Innovating at the Edge Meetups

Types of Edge Computing – Part 2 ETSI MEC Deployment Models

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Agenda

- Recap from Part 1
- ETSI MEC Introduction
- Overview of MEC deployments
  - MEC in 4G, 5G migrations phases, MEC in 5G Rel. 15, Rel. 17
- Examples of MEC deployments (V2X use cases)
- Ongoing Work and future directions
- Conclusion

Recap form Part 1

Types of Edge Computing – Architectural and Deployment Models

Edge Computing Types by Latency

TIERS	ON-PREMISE EDGE: INTELLIGENT SENSOR/GW	ON-PREMISE EDGE: INTELLIGENT EDGE	NETWORK EDGE	DC EDGE	PUBLIC CLOUD
NETWORK LATENCIES (Wire Round trip)	< 1ms	< 1ms	1-5ms	5ms + 1-2 ms (every 100kms)	5ms + 5 ms (every 400kms)
DEPLOYMENT REQUIREMENTS	**Compute Available Power:** < 50 W **Form Factor:** Small Box **Thermals:** NEBs **Mgmt.:** Remote	**Compute Available Power:** ~10KW **Form Factor:** Rack(s) **Thermals:** NEBS or Standard DC **Mgmt.:** Remote	**Compute Available Power:** <600 W **Form Factor:** Pizza box **Thermals:** NEBS **Mgmt.:** Remote	**Compute Available Power:** 9KW/rack 1KW sqm **Form Factor:** Rack(s) **Thermals:** NEBS or Standard DC **Mgmt.:** Remote	**Standard Data Center (DC)**

WHERE, WHAT & WHY

Intelligent Sensor/GW:

Use case	KPI
Intelligent Transportation	Data Privacy, Backhaul Traffic Savings, Reliability
V2V	Latency
Retail	Same as Int. Transp.
Video Analytics	Same as Int. Transp.

Intelligent Edge:

Use case	KPI
AR/VR	Latency. Backhaul Traffic Savings, Network scalability
Retail	Data Privacy, Backhaul Traffic Savings, Reliability
RT Streaming Healthcare	Same as AR/VR Access to services

Network Edge:

Use case	KPI
Intelligent Transportation	Data Privacy, Backhaul Traffic Savings, Reliability, throughput Latency
V2V	Latency
Video Analytics	Same as Int. Transp.
Drone/IoT	Same as Int. Transp.
Rural	Access to services

DC Edge:

Use case	KPI
Intelligent Transportation	Data Privacy
Video Analytics	Same as Int. Transp.
Drone/IoT	Same as Int. Transp.
Healthcare	Access to services
CDN & Storage	Backhaul traffic Savings Throughput
FaaS	Latency
AR/VR/MR	Latency

Public Cloud:

Use case	KPI
CDN	Backhaul Traffic Savings, Throughput
Storage GW	Same as CDN

Figure Source: https://networkbuilders.intel.com/solutionslibrary/composable-architectures-for-a-sustainable-edge

Access Edge

Transformation of Radio Access Network (RAN) into Disaggregated & Virtualized Functions

Utilize COTS Servers

Leverage Cloud-Native & DevOps Principles

O-RAN Ecosystem Gaining Traction

Manage RAN as IaaS or PaaS services

Leverage AI/ML to form the basis of connection management & data processing

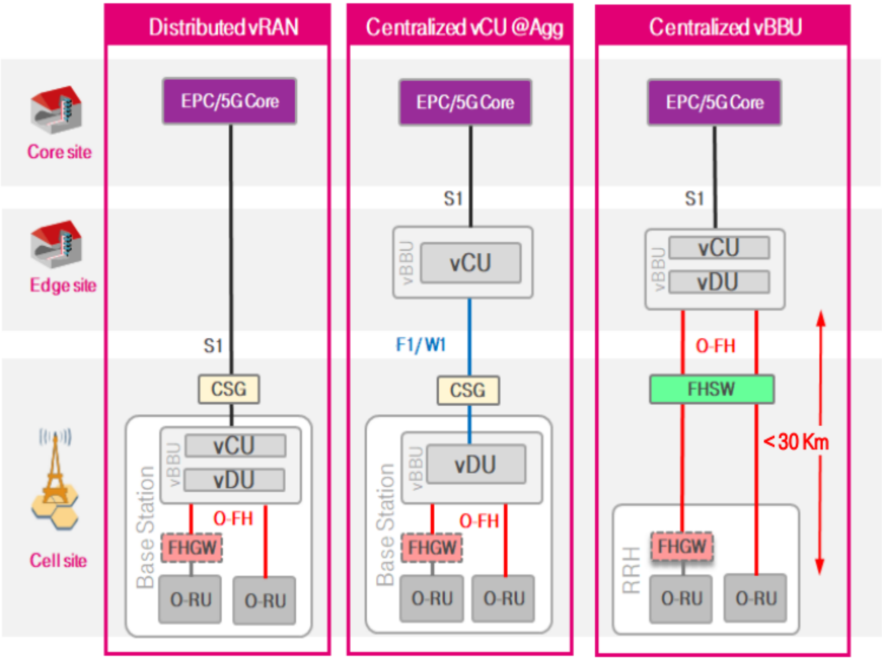


Figure Source: https://opennetworking.org/wp-content/uploads/2020/09/Petr-Ledl-Final-Slides.pdf

NOTE: Figure is showing example only. In practical cases, the edge deployment at S1 interface may come with multiple issues; many other alternative deployment options are possible (for more a detailed analysis see IEEE Tech Blog, Part 1 and Part 2)

How Does Everything Fit In?

- End-to-End view of IoT to Edge to Cloud Computing
- APIs play Crucial role in End-to-End Connectivity

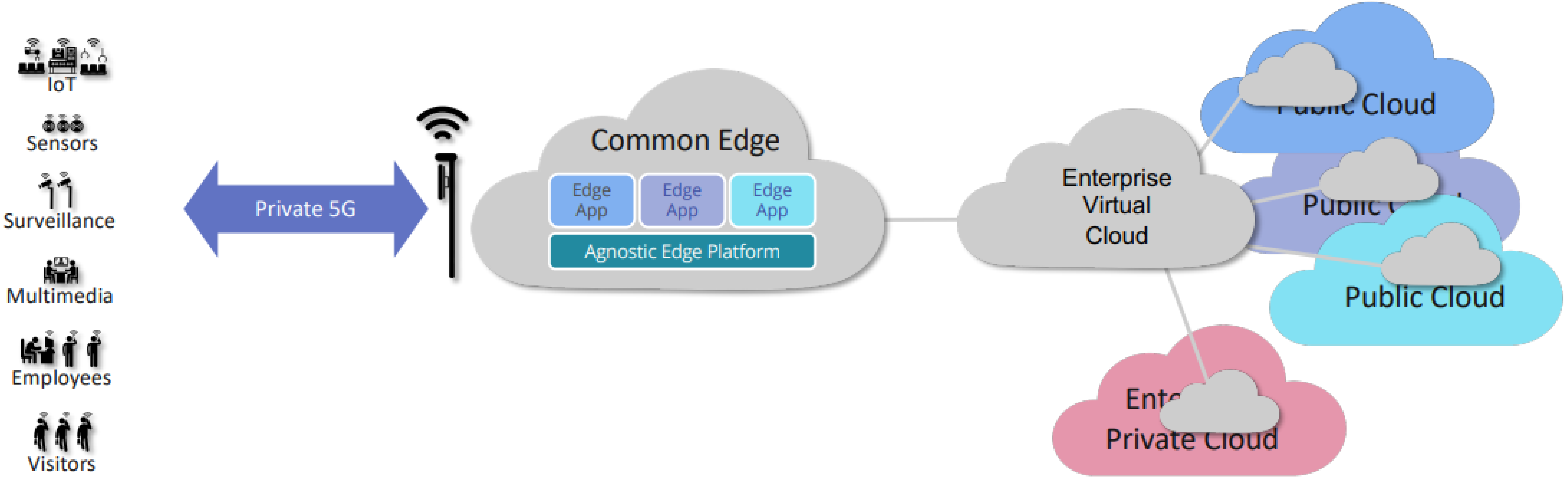


Figure Source: https://opennetworking.org/wp-content/uploads/2021/09/Enterprise-IoT-5G-Edge-Virtual-Cloud-v12.pdf

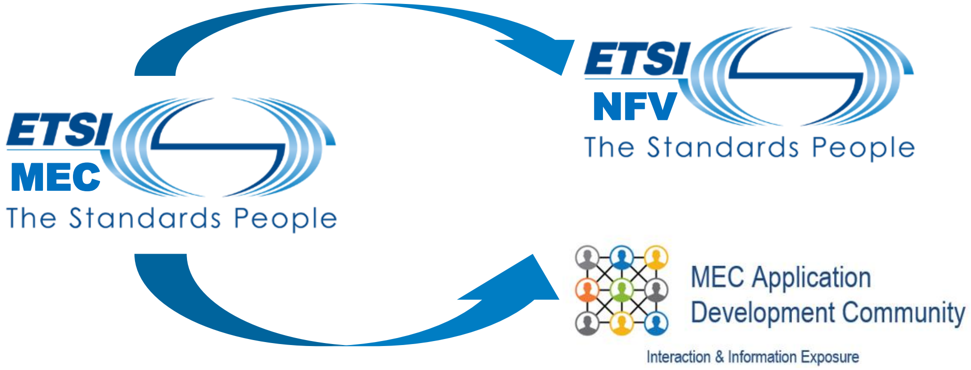
About – Dario Sabella

DARIO SABELLA works with Intel as Senior Manager Standards and Research, driving new technologies and edge cloud innovation for advanced systems, involved in ecosystem engagement and coordinating internal alignment on edge computing across standards and industry groups. In February 2021 has been elected as Chairman of ETSI MEC (Multi-access Edge Computing), while from 2019 he was serving as vice-chairman, previously Lead of Industry Groups, and from 2015 vice-chair of IEG WG. Since 2017 he is also delegate of 5GAA (5G Automotive Association) and Lead of gMEC4AUTO in 5GAA. Before 2017 he worked in TIM (Telecom Italia group), as responsible in various research, experimental and operational activities on OFDMA technologies (WiMAX, LTE, 5G). He is Innovation Manager at 6G Flagship EU project Hexa-X. Author of several publications (40+) and patents (30+) in the field of wireless communications, energy efficiency and edge computing, he has also organized several international workshops and conferences. Dario is IEEE Senior Member, recently appointed Senior Associate Editor of IEEE Consumer Electronics Magazine.

ETSI MEC Introduction

ETSI MEC – What we do

Foundation for Edge Computing created – Fully standardized solution to enable applications in distributed cloud created by ETSI MEC + 3GPP

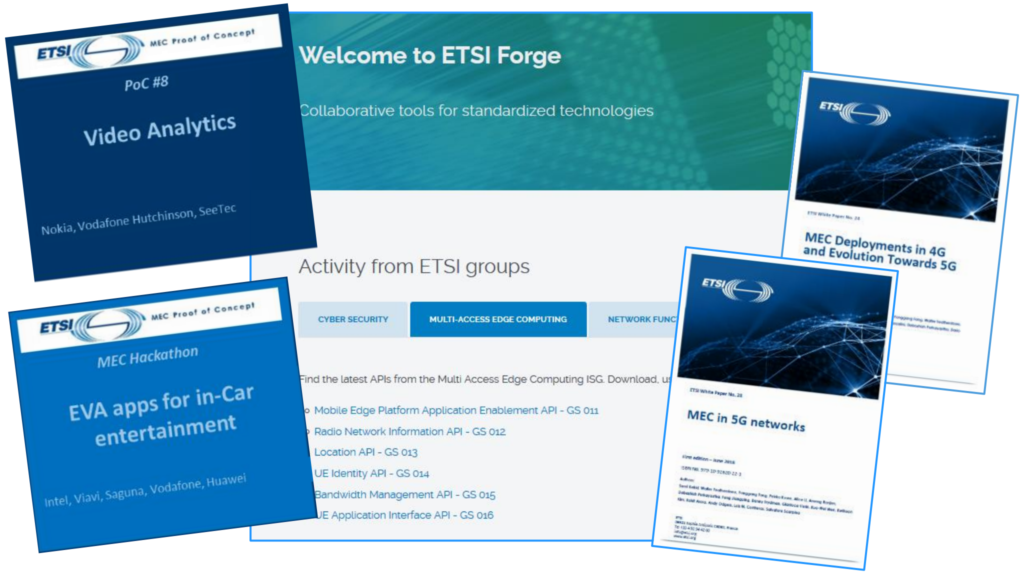


Application Life Cycle Management

RESTful based APIs for Runtime Application Services

Look at the new webpage with the **ISG MEC Leaders** and **Support Team**

https://portal.etsi.org/TB-SiteMap/MEC/MEC-Leaders-and-Support-Team



124 members - Operators – Technology Vendors – IT players – Application developers

ETSI MEC – Foundation for Edge Computing

MEC offers to application developers and content providers cloud-computing capabilities and an IT service environment at the edge of the network

Basic principles:

- *Open standard* → allowing multiple implementations and ensuring interoperability
- MEC exploiting ETSI *NFV framework* and definitions → enabling MEC in NFV deployments
- Alignment with *3GPP* based on fruitful collaboration of common member companies → enabling MEC in 5G
- Access-agnostic nature (as per MEC acronym - Multi-access Edge Computing) → enabling other accesses
- Addressing the needs of a wide ecosystem → enable multiple verticals (e.g. automotive), federations

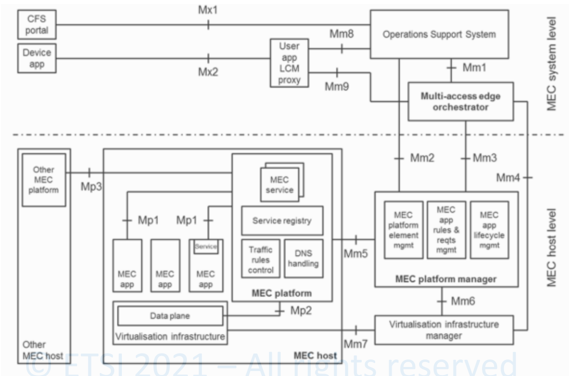
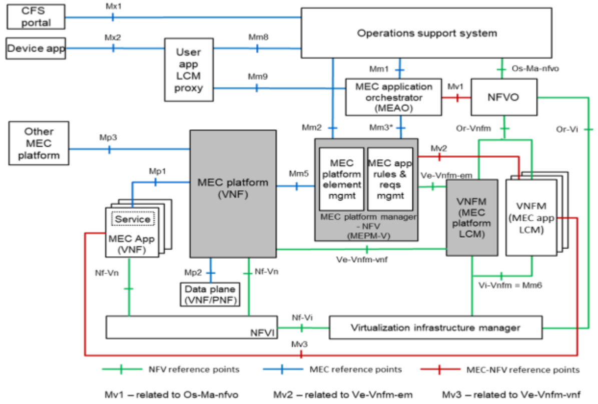
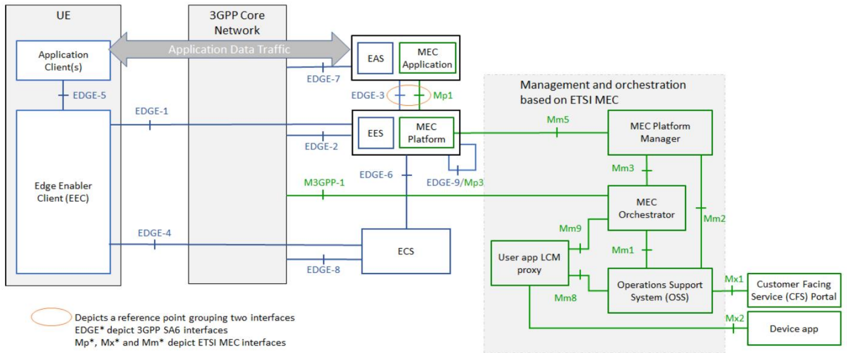
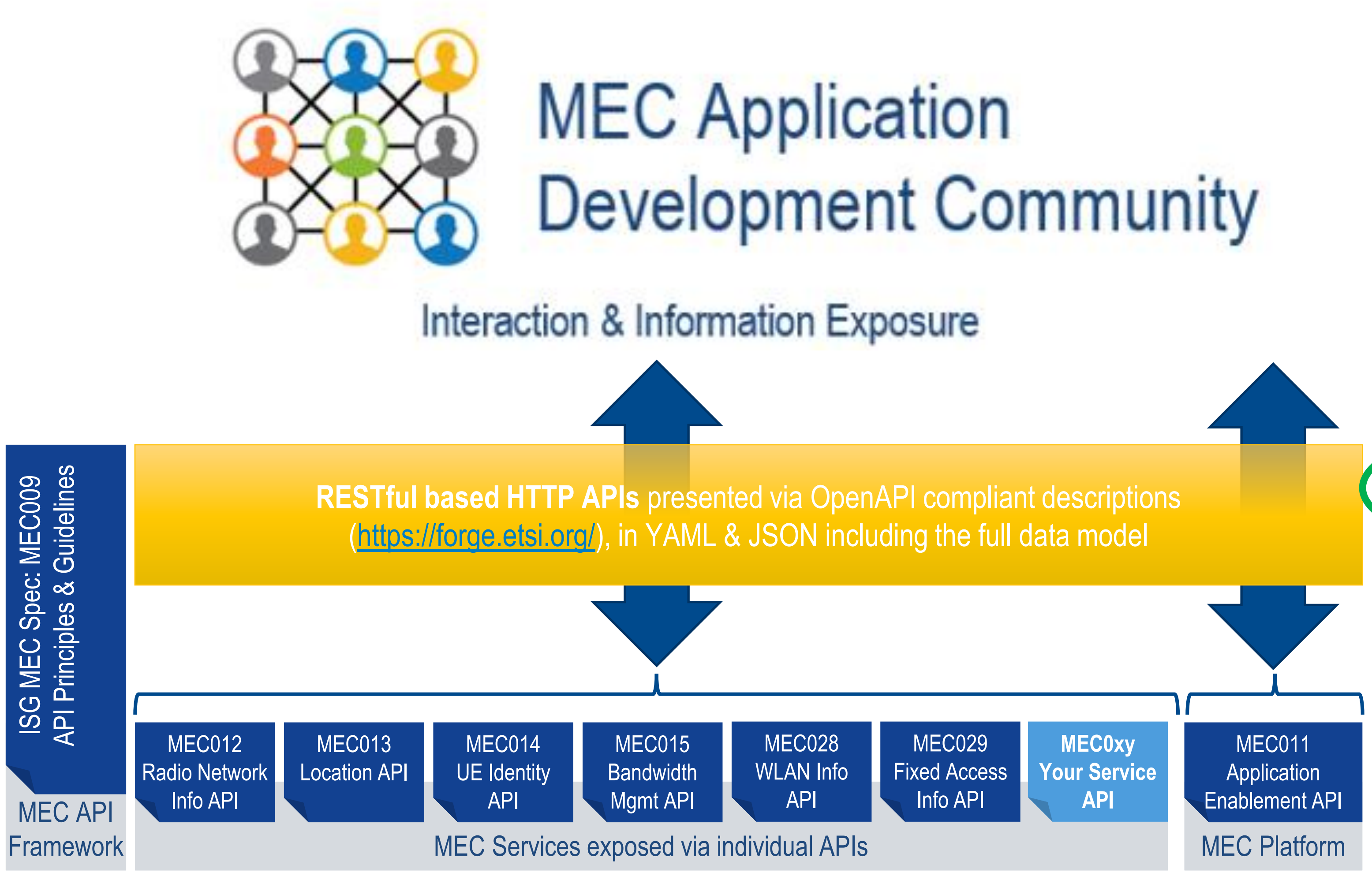


Figure 6-1: Multi-access edge system reference architecture





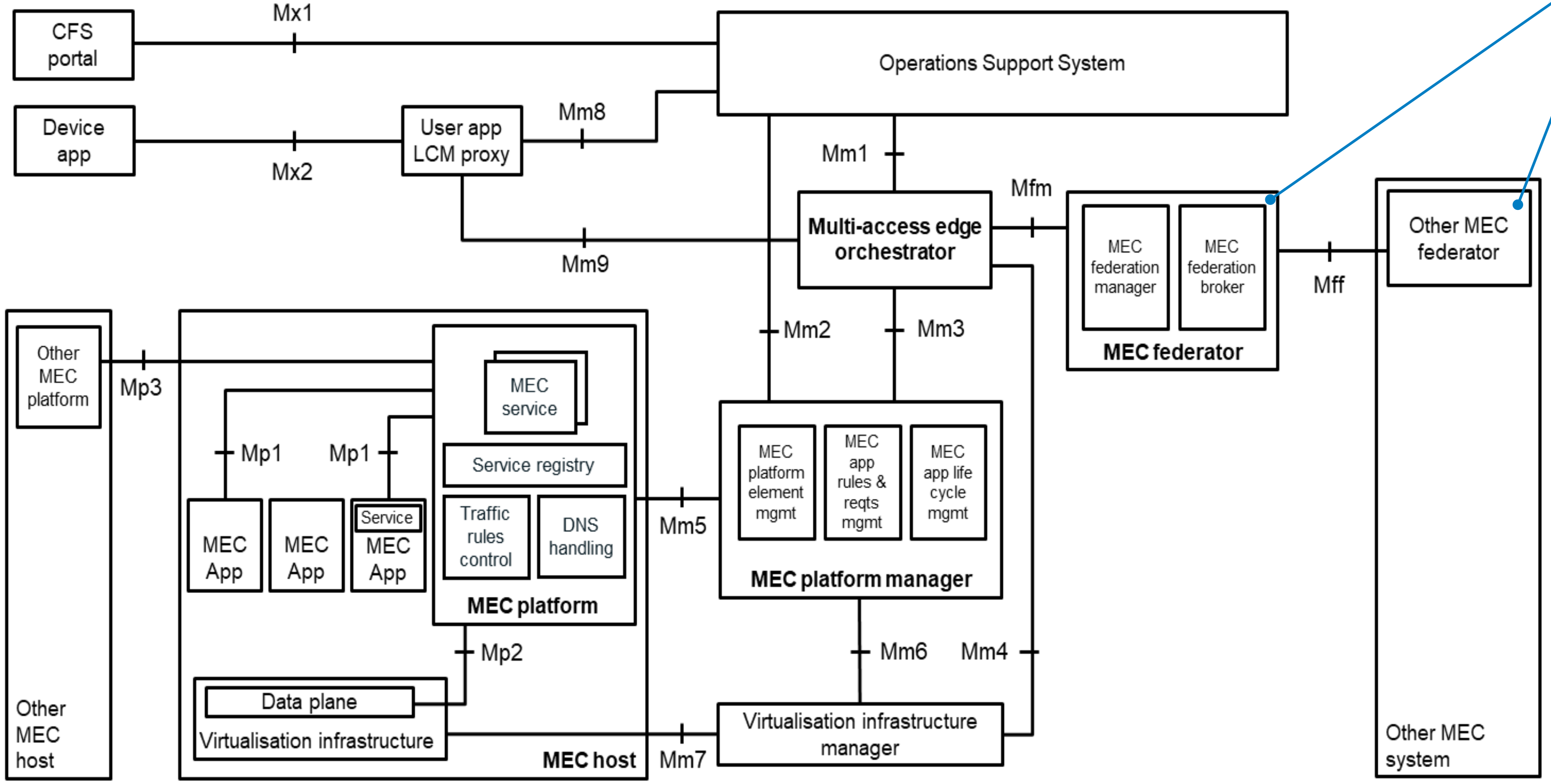
Enabling Global Application Portability



- ✓ Simple to use, well documented APIs, published with OpenAPI Framework
- ✓ Create innovative applications quickly and easily, reducing time-to-revenue
- ✓ New APIs (compliant with the MEC API principles) can be added
- ✓ Increase the Total Addressable Market (TAM)

ETSI MEC Architecture

Phase 3 deliverable published in March 2022
ETSI GS MEC 003 (introducing Architecture variant for MEC federation, as in figure)



***MEC federator** (MEF): enables a MEC federation between MEC systems*

- *A MEF interfaces to at least one MEO*
- *Each MEF enables information exchange with at least one other MEF*
- *A MEF may serve as a single point of contact for multiple MEFs in the MEC federation*

MEF may support the following functionality:

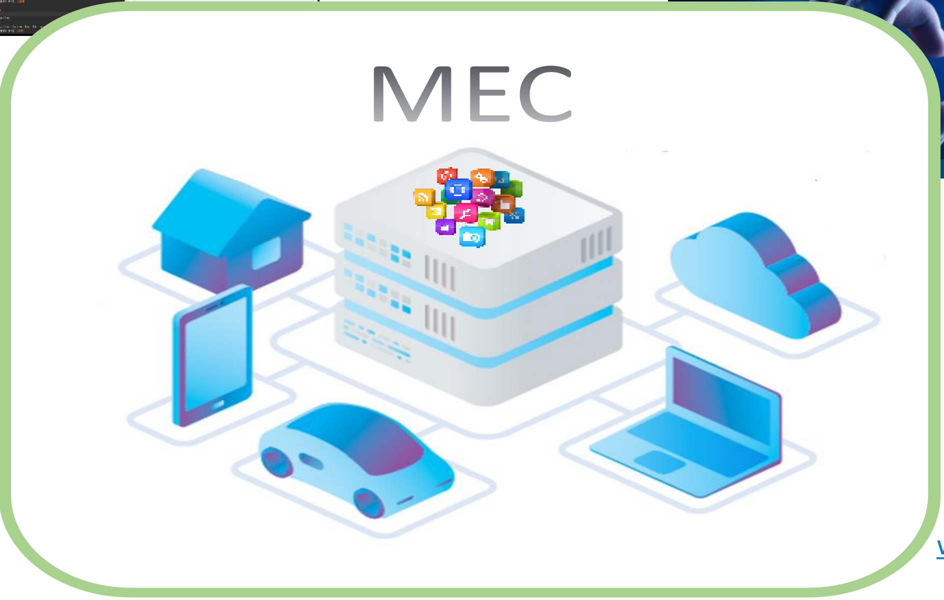
- registration of MEC system information by a MEO;
- MEC system discovery;
- broker capability acting as a one to many intermediary between MEFs;
- information (e.g. MEC system information) exchange;
- application lifecycle management (e.g. on-boarding/instantiation/termination) across different MEC systems;
- application monitoring across different MEC systems.

Reference: https://www.etsi.org/deliver/etsi_gs/MEC/001_099/003/03.01.01_60/gs_MEC003v030101p.pdf

ETSI ISG MEC DECODE Working Group: MEC Deployment and Ecosystem engagement activities

- OpenAPI representations: ETSI Forge
- Testing and Conformance
- MEC Ecosystem wiki
- PoCs (proof-of-concepts)
- MDTs (MEC Deployment Trials)
- MEC Sandbox
- Collaborations: Akraino
- Hackathons
- Plugtests
- MEC Tech Series

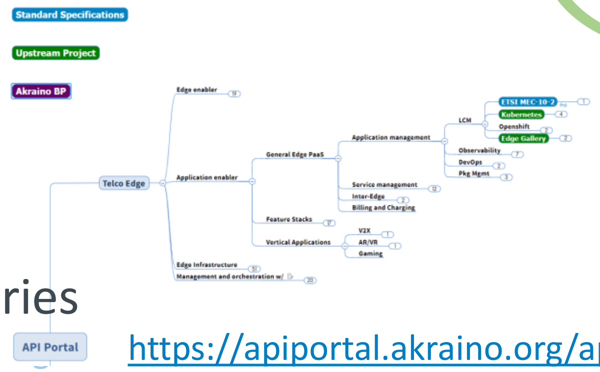
https://try-mec.etsi.org/



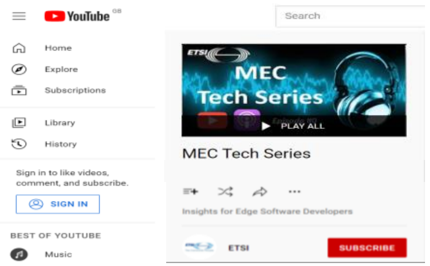
EDGE COMPUTING WORLD

10-12 Oct **2022**, SantaClara, CA, USA

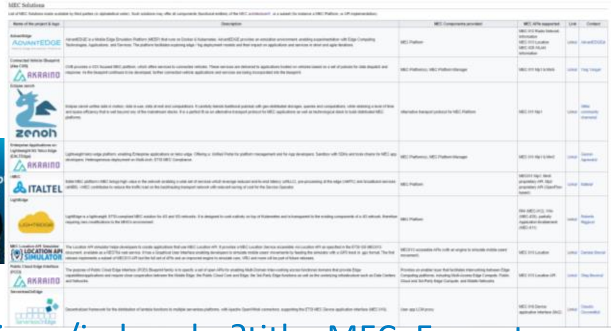
www.edgecomputingworld.com/edge-hackathon-2022



https://apiportal.akraino.org/apimap.html



1 - 15 Oct 2021
NFV&MEC IOP Plugtests 2021



https://mecwiki.etsi.org/index.php?title=MEC_Ecosystem

Overview of MEC Deployments

MEC in 4G, 5G migrations phases, MEC in 5G Rel. 15, Rel. 17

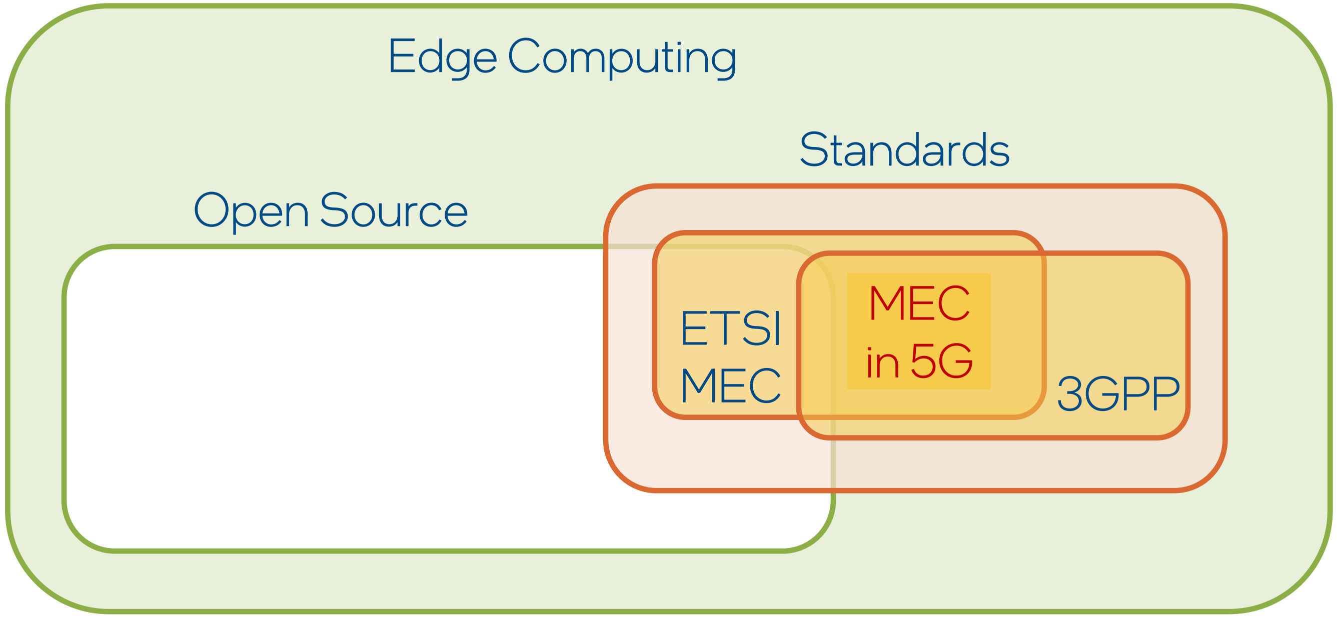
Scope of the ETSI/3GPP Alignment on Edge Computing

- General goal on aligning these standards, as asked by the industry, is to avoid duplication of work (or land to conflicting/diverging standards that would lead to market fragmentation), and to openly enable edge platforms and products that can be 1) compliant with 3GPP 2) ETSI MEC 3) **both**.
  - In particular, the third option (although not mandatory) can provide added value to the edge ecosystem, decrease implementation and deployment costs, and encourage adoption of edge computing.

Notes:

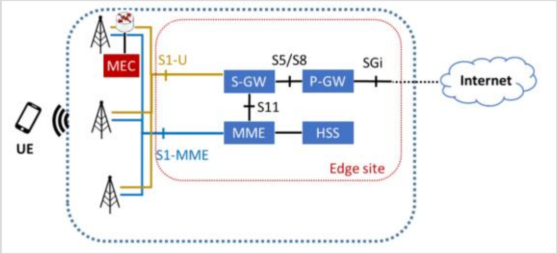
- In 5G, alignment of the 2 standards is the key.
- General consensus to align ETSI and 3GPP in order to *avoid duplication of work*.
- Anyway, alignment doesn't mean equivalence

(Note: ETSI MEC is *Multi-access* Edge Computing, thus including also Wi-Fi, fixed access, etc..)



MEC in 4G Deployments

- ETSI has already clarified how MEC can be deployed in 4G networks, given its access-agnostic nature [5], with many approaches:
  1. "bump in the wire" (BIW) (where the MEC sits on the S1 interface of the 4G system architecture),
  2. "distributed 4G-Evolved Packet Core" (d-EPC) (where the MEC data plane sits on the SGi interface),
  3. "distributed S/PGW" (d-GW) (where the control plane functions such as the MME and HSS are located at the operator's core site)
  4. "distributed SGW with Local Breakout" (SGW-LBO) - where the MEC system and the distributed SGW are co-located at the network's edge).



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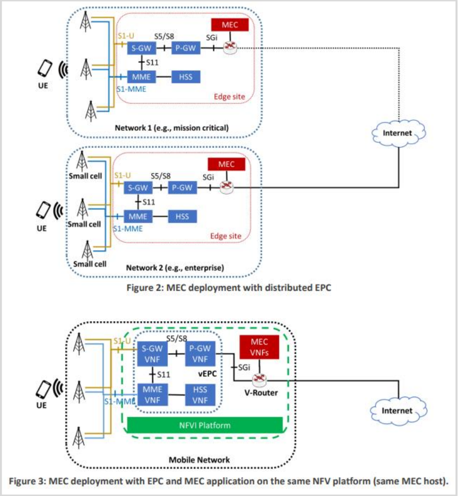

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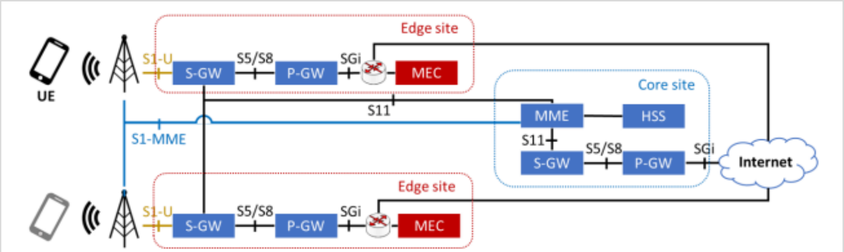

Figure 4: S-GW and P-GW MEC deployment

3.

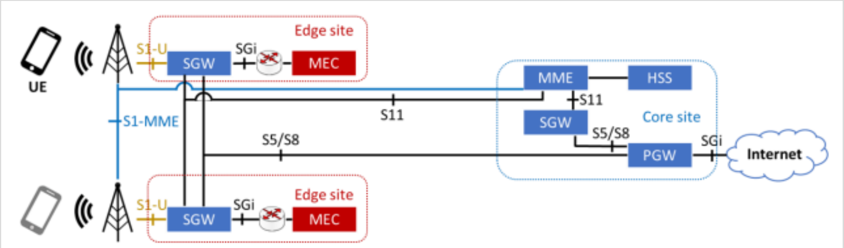

Figure 5: SGW-LBO MEC deployment

4.

MEC in 4G Deployments with CUPS

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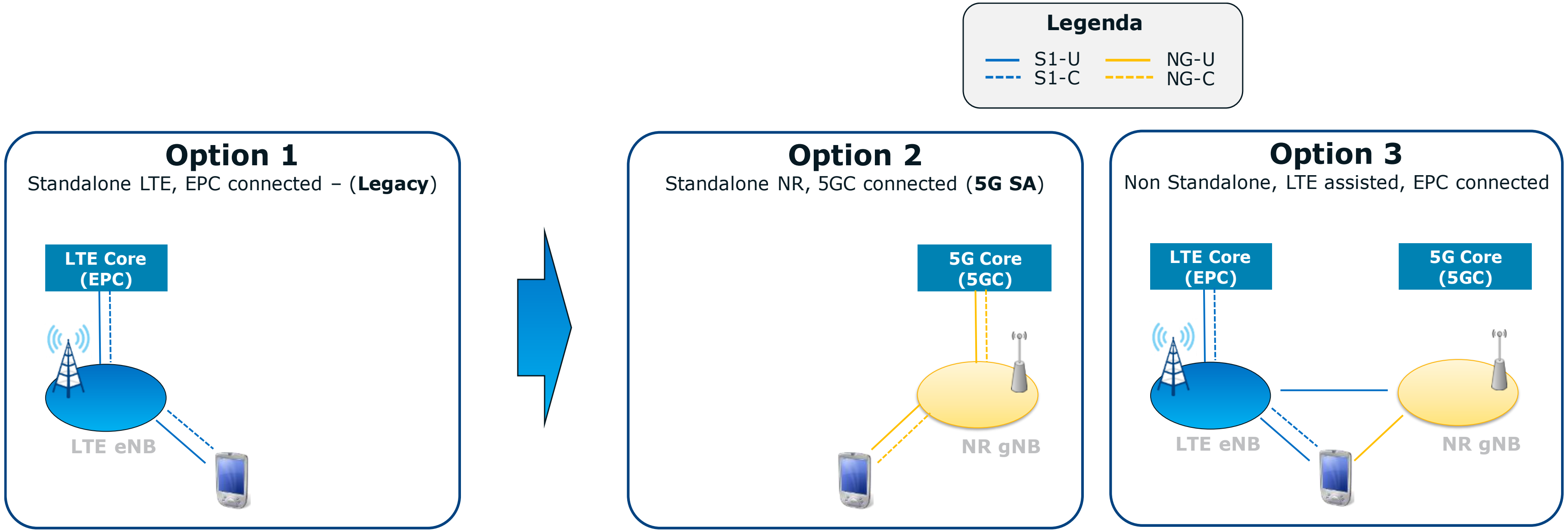
Control/User Plane Separation (CUPS)

- The deployment options above which distribute the EPC gateways at the edge, either co-located with or within the MEC host, can also be built using the CUPS paradigm standardized in 3GPP Release 14 and have the new User Plane built in the MEC host.
  - Local User Plane (UP) distribution allows the use of the CUPS architecture to locally steer the traffic. SGWC and PGW-C are the end points that populates the UP routing tables.

5G Migrations Phases

- GSMA published a document on "Operator Requirements for 5G Core Connectivity Options" [11], describing the various deployment options, and including the results of a survey conducted by GSMA with 20 Operators (and Operator groups) who are planning to launch 5G in the next 2 years to understand which of the Options they are considering for their deployment plans.
- A widely accepted sequence for 5G deployment phases (starting from 4G networks) is to consider first Option 3 (5G NSA) and then Option 2 (5G SA)

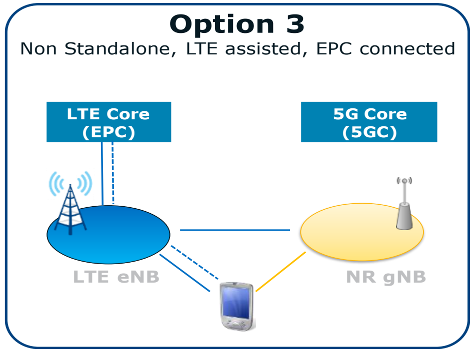


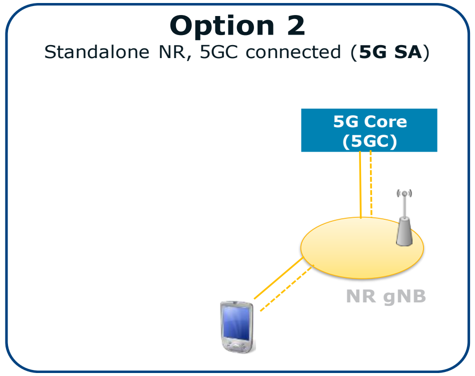
5G Migrations Phases - Status

- Operators started deploying 5G under Option 3 (5G NSA)
- and then are gradually moving to Option 2 (5G SA)

	China	South Korea	Japan	USA	EU
5G Mode[6]	NSA/SA	NSA/SA	NSA/SA	NSA	NSA/SA
Approximate number of 5G base stations	916,000	162,000	50,000	50,000	112,000
Population	1,402,000,000	51,780,000	125,800,000	329,500,000	447,706,000
People per base station	1531	319	2516	6590	3988
5G target bands assigned	700 MHz 2.6 GHz 3.6 GHz	3.6 GHz 28 GHz	3.6 GHz 3.6 - 4.1 GHz 4.5 GHz 28 GHz	600 MHz 2.5 GHz 3.45 - 3.55GHz 3.5 - 3.7 GHz 3.7 - 3.98 GHz 24 GHz 28 GHz 39 GHz 47 GHz	700 MHz 3.6 GHz 26 GHz
Indicative 5G subscriber numbers	**166 million** (China Mobile only; source: China Mobile Research Institute) **173 million** (source: Ericsson 2020)	**17 million** (source: 5G Forum, Korea)	**14.19 million** (source: Japan times)	**15.8 million** (in Dec 2020; source: Insider Intelligence) **14 million** (including Canada; source: Ericsson 2020)	**8 million** (source: Ericsson 2020)

https://5gobservatory.eu/observatory-overview/5g-scoreboards/

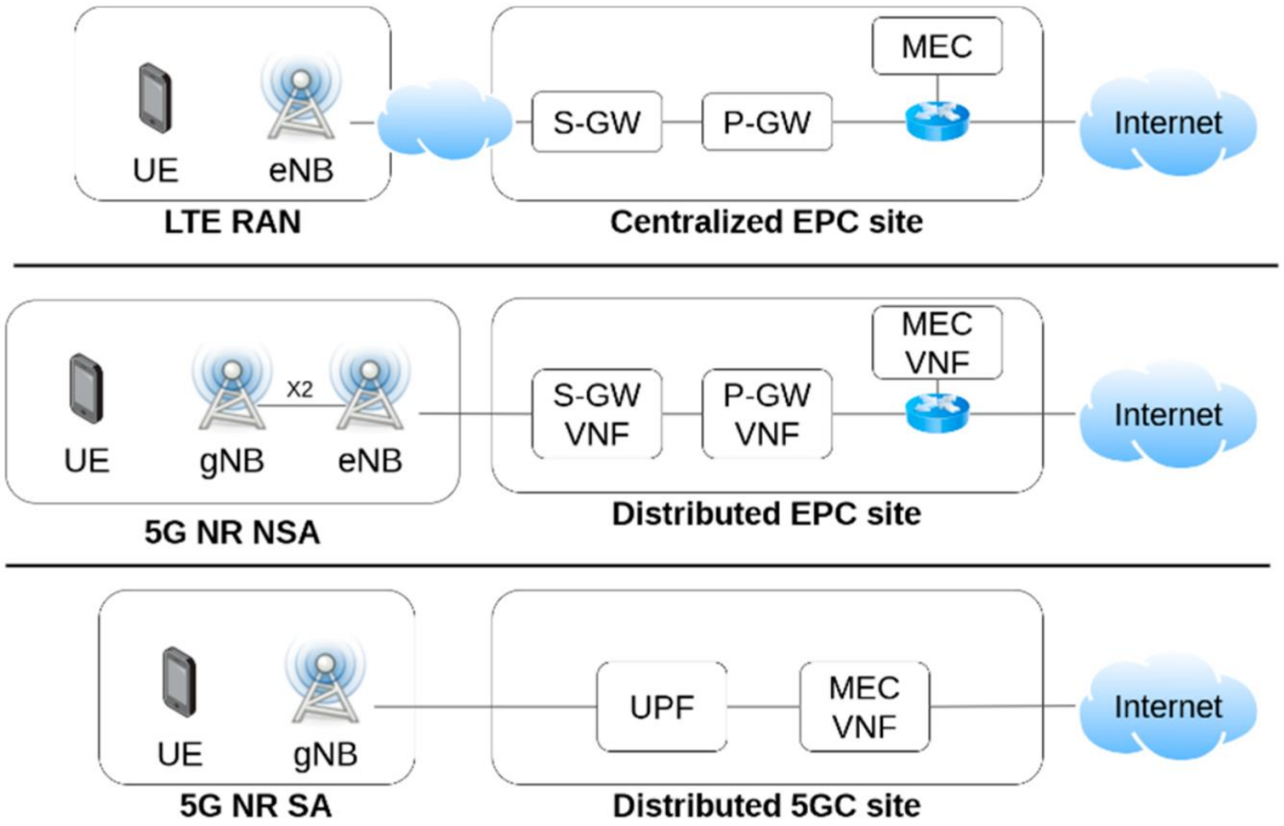




Example: VF Germany planning to bring 5G SA to 98% of German households by 2025.

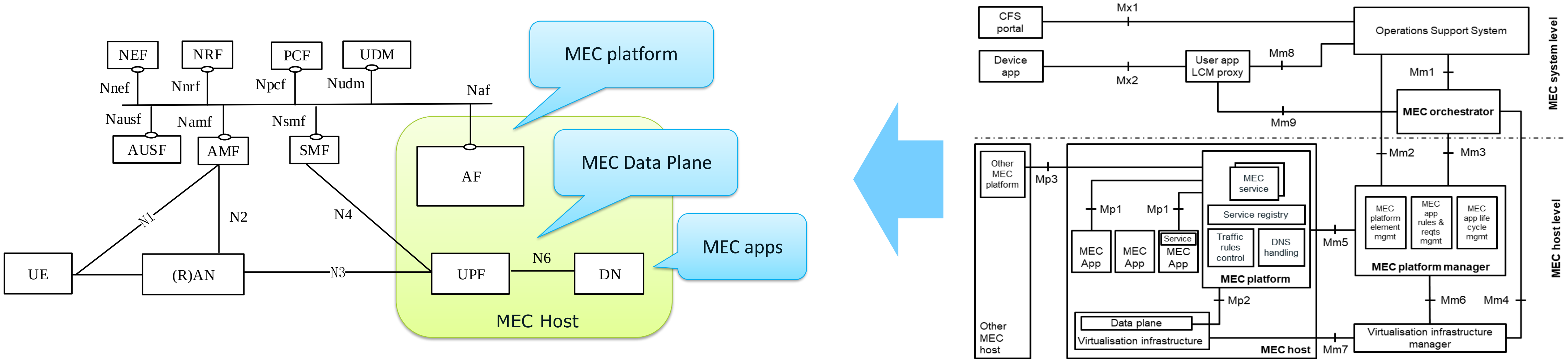
MEC in 5G – Migrations Phases

- The figure below shows examples of MEC deployment [12] in:
- 4G with Centralized EPC (top)
- 5G NSA (middle) and
- 5G SA (bottom)



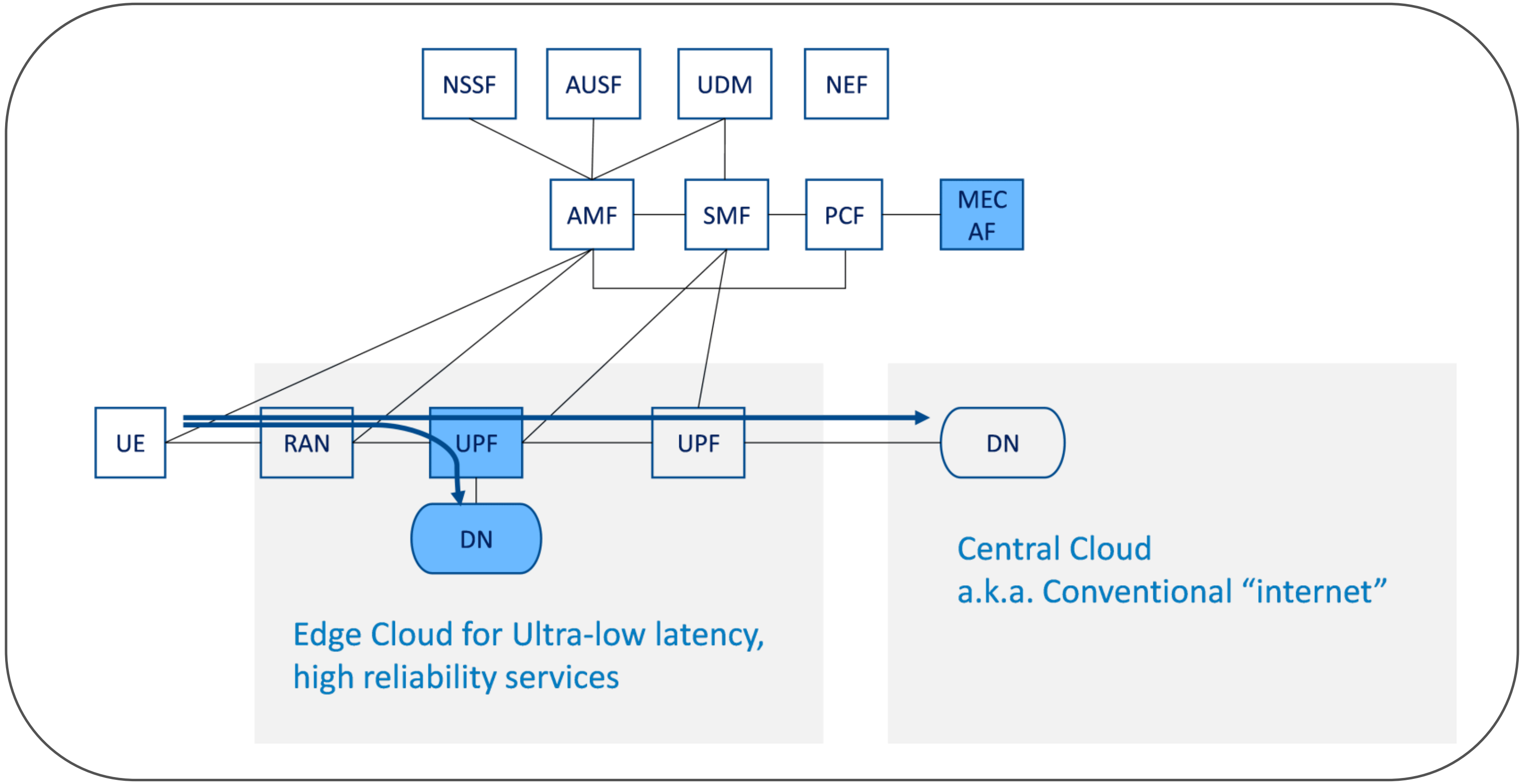
MEC in 5G – Rel. 15 Onwards

- MEC host can be associated to AF and UPF in 5G architecture.
- In addition, since in 3GPP the user traffic is routed to the local Data Network, MEC Apps can be mapped in 5G architecture as located in the DN



MEC in 5G – Rel. 15 Onwards

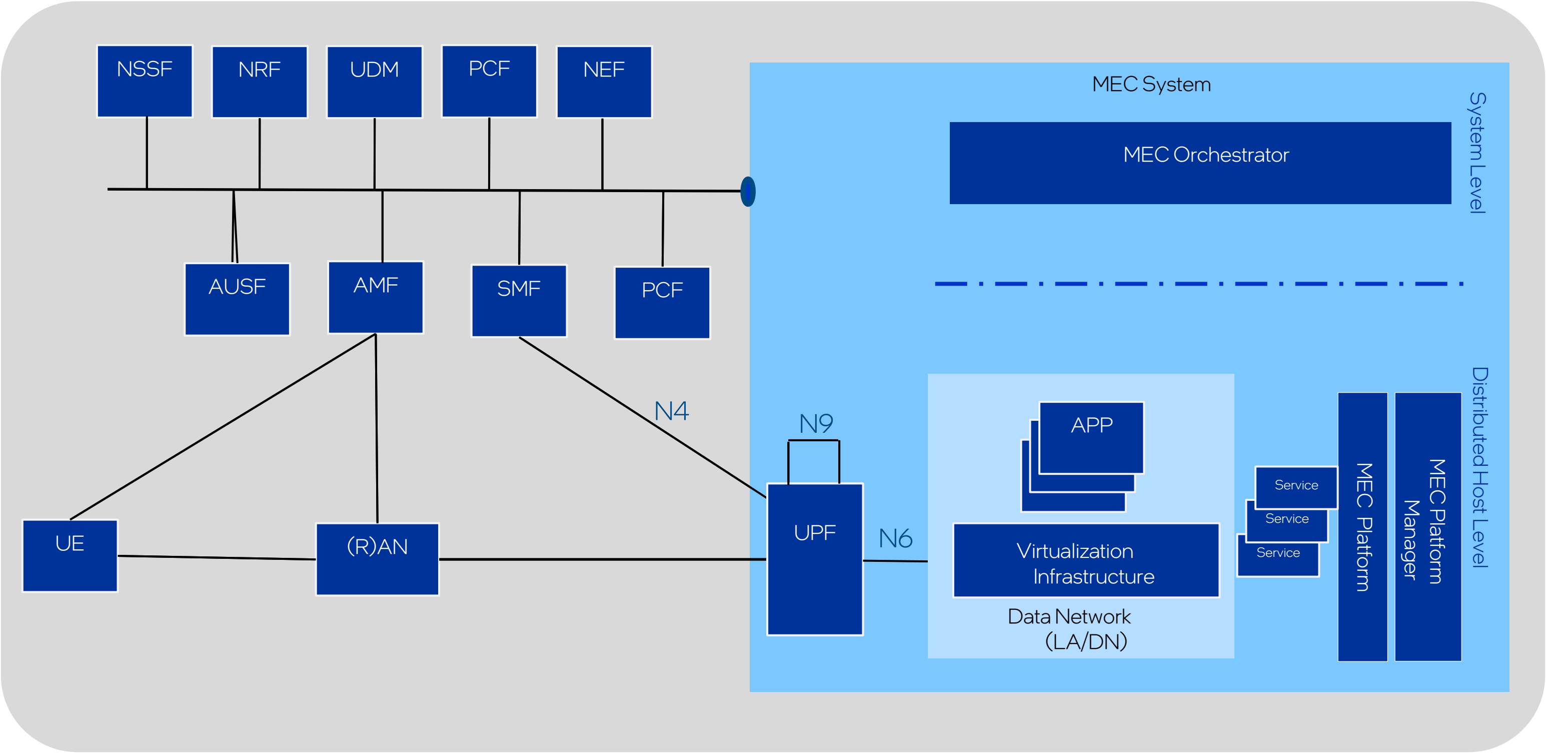
- Figure below illustrates an example of how concurrent access to local and central DN (Data Networks) works. In this scenario, the same UP session allows the UE to obtain content from both the local server and central server (service continuity is enabled by IP address anchoring at the centralized UPF, with no impact on UE by using Uplink Classifier -ULCL).



MEC in 5G – Rel. 15 onwards (ref. MEC 031)

- The ETSI white paper "MEC in 5G networks" [6] has initially set the scene for this study item
- ISG MEC investigated the opportunities offered to MEC by the 5G system and its edge computing enablers
- MEC 031 technical report [7] was published in October 2020 (*)

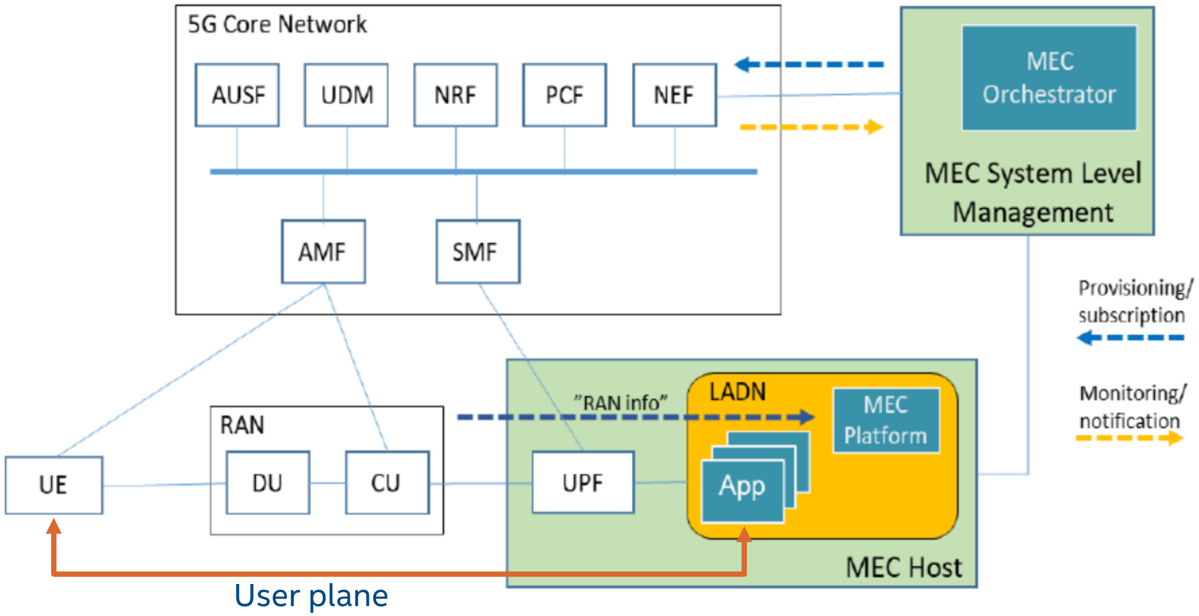
- The scope included the following
  1. C-plane interactions with 5GC,
  2. Functional split between MEC and 5GC wrt. API framework,
  3. Organization of MEC as an AF,
  4. Pertinent interactions of MEC with (R)AN



(*) ETSI GR MEC 031 V2.1.1 (2020-10) - Multi-access Edge Computing (MEC) MEC 5G Integration https://www.etsi.org/deliver/etsi_gr/MEC/001_099/031/02.01.01_60/gr_MEC031v020101p.pdf

MEC in 5G – Capabilities Exposure

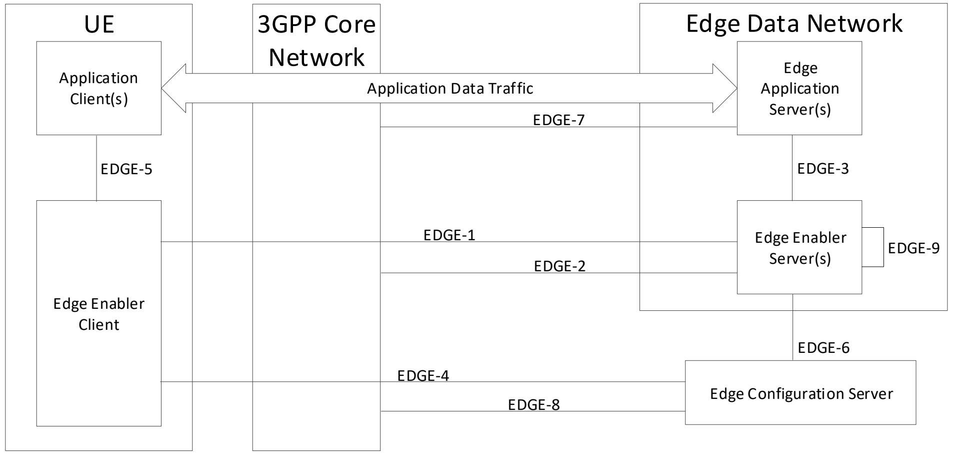
- MEC services are typically envisaged as being offered and supplied by Mobile Network Operators.
- However, a MEC service can also be offered by the third parties. As a consequence, the NEF is used as an entry point in the 5G network to enable this information exposure, when MEC (as AF) resides outside the 3GPP domain.
- The diagram below shows an example of how a third-party cloud service provider could leverage 5G network functions in harmony with the MEC architecture to provide an edge computing service.



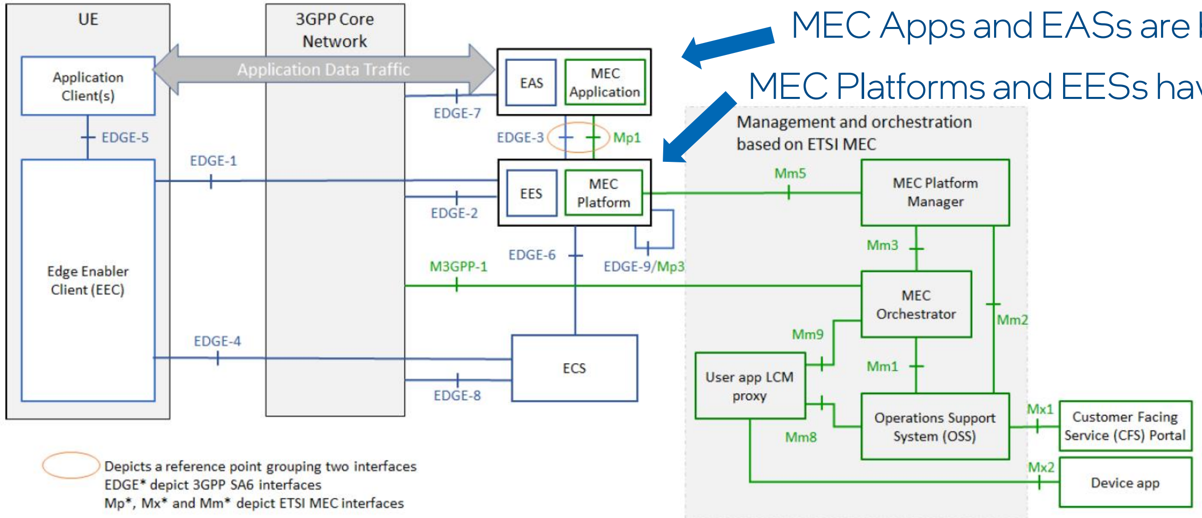
- The MEC orchestrator as a 5G AF interacts with NEF and with other relevant NFs with regards to overall Monitoring, Provisioning, Policy and Charging capabilities.
- On the other hand, services offered by a MEC Host such a RNIS rely on direct exposure to the CUs/DUs of the 5G RAN.
- NEF can handle control plane functions for third-party service providers to manage MEC operation.
- Network information exposed by the NEF is consumed by MEC services and can be exposed to MEC applications.
- This allows a clear separation between the MNO and the third-party service provider.

MEC in 5G – Rel. 17

- The EDGEAPP architecture defined in SA6 introduced new functional entities:
  - **Edge Enabler Client (EEC)**, who enables discovery of Edge Application Servers and provisioning of configuration data;
  - **Edge Enabler Server (EES)**, providing to EEC the information related to the Edge Application Servers, and also exposing capabilities of 3GPP net-work to Edge Application Servers;
  - **Edge Configuration Server (ECS)**, providing supporting functions need-ed for the EEC to connect with an EES.



3GPP TS 23.558 "Architecture for enabling Edge Applications; (Release 17)



MEC Apps and EASs are basically the same

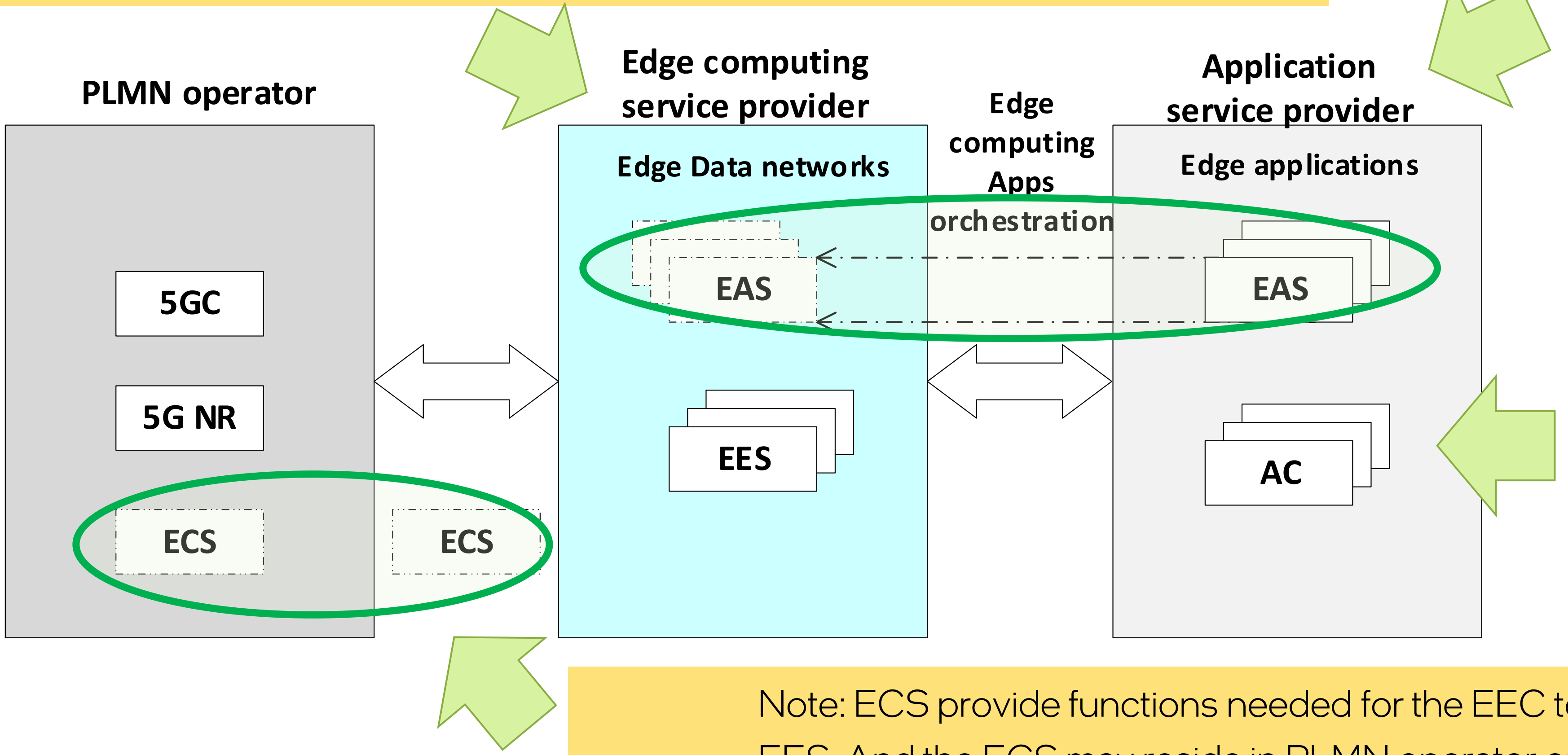
MEC Platforms and EESs have very similar duties

More recently, a Synergized Mobile Edge Cloud architecture is supported by 3GPP and ETSI ISG MEC specifications

Ref. ETSI White paper: "Harmonizing standards for edge computing - A synergized architecture leveraging ETSI ISG MEC and 3GPP specifications", July 2020, link here

Relationship of Service Providers in the Edge Computing Network Deployment

The edge computing service provider (ECSP), responsible for the deployment of edge data networks (EDN) that contain EAS and EES



The application service provider (ASP), responsible for the creation of edge application servers (EAS)

Application clients (AC), representing the edge computing application running in the server and UE client

Note: ECS provide functions needed for the EEC to connect with an EES. And the ECS may reside in PLMN operator or ECSP.

Ref. 3GPP TR 28.814

Examples of MEC Deployments

V2X use cases

Examples of MEC 5G Deployments (V2X use cases)

- Scenario 1 (5GAA, MEC4AUTO) (*)
  - It is assumed that each client apps communicates with the local server app (MEC app Y) by means of traffic offloading to DN of each MNO via N6 interface.
  - The server apps communicate with each other through a controlled IP network.
  - The communication involves the edge service (control) plane traffic between MEC platforms of both MNOs and between the MEC platform and local server application of each MNO

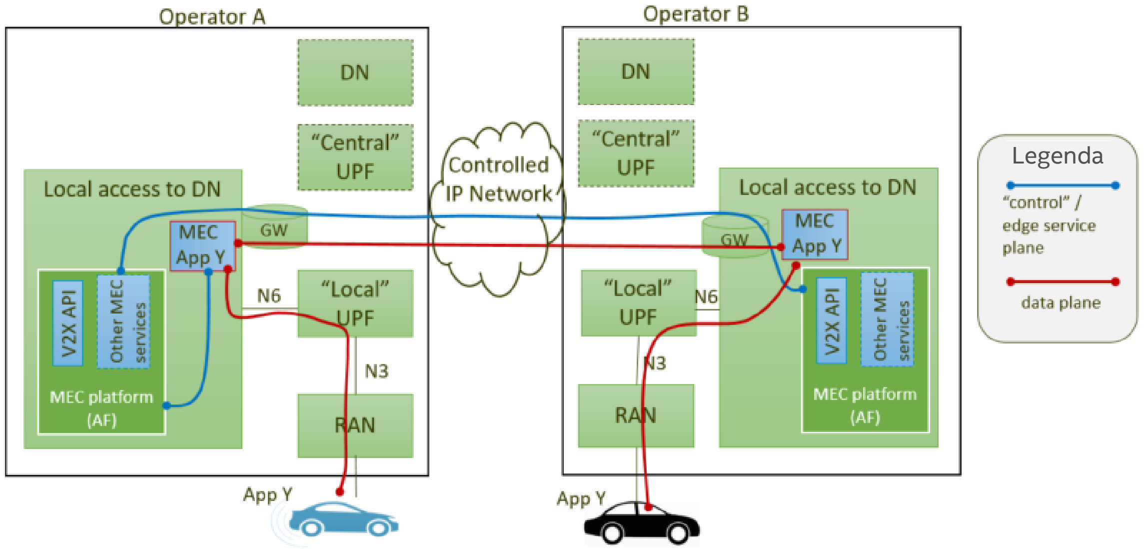


Illustration of Scenario 1, where both MNOs have MEC platforms and MEC application Y (Multiple OEM vehicle use case)

(*) Ref. https://5gaa.org/wp-content/uploads/2021/03/5GAA_A-200150_MEC4AUTO_Task2_TR_MEC-for-Automotive-in-Multi-Operator-Scenarios.pdf

Examples of MEC 5G Deployments (V2X use cases)

- @ CoSP edge setup

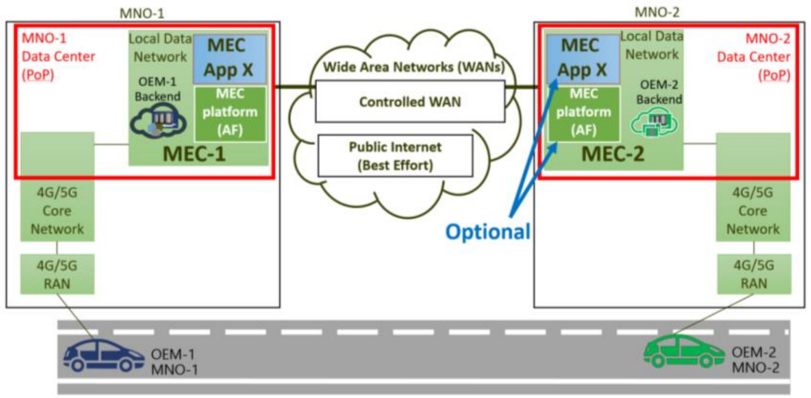


Figure 7.1-2: End-to-end QoS in a multi-MNO environment through controlled WAN(s)

End-to-end QoS in a multi-MNO environment through controlled WAN(s)

- @ Neutral Host edge setup

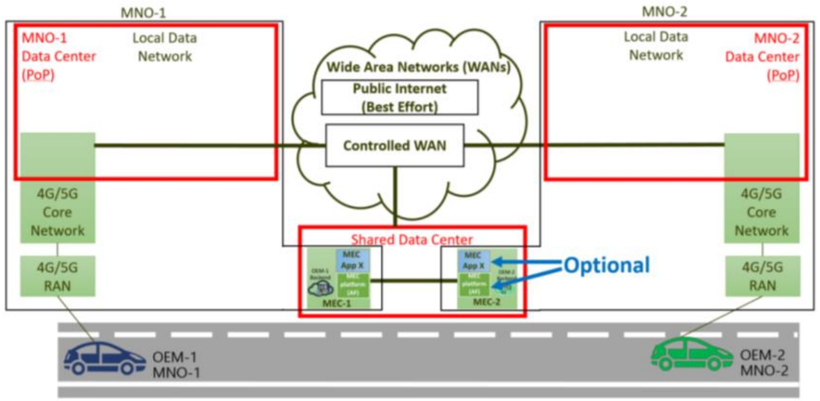


Figure 7.1-3: End-to-end QoS in a multi-MNO Environment through MEC hosting in a shared data centre

End-to-end QoS in a multi-MNO Environment through MEC hosting in a shared data centre

There is no preference among the solutions, in principle. Their applicability depends on individual MNO properties like existing deployments and further services that they offer (e.g. if they are also in the data centre and/or WAN business) and what the services from other stakeholders (shared data centre and WAN provider) cost.

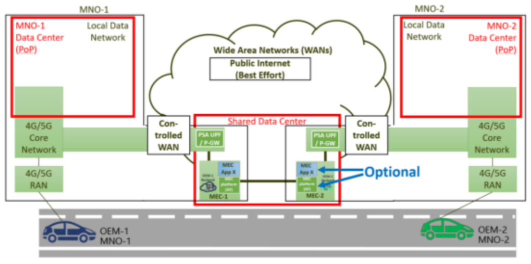


Figure 7.1-4: End-to-end QoS in a multi-MNO environment through gateway and MEC hosting in a shared data centre

Note: deploying gateways at shared data center is also an option

Ongoing Work and Future Directions

ONGOING

MEC in 5G – Rel. 18

- Solution#11 (to KI#5) specifies a **CAPIF deployment option** for:
  1. allowing EASs to invoke MEC services, and
  2. exposing Service APIs provided by EES or EAS (as described in KI#2) to MEC Applications

Note: the figure is to illustrate what EDGEAPP and ETSI MEC could look like when they exploit CAPIF for invoking and exposing their APIs. There is **currently** no such architecture defined in EDGEAPP or ETSI MEC as shown in figure

Recently SA6 approved a new external TR (led by Intel) that will capture topics for alignment and collaboration of 3GPP with ETSI MEC and GSMA OPG.

TR 23.958	Edge Application Standards in 3GPP and alignment with External Organizations

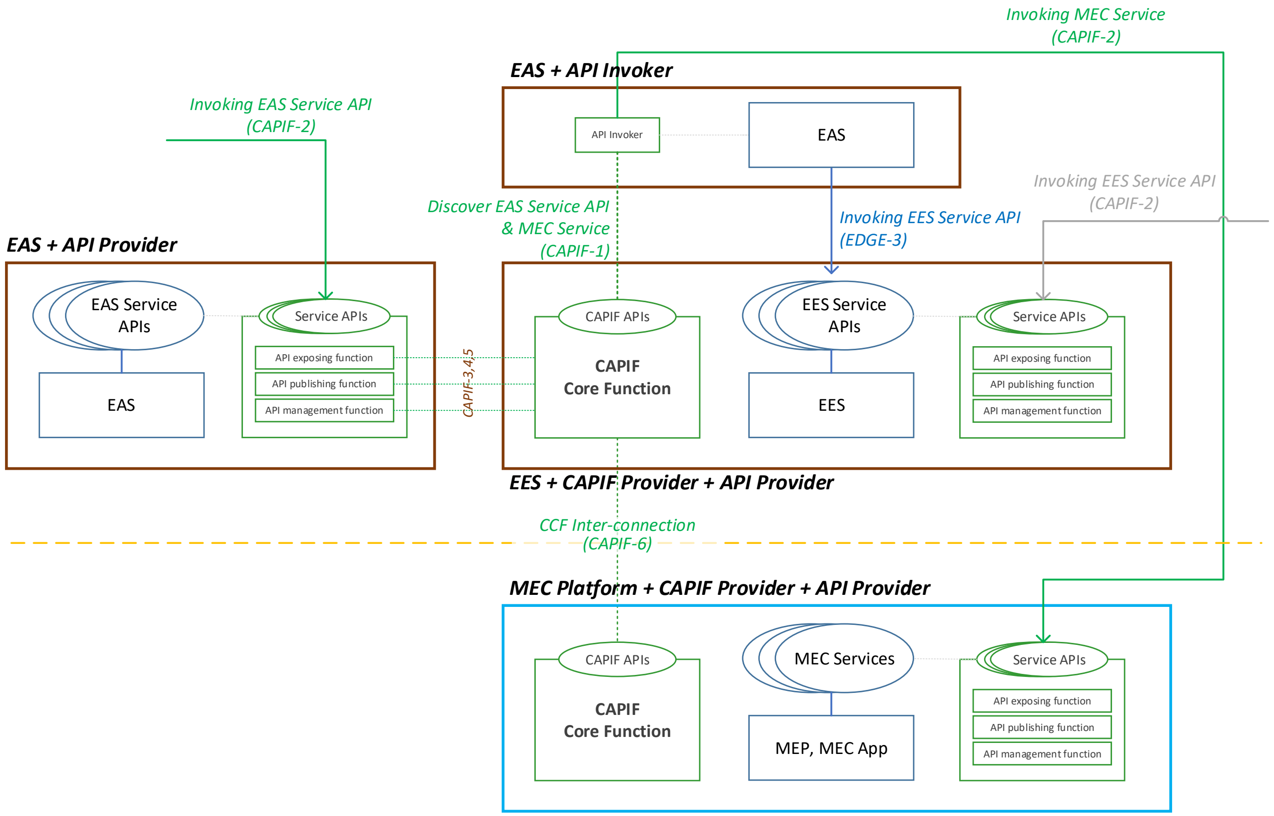


Figure - A deployment option for alignment with ETSI MEC using CAPIF

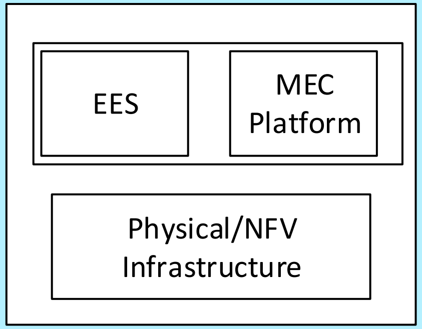
Ref. 3GPP TR 23.700-98 “Study on Enhanced architecture for enabling Edge Applications; (Release 18)”

MEC in 5G – Rel. 18 – Deployment Options

ONGOING

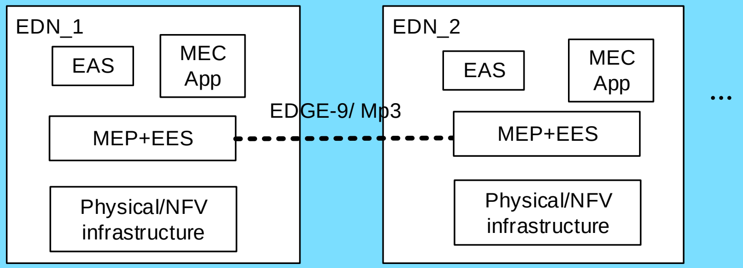
1. Collocated Platforms

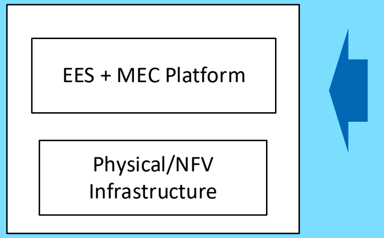
- The two platforms (EES and MEP) are co-located, and made by a **single (unique) equipment**, which is **compliant with both standards**
- They are seen as **two different AFs** on a **single Physical/NFV Infrastructure**.



2. Converged Architecture

- **MEP+EES** is able to satisfy all the functionalities of MEP defined in ETSI and EES defined in SA6
- A **uniform API** is defined for the EAS and MEC app, i.e., EDGE-3 and Mp1 are unified into one interface and the **EAS and MEC app will consume the same service from the MEP+EES**.
- **EDGE-9 and Mp3** are **unified** into one interface

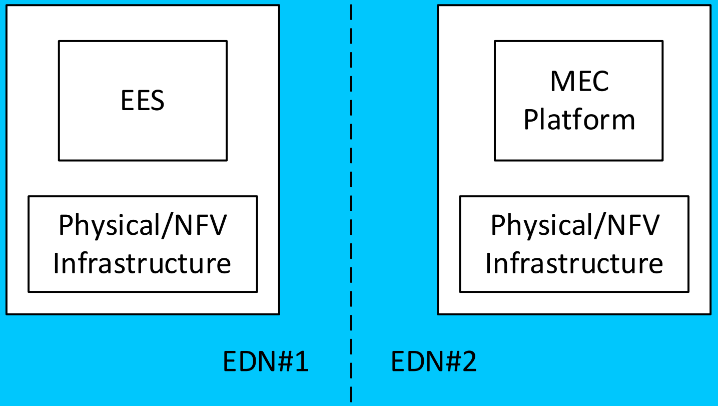




Variant: the two platforms are **co-located** which can be implemented as a **single AF** (e.g. realized as **one VNF**) **compliant with both standards**

3. non-Collocated Platforms

- The two platforms are **non-collocated**, and reside in two different data networks, where EES is in the Mobile Network Operator (MNO) domain while the ETSI MEC platform is in another MNO domain.
- They are seen as **two different AFs in two different EDNs**



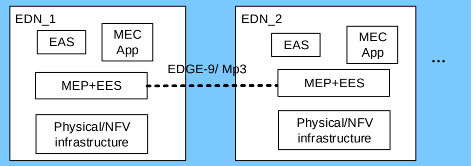
Ref. 3GPP TR 23.700-98 "Study on Enhanced architecture for enabling Edge Applications; (Release 18)"

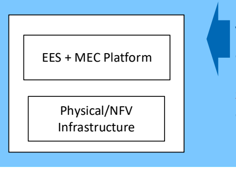
Converged Architecture: Evolution Options

ONGOING

2. Converged architecture

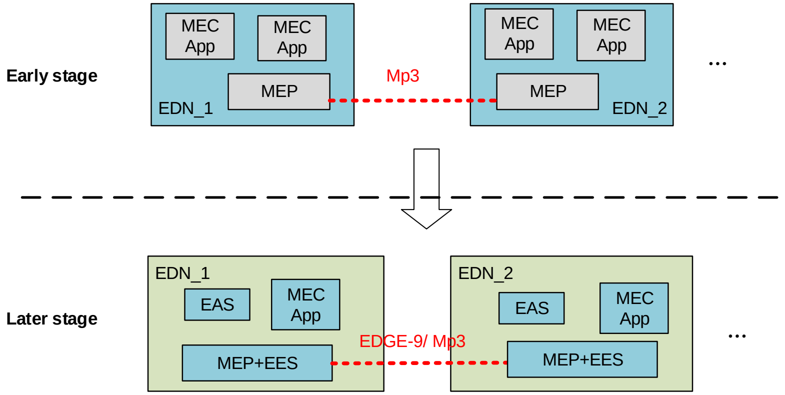
- MEP+EES is able to satisfy all the functionalities of MEP defined in ETSI and EES defined in SA6
- A uniform API is defined for the EAS and MEC app, i.e., EDGE-3 and Mp1 are unified into one interface and the EAS and MEC app will consume the same service from the MEP+EES.
- EDGE-9 and Mp3 are unified into one interface



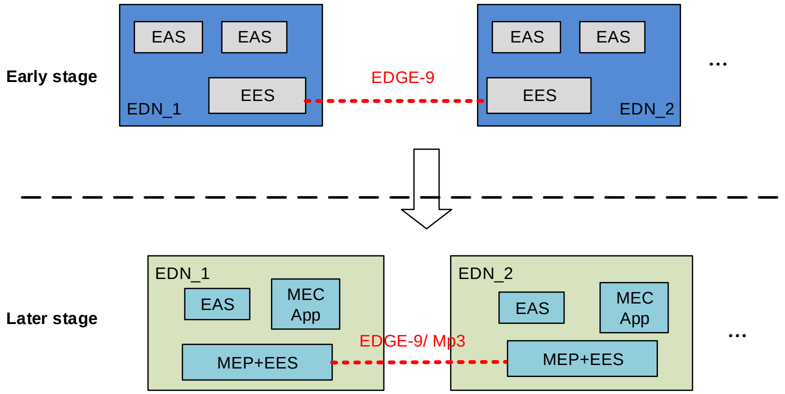


Variant: the two platforms are co-located which can be implemented as a single AF (e.g. realized as one VNF) compliant with both standards

Evolution Option #1- An early stage deployed MEP is enhanced to support the functionality of EES in a later stage



Evolution Option #2- Enhancement of a deployed EES to support the functionality of MEP

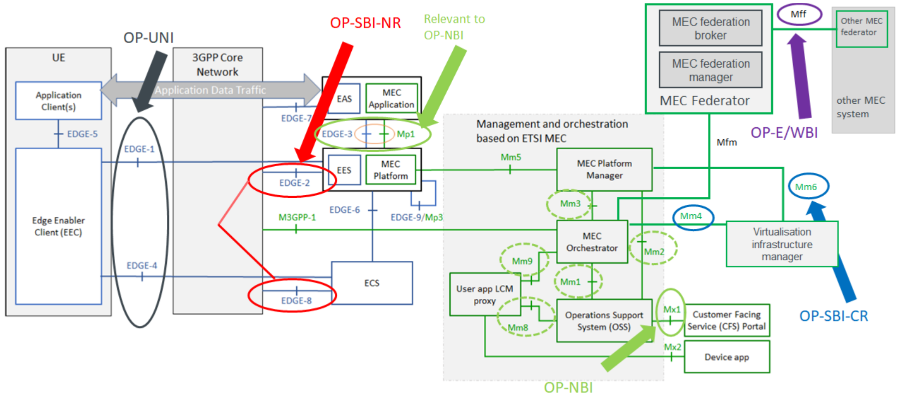


Ref. 3GPP TR 23.700-98 "Study on Enhanced architecture for enabling Edge Applications; (Release 18)"

Ongoing Work (MEC Phase 3 and 3GPP Rel. 18)

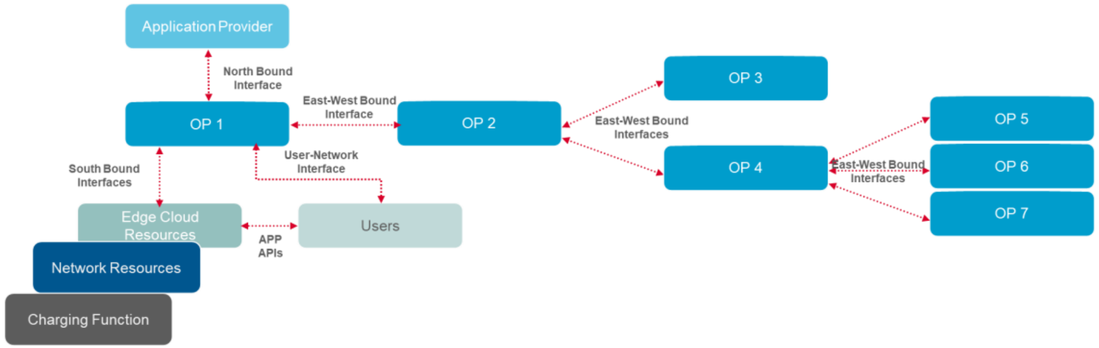
- At the Joint Workshop with GSMA OPG and 3GPP (21/01/2022) ETSI MEC presented the proposed approach for the SDO mapping for a joint standardization work on MEC Federation.

GSMA OPG asked 3GPP and ETSI MEC to **collaborate** together, and to discuss and agree upon the approach to be adopted to avoid industry fragmentation



Ref. [14] ETSI White paper "MEC federation: deployment considerations"

- Moving forward on Telco Edge Cloud …



- According to GSMA OPG «*Federating Edge and Cloud domains is key to be successful. This is the major differential of OP and shall be defined as a priority*»
- Anyway, also in perspective, they want that «*Network slicing would be a key capability*»

Ref. GSMA OPAG joint workshop with ETSI MEC and 3GPP, online meeting, 21/01/2022: https://www.gsma.com/futurenetworks/resources/operator-platform-api-groupwith-3gpp-etsi-workshop-recording/

Conclusions and Future Directions

- MEC can be deployed in 4G networks, given its access-agnostic nature, with many approaches.
  1. "bump in the wire" (BIW) (where the MEC sits on the S1 interface of the 4G system architecture),
  2. "distributed 4G-Evolved Packet Core" (d-EPC) (where the MEC data plane sits on the SGi interface),
  3. "distributed S/PGW" (d-GW) (where the control plane functions such as the MME and HSS are located at the operator's core site)
  4. "distributed SGW with Local Breakout" (SGW-LBO) where the MEC system and the distributed SGW are co-located at the network's edge).
- The deployment options above which distribute the EPC gateways at the edge, either co-located with or within the MEC host, can also be built using the CUPS paradigm standardized in 3GPP Release 14 and have the new User Plane built in the MEC host.
- MEC deployment in 5G (Rel.15) is seen as an AF (Application Function) in 3GPP architecture.
- From Rel.17 on, MEC deployment is referred to the EDGEAPP architecture defined by SA6
  - Further work still is ongoing, to better align MEC and EDGEAPP (e.g. Mp1/EDGE-3, and EAS/MEC app)
- Joint collab. between ETSI MEC & 3GPP targeting alignment respectively Ph.3 & Rel.18 onward.

Suggested reading: IEEE ComSoc Technology Blog (Dec 2021): «ETSI MEC Standard Explained»» (part 1, part 2)

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Thank you / Q&A