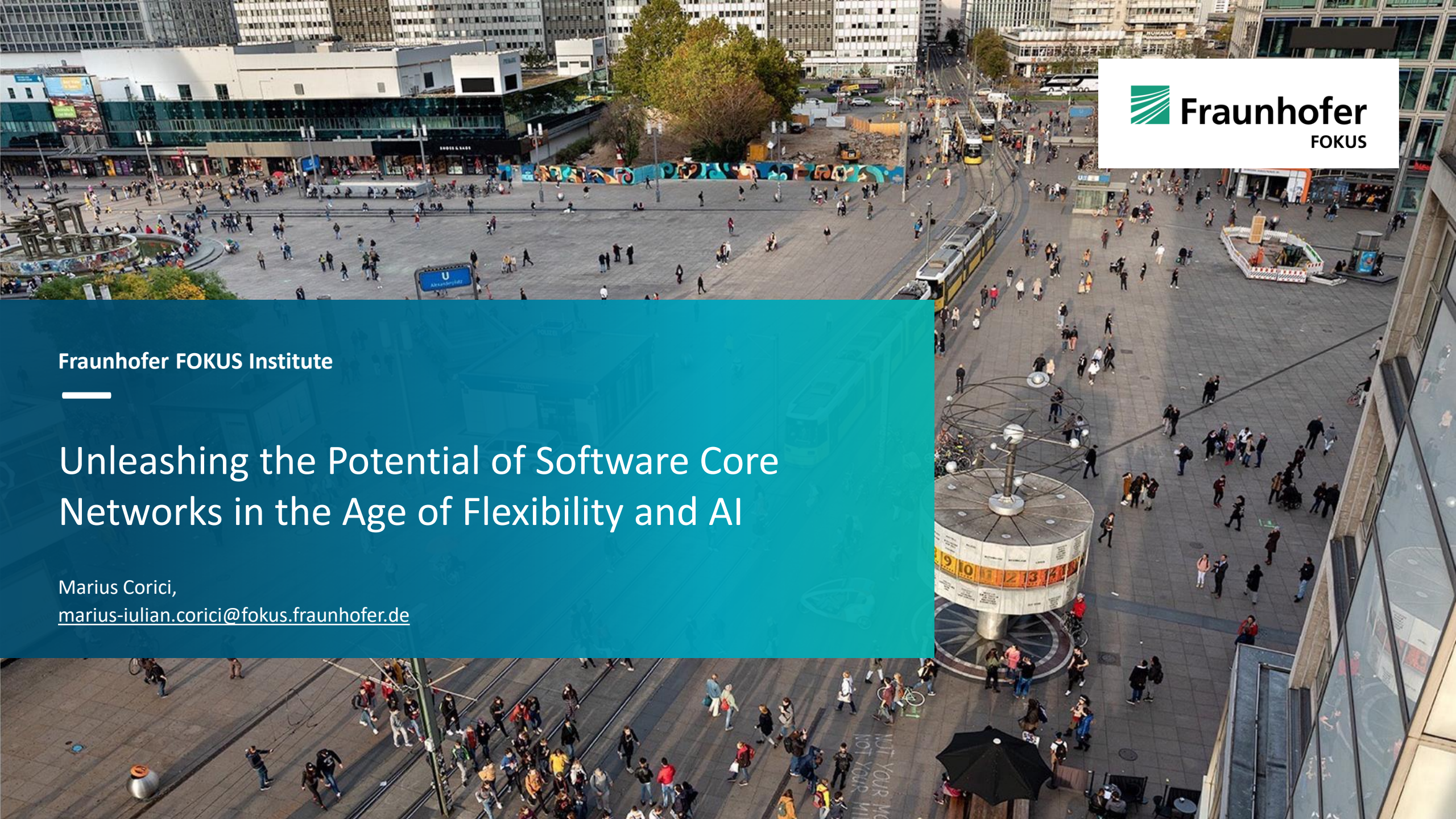

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# Unleashing the Potential of Software Core Networks in the Age of Flexibility and AI

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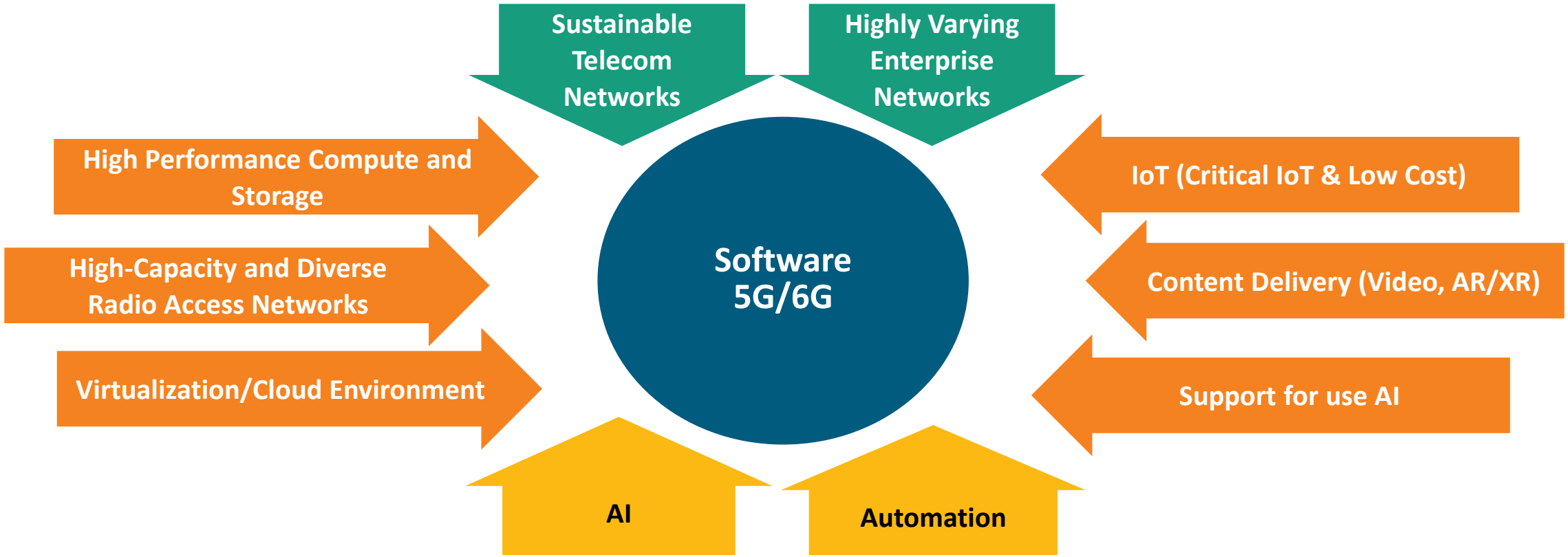
# Putting Beyond 5G  Into Context

- Enable to address in a cost-efficient manner the highly distinct requirements
- Maintaining a single network implementation



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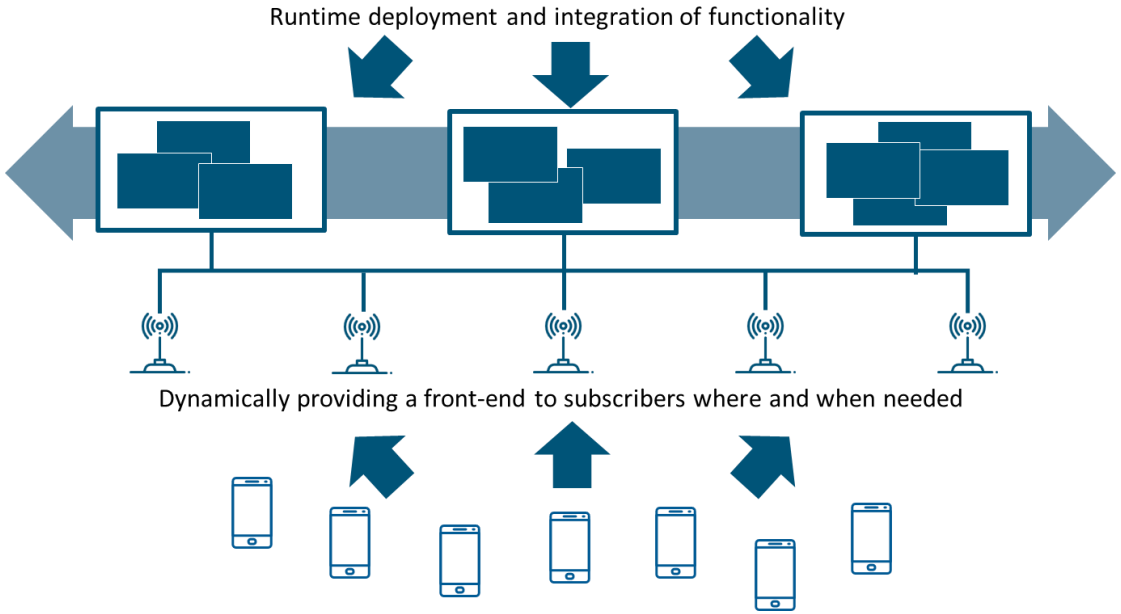
# Why Software Networks?

- Programmability (via APIs, SDN and NFV frameworks)
- Service elasticity & runtime adaptation
- Cross-layer observability (telemetry, monitoring hooks)
- Independence from location — enabling edge/cloud shift
- Beyond 5G: Morphing – becoming what is needed for the local deployment

- Flexibility comes with new risks
  - Complexity – complex systems tend to reach unpredictable bad states
  - Hard to find appropriate profiles
  - Too much adaptation could push too many changes



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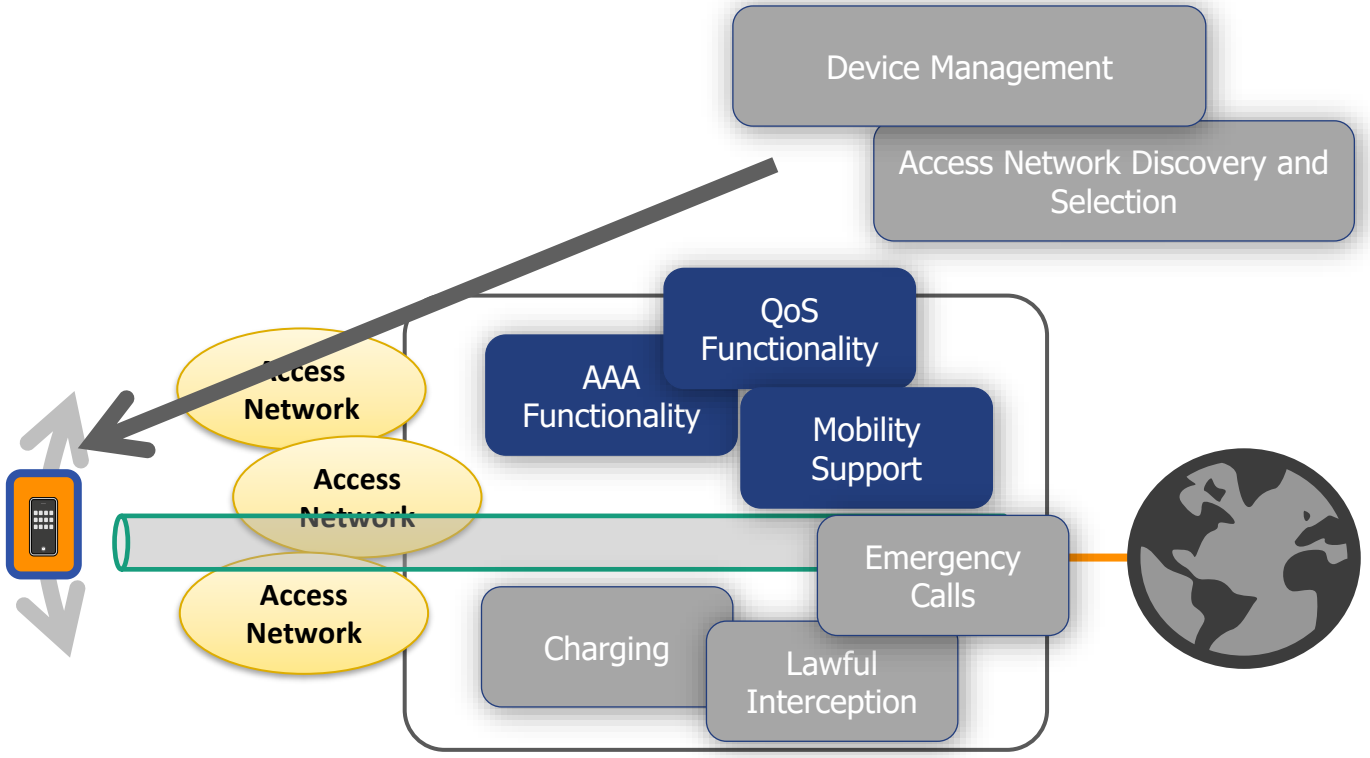
# Carrier-Grade Expectations in a Software World

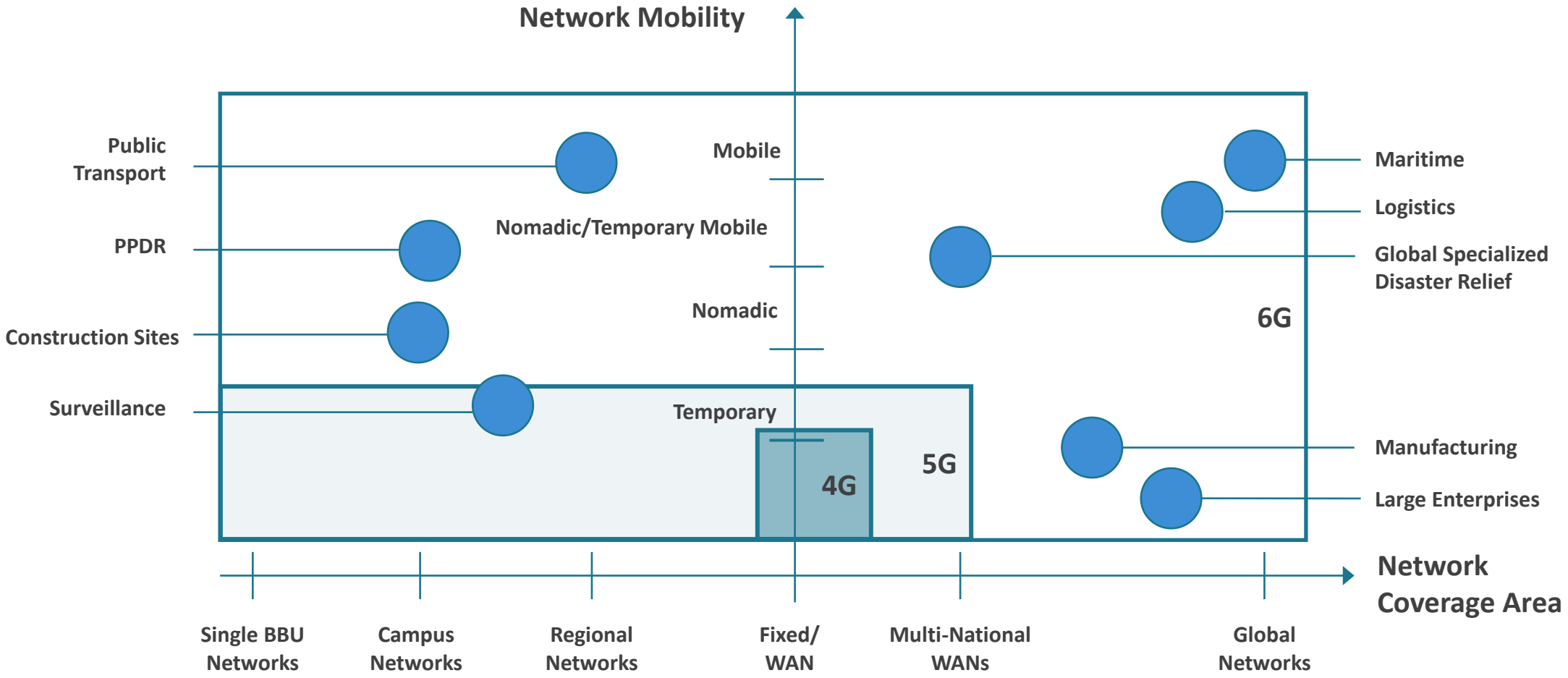
- Carrier grade requirements:
  - High availability and reliability (5-nines, 6-nines, …)
  - Maintaining service SLAs
  - Interoperability and lifecycle manageability
  - Deterministic behavior despite abstraction
- Sustainability requirements:
  - Ultra-adapted to the deployment environment
  - Ultra-adapted to the use case
  - Cost efficiency
  - Fitted energy consumption






SLA – Service Layer Agreement

# New 6G Use Cases: Mobility and Coverage Area Variations



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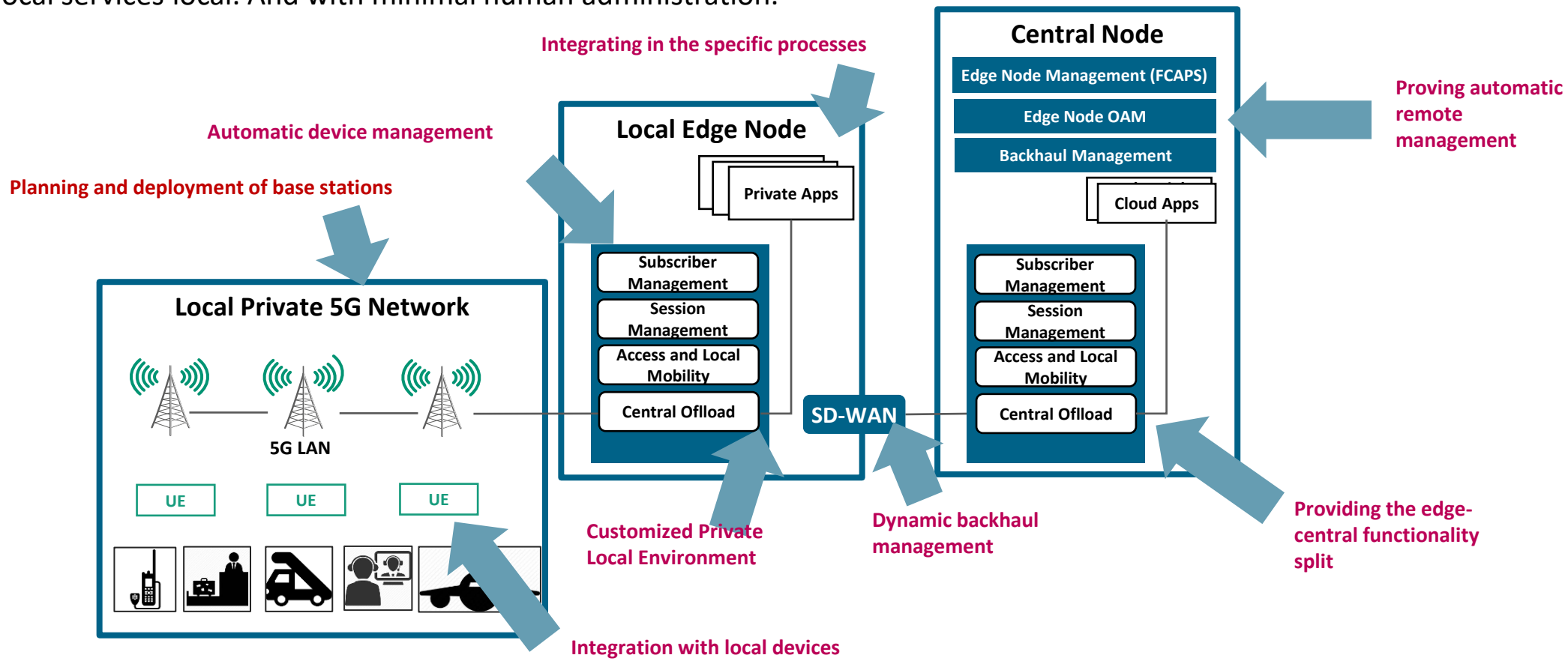
# Use Cases: Automatic Deployment @ Use Case Location

- Maintain local services local. And with minimal human administration.



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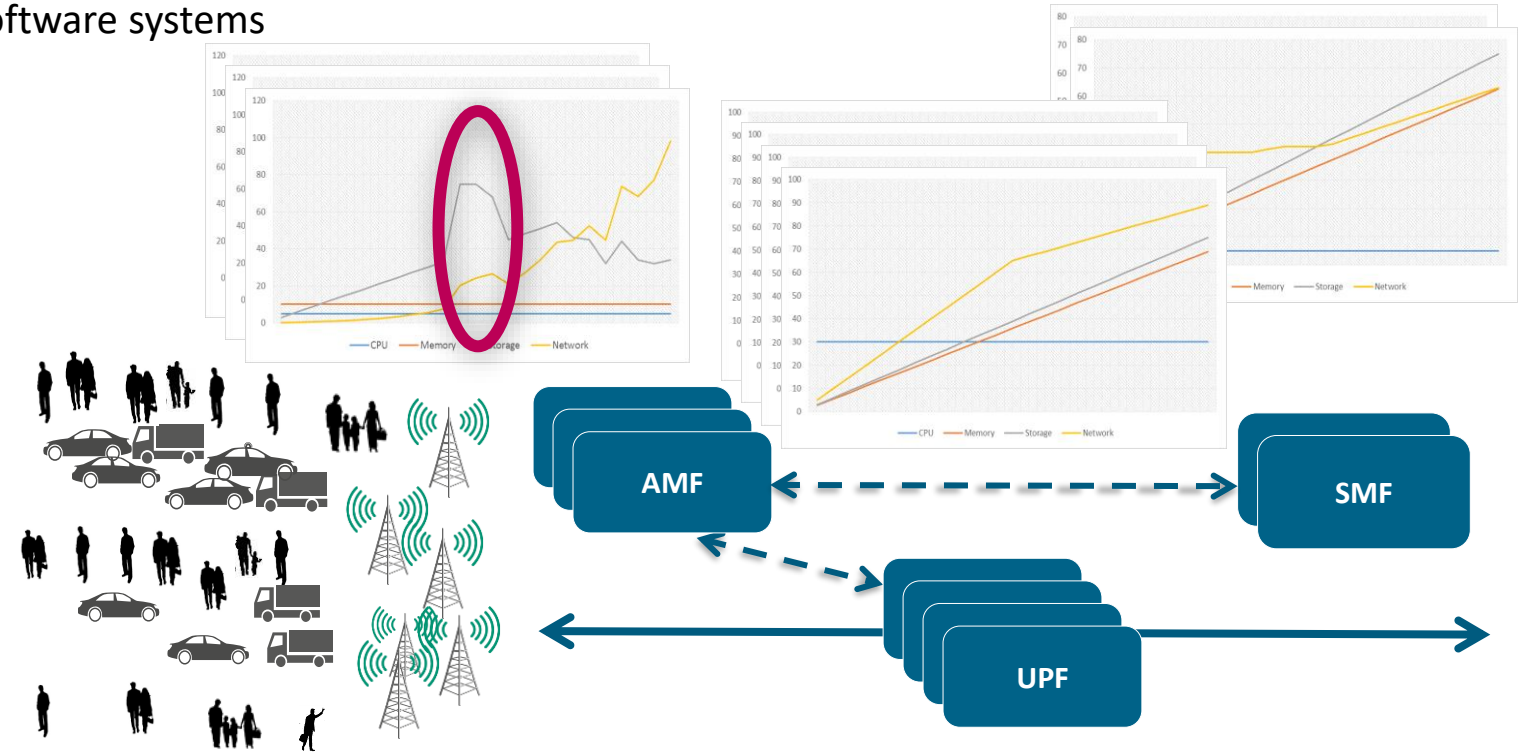
# Use Cases: Automatic Understanding and Adaptation of System Behavior

- Determining patters which are not expected in the behavior of the system
- Adapt the system to these unexpected patterns
- Forensics / backwards traceability of (failed) software systems

- Handling unforeseen/surprise sitations



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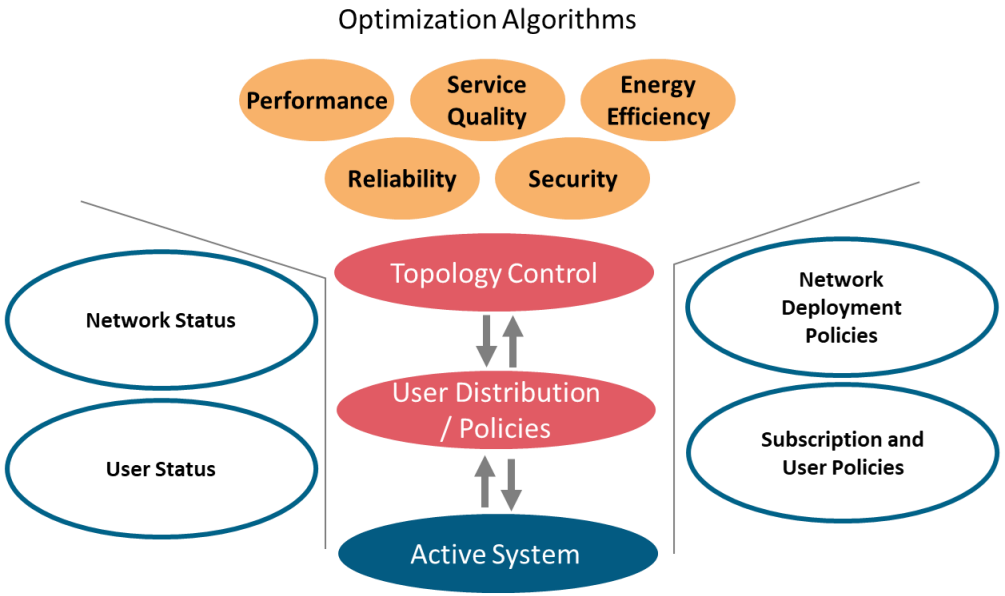
# Use Case: Increasing Network Utility / “Usefulness”

To address the large variation in deployment models and size beyond 5G/6G networks should be customizable to the specific use case requirements

- Highly dynamic scheduling of resources (frequencies, compute, etc.)
- Flexible, use case adapted network characteristics:
  - Performance, Quality of Service, Robustness, Security and Energy Efficiency
- Dynamic load balance across locations
- Use the user profiles for customization
- Increase computing capabilities where and when needed
- Develop a set of dynamic mechanisms for information performance

All of these features were solved by the IT industry by implementing cloud computing services




Coordinated/Conflict-Free Continuous Near-Real Time Network Adaptations



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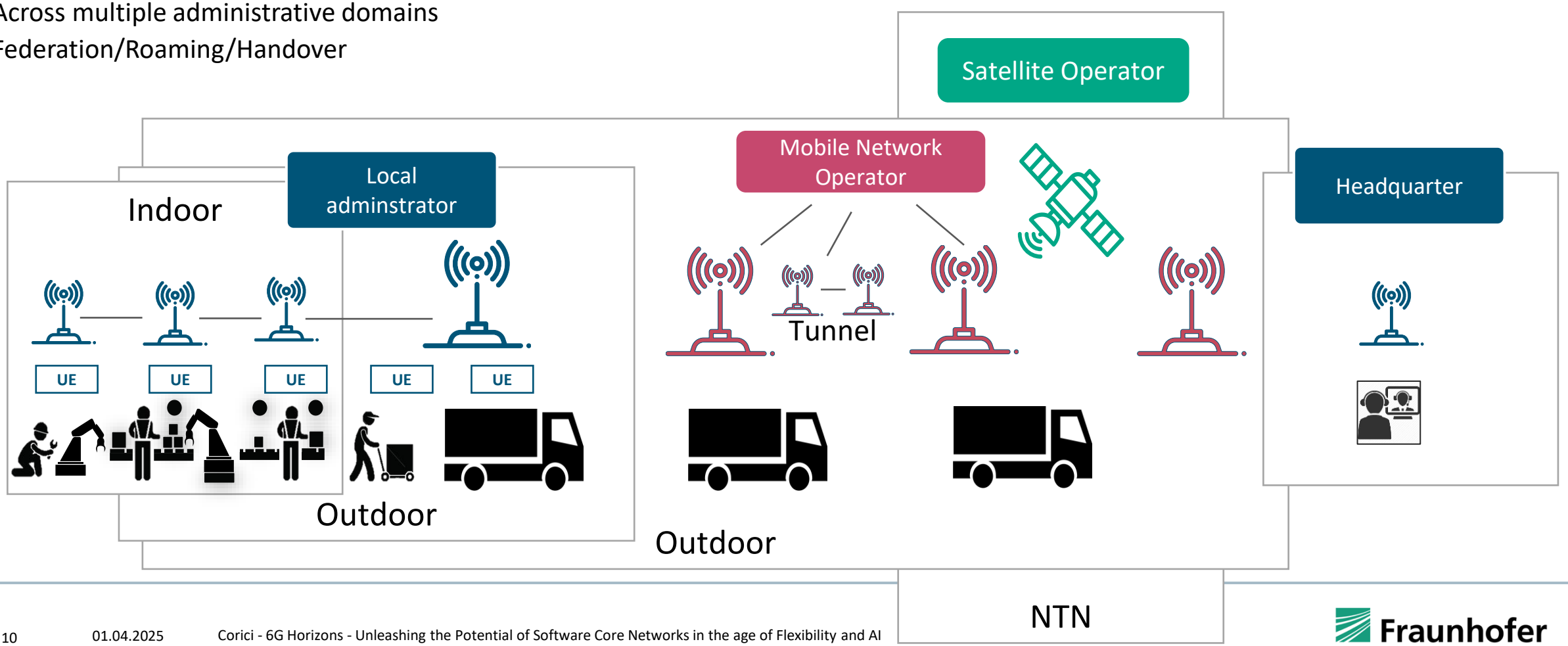
# End-to-End Networks

**Dynamic combination of an end-to-end service:**

- Across multiple access technologies
- Across multiple administrative domains
- Federation/Roaming/Handover



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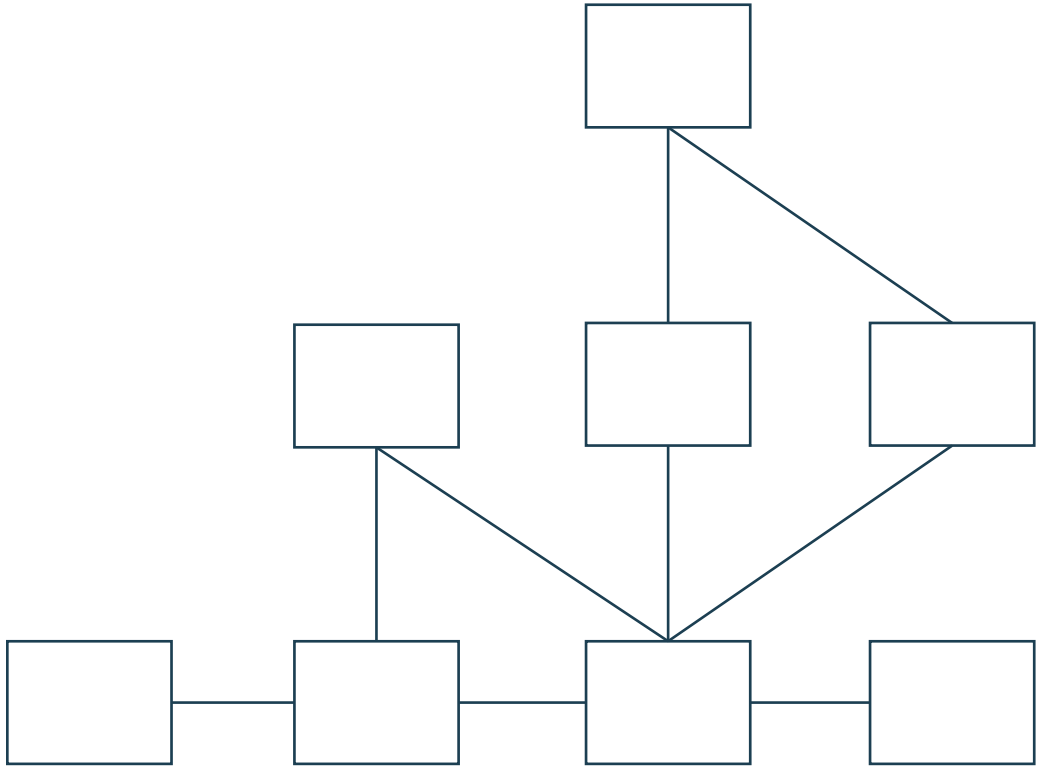
# Towards a Systematic definition of Network Complexity

What is complexity:

- Number of components involved
- Parallelization across same type components
- Number of interfaces (includes surface to external)
- Intensity of interaction
- Number of decision elements
- Lengths of hierarchy
- Components' heterogeneity



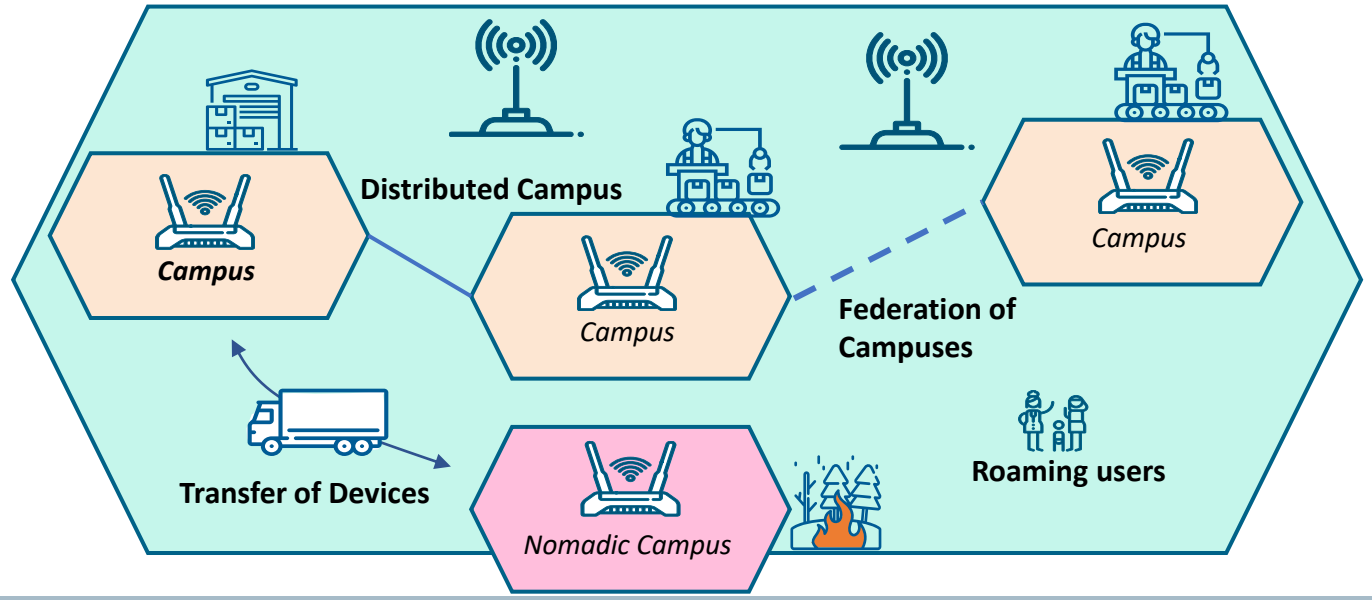
Adapted based on the definition from John L. Casti: https://www.britannica.com/science/complexity-scientific-theory/Surprise-generating-mechanisms

# Use Cases: The “White Box” Development

- Reducing the development costs by:
  - Developing once
  - Highly customize for many deployments and use cases

- Goal: to use ultra-configured “white boxes”
- Goal: maintain the 6G convergence against diverging requirements
- Goal: Show that a single software piece can be ultra-customized for different use cases

- Can we maintain the convergence?



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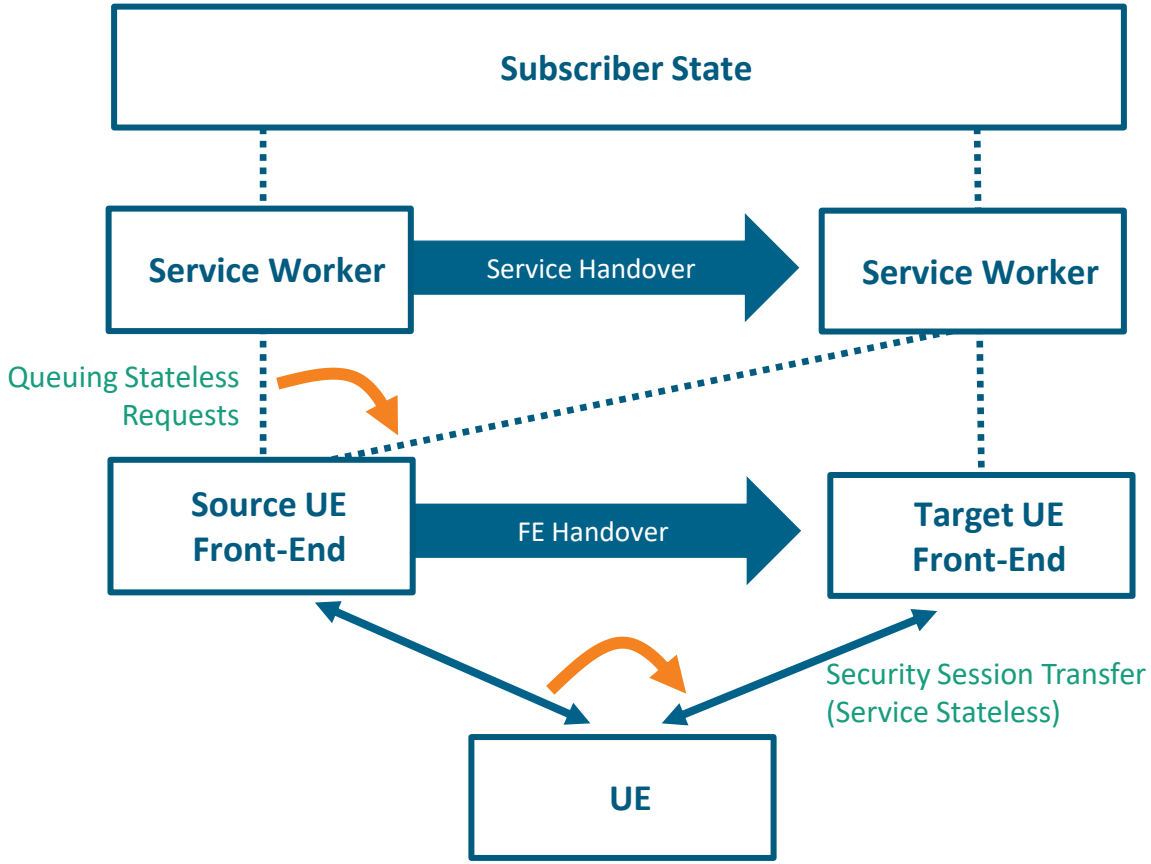
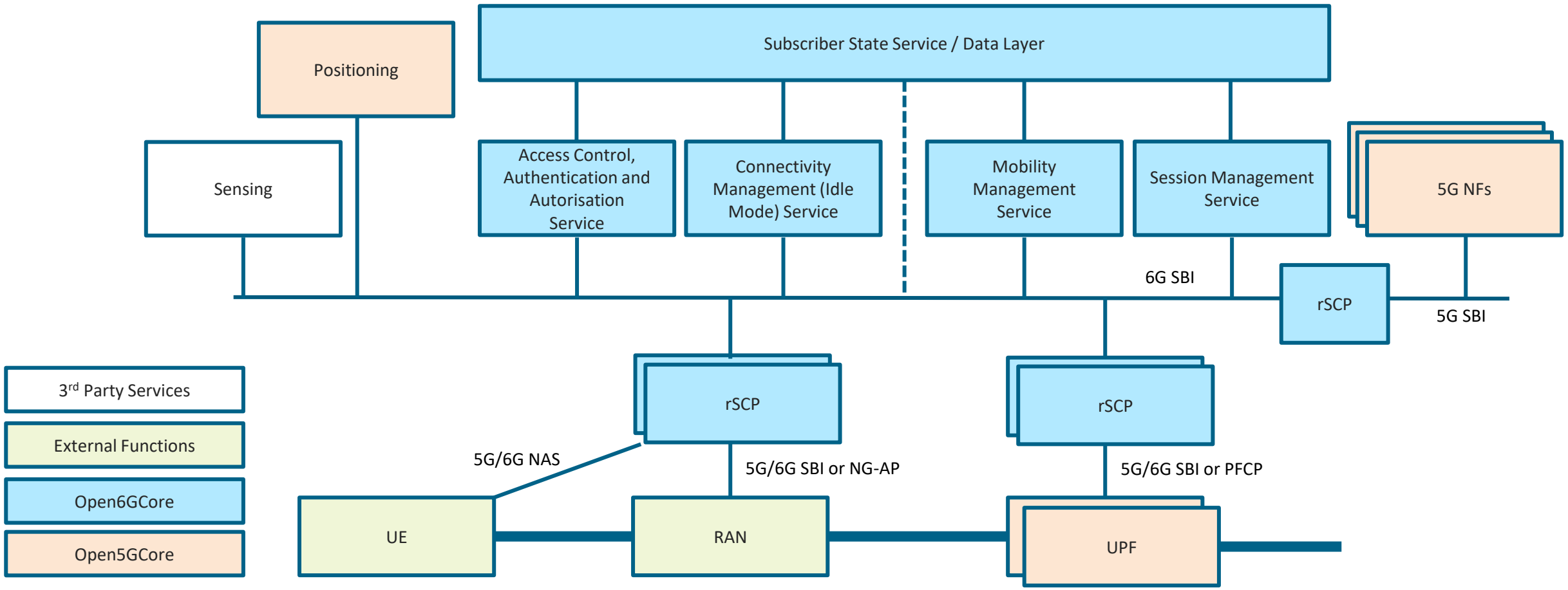
# Open6GCore Rel. 1 – Available from June 2025

- Multiple sizes by design: from Raspberry Pi to Cloud
- Ultra flexibility:
  - Very fast scaling
  - Fluidity – Infrastructure free – Dynamic Deployment
  - Seamless migration between versions / Native DevOps
- Performance:
  - Easy load balancing
  - Seamless scaling / using cloud scaling
- Complexity Reduction: better composition of procedure
- Morphing at runtime: changing the functionality during service runtime
- Reality check: should work with 5G UEs and 5G RAN



# Open6GCore – Integrating 5G and new/not-yet-known 6G services



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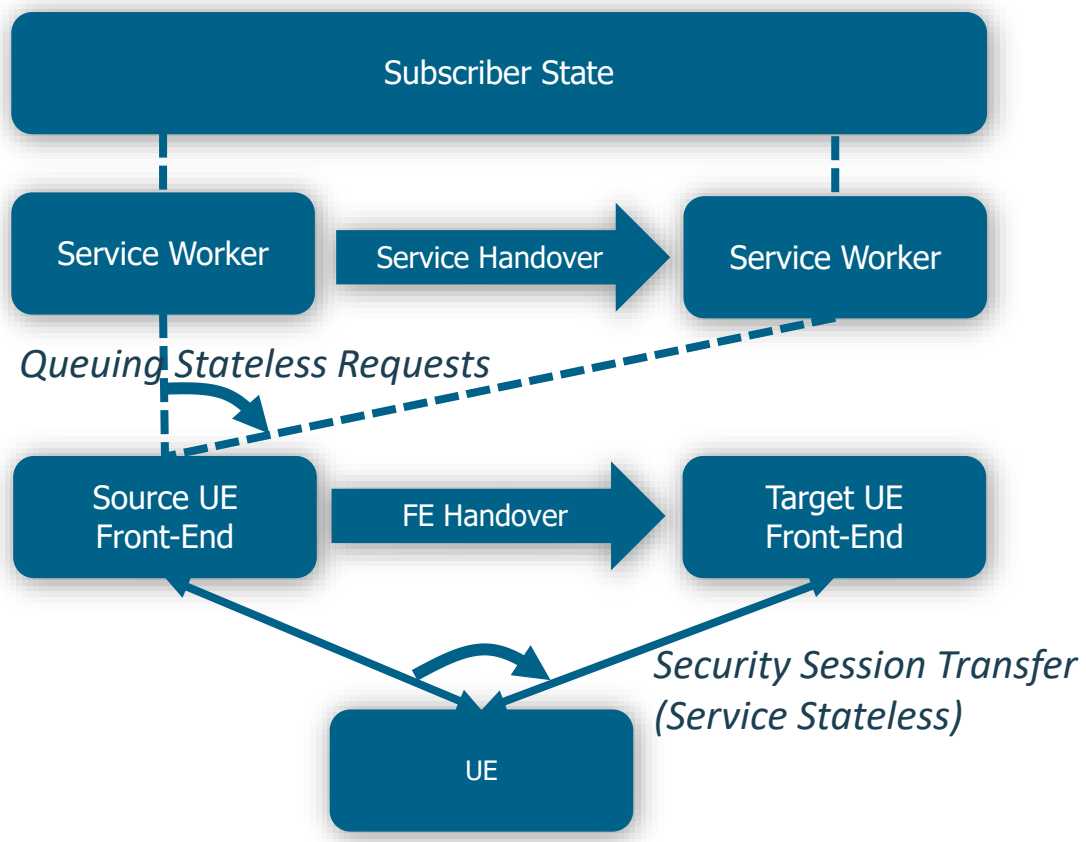
# 6G Flexibility Mechanisms

- Front-ends maintain only the UE-Core security session transfer (service stateless)
- Workers are service stateless
- Single subscriber state

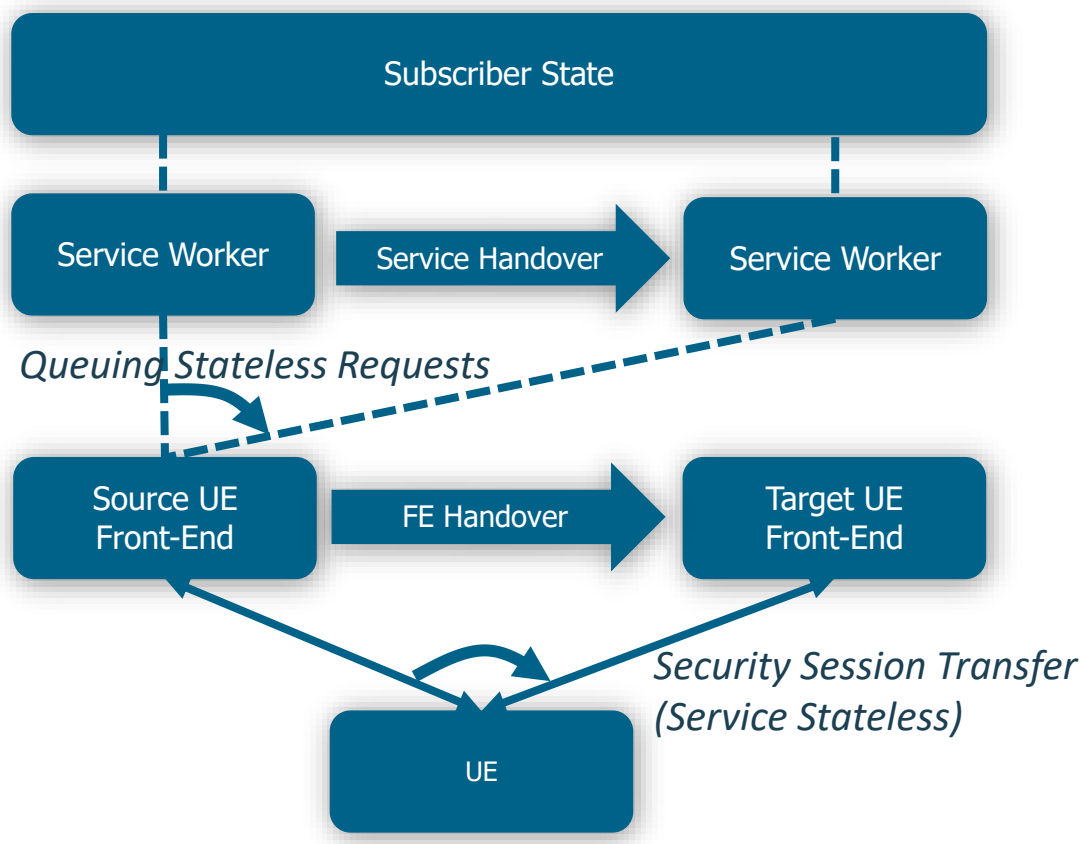
➔ Due to the stateless nature, the service can be easily handed over




UE – User Equipment
FE – Front-End

# Flexibility Mechanisms Usage

- Performance
  - Load balancing
  - Easy scaling
- Reliability
  - Stateless hot-standby with fast transfer
- Security
  - Dynamic creation of quarantine zones
- Dynamic deployment
  - Migrating users to new locations
- Continuous upgrades
  - Replacement of old with new versions of the network functions

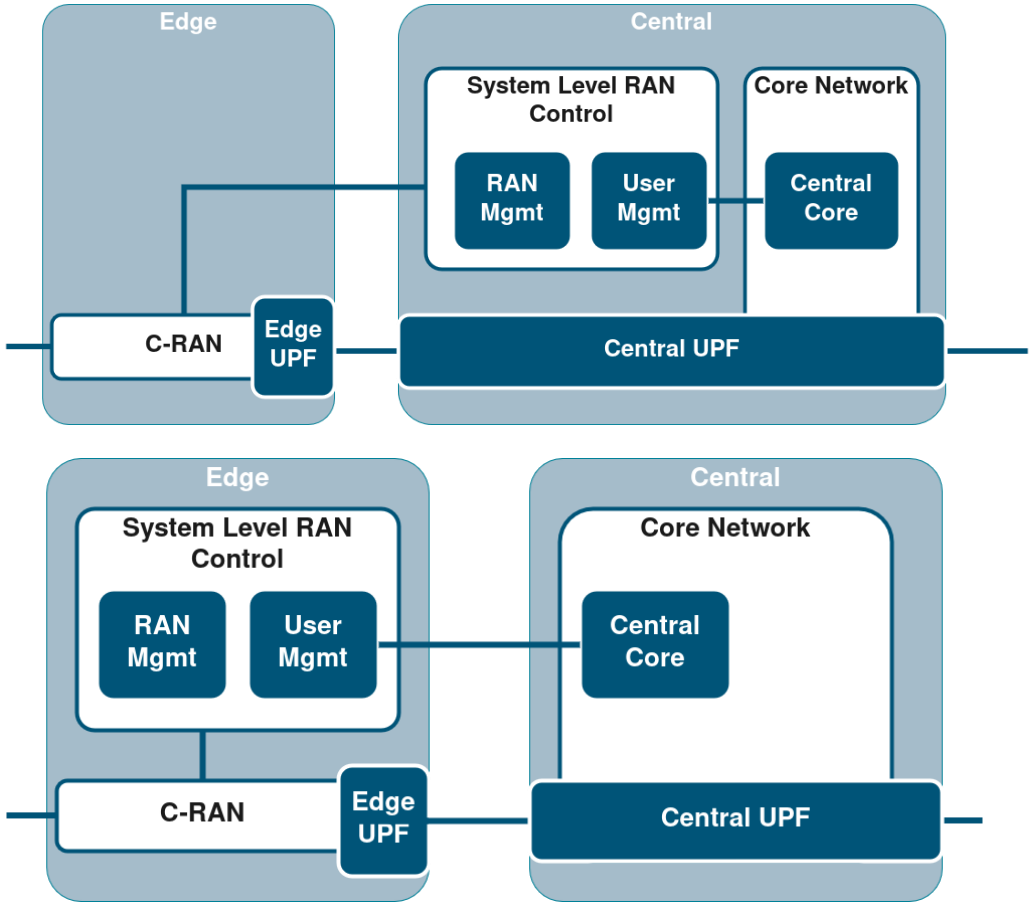


# Core Means Essential not Central

- Part of the core network can be effectively be deployed at the edge:
  - Power control and Energy Efficiency
  - Interference coordination across multiple RANs
  - Reliability and security – anomaly detection

  - **Local paging across RANs**
  - **Local mobility management without central involvement**
  - **Dynamic resource coordination – load balancing and user distribution**

- C-RAN creates a natural edge of the network



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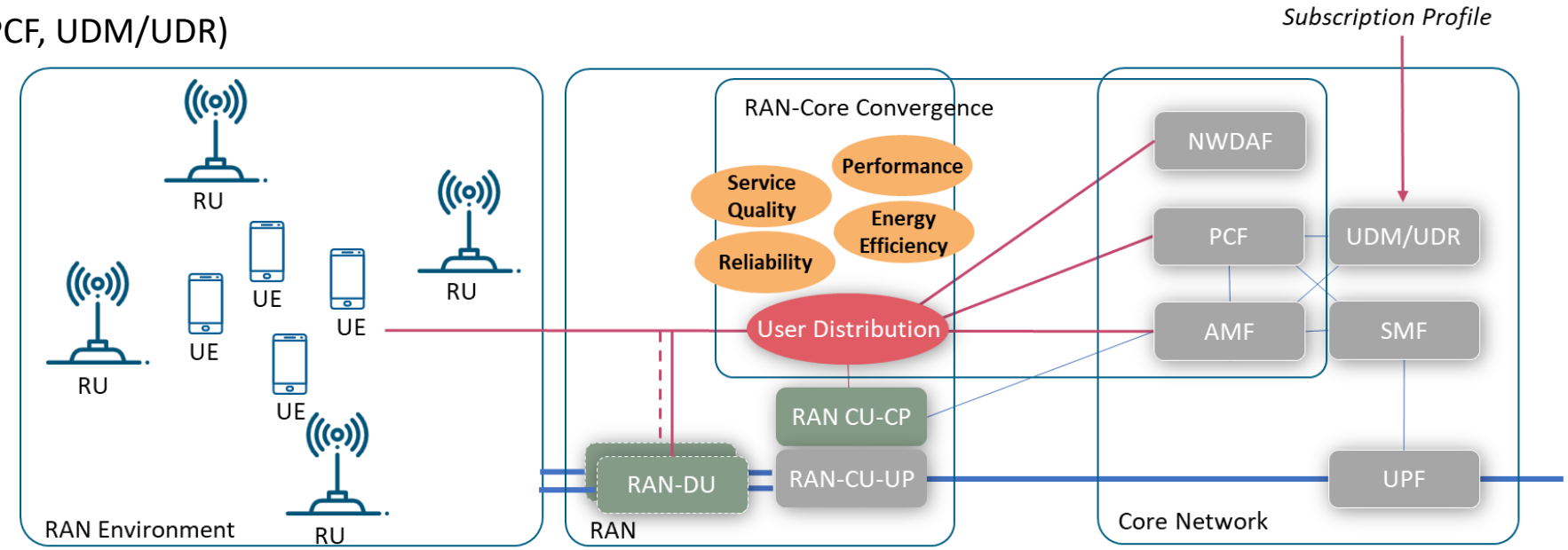
# RAN-Core Convergence

## Providing subscriber control in near real-time across a coherent control plane

- Administrative UE distribution in the RAN environment:
  - Policies transmitted to the UE
  - RAN commands – using the near RT RIC functionality
- Dependent on:
  - QoS and Mobility patterns (NWDAF)
  - Policies and subscription profile (PCF, UDM/UDR)
  - Macro-mobility(AMF)



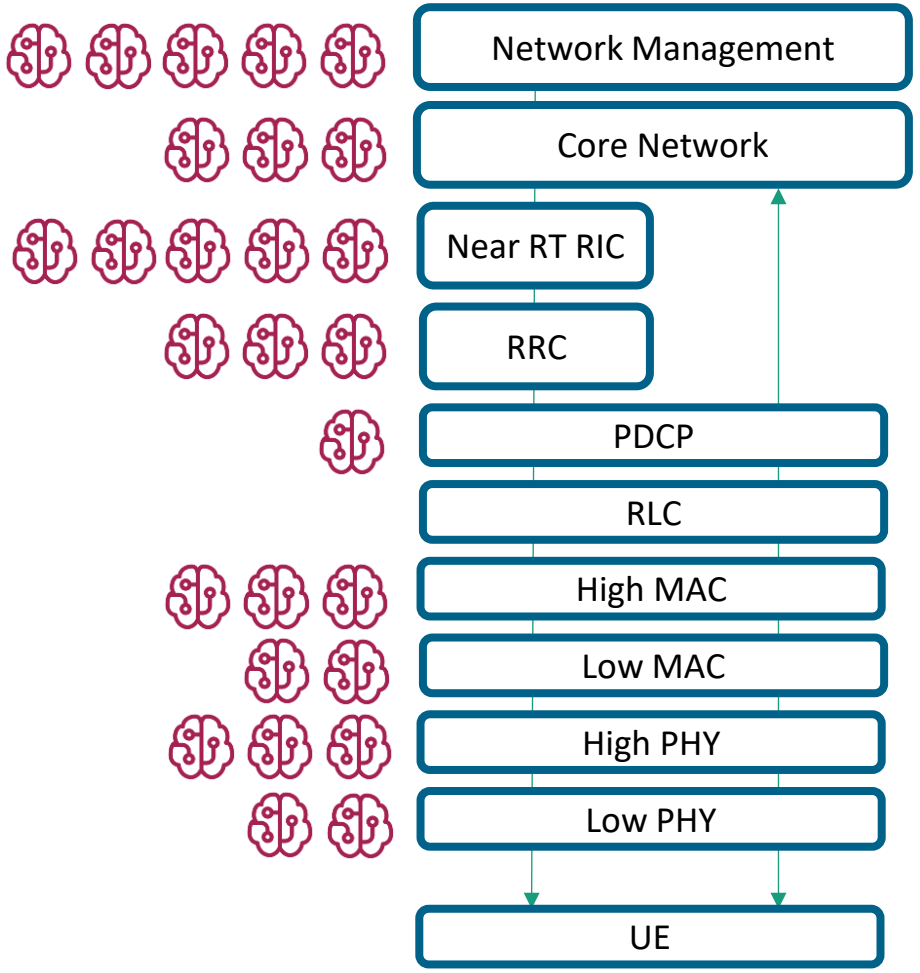
# Native AI

- Different optimizations at different levels
  - Many optimizations are possible

i.e. any parameter that would work better if dynamic

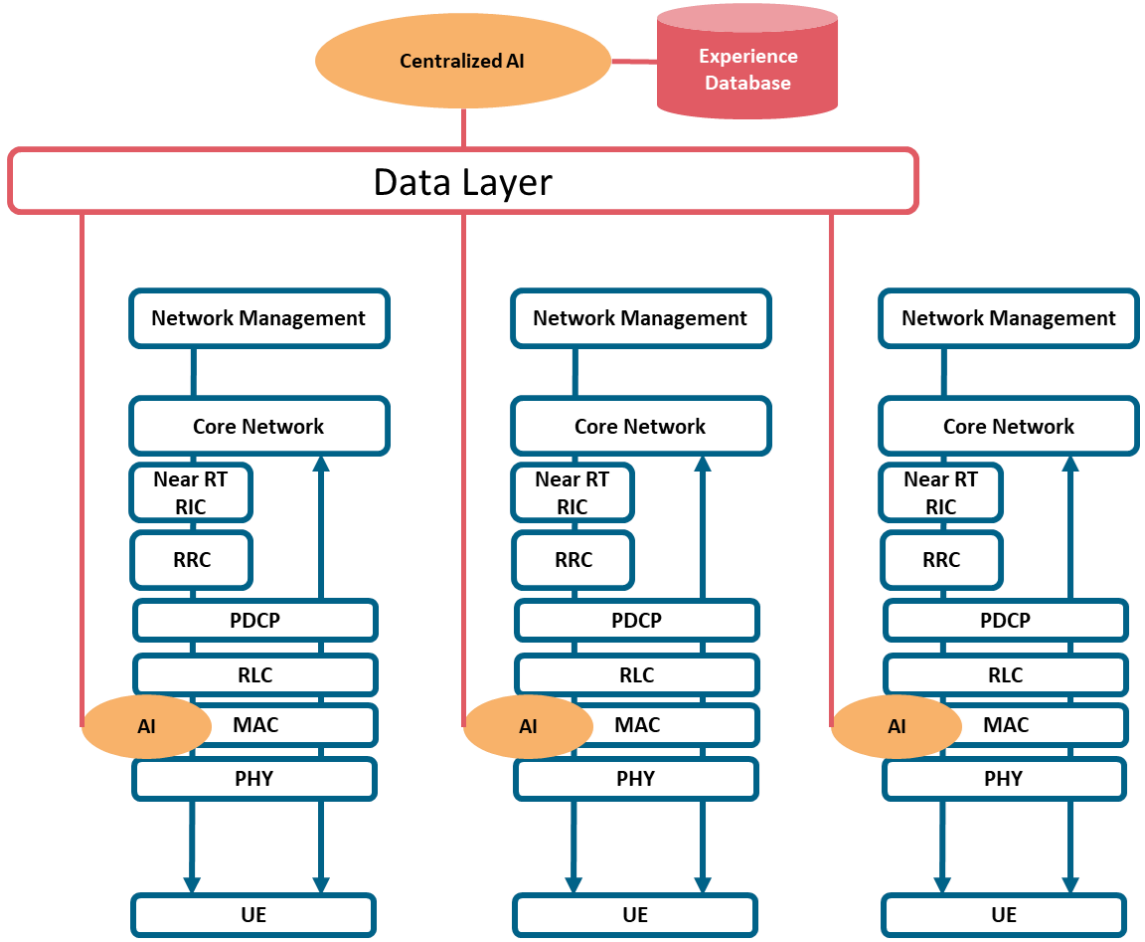
- Optimizations impact each other:
  - Within the same layer
  - Between layers

- Models trained locally are (maybe) good locally
- Although models are embedded in the stack, they need an „out-of-band“ communication



# An “out of band” communication is needed

- To be able to communicate between the different agents
  - Situations
  - Solutions
- Basic federated learning would work ONLY when the local situation is similar



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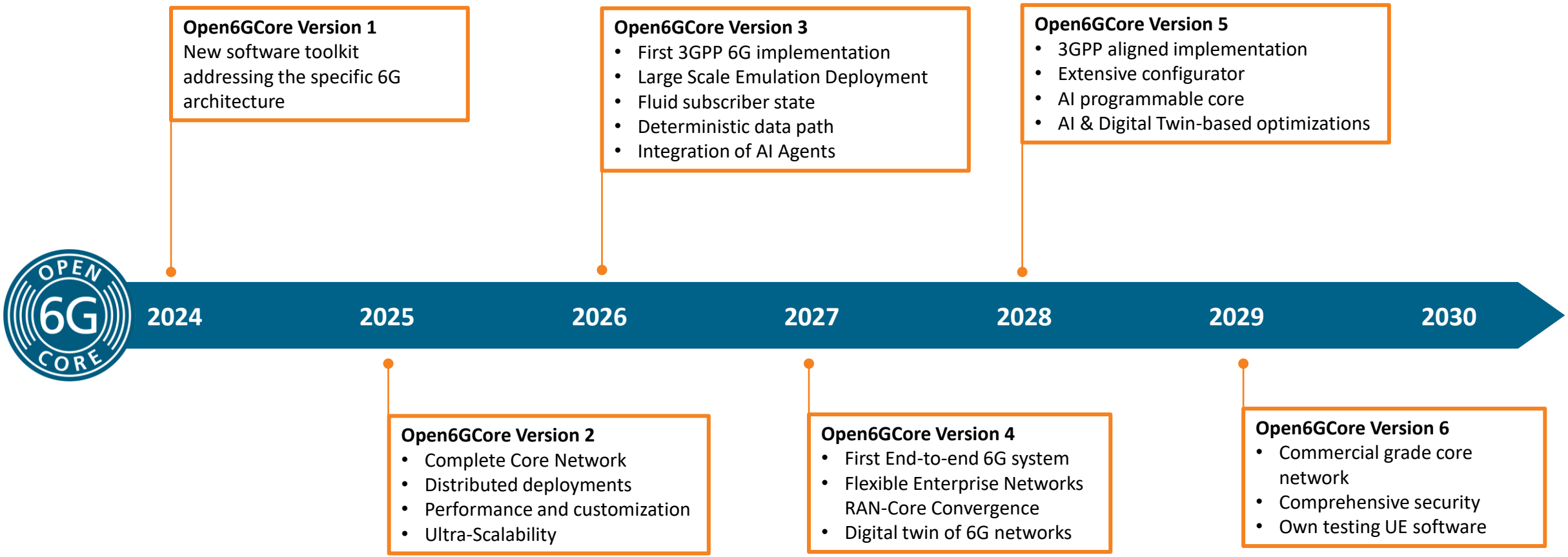
# Open6GCore Long Term Roadmap



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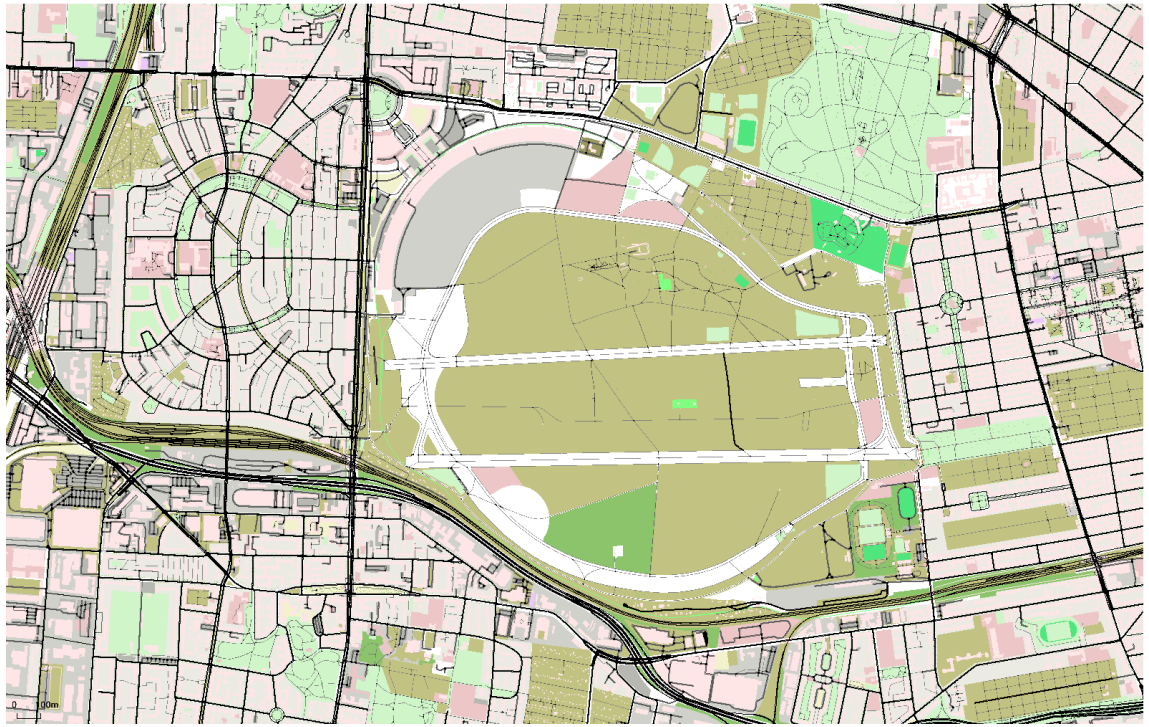
# OpenLanes: Large Scale Network Emulator System for Network Digital Twins

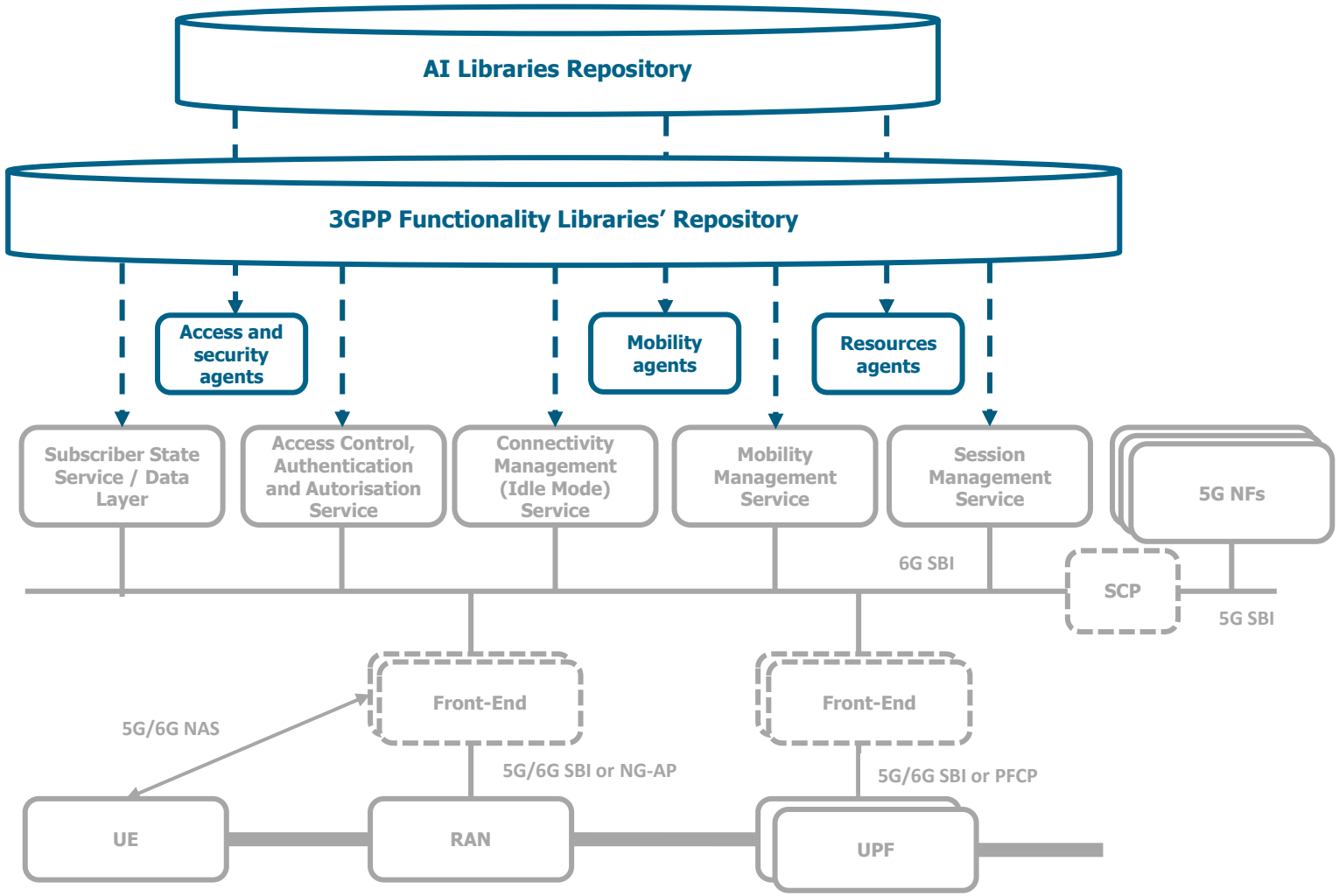
**Providing an easy-to-use, large-scale network emulation to automatically test new concepts in a large number of real networks**

- Generic Emulator of Large-Scale Networks (>400 nodes)
  - Delay, Capacity, Packet Loss
  - Non Terrestrial and Terrestrial Networks
- Support for Open Street Maps and SUMO Trajectories
- Support for static and dynamic topologies
  - Automated tests across multiple network topologies
  - Topology changes can be described in a Time Series
- Highly configurable
  - Configuration GUI for Scenario Selection
  - Automatic configuration mechanisms
  - Next version: including a large number of telecom backbone and satellite constellation relevant topologies
- Can be interfaced with real nodes/hardware devices
  - Testing networking of nodes in complex networks



# The Future Core is Fluid and Smart

- No Network Function Core – replaced by small pieces of execution highly groupable and customizable
  - Maintain pieces and stacks from AMF, SMF, etc.
  - Can be re-combined for the specific use case – need a binding mechanism
  - Can have dynamic parameters to meet the end-to-end service goals
- Very close closed-loop automation
  - Shifting decisions to the intelligent entities/agents
  - Distributed analytics
- Data Pipelines & Repositories: flowing the data and actions from sources to destinations



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