

# **Edge Computing, 5G and 6G**

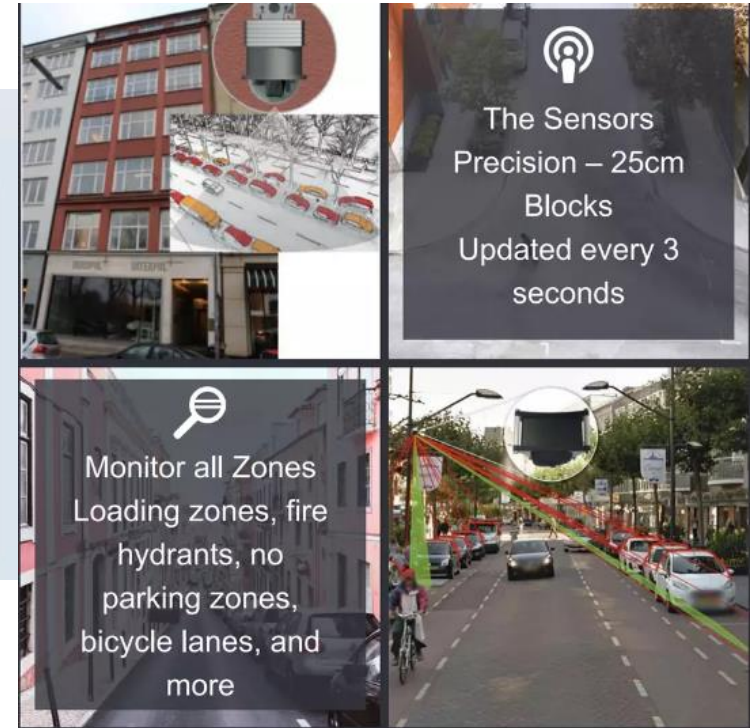
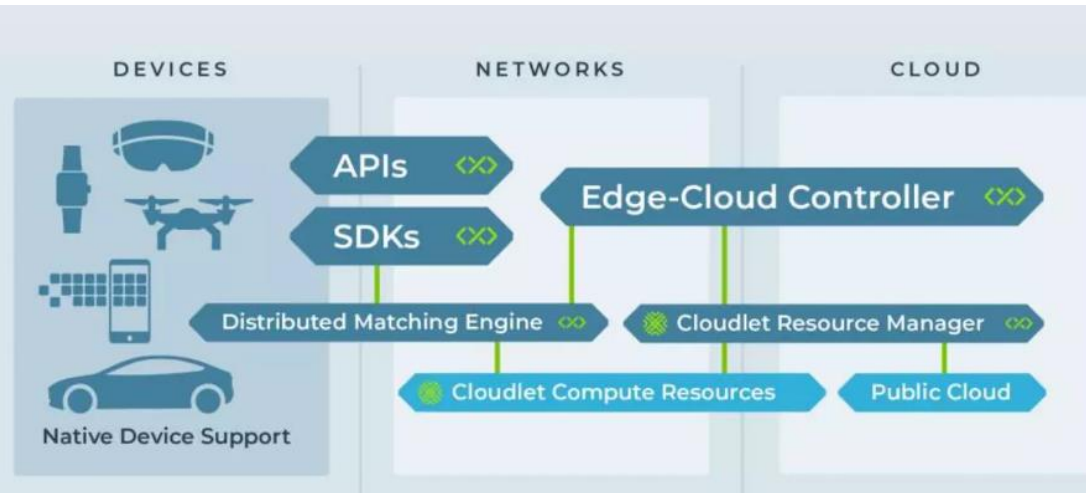
**Mestrado em Engenharia de  
Computadores e Telemática**

**2022/2023**

# Mobile Edge Computing (MEC)

- Concept in 5G
- Brings the cloud closer to the network edge
- Opens the edge for applications from 3<sup>rd</sup> parties
- Provides services to enhance applications with context information (network information, location)
- Traffic redirection
- Ultra-low latency
- Facilitates running applications at the right location and at the right time
- Different IoT solutions have different network requirements
  - Autonomous vehicles and medical equipment with strong latency requirements with critical decisions
  - Edge computing to enable strong processing and decisions near the needs of the reactions

# Simplified MEC vision

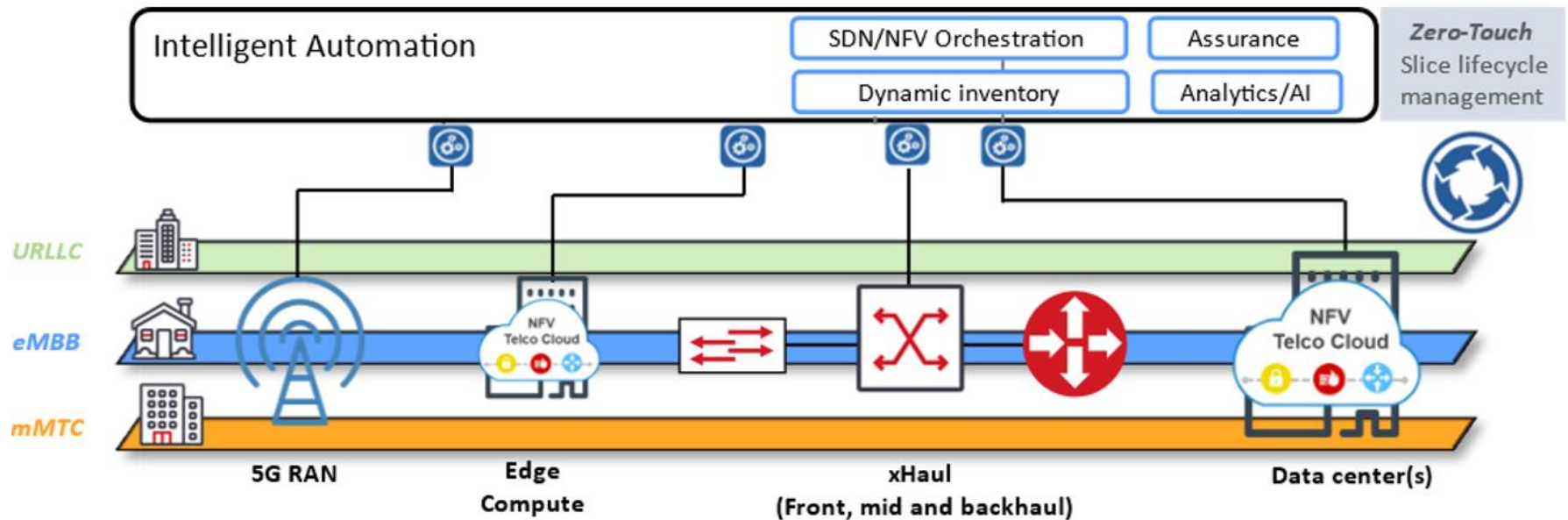


- iPhone security
  - Host sensitive biometrics or encryption information on user device and not in the cloud
  - Does not need to handle user security information
- AWS DeepLens
  - Camera with Linux OS, machine learning in the device
  - Near-time set of intelligence tools integrated into APIs

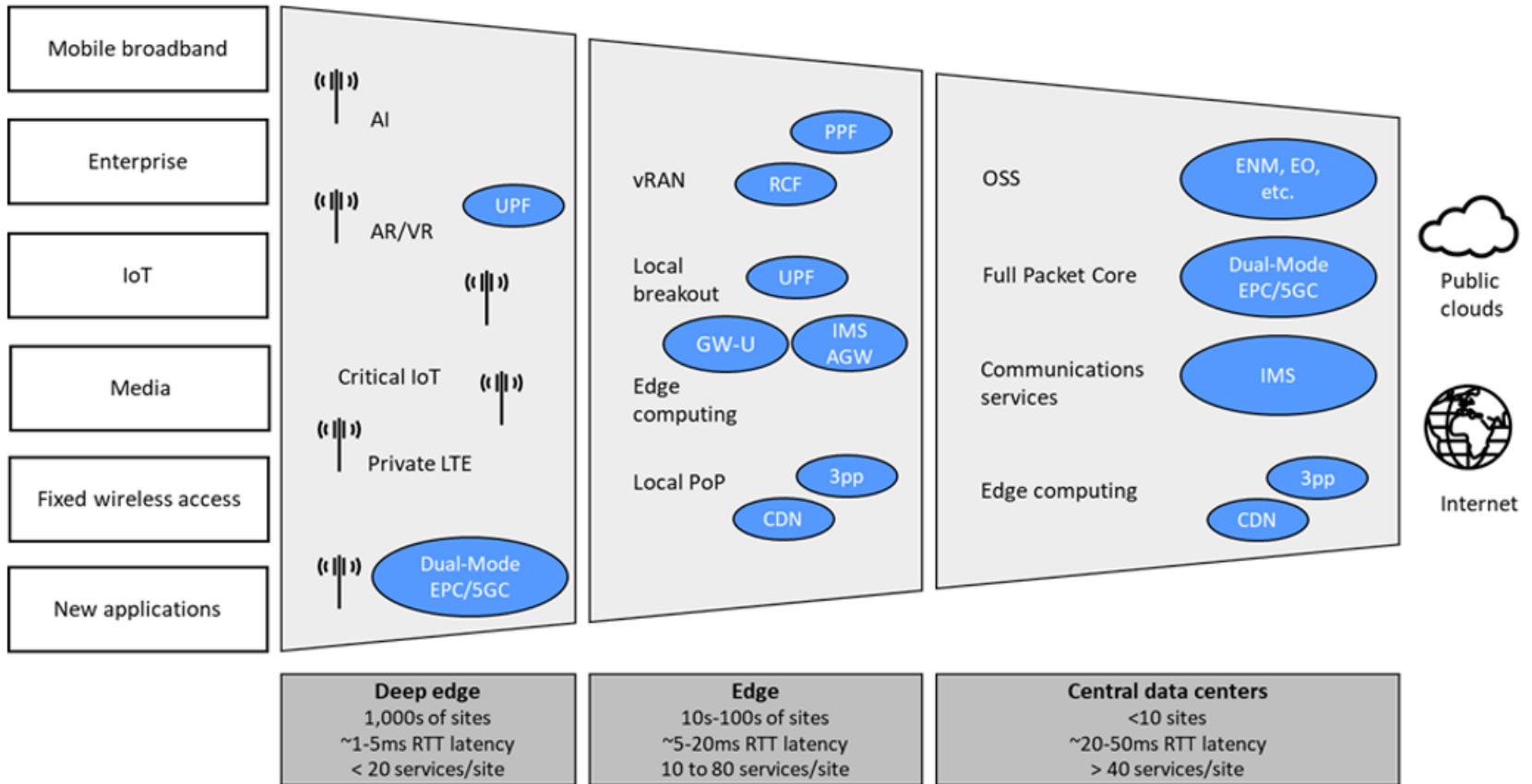
# Edge and Cloud

- Edge computing devices depend on network access to the cloud to receive machine learning and complex event processing models
- They also need to send sensors and status data back to the cloud
- Strong bandwidth requirements → 5G to 6G
- Low latencies
- Massive amounts of nodes

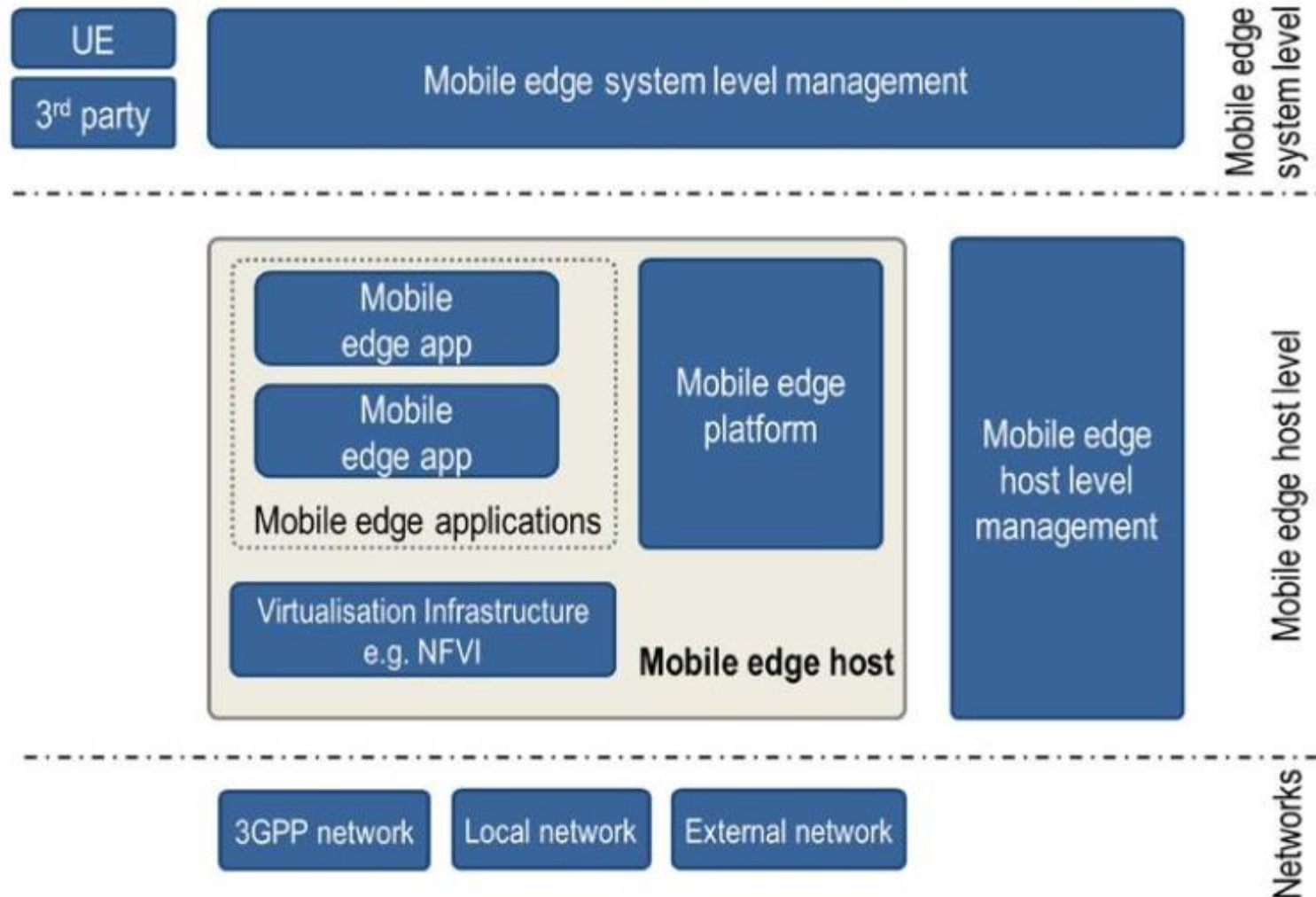
# Distributed intelligence and 5G



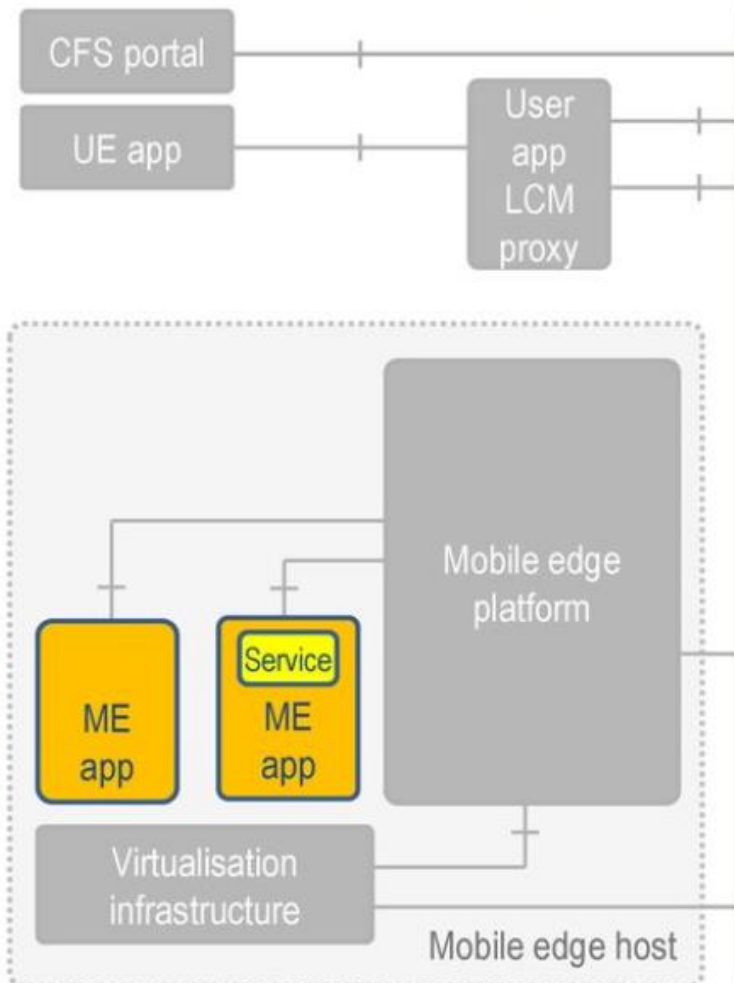
# Distributed Edge and 5G



# 7 Edge Computing: ETSI MEC Reference Architecture



# MEC: Mobile Edge Apps



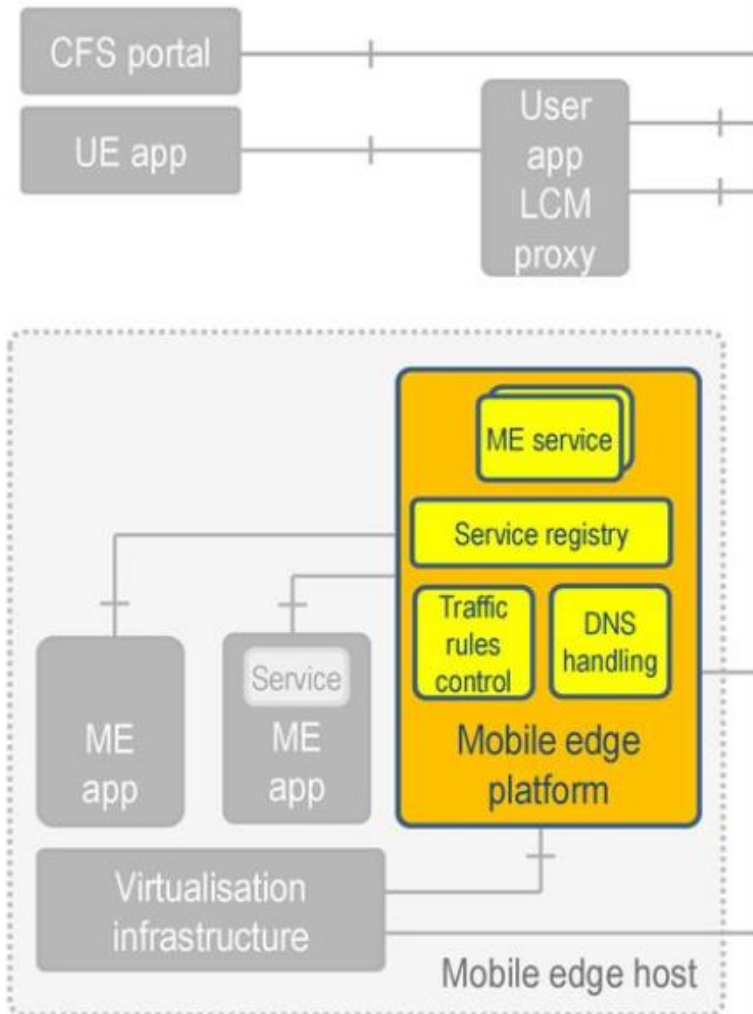
## Mobile edge applications:

- Run as virtual machines
  - Typically consume, but may also provide mobile edge services
  - May provide information to aid the lifecycle management (e.g. indication of availability)
  - Have associated rules and requirements and rules regarding:
    - DNS configuration and traffic redirection (originate/inspect/modify)
    - Compute/ Storage/Networking resources, maximum latency, required services
- The rules and requirements are validated by mobile edge system level management
- Assisted by mobility information may relocate user state
  - If supported, may be relocated to another mobile edge host

**Examples: handover, caching, ML processing, video processing, etc.**



# MEC: Mobile Edge Platform



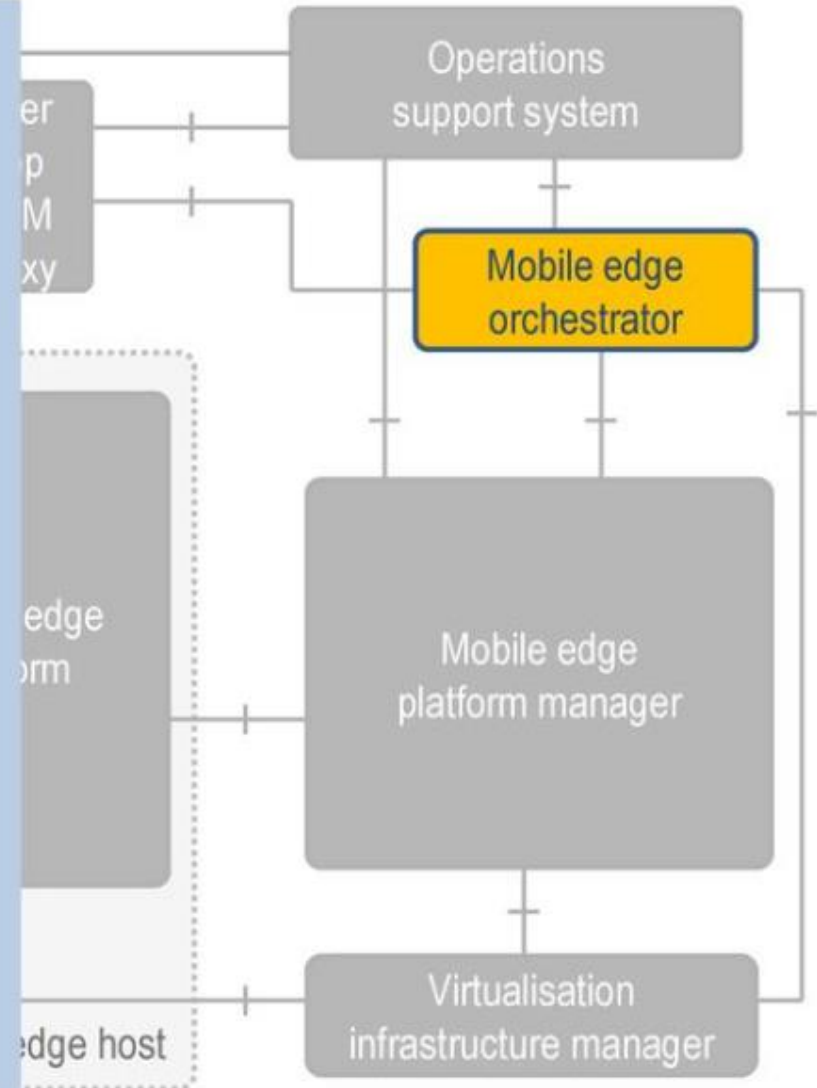
## Mobile edge platform:

- An environment where applications can discover, advertise, consume and offer mobile edge services
- Controls data-plane in the virtualization infrastructure ("SDN") based on traffic rules
- Configures DNS proxy/server based on DNS records from the mobile edge platform manager
- Provides mobile edge services. May also consume mobile edge services provided by the applications
- Provides access to persistent storage and time of day information

# MEC: Mobile Edge Orchestrator

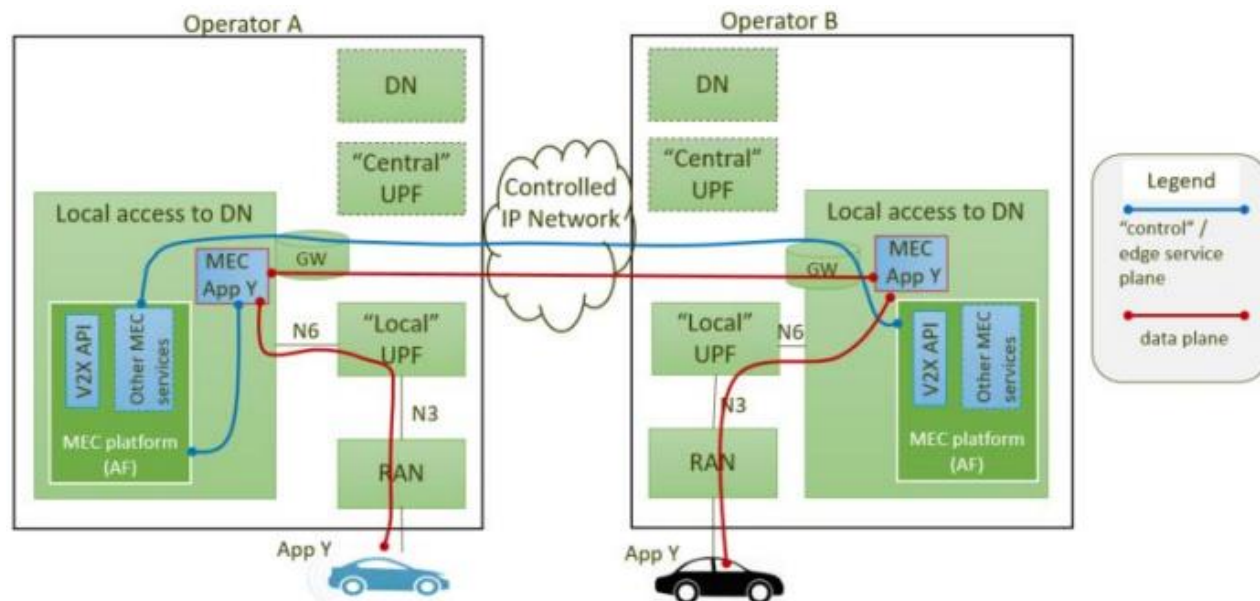
## Orchestrator:

- Maintains an overall view of the system and mobile edge hosts, available resources, available services and topology
- On-boards application packages, including
  - an integrity check and authenticity
  - validation of the application rules and requirements; if necessary adjusts them to comply with operator policies
  - Maintenance of a record of on-boarded packages
  - Preparation of the virtualization infrastructure manager(s) to handle the apps
  - Selection of the appropriate host for the application, satisfying its rules and requirements
- Triggers application instantiation and termination
- Optionally, triggers application relocation



# Examples using Edge Computing

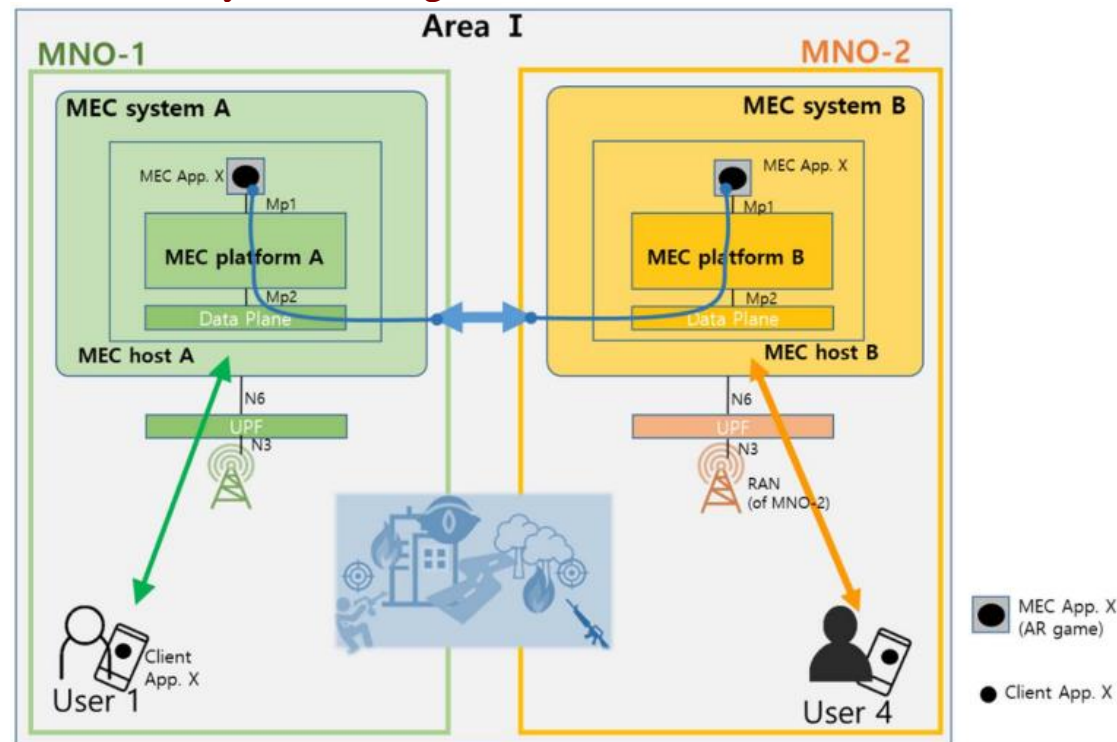
- A V2X application instance may be running on a car connected to MNO 1 which is equipped with a MEC system from vendor 1, and communicating with another V2X application instance, running on a second car connected to MNO 2, which, in its turn, is equipped with a MEC system from vendor 2.
- V2X service is implemented with two instances of the "MEC App Y", each of which communicates with its corresponding Client App, i.e. "App Y", and is also connected with a MEC platform in each respective MEC system (domain).



# Examples using Edge Computing

- MEC is envisioned as a promising means to deliver better Quality of Experience (QoE) for immersive AR applications
  - Reduces the delay
  - Addresses computation-intensive and battery-consuming tasks offloaded from the mobile devices.

2 MEC application Xs, instantiated on MEC hosts of MEC system A and MEC system B respectively, communicate and coordinate together for synchronizing the game scenario. Information to be exchanged between the two MEC applications for coordination mostly include users' game play actions such as players' position, movement, direction, game control and the status of game contents virtually created.

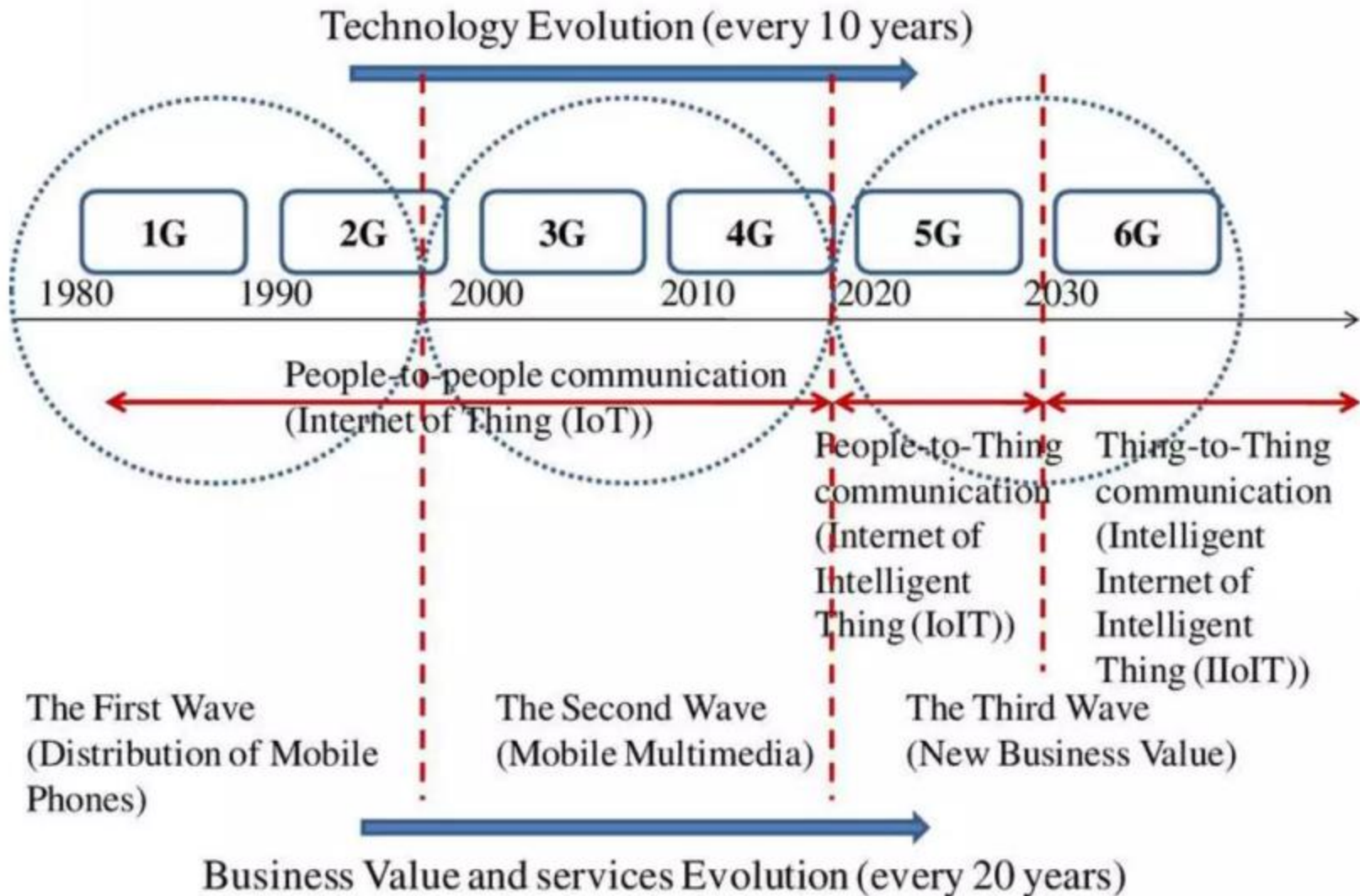


# MEC future

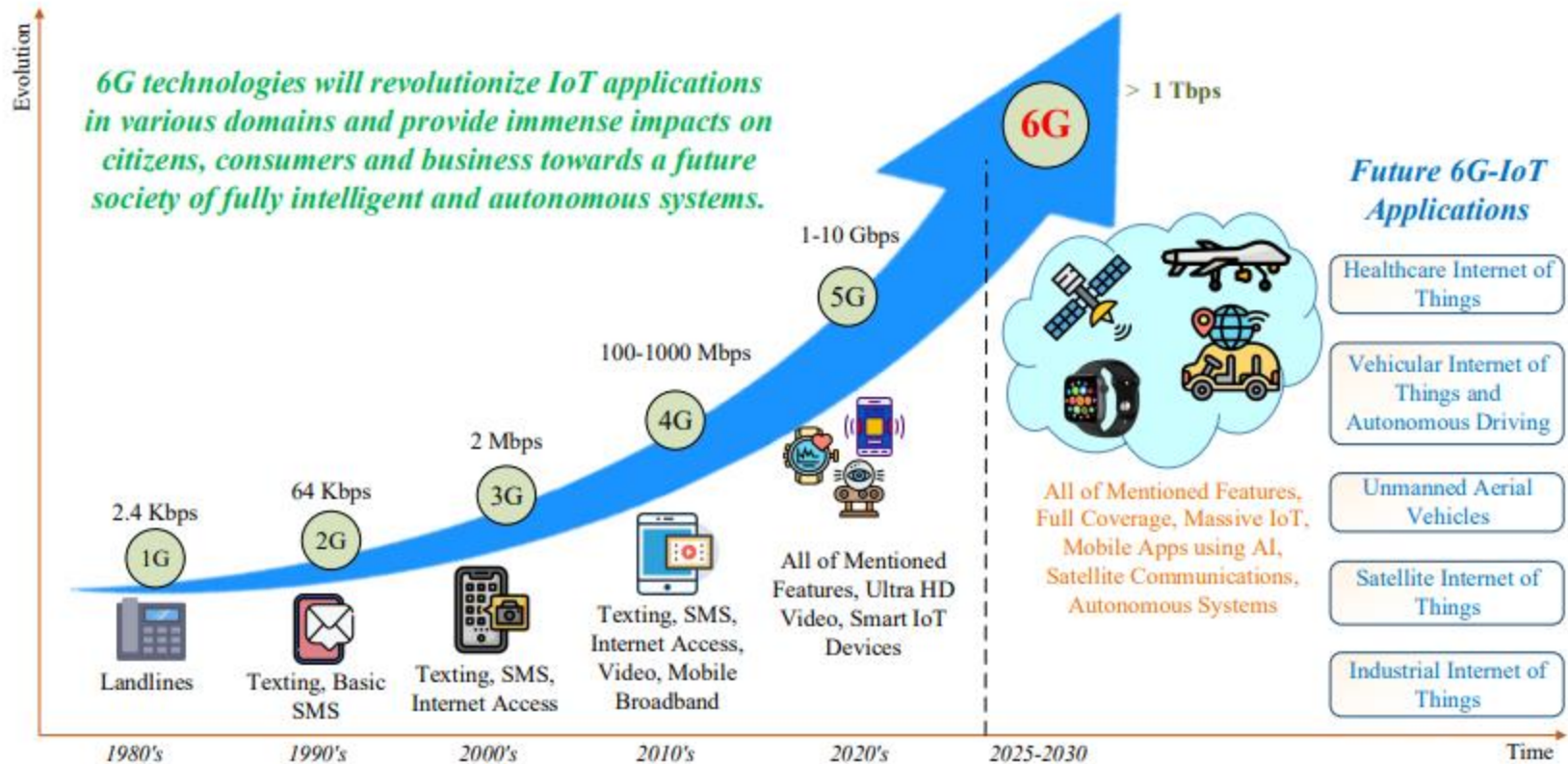
- MEC is identified as a key enabler for IoT and mission critical vertical solutions
- Key architectural concept and technology for 5G
- Enables applications to be deployed and run in a virtualized environment
  - Services orchestrated and instantiated on demand where needed
- Myriad of different scenarios: health, industry, IoT, automotive, environment, etc
  - Change the application deployment
- Enabled autonomous networks and systems!



# What about 6G?



# What about 6G?



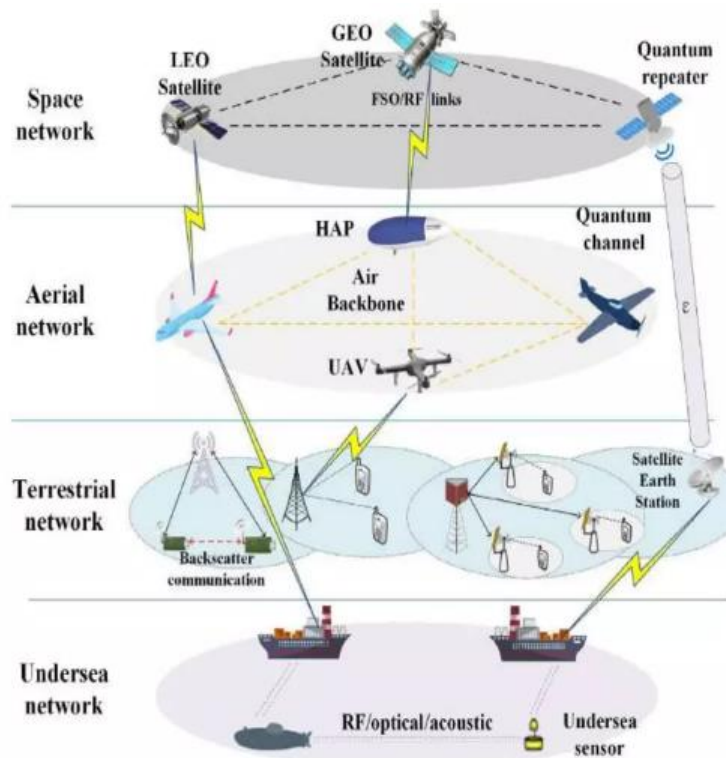
# 6G: self-organization, p2p relationships

## 6G networking and connectivity

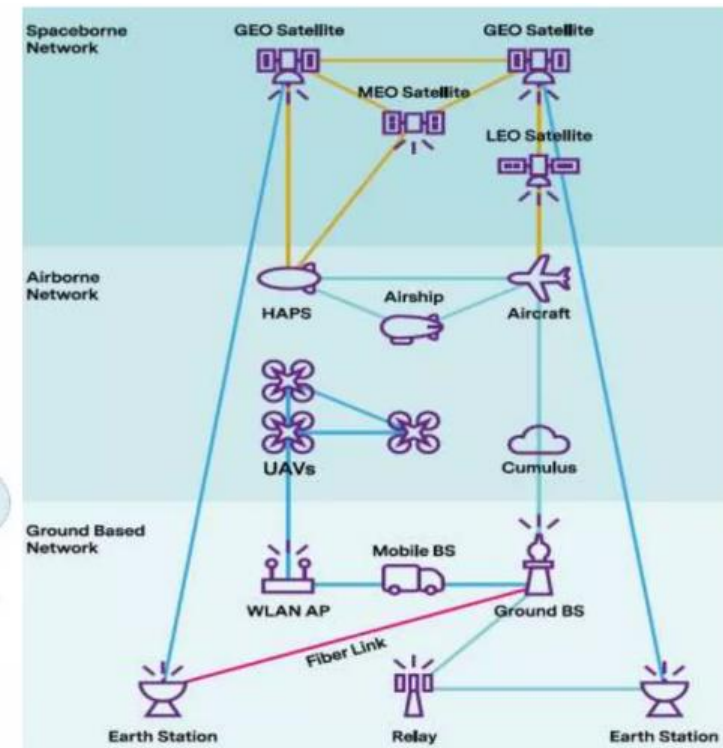
### Integrated Space Aerial, Terrestrial and Undersea Network

Ubiquitous 3d coverage

LEO- Low Earth Orbit  
MEO- Medium Earth Orbit  
GEO- Geostationary Earth Orbit  
HAP- High Altitude Platforms  
UAV- Unmanned Aerial Vehicle



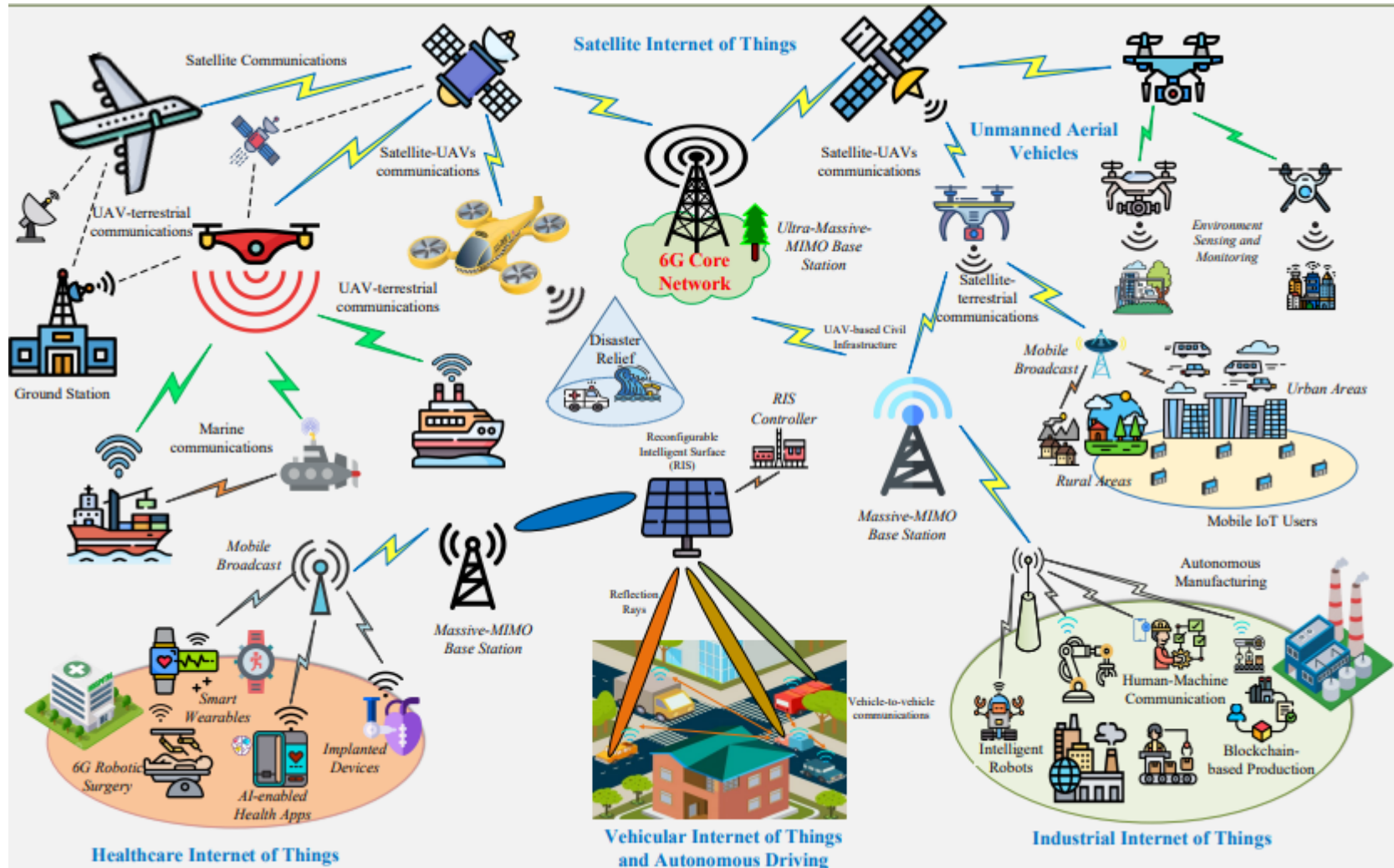
Source: T.Huang, et al., "A Survey on Green 6G Network: Architecture and Technologies", IEEE Access, VOLUME 7, 2019, <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8922617>



Source: 6G FlagShip, "WHITE PAPER ON BROADBAND CONNECTIVITY IN 6G", 6G Research Visions, No. 10 June 2020, Univ. of Oulu



# 6G in a 3D space



- [https://www.etsi.org/deliver/etsi\\_gr/MEC/001\\_099/035/03.01.01\\_60/gr\\_mec035v030101p.pdf](https://www.etsi.org/deliver/etsi_gr/MEC/001_099/035/03.01.01_60/gr_mec035v030101p.pdf)
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