Edge and Fog Integration for future 5G communication networks

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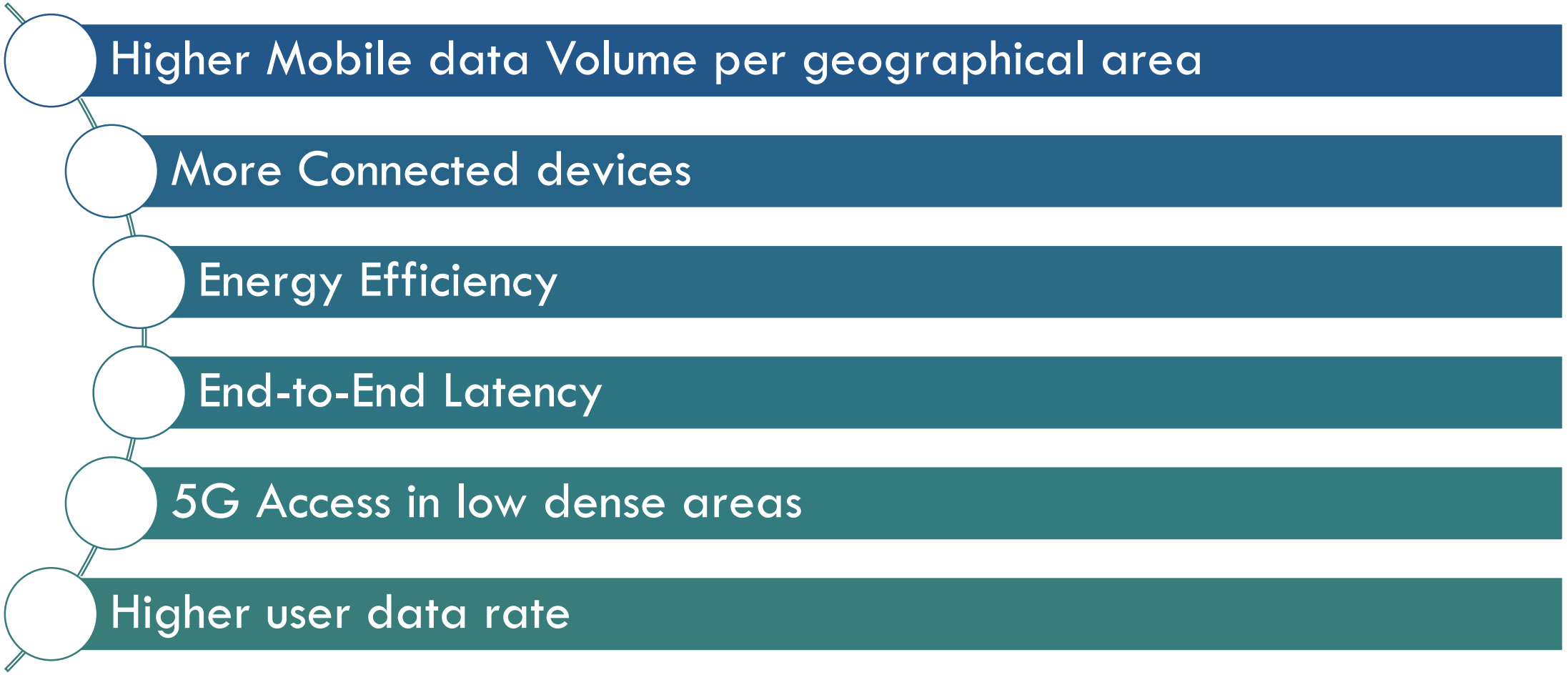
5G-Challenges in terms of KPIs



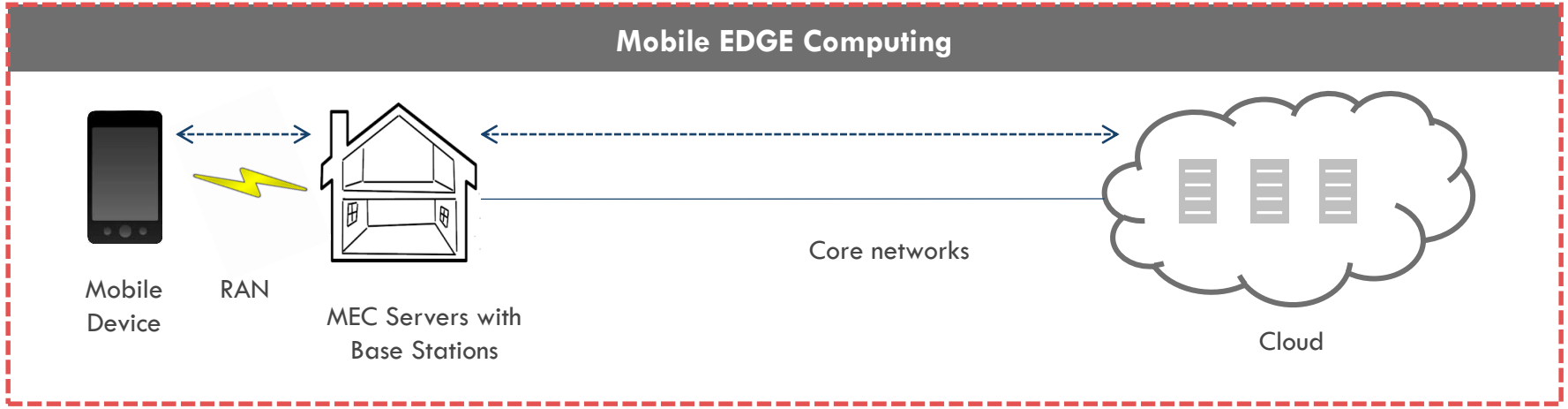
Source: https://5g-ppp.eu/kpis/

Mobile Edge Computing – Overview

MEC brings computing and IT capabilities closer to user.

- Mobile edge computing provides IT and cloud-computing capabilities within the Radio Access Network (RAN) in close proximity to mobile subscribers.
- The aim is to reduce latency, ensure highly efficient networks operation and service delivery and offer an improved user experience.
- With MEC, mobile device can offload computing tasks to MEC servers and fetch contents from MEC servers via RAN instead of doing such jobs to/from cloud servers via RAN and Core networks.

- Key Characteristics
  - On premises
  - Proximity
  - Lower Latency
  - Location Awareness
  - Network context information



Mobile Edge Computing – Overview

A variety of requirements are the reason for the existence of Mobile Edge Computing.

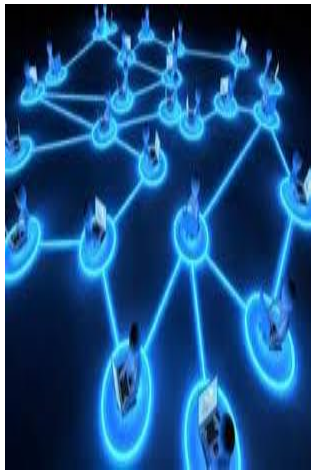
Real-Time	Interactive	Private	IoT	Data and compute heavy
Lowest application latency end-to-end, for a real time user experience or critical communications	Maximum transaction rate between device and cloud for an interactive user experience	Local communications for robust performance, privacy, and security	Real time insights from data exploited at the point of capture, minimum cloud ingress bandwidth	Local compute and storage for most demanding workloads to go mobile





Mobile Edge Computing – Overview

MEC integrates with a number of technologies leading to a scenario of mutually enforcing adoption.



Network Virtualization

Implementation of SDN and NFV will reduce the barriers to entry for MEC.
NFV application in radio access network (RAN) is important.

Small Cells and Heterogeneous networks

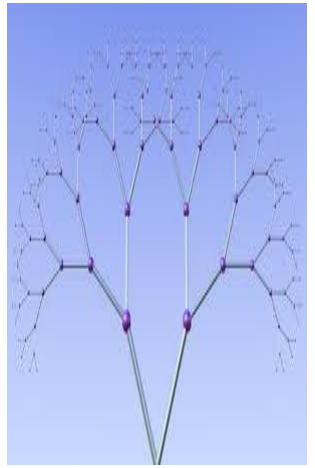
MEC allows customized services in various use cases such as enterprise and venue applications ex. Shopping malls, stadiums.

IoT Connectivity

Industrial internet allows support for lower cost devices that packs less processing than otherwise required resulting in lower latency and faster response.

Slicing

A technology that provisions instances of the network to serve application with specific performance criteria.



Fog Computing - Overview

Fog Computing is a term defined by cisco that refers to extending Cloud computing to the edge of an enterprise's network.

Fog computing extends cloud computing model closer to the edge of the network.

Fog Computing can be defined as

Fog computing can be defined as:

- An alternative to cloud computing that puts transactions and resources at the edge of the network, rather than establishing channels for cloud storage and utilization.
- Fog computing reduces the need for bandwidth by not sending every bit of information over cloud channels and instead aggregating it at certain access points, such as routers.
- Fog computing facilitates the operation of compute, storage and networking services between end devices and cloud computing data centers.

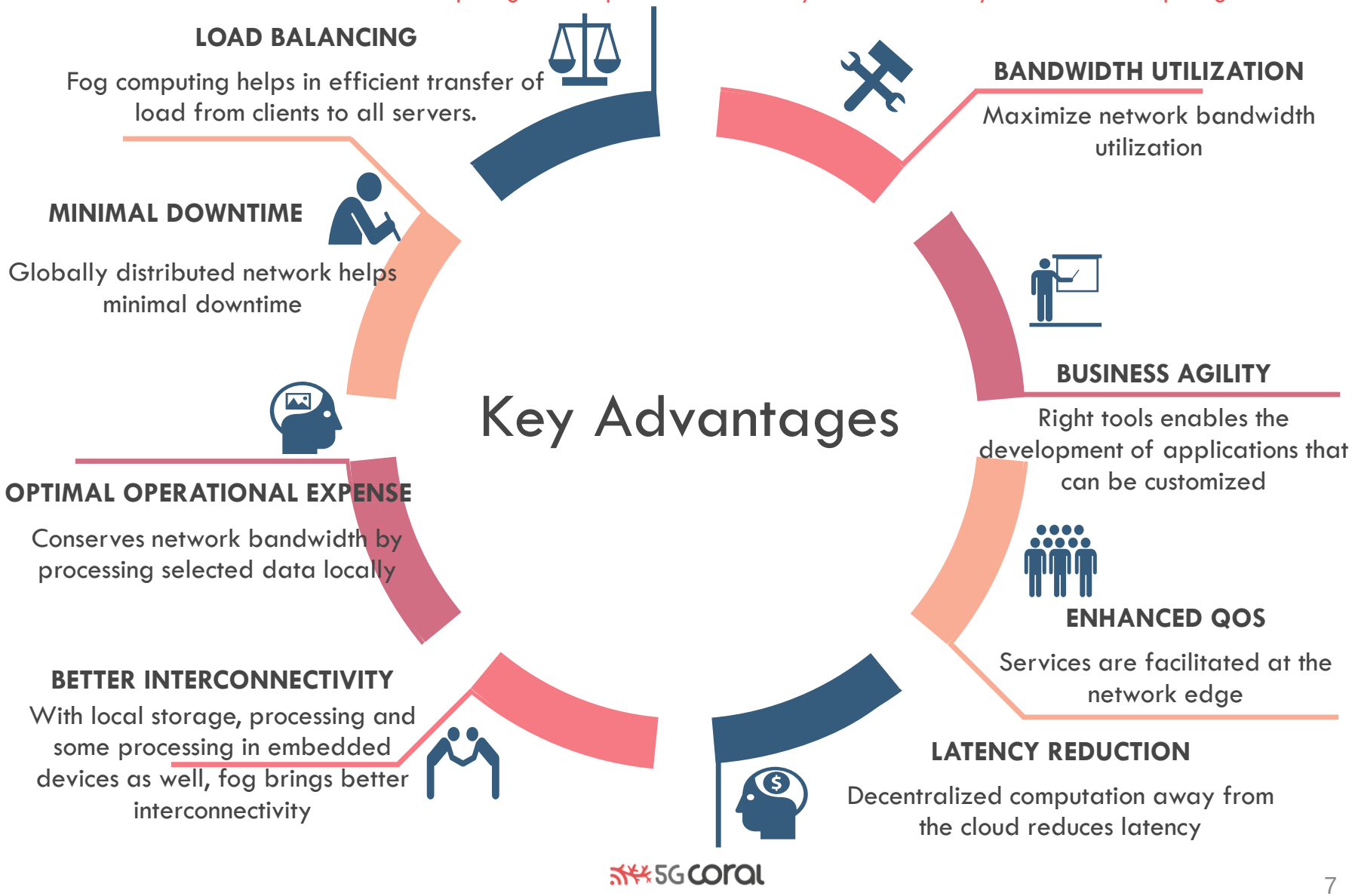
OpenFog Consortium defines Fog Computing

Fog computing is a system-level horizontal architecture that distributes resources and services of computing, storage, control and networking anywhere along the continuum from Cloud to Things.

- **Horizontal architecture:**
  Supports multiple industry verticals and application domains, delivering intelligence and services to users and business.
- **Cloud-to-Thing continuum of services:**
  Enables services and applications to be distributed closer to things, and anywhere along the continuum between Cloud and Things.
- **System-level:**
  Extends from the Things, over the network edges, through the Cloud, and across multiple protocol layers – not just radio systems, not just a specific protocol layer—not just at one part of an end-to-end system, but a system spanning between the Things and the Cloud.

Fog Computing - Overview

Fog Computing addresses several limitations of the cloud computing and helps to boost usability and accessibility in different computing environments.



MEC Vs Fog Computing

Though MEC and Fog computing sounds quite similar as they bring data-centre capabilities to the edge of the networks, there are few key distinctions between them.

Multi-access Edge Computing	Vs	Fog Computing
Edge Computing primarily relies on separate nodes that do not form a network		Fog computing has a hierarchical and flat architecture with several layers forming a network.
Edge Computing runs its nodes in silos, requiring data transport back through the cloud for peer-to-peer traffic.		Fog computing has extensive peer-to-peer interconnect capability between nodes.
MEC standards are largely compute oriented		OpenFog Consortium's reference architecture also embraces storage and deep packet networking.
MEC focuses on single layer of nodes in the RAN or base transceiver station (BTS)		Fog computing offers a deeper hierarchy
Deployment strategy: One or More Servers sitting behind the base station. Controlled by an Operator		Deployment Strategy: Distributed computing beyond the base station Controlled by private networks

Source: OpenFog Consortium

Why do we need to integrate edge and fog?

NEED of an Edge and Fog Computing System (EFS)

- Tight coordination/integration between Operator's and Private network
- Connection density
- Low latency communication
- Increase spectrum efficiency
- Enhance mobility
- Fleet management
- Higher throughput
- Context awareness
- Vehicle to anything (V2X)
- So on..

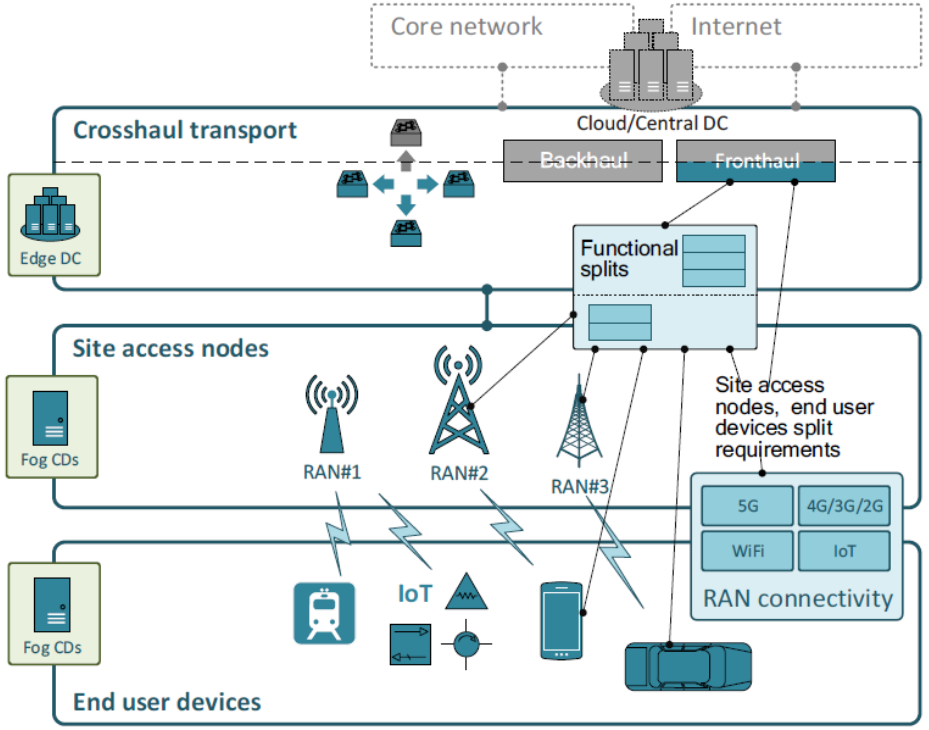
Edge and Fog (EFS) Integration

- MEC: Centralized computing architecture with aim to build dedicated cloud infrastructure closer to the end users, e.g., Telecom Central Offices
- Fog: Distributed Computing in diverse computing devices around the end-user

MEC V-RAN functions

Fog — Computing gears for different RATs, e.g., CDN functions

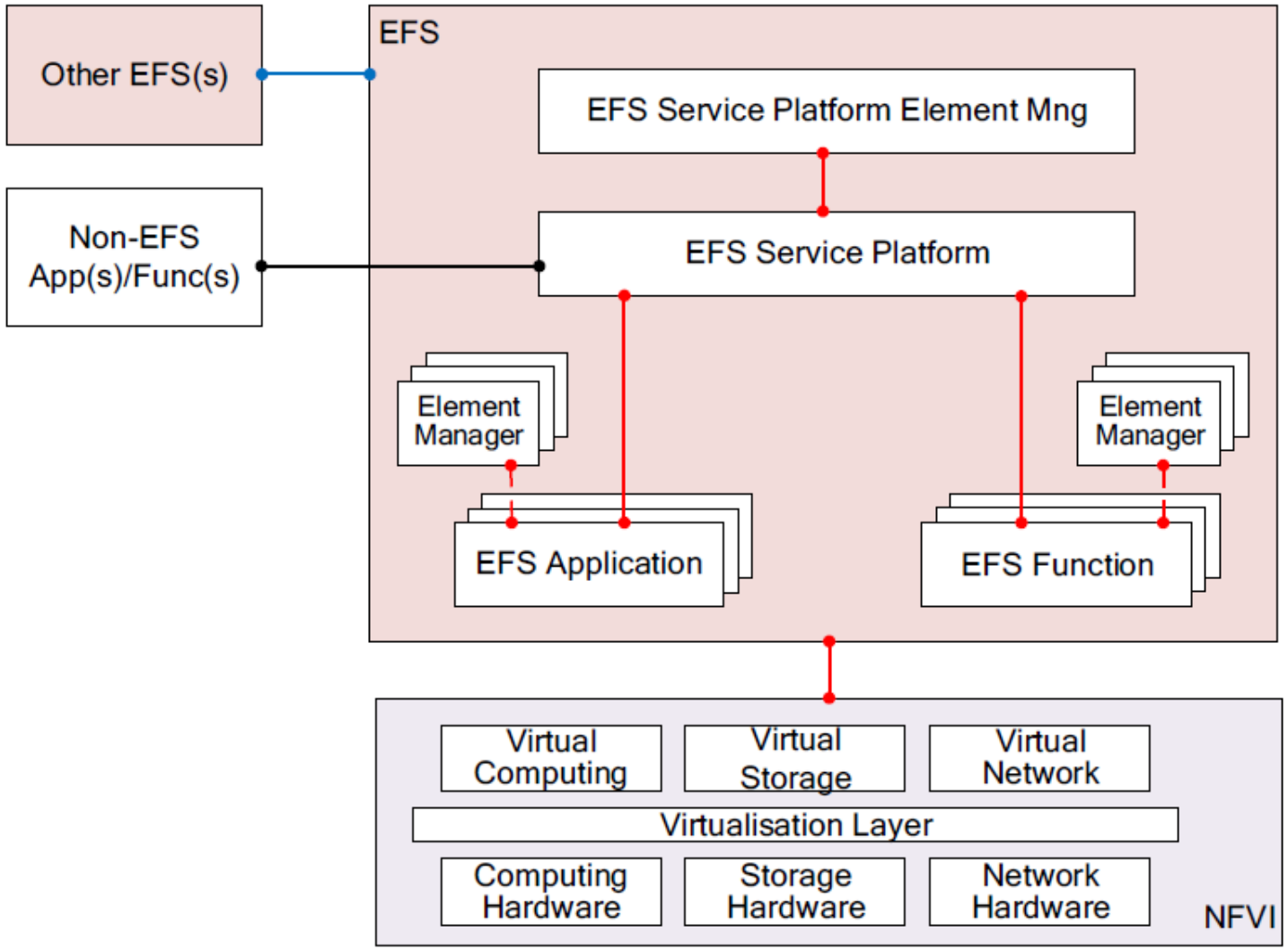
Fog — Small computing gears in connected cars, smart phones, Factories etc.



EFS Architecture

EFS is a logical entity, composed of

- Applications
- Functions
- Services

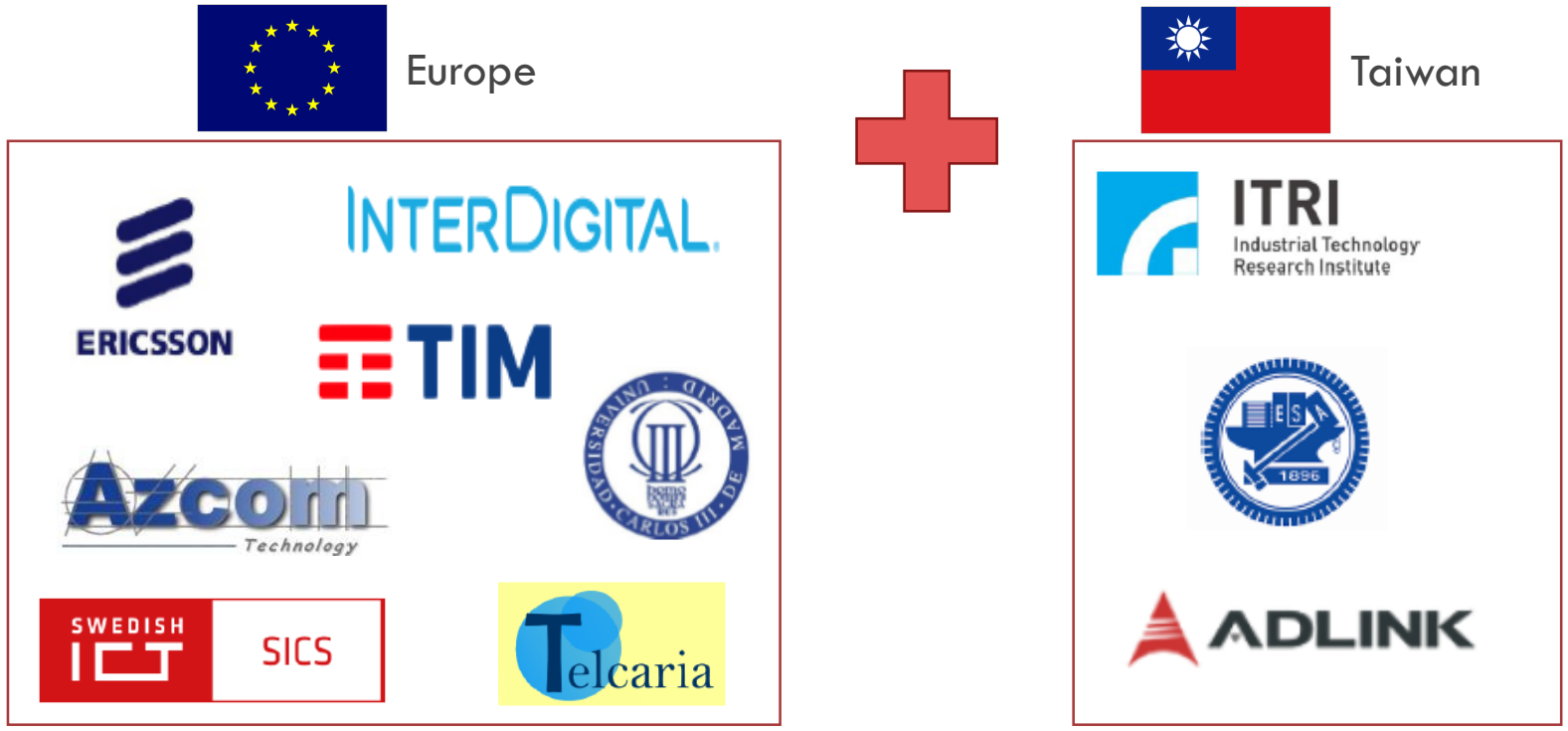


Technological Gaps and Challenges

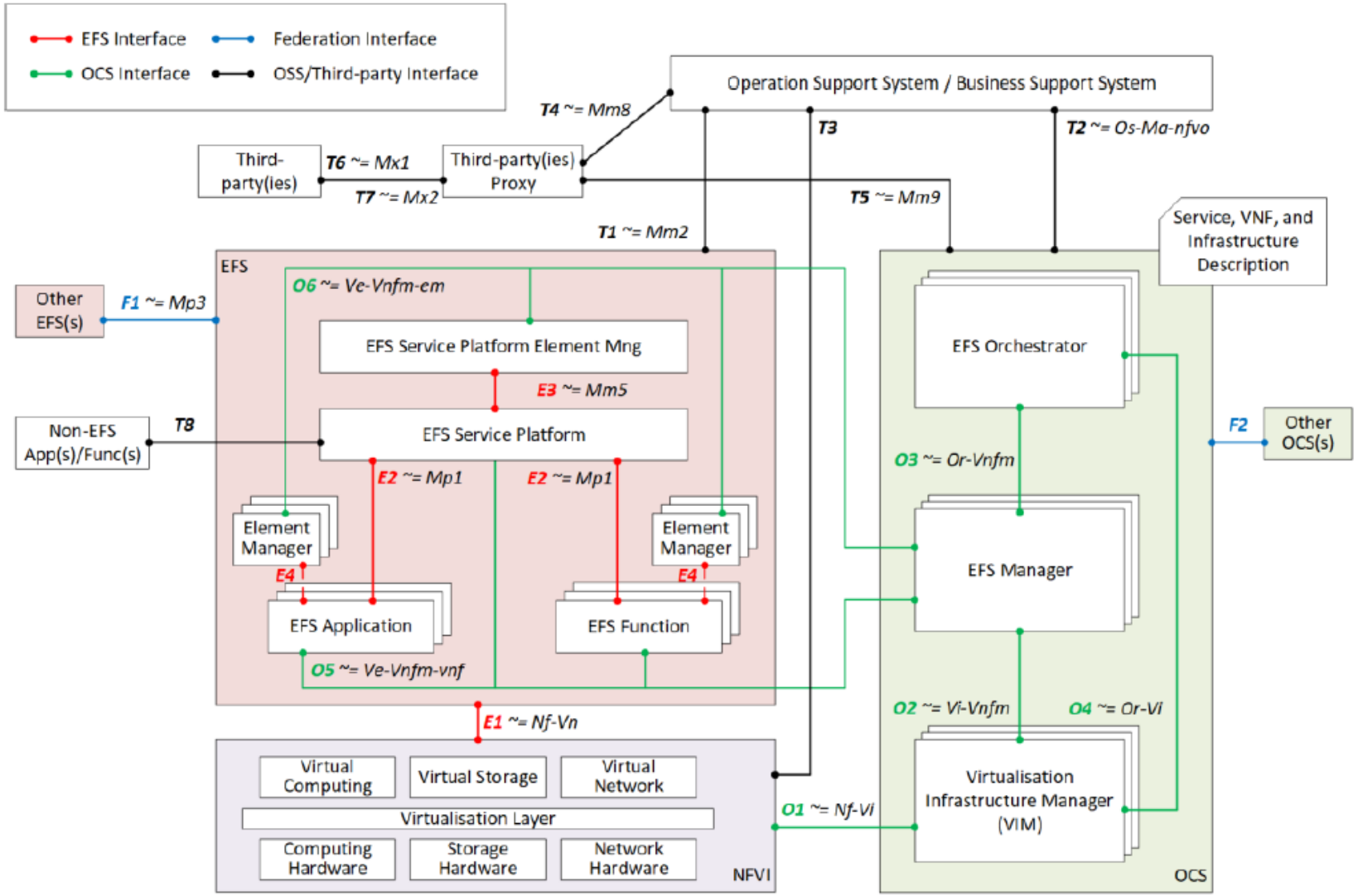
- Volatility of Resources
  - Operational interruptions
  - E.g., Connected vehicles, Smart Phone
- Heterogeneity of RATs
  - Extraction and exposure of context information from different RATs
  - Performance optimization of multi-RAT network and applications
- Applicability to Internet of Things
  - IoT gateway is simply an interface to the wireless environment.
  - Efficient architecture to meet performance requirements of the wireless protocols
- End User Terminal Virtualization
  - Computation Offloading 1)When 2) Where 3) What tasks?
  - Computation Offloading under what constraints (e.g., Security, Privacy, SLA(s))
- Security
  - Secure the APIs to third party developers i.e., EFS applications

5G-CORAL

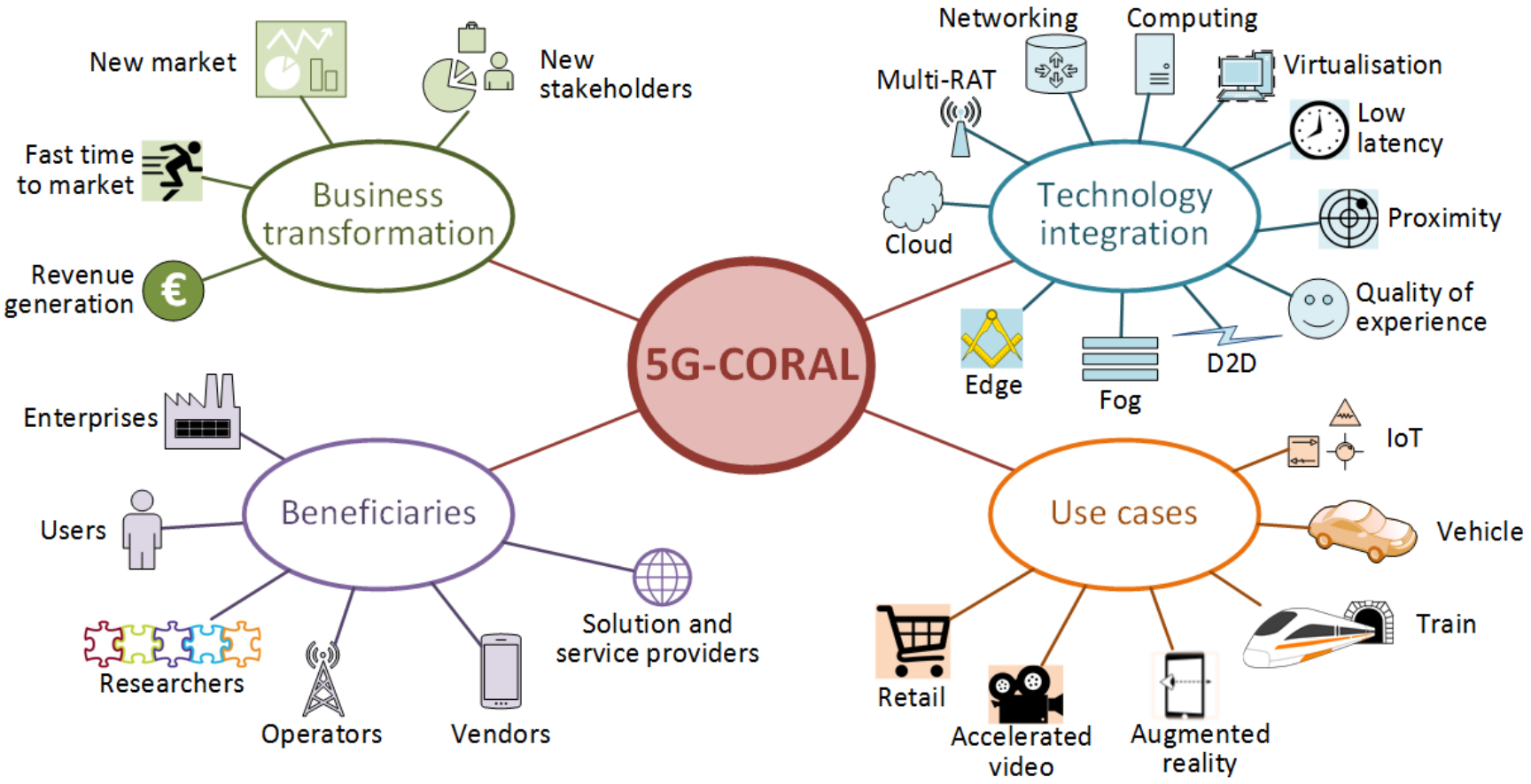
- A joint EU-Taiwan bid to the Research and Innovation Action H2020 ICT-08-2017, addressing 5G Convergent Technologies with focus on Access Convergence.



5G-CORAL Architecture



Impact on the Market



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Thank You

Q&A

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