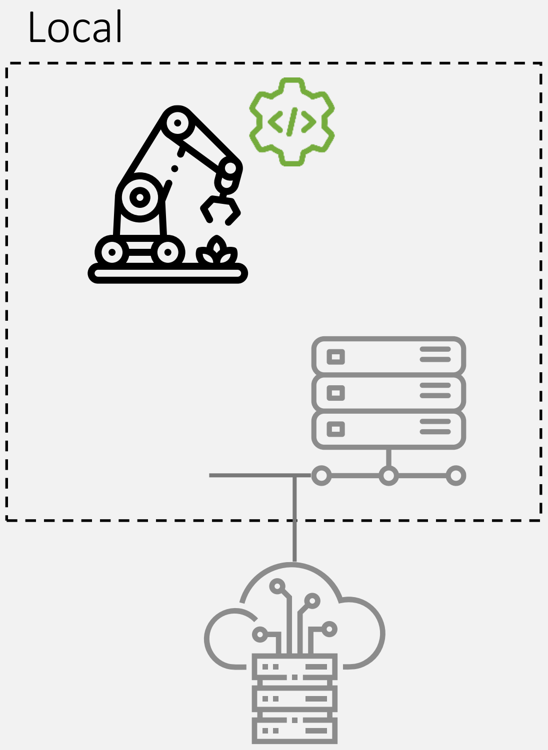


- **Live migration** of the virtual access point functions based on the coarse localization and the Wi-Fi signal strength
- Follow the robots path and provide the required coverage.

Phase III - Network-assisted D2D communication between the robots in order to improve the robot coordination and movement precision

3) Local vs Edge

- Cost savings – resource pooling
- Easier and faster adaptation to changes (no resource limitations)
- Stronger management (software upgrades)
- Simplification of architecture



2) Local vs Edge – Example I

Digital Twin for robot manipulator

Digital Twin (architectural shift)

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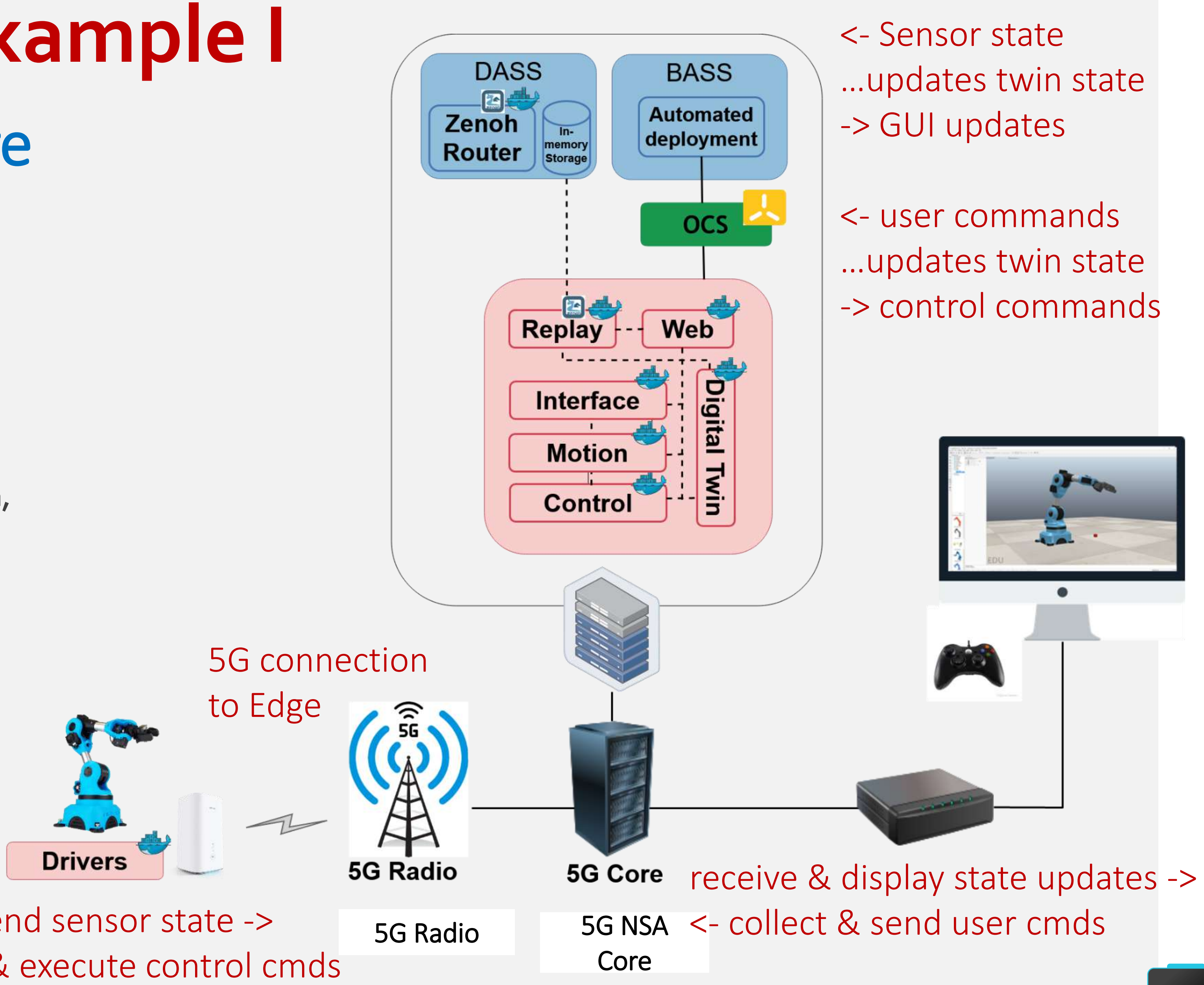
2) Local vs Edge – Example I

Technology and architecture

- **Connectivity:**
  - 5G CPE Pro Baloong 500
  - 5G NSA (BB630 baseband and Advance Antenna System AIR 6488)
- **Edge resources:**
  - **Modules at the robot:** Drivers
  - **Modules at the Edge:** Control, Motion, Interface, Digital Twin, Replay and Web
- **Robotic system:** Niryo One
- **Digital Twin:** CoppeliaSim
- **Controller:** XBOX controller, Web application
- **BASS:** Java Spring
- **DASS:** Zenoh



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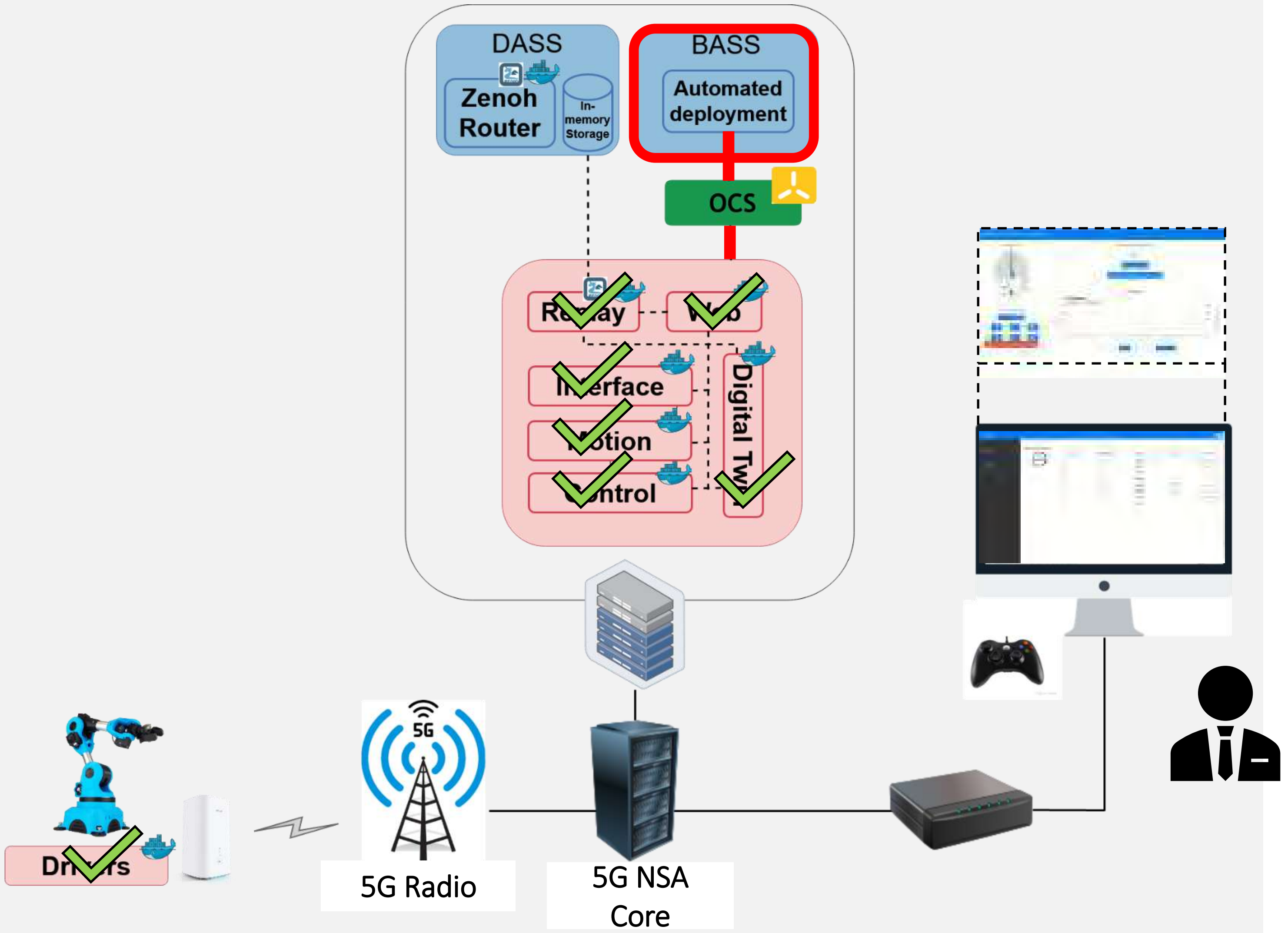
Demonstration description

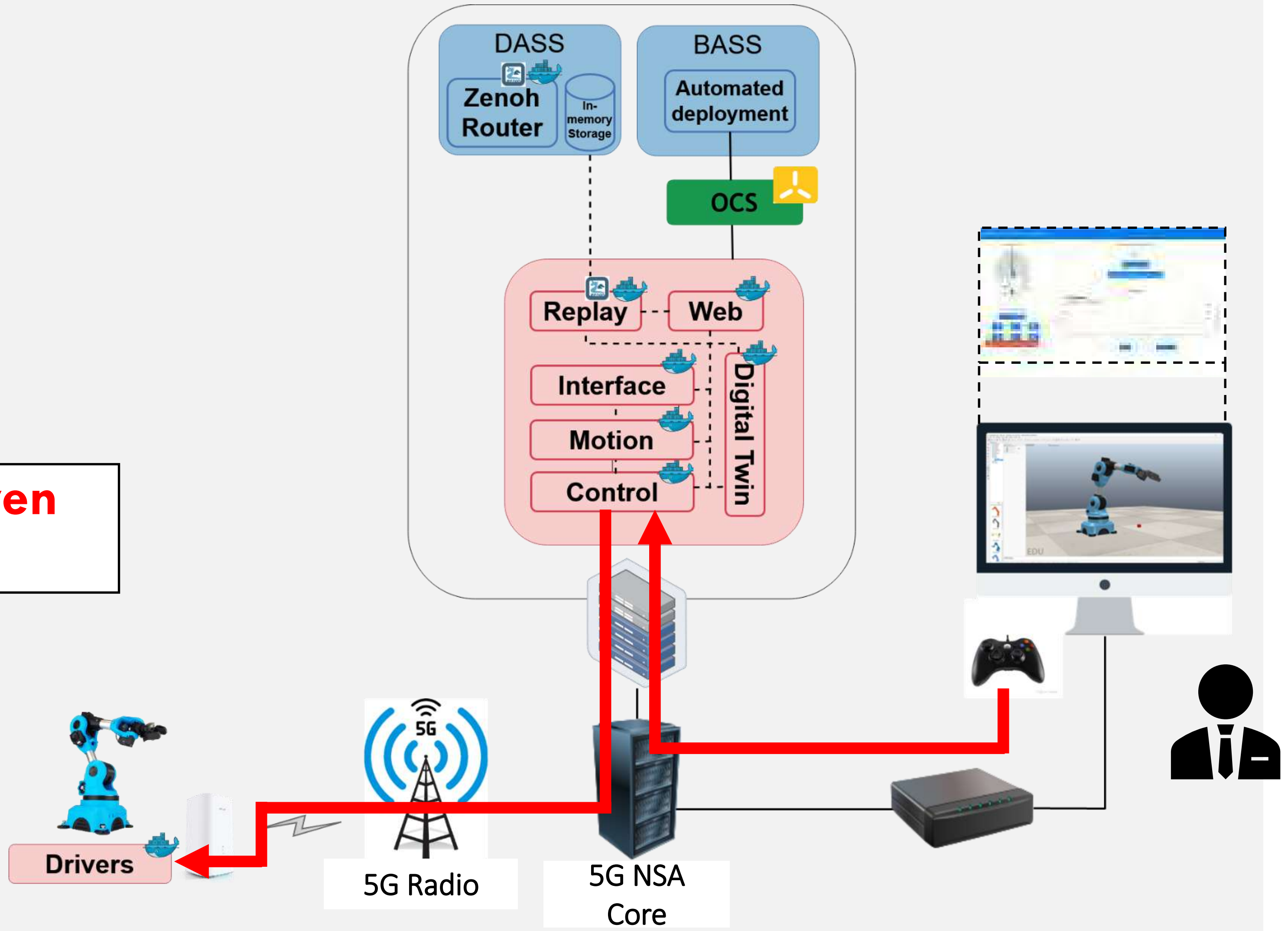
1. BASS Automated deployment



Demonstration description

1. BASS Automated deployment
2. Remote control in Digital Twin applications over 5G

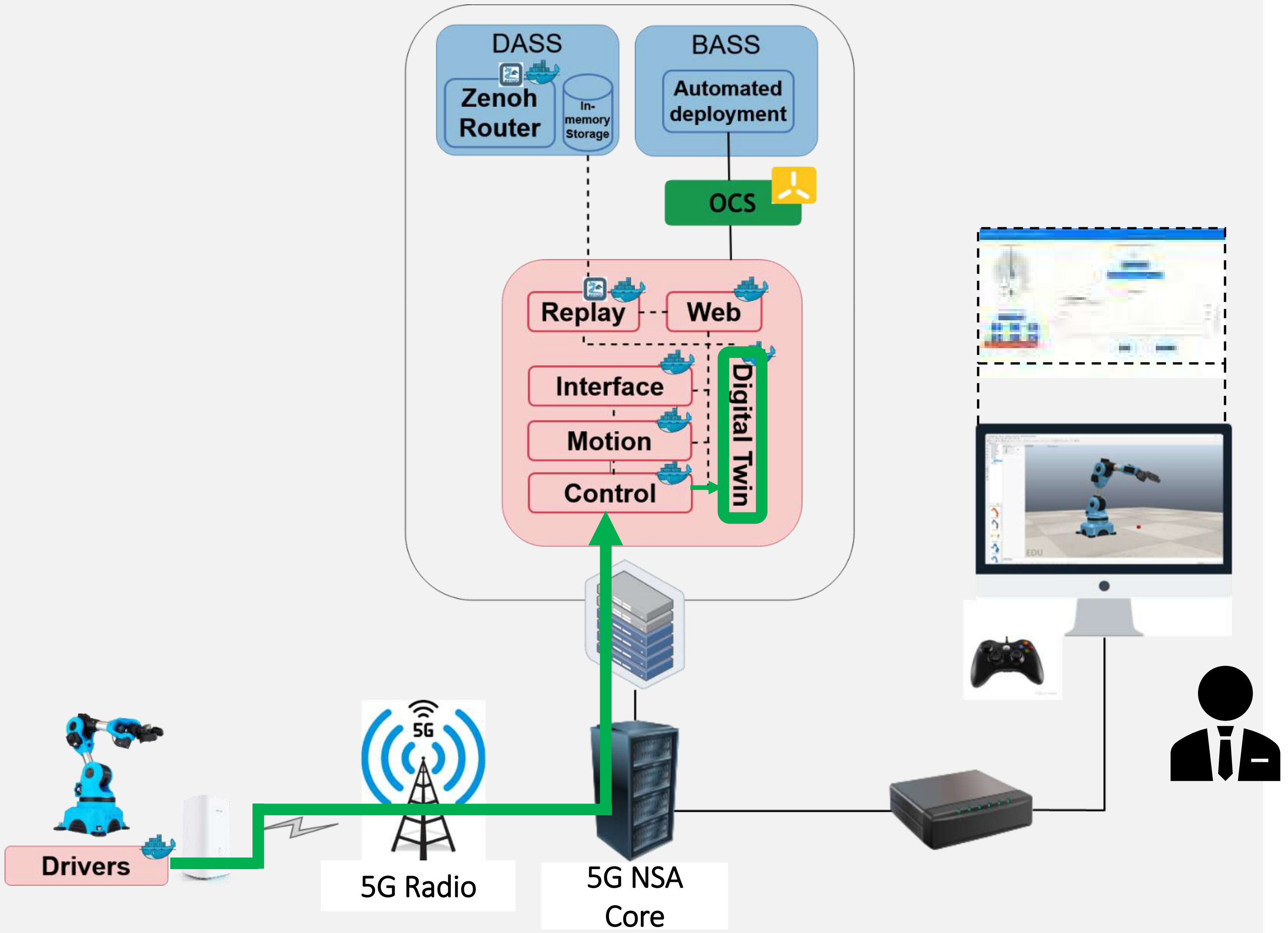
Manipulation commands at given control-loop in downstream



Demonstration description

1. BASS Automated deployment
2. Remote control in Digital Twin applications over 5G

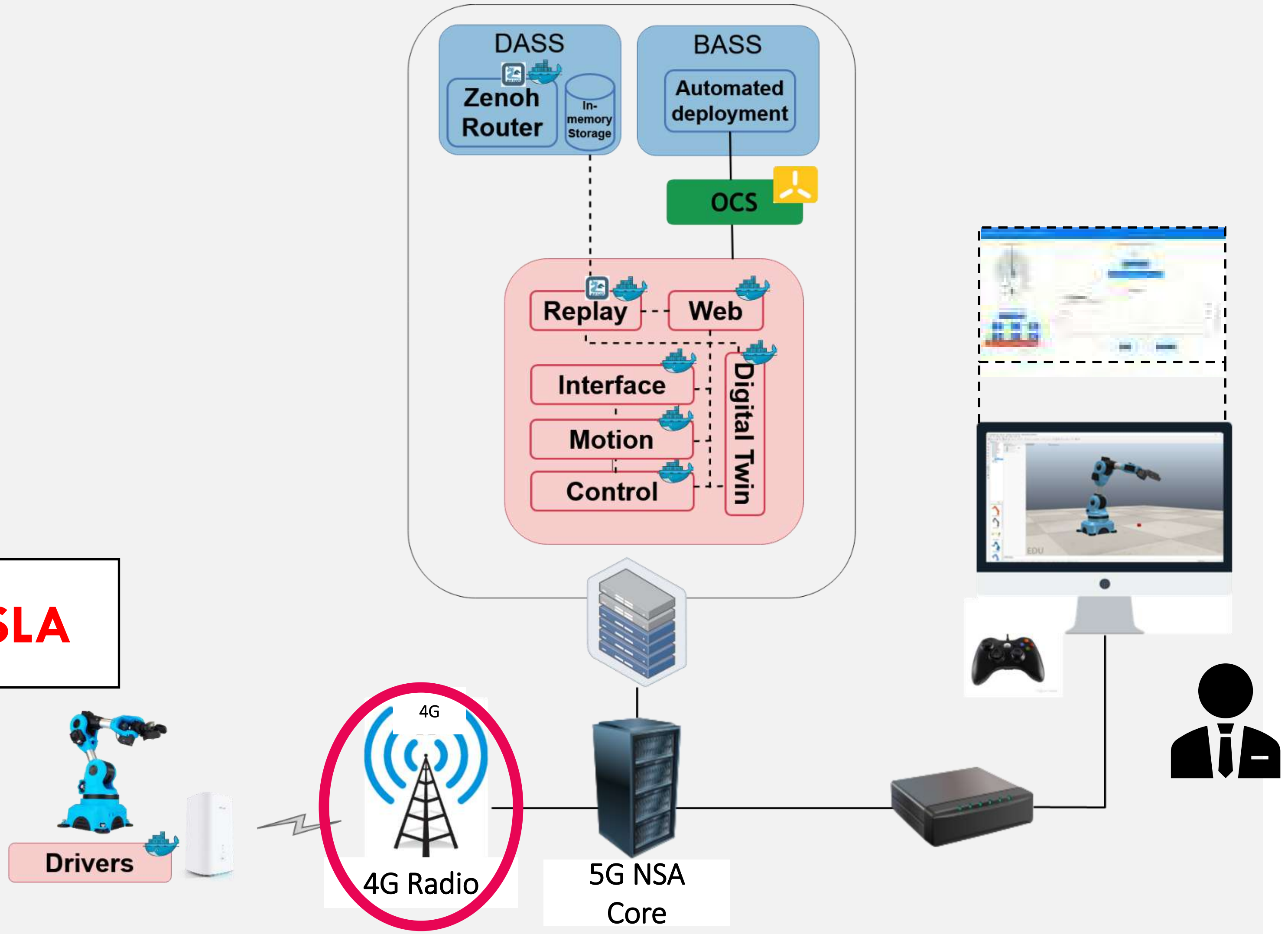
Robot joint states in upstream



Demonstration description

1. BASS Automated deployment
2. Remote control in Digital Twin applications over 5G
3. Remote control in Digital Twin applications over 4G

Latency too high, doesn't meet SLA



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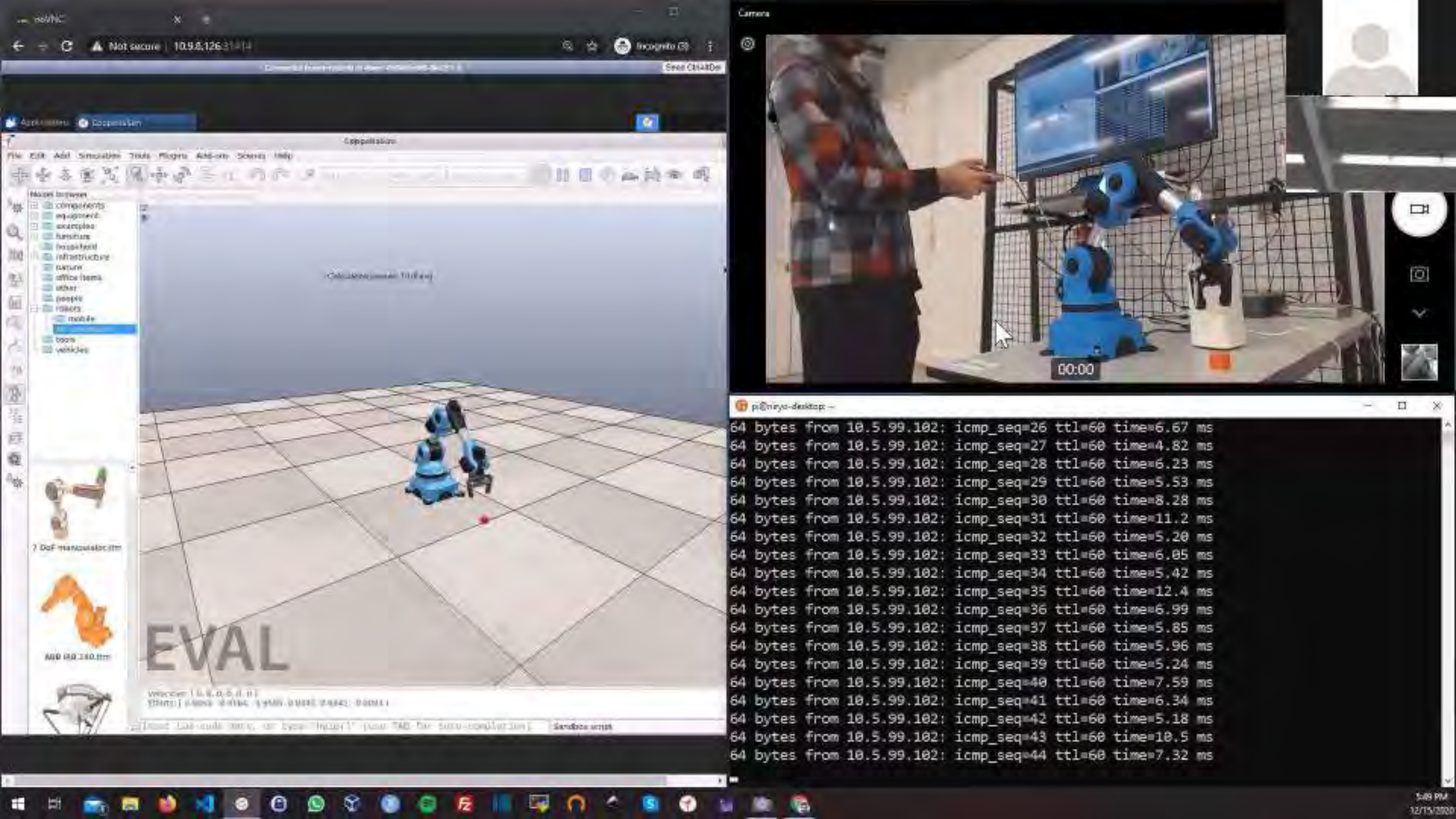
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Not secure
Camera
File Edit Add Simulation Tools Plugins Add-ons Scenes Help
Model browser
components
equipment
examples
furniture
household
infrastructure
nature
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EVAL
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64 bytes from 10.5.99.102: icmp_seq=44 ttl=60 time=7.32 ms

2) Local vs Edge – Example I

Advantages over Local

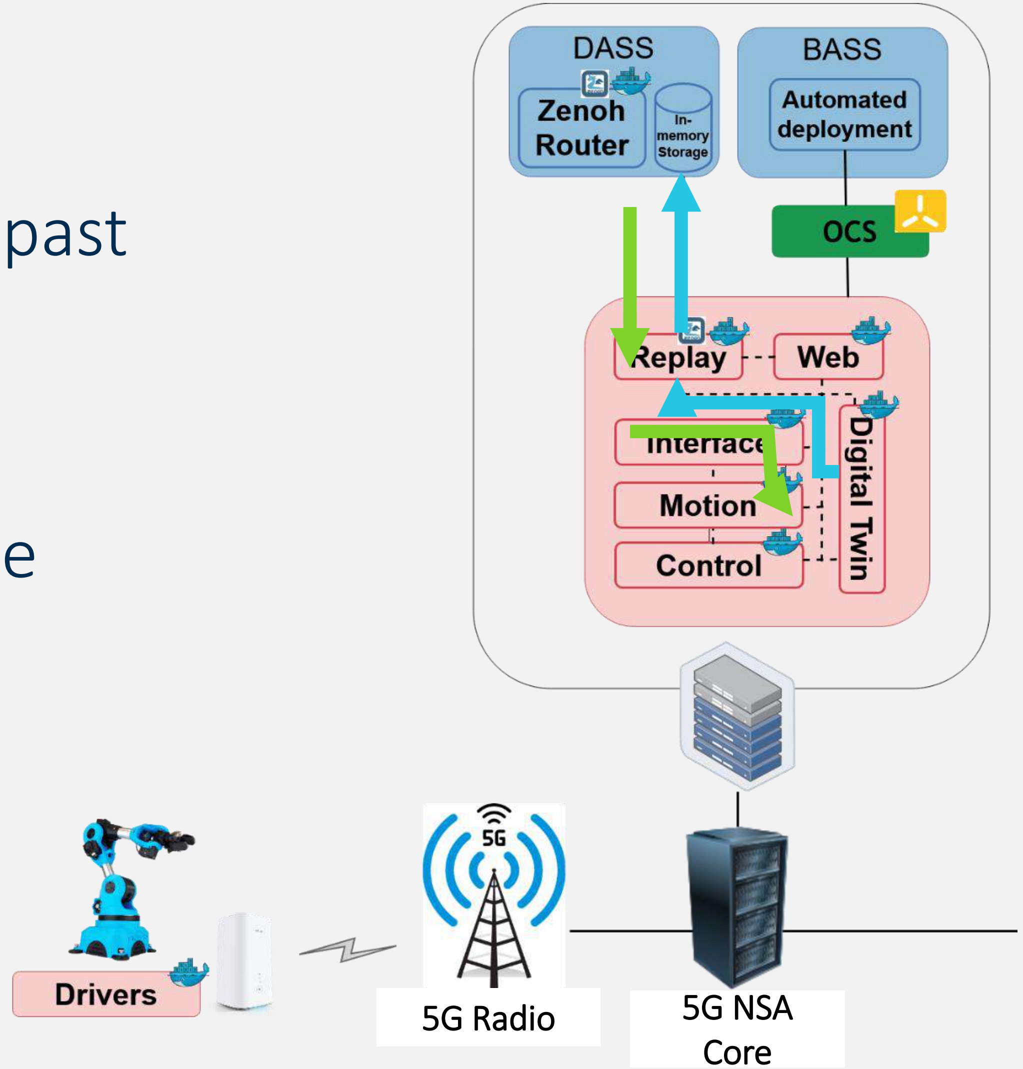
- Compute hardware required at robot is cheap
- Without upgrading robot hardware, additional advanced functionalities can be added with ease (and scaled). Examples:
  - Image processing with AI without GPU in robot
  - New coordination opportunities without complex sync protocols (mass customization, mixed manufacturing, small-batch manufacturing…)
- Virtual (remote) troubleshooting and support
  - Replay function

2) Local vs Edge – Example I

Replay function

- Goal: replay given robot sequence in the past

- Step 1 – store digital twin sates in Zenoh
- Step 2 – regather past data and reproduce again the same commands



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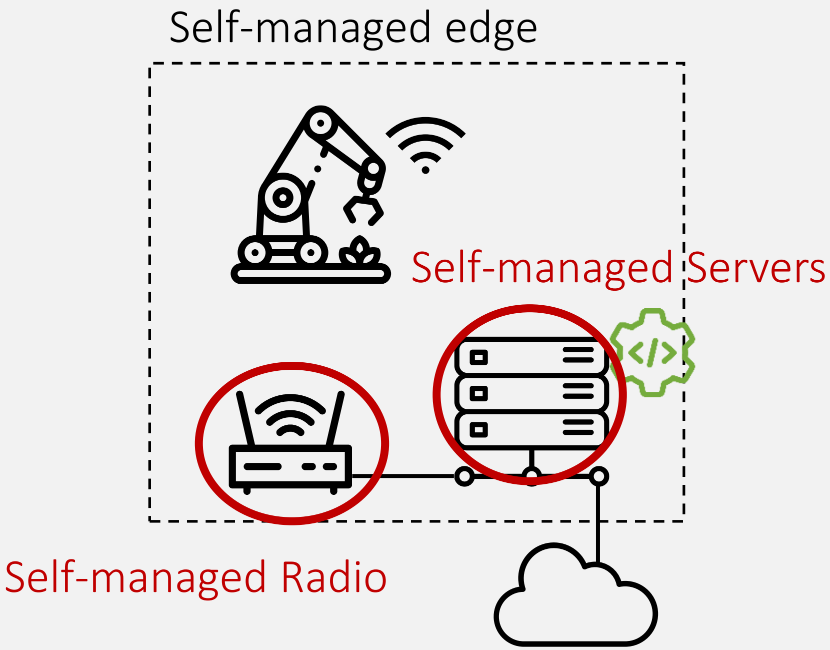
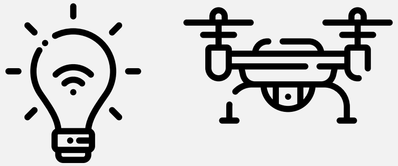
4) Self-managed Edge vs 5G Edge

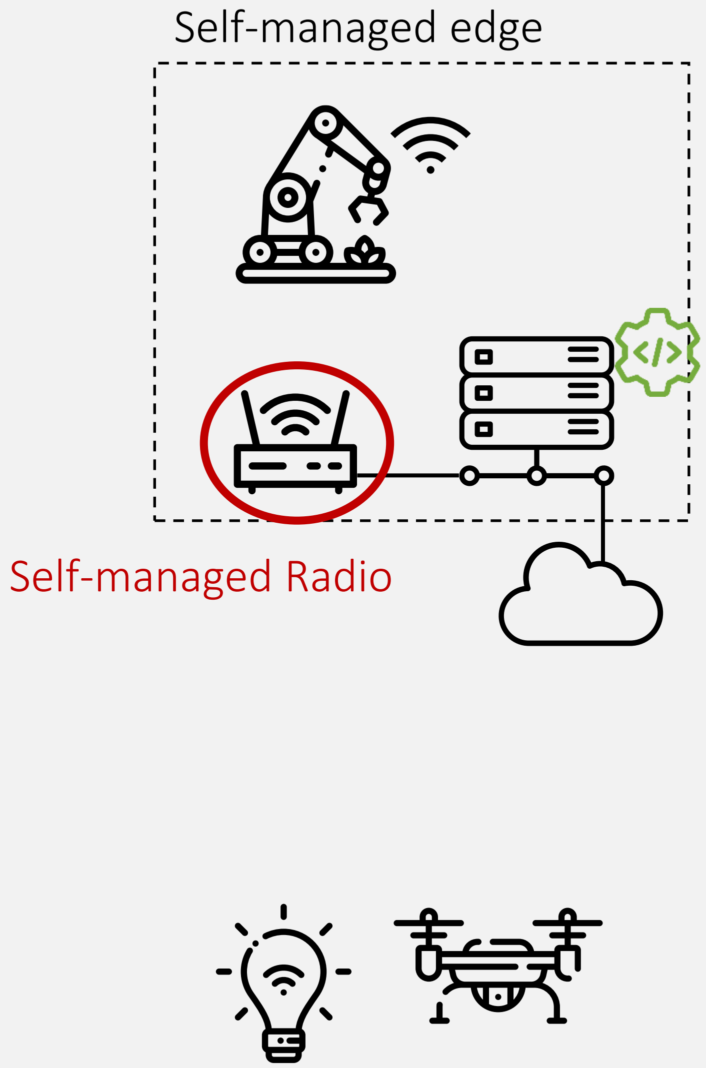
- 4.1) Self-managed connection
  - Wireless – Wifi
  - Wired
- 4.2) Self-managed servers





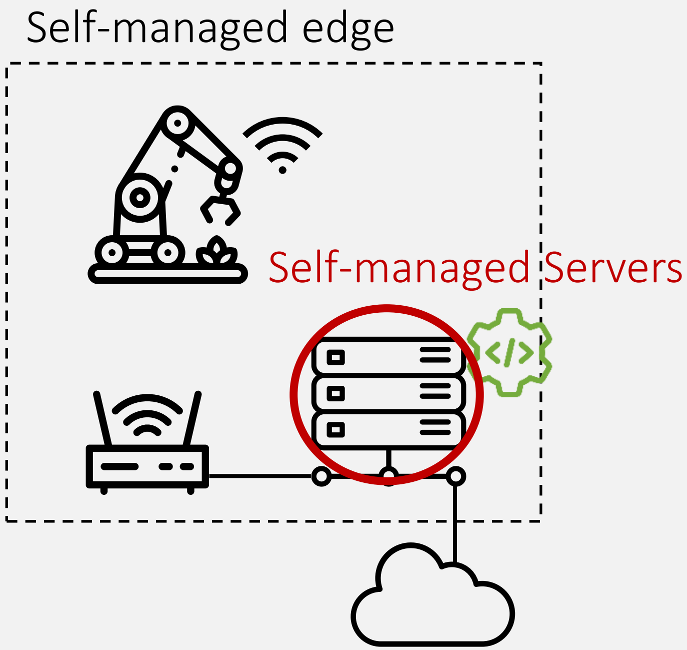
4.1) Self-managed Edge vs MEC – Radio

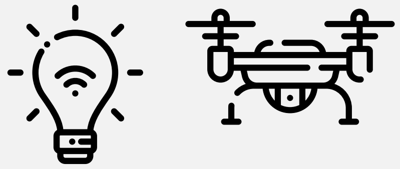
- WiFi
  - Unlicensed spectrum (ISM) -> interferences
  - Security is worse (although has improved)
  - No integrated handover
  - No latency guarantee (CSMA/CD)
  - Even in good conditions high latency
  - Cells are small
- Wired
  - No mobility
  - Lack of flexibility
  - Complex to manage



4.2) Self-managed Edge vs MEC – Compute

- **Mobility**
- Advantages similar to cloud vs self-hosted:
  - Quick deployment
  - On-demand self service and scaling
  - Allows pay-per-use
  - High-availability





Other use cases – Many of them!!

Manufacturing: quickly adapt production equipment and dense sensor IoT network for real-time information of production processes

Intralogistics: outsource partial functions of autonomous systems to the edge. Advantages: reducing processor capacities in the vehicles, nearly limitless data storage, outsourcing of data-intensive workloads like image processing.

Logistics:

Ports (real-time overview using cameras, automating operations)

Rail and trucks: flexible communication between the infrastructure, the trains and personnel, as well as data service to passengers.

Smart City: interconnected infrastructure (vehicles, traffic lights, door, supermarkets…)

Power utilities: energy supply from energy sources that often fluctuate requires monitoring and control of devices installed in private households, companies and distribution networks at a speed and volume that greatly exceeds current parameters. Retail markets for energy are being created to facilitate real-time energy transactions with the help of blockchains.

Mobile infrastructure

Other: Mining, Medicine…

3. 5G Services

- Plan & Strategy
- Network Planning
- Software Design and Development

3.1 Plan & Strategy

Plan & Strategy: we help companies identify 5G and Edge-based opportunities and build a digital strategy & transformation roadmap around these.

Services

- **Potential use cases and revenue channels**: identification of how 5G and Edge Computing technologies can add value, transform current services or create new revenue channels
- **Requirements identification**: type of 5G network deployment suitable for the client's qualitative, spatial and security requirements. Possible deployments include private networks operated in-house, virtual slices of public infrastructure of hybrid models.
- **Feasibility study**: determine if the conditions for spatial (location, topography, humidity..), legal (security and health standards, certifications and radio licenses) and organizational (how internal processes must be adapted and how existing systems can be integrated) are met.

3.2 Network Planning

Network Planning: we lead the design of the mobile network architecture and its integration into existing systems to meet the desired operational requirements.

Services

- **Radio network**: achieve the required radio coverage depending on the expected volume traffic, the site conditions (surroundings, furnishings between spaces, etc.) and the KPIs
- **Connection design:** planning of the connection to the external data network (e.g., the service provider's core) to ensure sufficient bandwidth, availability and other network requirements via the appropriate QoS mechanisms.
- **Integration and service architecture**: integration with existing systems and infrastructure as well as the planning of the layout of network and computing (servers, databases or productions systems) resources.

3.3. Software Design and Development

Software design, remodeling and development: we help clients design, adapt, develop, test and ensure a return on investment on 5G and Edge applications, as well as in hybrid models with IoT or cloud services or use cases.

Services

- **KPI:** identification of required KPIs for verticals
- **Design of new services**: design and development of novel services that are enabled by the 5G network new capabilities
- **Adaptation of existing applications**: adaptation of existing services to take advantage of the new capabilities that 5G and the Edge offers
- **Early testing and validation**: as partners of the 5TONIC laboratory founded by Telefonica and IMDEA Networks we also have access to testing and validation environments for 5G use cases.

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LEADING THE DIGITAL TRANSFORMATION OF COMPANIES

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Thank You

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