"Edge" in 5G Network Mobility
&
5G ETSI MEC synergy

to
Akraino TSC API Sub-committee

by
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5G White Paper

By NGMN Alliance

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1. "5G Network Mobility at "Cell" & "Cloud" Edge - NGMN WP Feb 2015 - 2

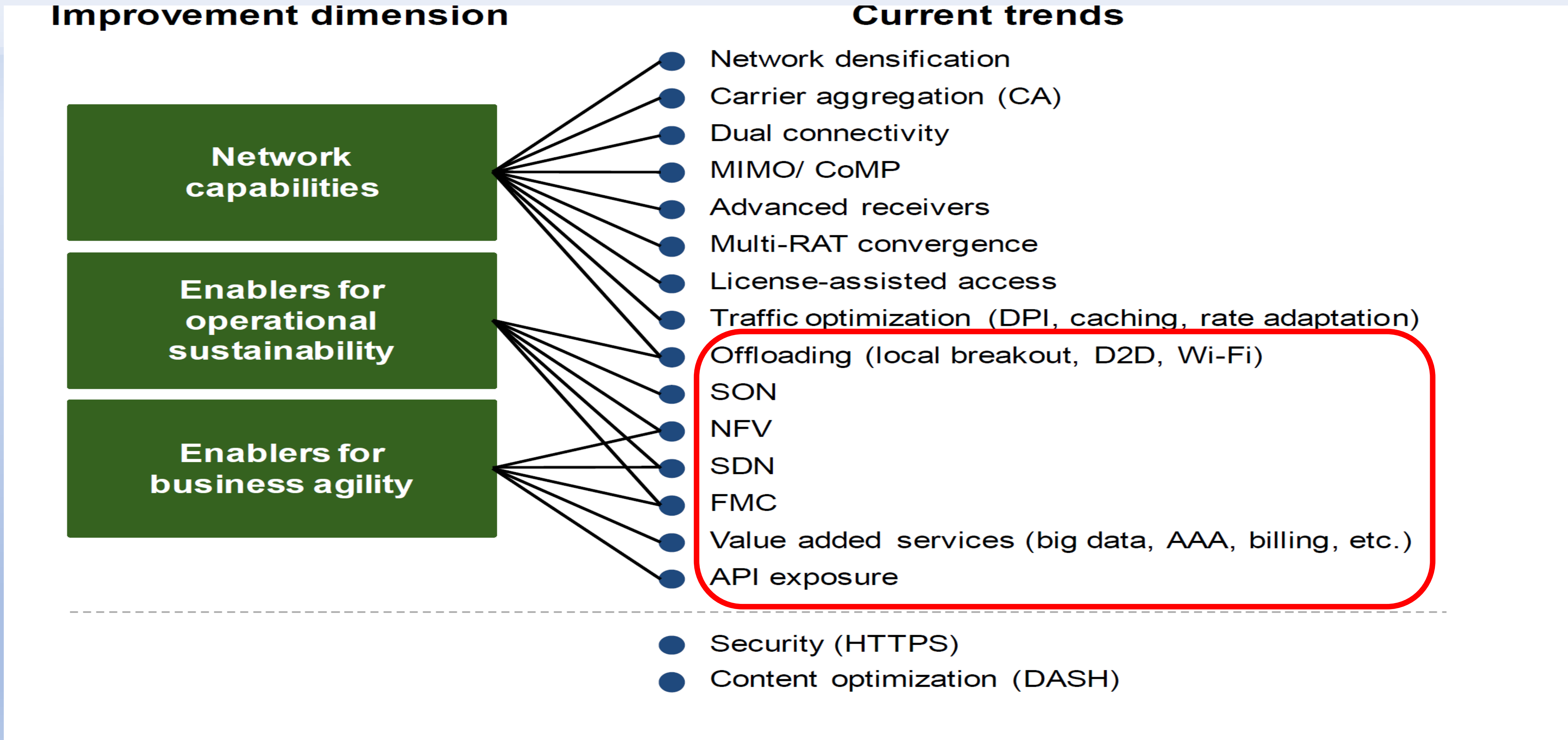

Figure 6: Ongoing technology trends

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Radio

Leverage spectrum
- Exploit higher frequencies and unlicensed spectrum
- C/U-path split, UL/DL split, multiple connectivity

Enable cost-effective dense deployments
- Integrate third party/user deployments
- Automate configuration, optimization and healing
- Enhance multi-RAT coordination
- Support multi-operator/shared use of infrastructure

Coordinate and cancel interference
- Build-in massive MIMO and CoMP
- Exploit controlled non-orthogonal interference

Support dynamic radio topology
- Moving cells, relays, hubs, C-RAN, D-RAN
- D2D (e.g., for latency, disaster relief)

Network

Create common composable core
- Minimize number of entities and functionalities
- C/U-function split, lean protocol stack
- No mandatory U-plane functions
- Minimize legacy interworking
- RAT-agnostic core
- Fixed and mobile convergence

Operations & Management

Simplify operations and management
- Automation and self-healing
- Probeless monitoring
- Collaborative management
- Integrated OAM functionality
- Carrier-grade network cloud orchestration

Embrace flexible functions and capabilities
- Network slicing
- Function variance
- Flexible function/service/application allocation
- Leverage NFV/SDN
- State-disintegrated functions
- Graceful degradation

Support new value creation
- Exploit big data and context awareness
- Expose radio and network APIs
- Facilitate XaaS

Build in security and privacy
- Extend C-plane security (e.g., HetNets)
- Ensure location privacy and identity protection from (unlawful) disclosure

Figure 7: 5G design principles

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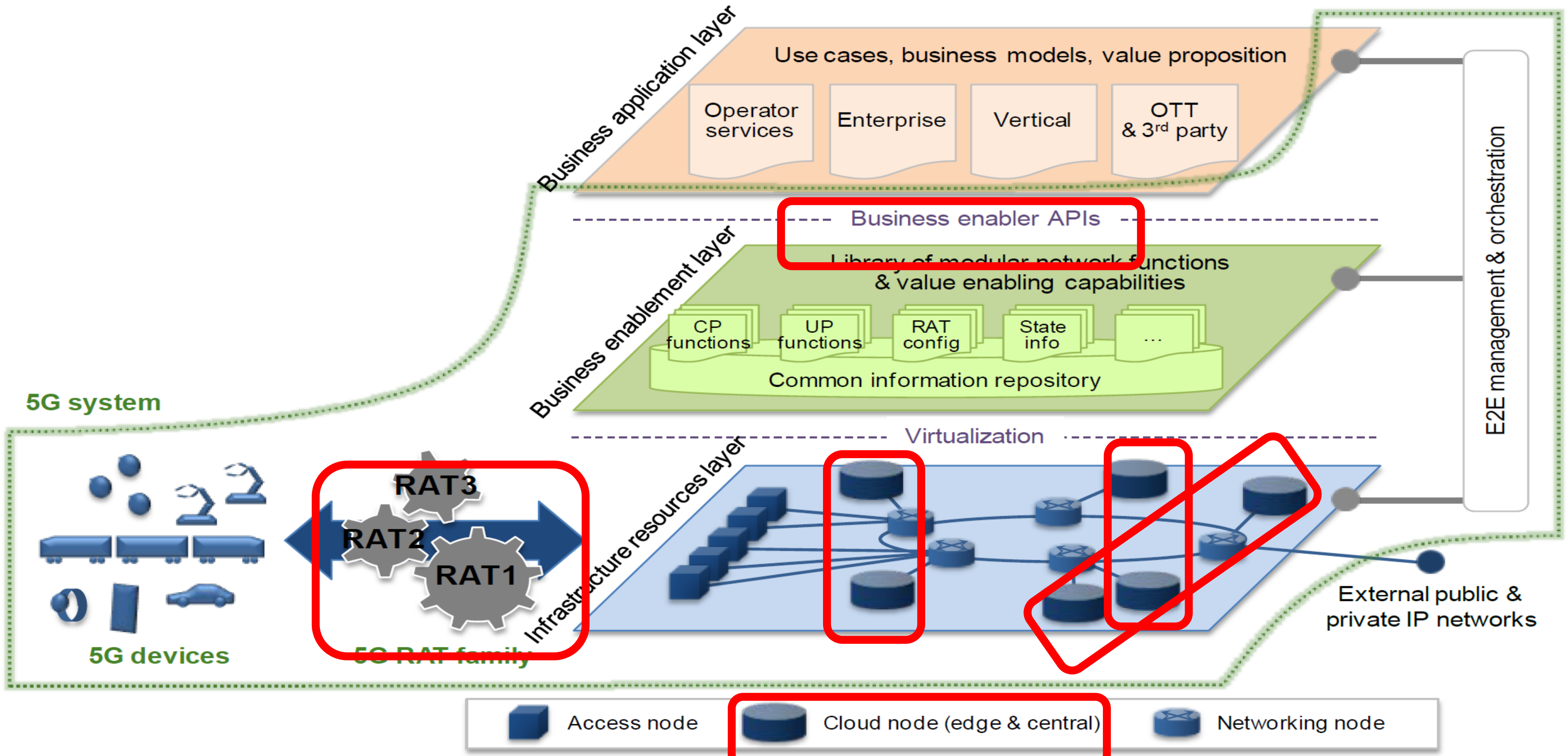

Figure 8: 5G Architecture

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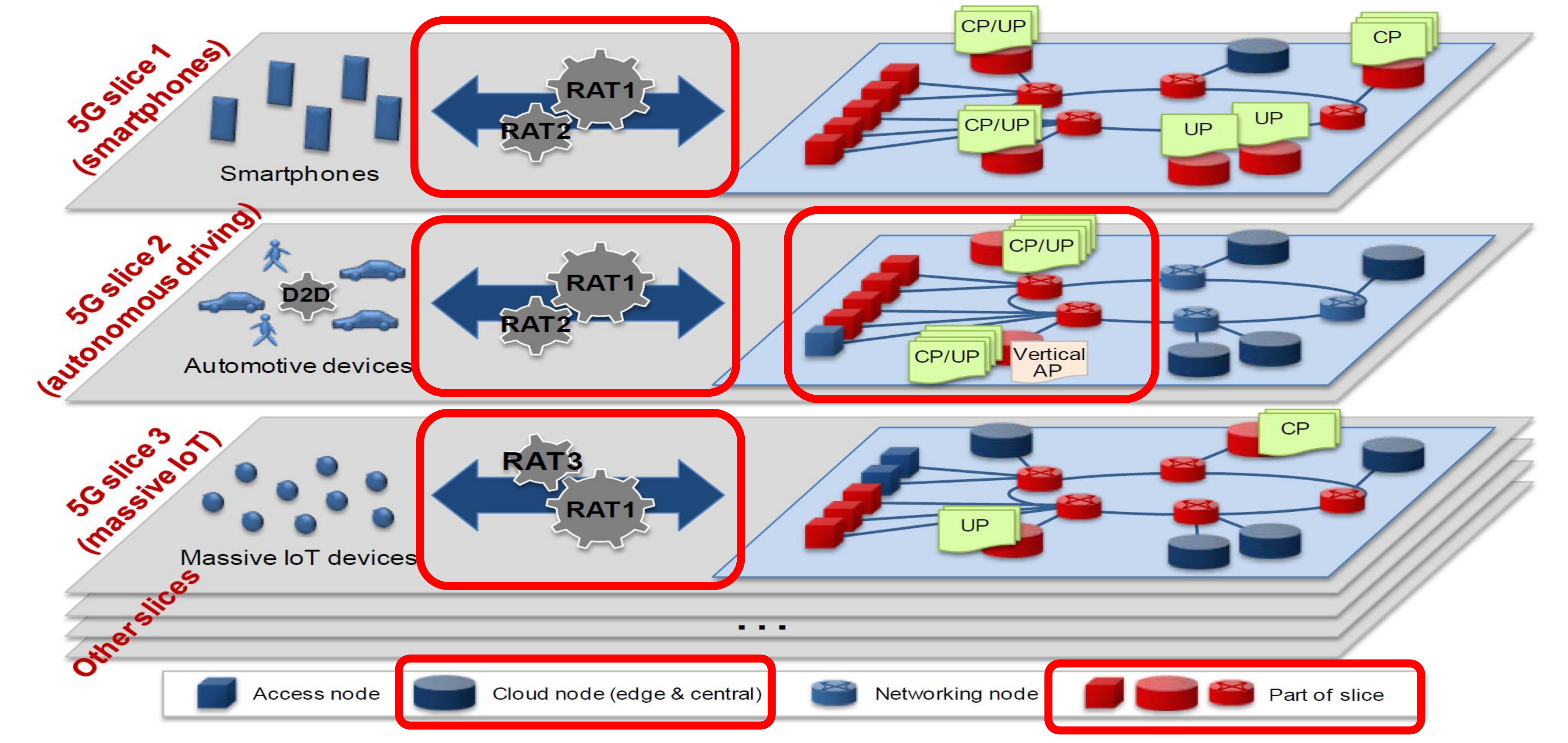

Figure 9: 5G network slices implemented on the same infrastructure

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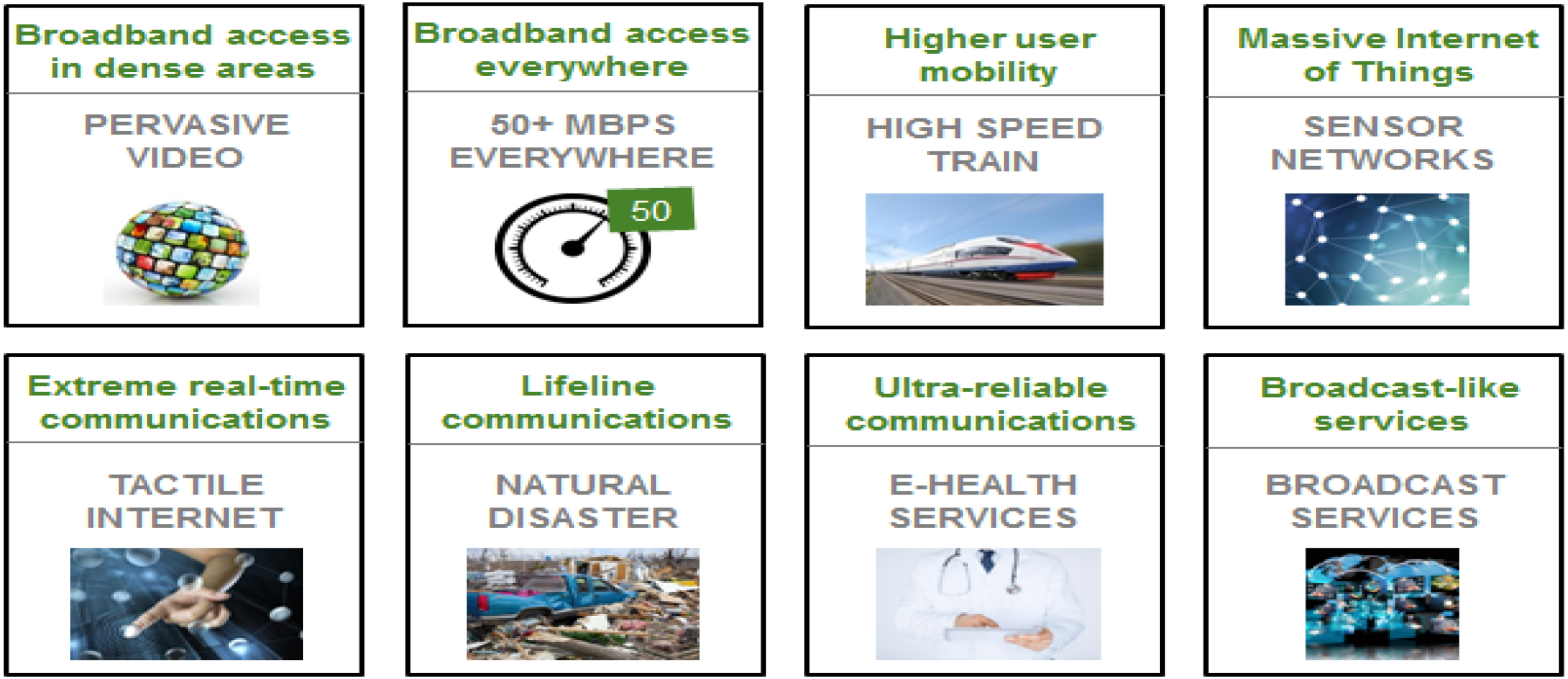

Figure 1: 5G use case families and related examples

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Role	Business Models	
Asset Provider	**XaaS: IaaS, NaaS, PaaS** Ability to offer to and operate for a 3rd party provider different network infrastructure capabilities (Infrastructure, Platform, Network) as a Service.	**Network Sharing** Ability to share Network infrastructure between two or more Operators based on static or dynamic policies (e.g. congestion/excess capacity policies)
Connectivity Provider	**Basic Connectivity** Best effort IP connectivity in retail (consumer/business) & wholesale/MVNO	**Enhanced Connectivity** IP connectivity with differentiated feature set (QoS, zero rating, latency, etc..) and enhanced configurability of the different connectivity characteristics.
Partner Service Provider	**Operator Offer Enriched by Partner** Operator offering to its end customers, based on operator capabilities (connectivity, context, identity etc.) enriched by partner capabilities (content, application, etc..)	**Partner Offer Enriched by Operator** Partner offer to its end customers enriched by operator network and other value creation capabilities (connectivity, context, identity etc.)

Figure 2: 5G Business models - Examples

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4.1.5 User Experience KPI's

Table 1: User Experience Requirements

Use case category	User Experienced Data Rate	E2E Latency	Mobility
Broadband access in dense areas	DL: 300 Mbps UL: 50 Mbps	10 ms	On demand, 0-100 km/h
Indoor ultra-high broadband access	DL: 1 Gbps, UL: 500 Mbps	10 ms	Pedestrian
Broadband access in a crowd	DL: 25 Mbps UL: 50 Mbps	10 ms	Pedestrian
50+ Mbps everywhere	DL: 50 Mbps UL: 25 Mbps	10 ms	0-120 km/h
Ultra-low cost broadband access for low ARPU areas	DL: 10 Mbps UL: 10 Mbps	50 ms	on demand: 0-50 km/h
Mobile broadband in vehicles (cars, trains)	DL: 50 Mbps UL: 25 Mbps	10 ms	On demand, up to 500 km/h
Airplanes connectivity	DL: 15 Mbps per user UL: 7.5 Mbps per user	10 ms	Up to 1000 km/h
Massive low-cost/long-range/low-power MTC	Low (typically 1-100 kbps)	Seconds to hours	on demand: 0-500 km/h
Broadband MTC	See the requirements for the Broadband access in dense areas and 50+Mbps everywhere categories		
Ultra-low latency	DL: 50 Mbps UL: 25 Mbps	<1 ms	Pedestrian
Resilience and traffic surge	DL: 0.1-1 Mbps UL: 0.1-1 Mbps	Regular communication: not critical	0-120 km/h
Ultra-high reliability & Ultra-low latency	DL: From 50 kbps to 10 Mbps; UL: From a few bps to 10 Mbps	1 ms	on demand: 0-500 km/h
Ultra-high availability & reliability	DL: 10 Mbps UL: 10 Mbps	10 ms	On demand, 0-500 km/h
Broadcast like services	DL: Up to 200 Mbps UL: Modest (e.g. 500 kbps)	<100 ms	on demand: 0-500 km/h

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4.1.2 User Experienced Data Rate

Data rate requirements are expressed in terms of user experienced data rate, measured in bit/s at the application layer. The required user experienced data rate should be available in at least 95% of the locations (including at the cell-edge) for at least 95% of the time within the considered environment. The user experienced data rate requirement depends on the targeted application/use case. It is set as the minimum user experienced data rate required for the user to get a quality experience of the targeted application/use case.

Use case specific user experienced data rates up to 1 Gb/s should be supported in some specific environments, like indoor offices, while at least 50 Mb/s shall be available everywhere cost-effectively. Use case specific user experienced data rate requirements are specified in Table 1.

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4.1.4 Mobility

Mobility refers to the system's ability to provide seamless service experience to users that are moving. In addition to mobile users, the identified 5G use cases show that 5G networks will have to support an increasingly large segment of static and nomadic users/devices. 5G solutions therefore should not assume mobility support for all devices and services but rather provide mobility on demand only to those devices and services that need it. In other words, mobility on-demand should be supported, ranging from very high mobility, such as high-speed trains/airplanes, to low mobility or stationary devices such as smart meters.

The mobility requirements are expressed in terms of the relative speed between the user and the network edge, at which consistent user experience should be ensured (see Consistent User Experience requirement). Use case specific mobility requirements are specified in Table 1.

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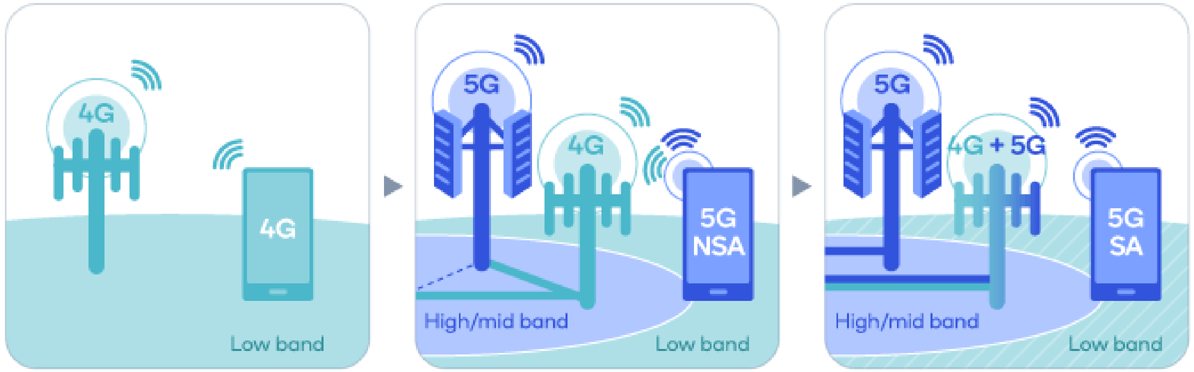

1. 4G
2. 4G/5G NSA with Dual Connectivity
3. 4G/5G SA with Dynamic Spectrum Sharing

4.2.3 Spectrum Efficiency

Spectrum efficiency should be significantly enhanced compared to 4G in order for the operators to sustain such huge traffic demands under spectrum constraints, while keeping the number of sites reasonable. Spectrum efficiency improvements should apply in both small and wide area cells, in both low and high frequency bands, in both high and low mobility scenarios.

In particular the average spectrum efficiency (measured in bit/s/Hz/cell) and the cell-edge spectrum efficiency (measured in bit/s/Hz/user) should be improved.

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Technology building block name	**Advanced multiple access technologies**
Category	RAN
Description	Advanced multiple access technologies should provide higher network spectral efficiency; the performance gap between cell-centre and cell-edge users could be reduced, and the number of simultaneous (access) users could be increased. Non orthogonal multiple access (NOMA) scheme efficiently exploits the channel gain difference among/between users to achieve high spectral efficiency. In NOMA, multiple users can transmit signals at the same spatial-time-frequency resource during uplink transmission, or the signals of multiple users can be transmitted by eNB at the same spatial-time-frequency resource during downlink transmission. To obtain multi-user multiplexing gain, advanced interference cancellation should/must be carried out/implemented on receiver side. Additionally, power allocation and multi-user scheduling are needed at the transmitter side.

2. ETSI MEC re-named in March 2017 & 3GPP 5G NSA Rel. 15 Mobility - 1

ETSI Multi-access Edge Computing (MEC) starts 2nd Phase & Renews Leadership Team

*Sophia Antipolis, **28 March 2017***

https://www.etsi.org/newsroom/news/1180-2017-03-news-etsi-multi-access-edge-computing-starts-second-phase-and-renews-leadership-team

ETSI's MEC ISG has

1. **Renamed MEC** to **Multi-access Edge Computing** to better reflect Non-Cellular Operators' Requirements.

2. **A New Leadership** Team: Alex Reznik new Chair

3. A **New Scope** to address:
   - **multiple MEC Hosts**
   - **different Networks**
   - **Edge Applications in a Collaborative Manner.**

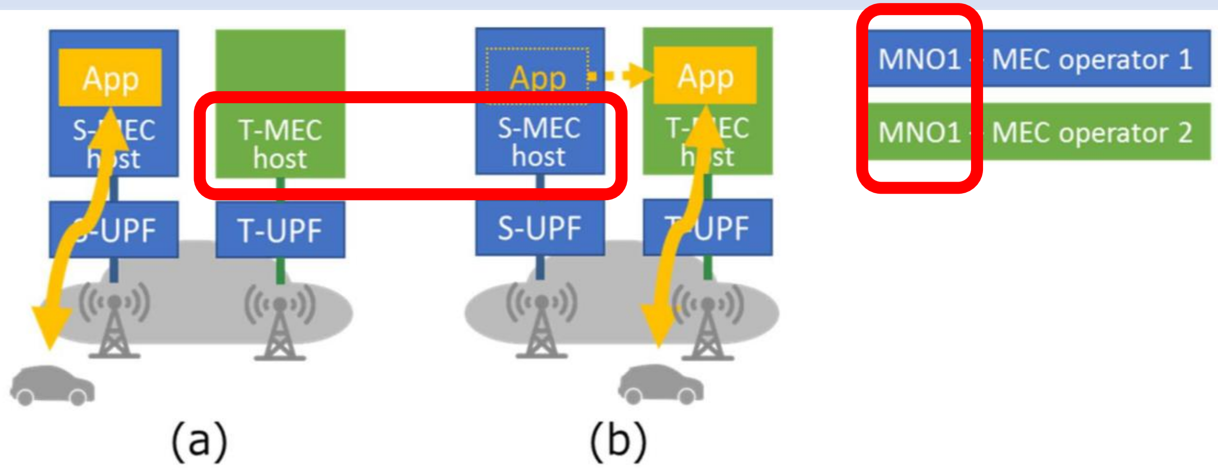


Figure 5.1.1.3-2: Inter-operator mobility support

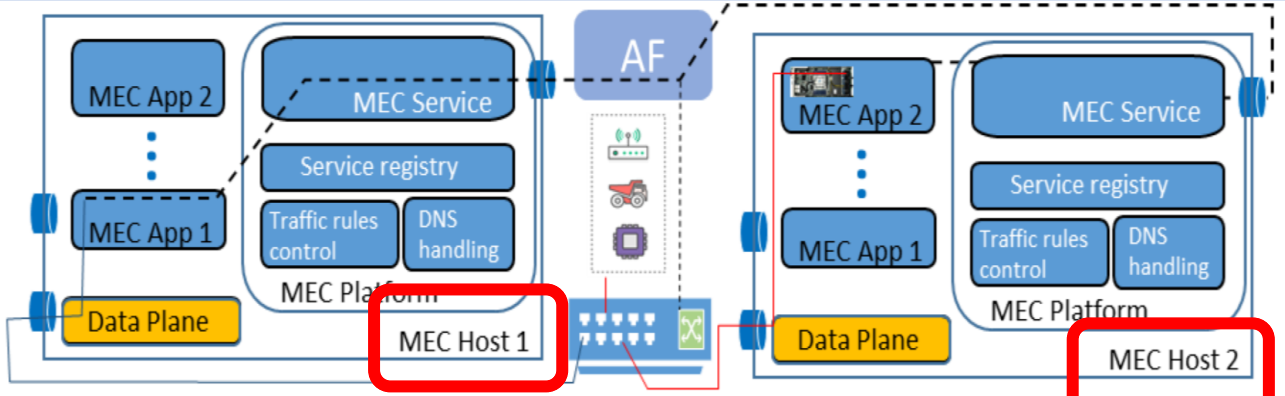


Figure 10. Traffic steering to alternative MEC host.

2. ETSI MEC re-named in March 2017 & 3GPP 5G NSA Rel. 15 Mobility - 2

1. **"Mobility" Paterns Re-defined/Diversified - UEs categorized/defined as:**
   1. **Stationary** during their entire usable life (e.g., sensors embedded in infrastructure)
   2. **Nomadic during Active Periods**, but Stationary **between activations** (e.g., Fixed Access)
   3. **Mobile within a Constrained & Well-Defined Space/Area** (**Spatially Restricted** e.g., in a Factory or Stadion or Airport),
   4. **Fully Mobile (WAN)**.

0 IP Anchor Node & UE - Relay) - deployed at the "Edge" for
- 5G Network Traffic offloading onto traditional IP Routing Networks

- as UE moves, changing the **IP Anchor Node** needed in order to reduce
  - IP Traffic Load,
  - End-to-End latency
  - Better User Experience

- Seamless access to both 3PGG and non - 3GPP Network Access Technology (e.g WiFi, Bluetooth, Ethernet &..)

- Dynamic Subscriber Management via GSMA Standardised eUICC OTA Platform (SM-DP & SM-SR Platform)

2. ETSI MEC renamed in March 2017 & 3GPP 5G NSA Rel. 15 Mobility - 3

Relation of Communication Service: **Availability and Reliability**

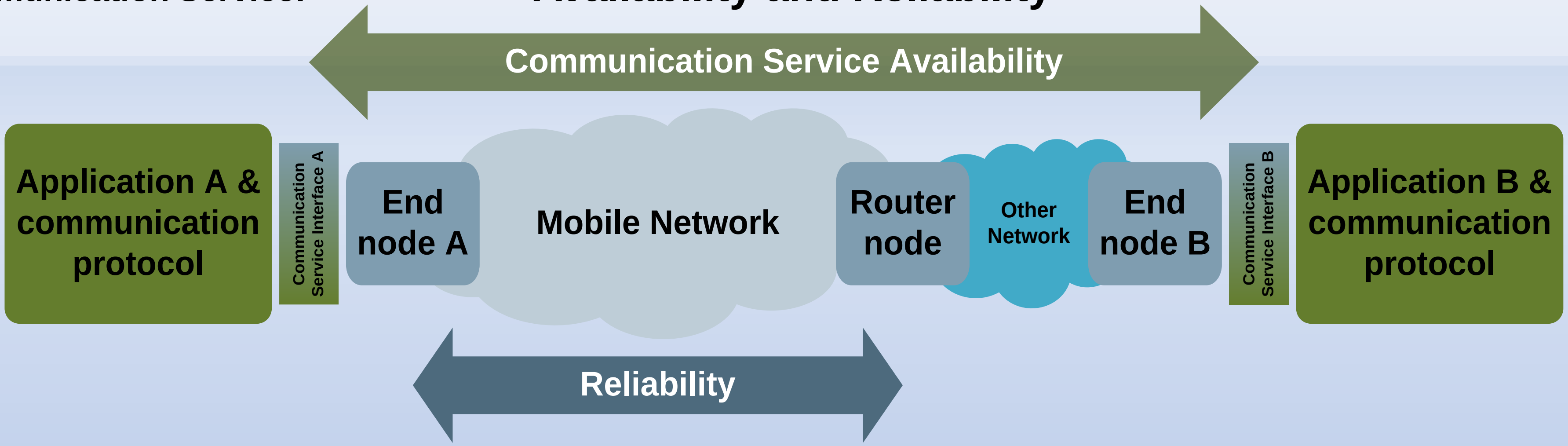


Figure C-4: Example in which communication Service Availability & Reliability have different values.

Packets are delivered over a daisy chain of a Mobile Network and another Network (e.g. IEEE 802.11n based).

Reliability is evaluated for the Mobile Network only,
Availability depends on the performance of both Networks.

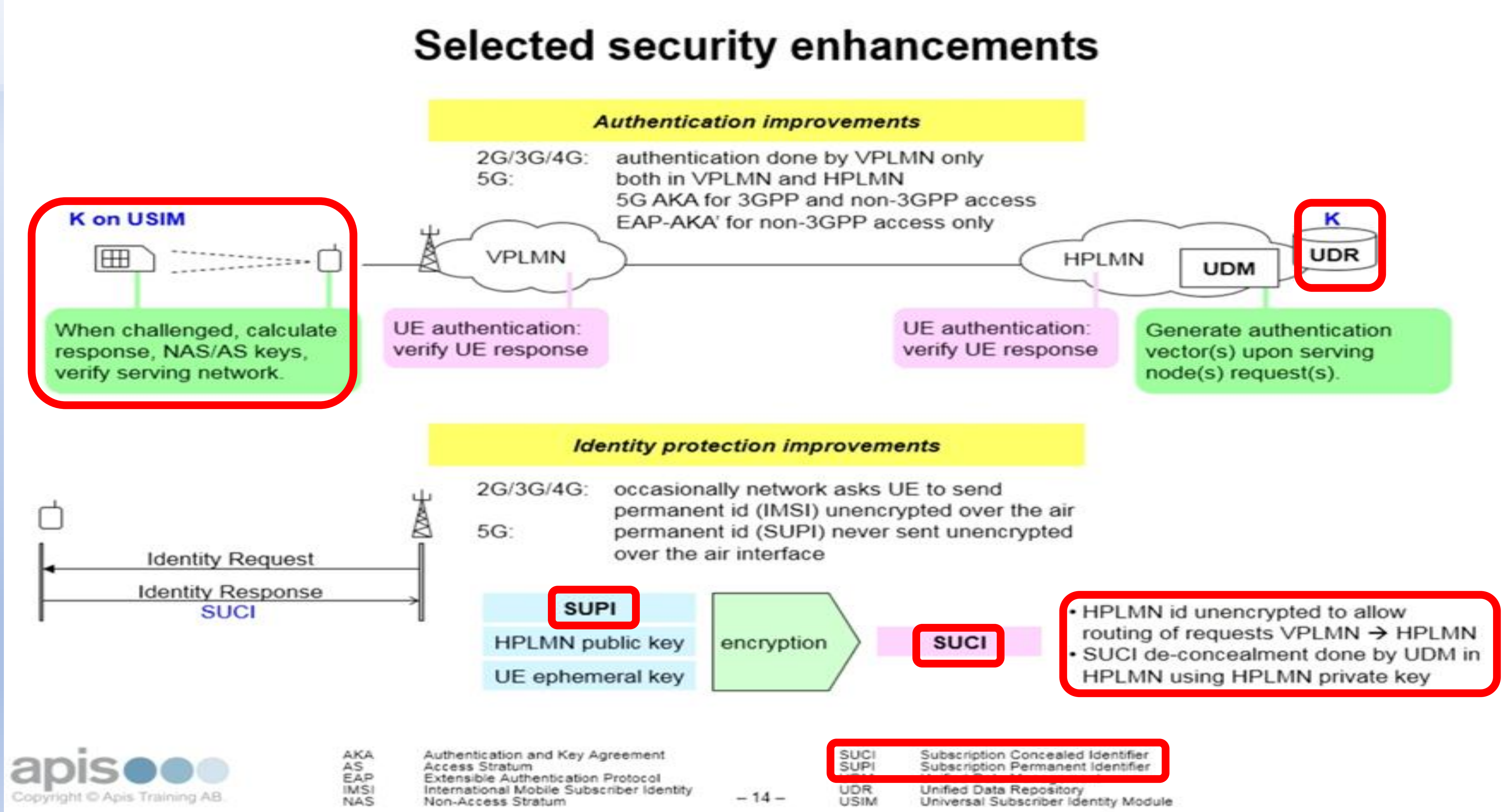
Communication Service **Availability** - measured between the two (2) Communication Service Interfaces,

Reliability - measured between End Node A and the Router Node.

This has implications for, e.g. the maximum communication latency allowed for each network. In case the agreed end-to-end latency between the service interfaces is, for instance, 100 ms, and the 802.11n network has a latency of 30 ms, the maximum allowable latency for packages in the mobile network is 70 ms (NOTE). So, if the latency in the mobile network exceeds 70 ms, the communication service availability is 0%, despite the agreed QoS stipulating a larger end-to-end latency, i.e. 100ms.

NOTE: The transit time through the router node is not considered here. It is assumed to be very small and much less than 100 ms.

2. ETSI MEC renamed in March 2017 & 3GPP 5G NSA Rel. 15 Mobility - 4



3.1 5GS Network Capabilities & MEC Integration - 1

In the **5GS Specifications** there is a **Set of New Functionalities that serves as Enablers for Edge Computing.**

These Enablers are essential for Integrated MEC Deployments in 5G Networks.

1. Local Routing and Traffic Steering:

- 5G CN provides the means to select Traffic to be routed to the Applications in the Local Data Network (DN).
- A PDU Session may have multiple N6 Interfaces towards the DN.
- The UPFs that terminate these interfaces are said to support *PDU Session Anchor functionality*.
- UPF's Traffic steering is supported by Uplink Classifiers that operate on a set of Traffic Filters or
  - alternatively by IPv6 Multi-Homing, where multiple IPv6 prefixes have been associated with the PDU session

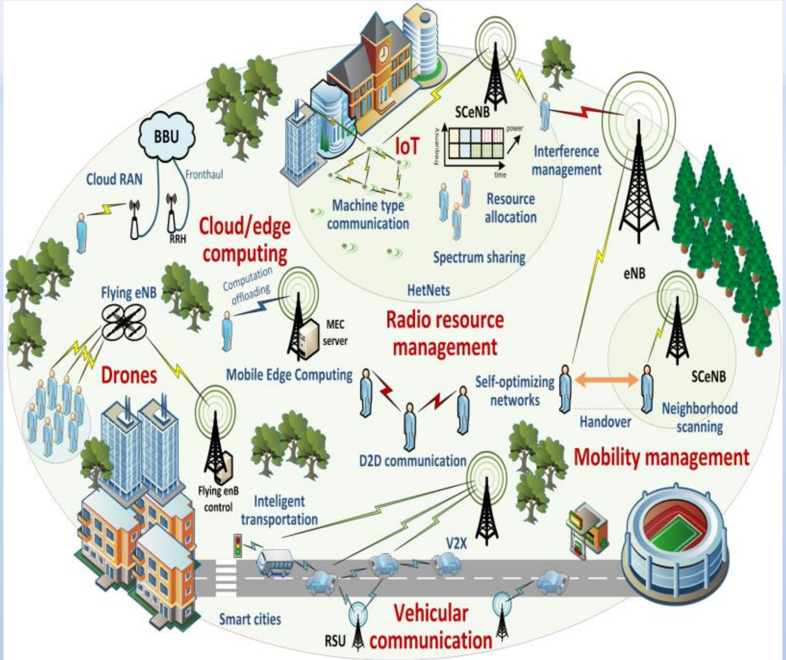
2. The AF ability to influence UPF (re)selection & Traffic Routing:

directly via the Policy Control Function (PCF) or indirectly via the Network Exposure Function (NEF), depending on the operator's Policies.

3. The SSC - Session & Service Continuity modes for different UE & Application Mobility Scenarios.

4. Support of Local Area Data Network (LADN) by the 5G Core Network

by providing support to connect to the LADN in a certain area where the applications are deployed. The access to a LADN is only available in a specific LADN service area, defined as a set of Tracking Areas in the serving PLMN of the UE. LADN is a service provided by the serving PLMN of the UE.



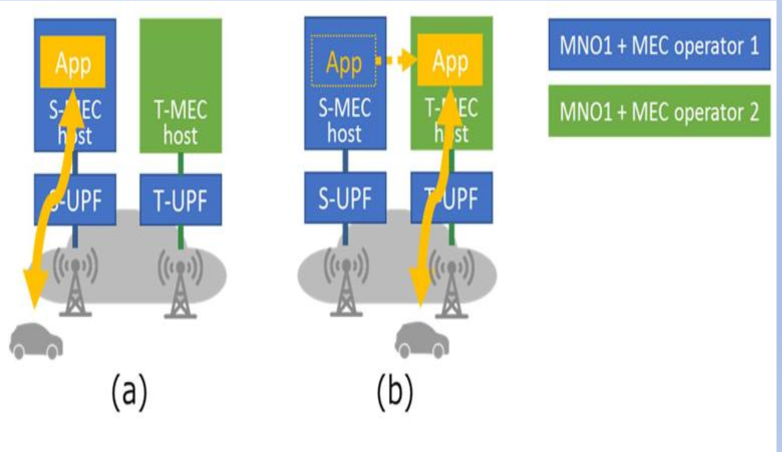


Figure 5.1.1.3-2: Inter-operator mobility support

3.1 5GS Network Capabilities & MEC Integration - 2

1. MEC & the local UPF collocated with the eNB/gNB Base Station
2. MEC collocated with a Transmission Node, possibly with a local UPF
3. MEC & the local UPF collocated with a Network Aggregation Point
4. MEC collocated with the CN Functions (i.e. in the same DC)

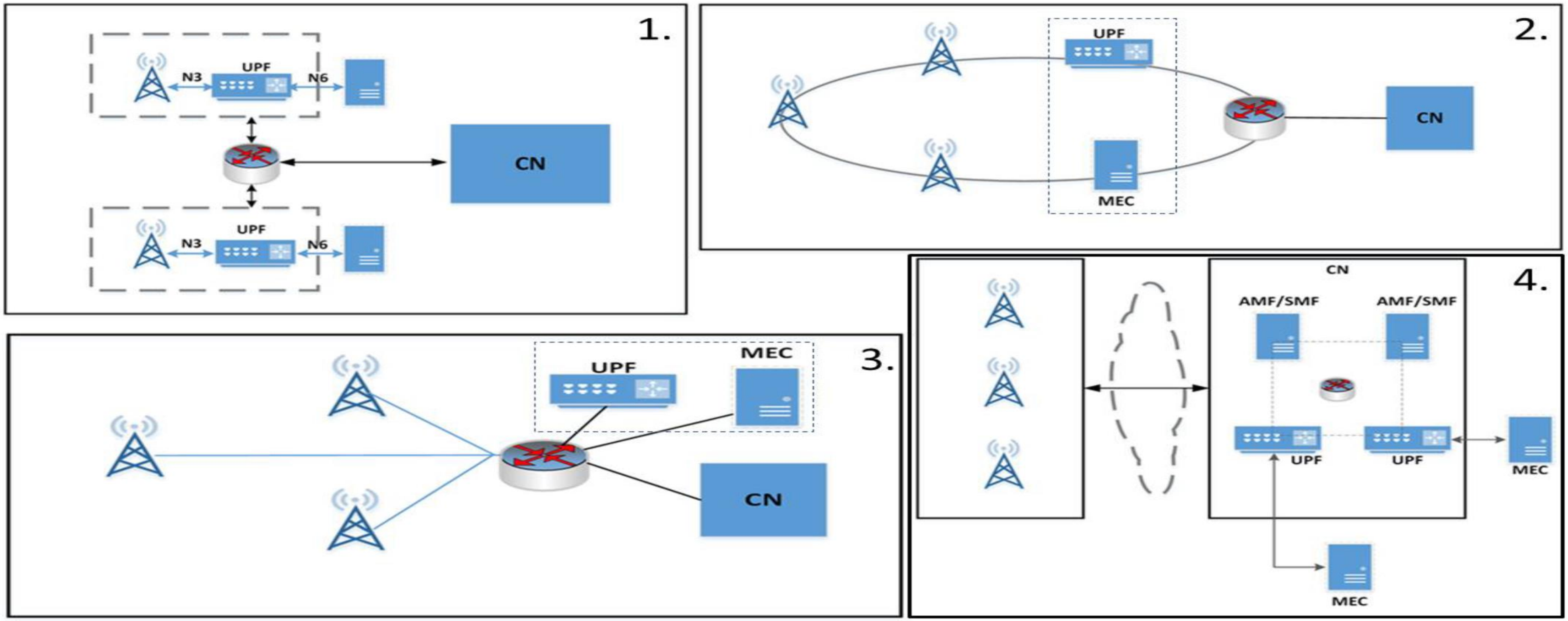


Figure 3. Examples of the physical deployment of MEC.

3.1 5GS Network Capabilities & MEC Integration - 4: 5G CAPIF & MEC Service Registry - 1

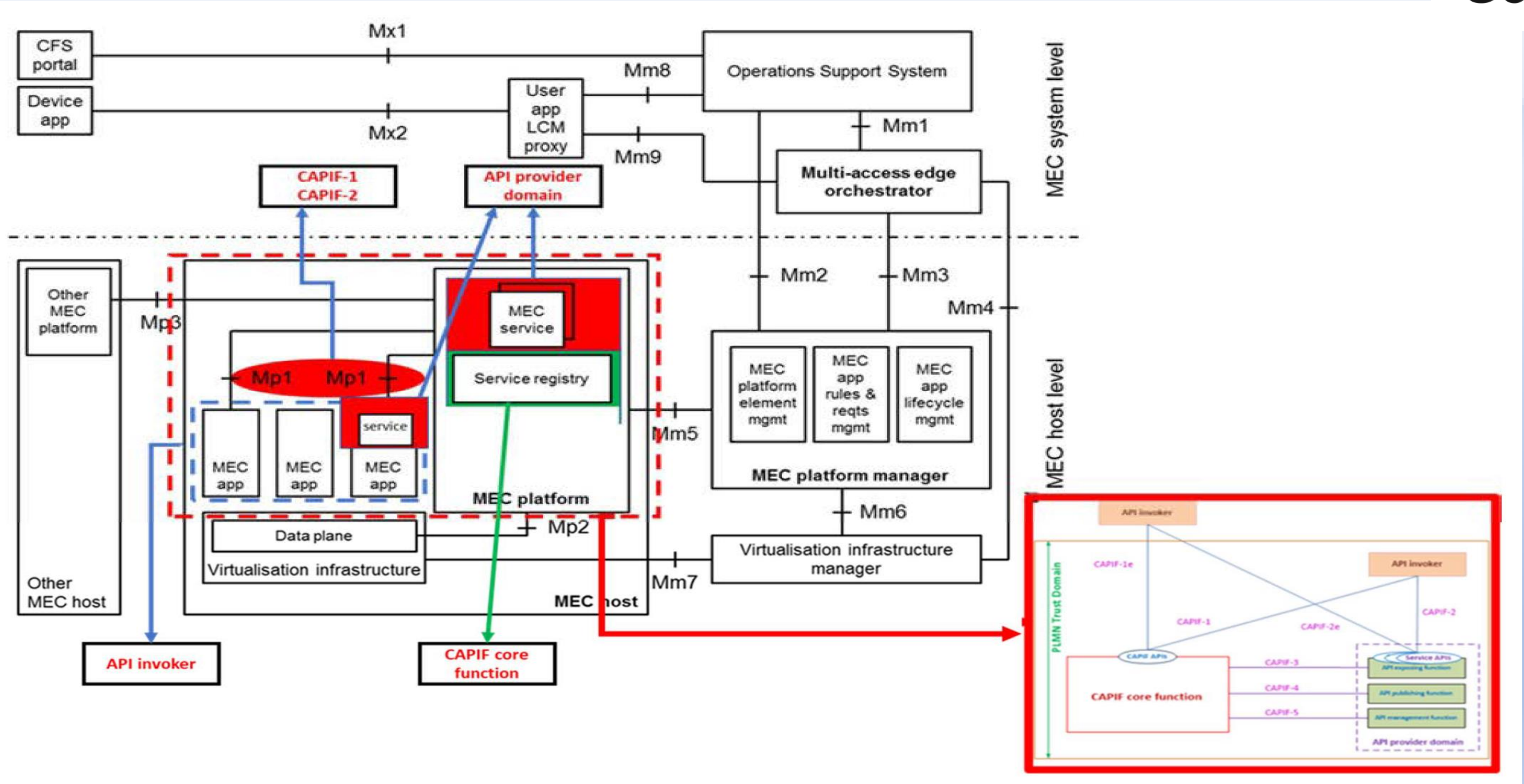


Figure 4.3.1-1: Relationship between MEC and 5G common API framework

3.1 5GS Network Capabilities & MEC Integration - 4: 5G CAPIF & MEC Service Registry - 2

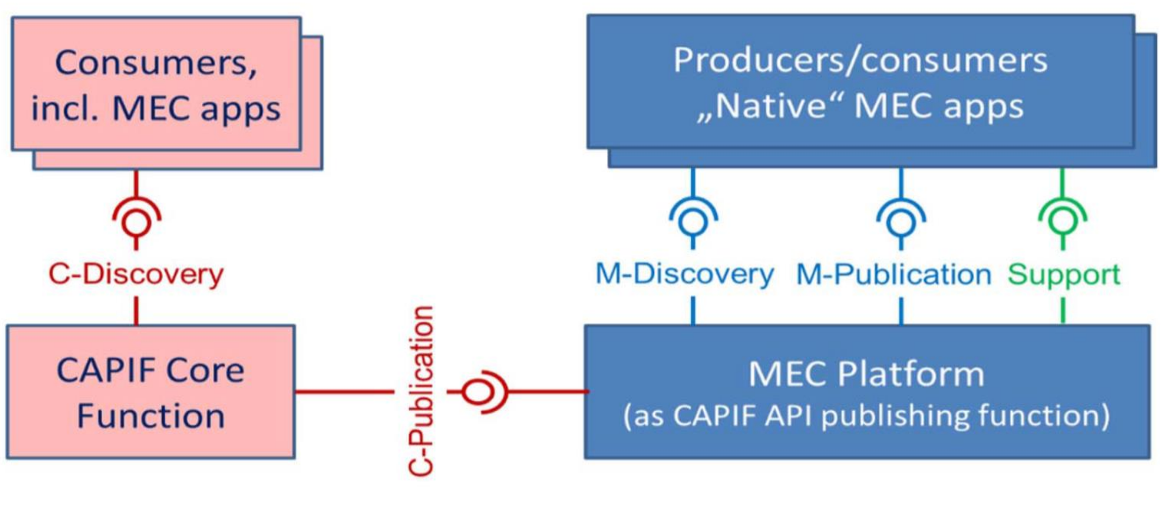


Figure 4.3.2-1: Loosely-coupled deployment of CAPIF and MEC

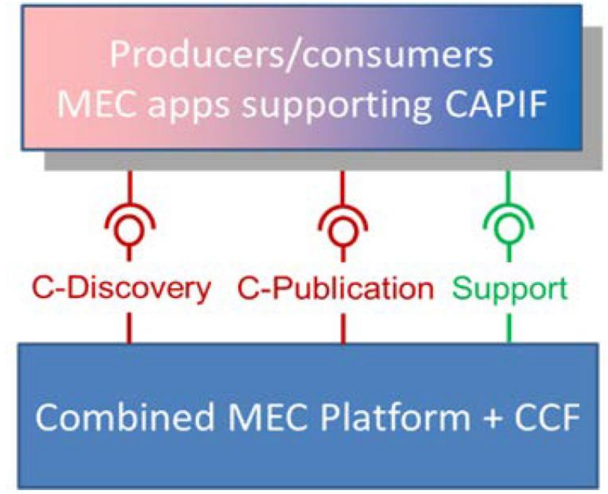


Figure 4.3.3-1: Fully-integrated hybrid deployment of CAPIF and MEC

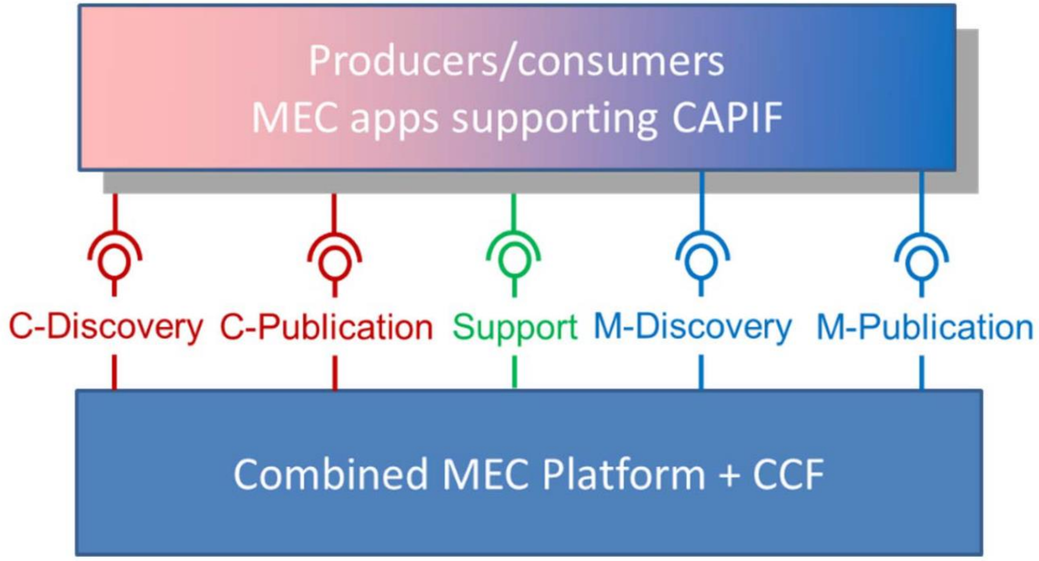


Figure 4.3.3-2: Hybrid deployment of CAPIF and MEC with support for MEC alternative transports

3.2 5GS Network Capabilities & MEC Integration - 1: Management Host & System Level

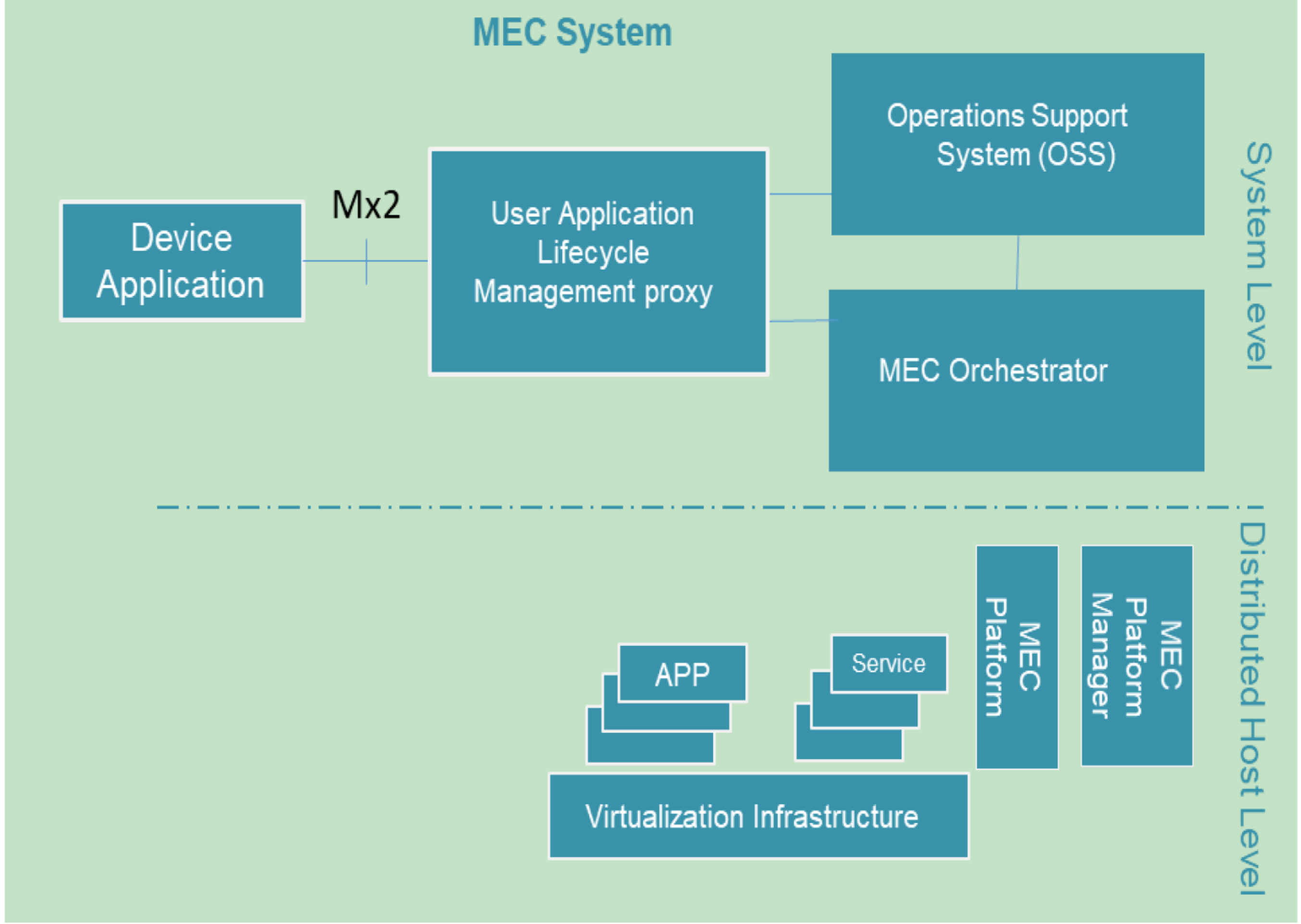


Figure 7. UE application API over Mx2 reference point

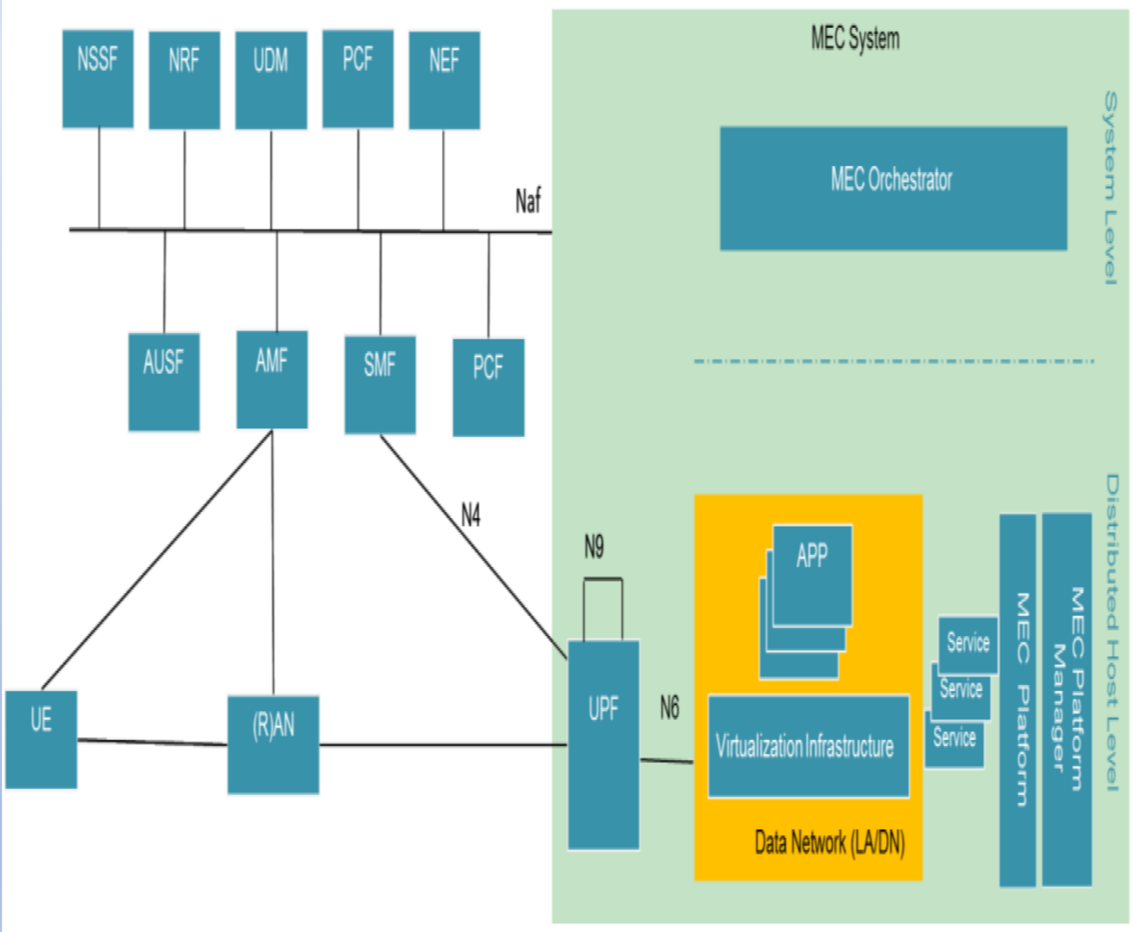


Figure 2. Integrated MEC deployment in 5G network

3.3 MEC Support for AVT

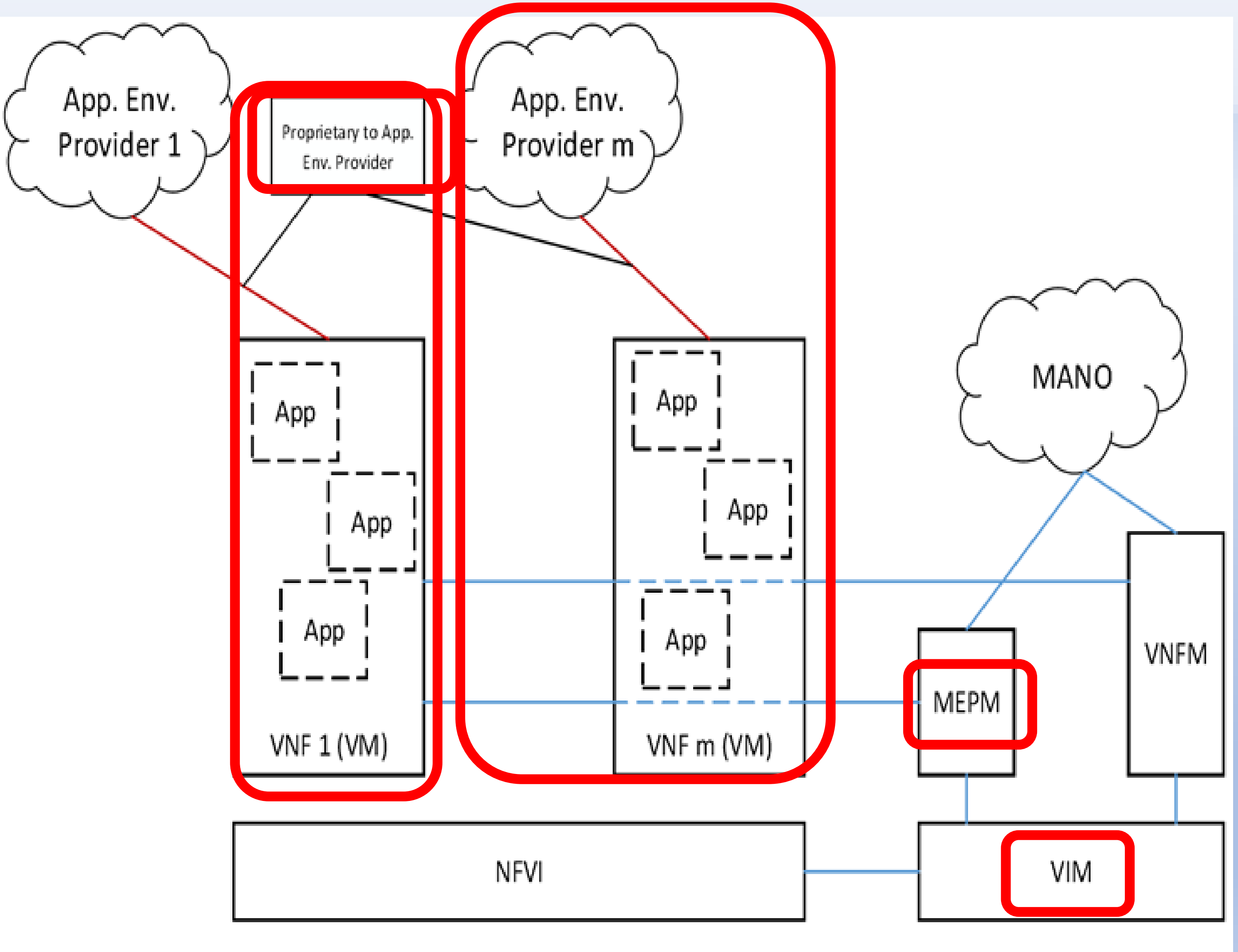


Figure 3: Illustrating a key use case for nested virtualization in MEC

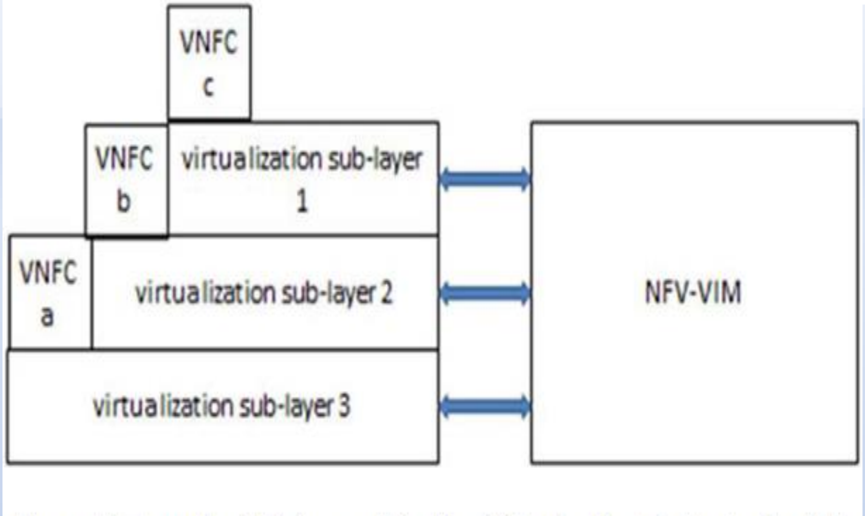


Figure 5: Example of Mixing and Nesting Virtualisation Technologies [i.7]

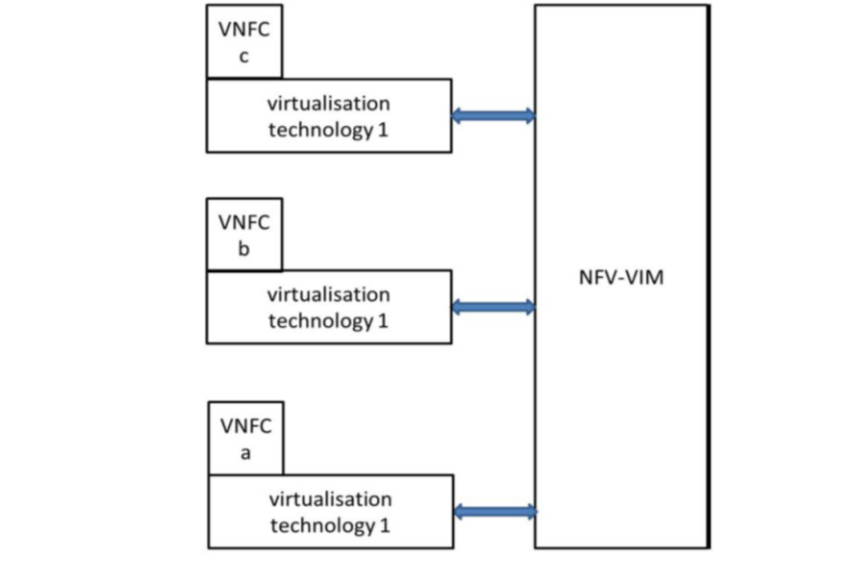
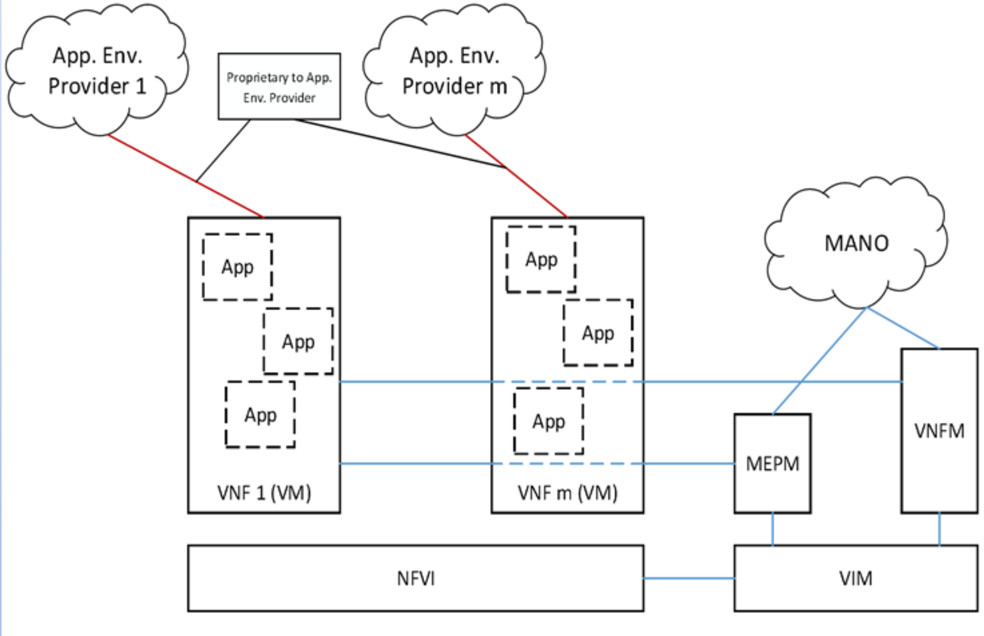


Figure 4: Example of Mixing of Virtualisation Technologies

MEC use of non-NFV Managed Virtualization Systems in the Nested Virtualization Sub-Layers

A differentiating aspect of MEC, as compared to NFV, is the potential need to deploy Applications belonging to multiple 3rd Parties' Application Environments, e.g. OS-Container based Application Environments or Higher-Layer Container based Environments, that might be supported where Application deployment inside each Environment is **managed by the Environment Operators, not the Operator of the MEC Host. Nesting of Virtualization Technologies** allows **MEC Host Operators to support multiple such Environments** by allocating a VNF (typically, but not always, consisting of a single VNFC) to each 3rd-Party Application Environment Owner, that is then, able to further allocate the Resources assigned to its VNF to the multiple Applications it runs, & to do so based on its own Internal Criteria. This situation is illustrated in Fig. 3, VNFs 1 to m (each consisting of a single VM) instantiated on an NFVI managed by VIM. The Management of VNFs VNF1 to VNFm is provided by the MANO Components as defined by ETSI NFV & ETSI MEC (MEPM, VNFM, etc.). However, **what happens inside each VNF is managed by the Application Environment Providers Own Management System** (usually elsewhere in the Cloud). **It is this Management System that provides all Application Management within the VNF & such Management does not need to be coordinated with the MEC/NFV MANO System**. In this case, the Top-Level MEC Host Operator does not perform any Management Functions for the Applications in the Sub-Layer. Its Management & Service Delivery interactions are strictly limited to the Virtualization Sub-Layer 1, while the Operators of the MEC Application Environments manage all interactions with their Client Applications. From a MEC Operator point of view, this approach appears to be the same as a Hypervisor-based Solution. It is not aware of nesting. As with Nesting the NFVI Virtualisation Layer can be composed of Multiple Nested Sub-Layers, each using a different Virtualisation Technology, & as illustrated in Fig. 5, the Components of the VNF run on different Nested Layers, each benefiting of the particular Characteristics of Virtualisation Technology of Choice.



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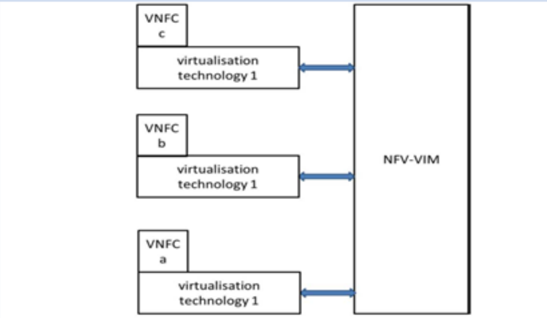

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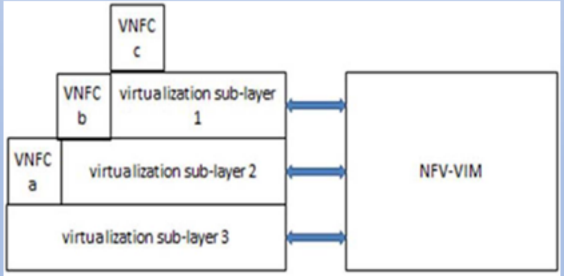


Figure 5: Example of Mixing and Nesting Virtualisation Technologies [i.7]

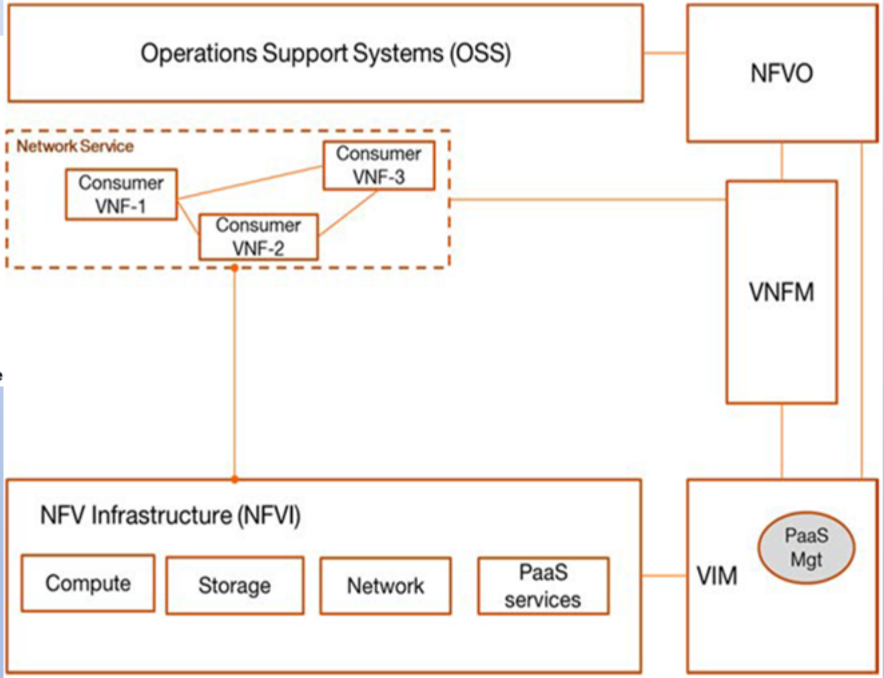


Figure 7.1.1.3.1-1: PaaS services as NFVI resources

PaaS Services as NFVI Resources Services Management

With this design option PaaS Services are modelled as a new type of NFVI resources (Fig. 7.1.1.3.1-1). Both common & dedicated PaaS Services are modelled as a new type of NFVI Resources in a similar way as acceleration resources. In such a case, the dependency of a Consumer VNF on a PaaS service is always specified as a constraint within the VNFD. The PaaS Service Management functionality is embedded in the VIM in a similar way as acceleration resources. When the VNFD of a Consumer VNF specifies a dependency on a PaaS dedicated Service, the VNFM requests the VIM to create & allocate the corresponding resource. When the VNFD of a Consumer VNF specifies a dependency on a PaaS common service, the VNFM requests the VIM to enable access to the corresponding resource from the Virtualised Compute Resources hosting the Consumer VNF.

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 1

ETSI ISG MEC

World Class Standards

MEC Developing SW for MEC Applications

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 2

ETSI MEC - Developing SW for MEC - Feb 2019

Figure 2, a MEC Host, at the network edge, with MEC Platform & VT (Compute, Storage & Networking) for Applications in VMs or Containers via via RESTful APIs, Discover, Advertise, Consume and offer Services.

The Edge Component(s) include a set of operations that the application performs at the edge cloud, e.g. to

- Offload the Computing away from the Terminal Device while still leveraging very Low Latency & Predictable Performance, or
- Offloading High Bandwidth Load from the Network Backbone, or
- Extracting some Information using RNI API or
- Location API.

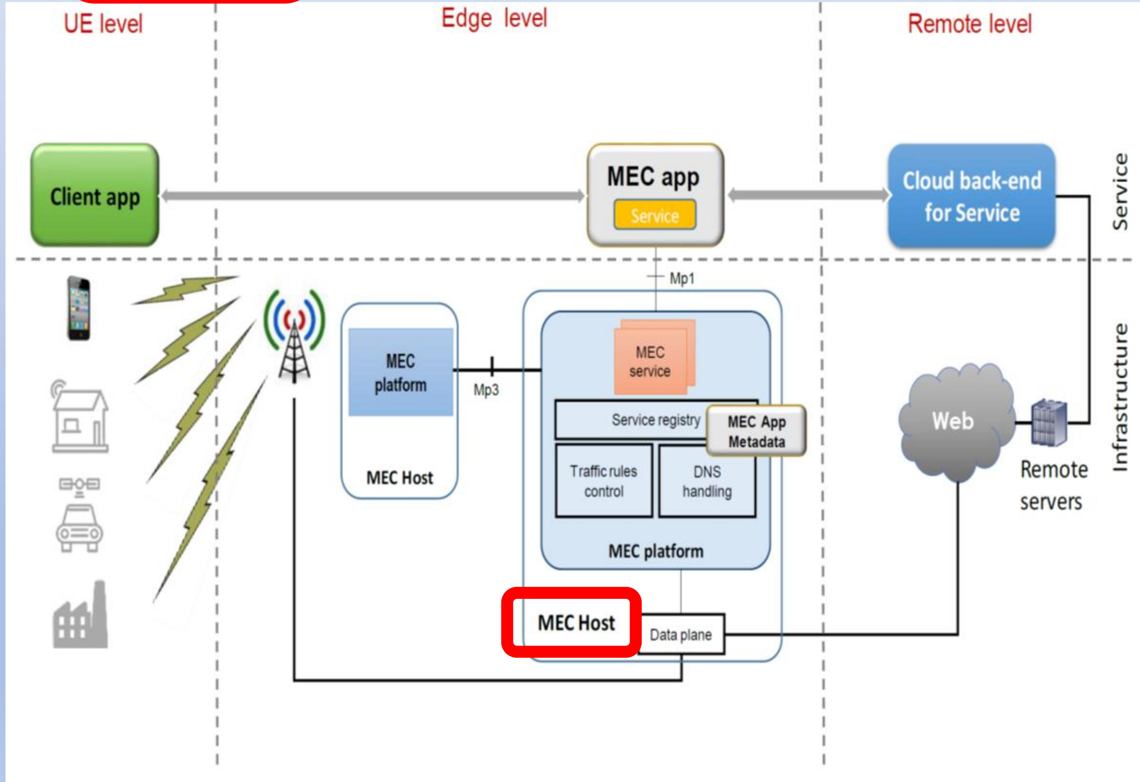


Figure 2: New application development paradigm introduced by MEC.

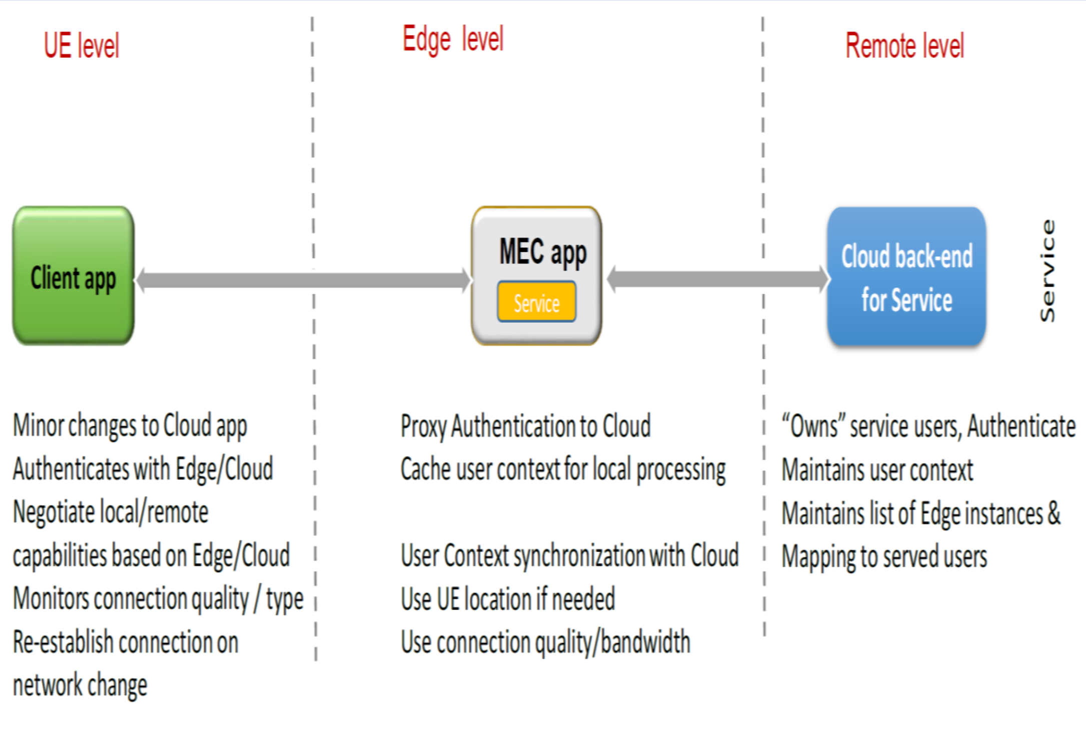


Figure 3: Example of splitting an application into "terminal", "edge" and "remote" components

MEC introduces a Standard for supporting an emerging Cloud Paradigm for SW Development communities with **a New Development Model with 3 "Locations": Client, Near Server, Far Server** as shown in Fig.2 below. The **Client Location** can be a traditional Smartphone or other Wireless Connected Compute Elements in a Car, Smart Home or Industrial Location that can run dedicated Client Applications. A MEC Host, usually deployed at the Network Edge, contains a MEC Platform & the Compute, Storage & Network is where the Applications & Networks should be completely Agnostic to each other. A Key Aspect of SW Design for MEC: the E2E Service can be split into three (3) Applications/ Components: Terminal Device Component(s), Edge Component(s) & Remote Component(s). This concept should NOT be confused with the traditional SW Modularization, but rather seen as a Distribution of Components to leverage different features of the computing environment.

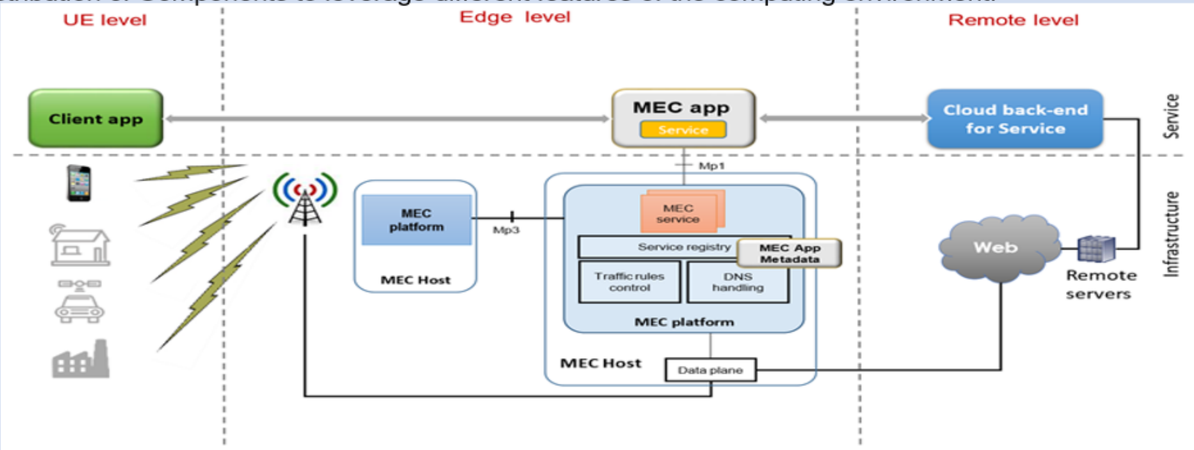


Figure 2: New application development paradigm introduced by MEC.

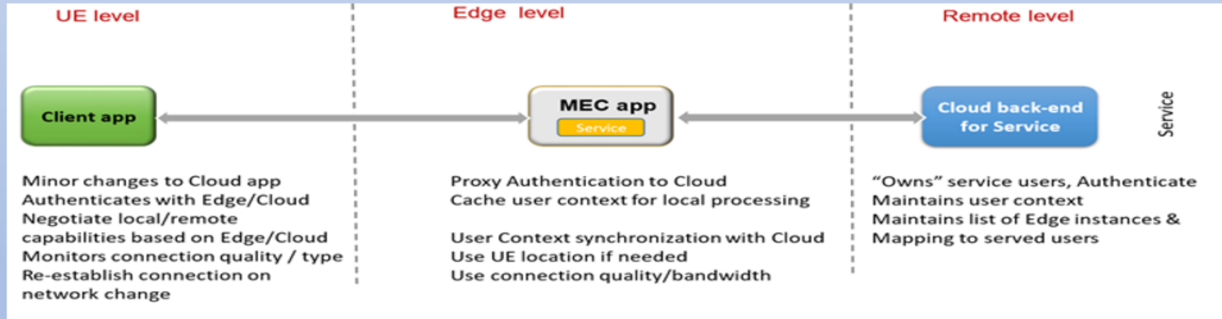


Figure 3: Example of splitting an application into "terminal", "edge" and "remote" components

MEC can be exploited to implement **Computation Offloading Techniques** among all the Application's Components. The Server can be programmed to Dynamically Shift the Processing among the Terminal, the Edge & the Remote Component(s), for reasons as Adaptation to Network Conditions, Improving Application Specific KPIs, Policies, Costs, etc. The Processing Distribution may be driven by certain Performance Objectives, e.g. providing the Best User Experience. Another aspect inherent to MEC is that service providers can exploit the Geographical Distribution to serve Different User Populations and thus tailor their Service knowing the Peculiarities of the Covered Area.

The MEC Platform's overall Capabilities are enhanced to support Multiple Access Technologies & full Application Mobility & at a lower level as specific applications are further developed to exploit Enhanced API Functionality, e.g., as the Radio Network Information (RNI) Service Capabilities expand into the Multi-access Domain.

The Microservices variant of the Service-Oriented Architecture (SOA) pattern has direct applicability to the SW Model envisaged for MEC & its Services & Applications. The Approach's ability, to compose a Distributed Application from Separately Deployable Services, that are expected to communicate via Web Interfaces (such as MEC's RESTful API approach) & perform a specific Business Function. DevOps practices (CI/CD) are considered as being highly complementary. with this approach.

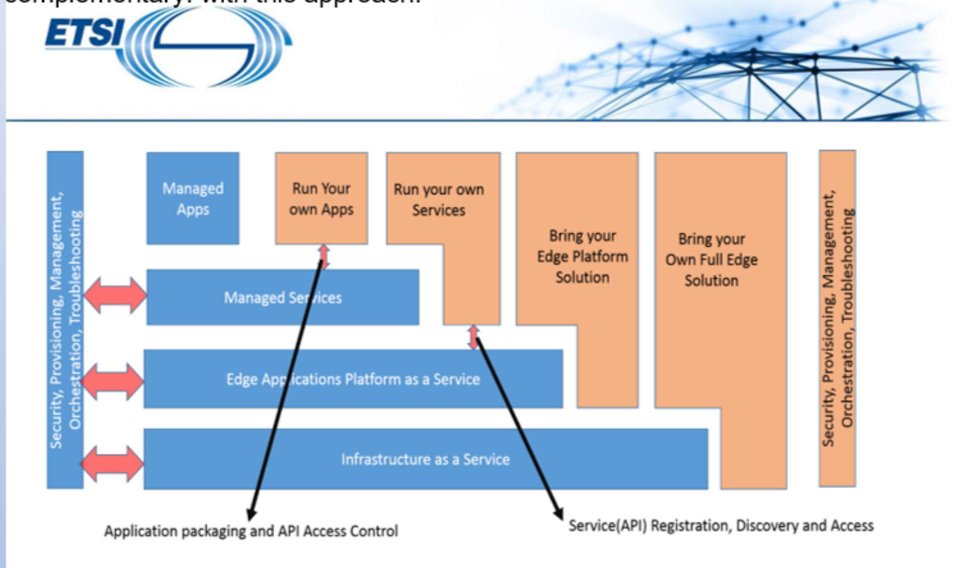


Figure 13: Overview of different cloud business models

Fig. above shows an overview of **different Cloud Business Models based on Layered Model**, while the fundamental Principles of Continuous Integration & Continuous Delivery (CI/CD) apply across the board, the realization of such practices will differ significantly depending on the SW Layer where the Development is performed & the Management boundaries of the Edge Stack. One of the **Key Operational Requirements for Edge Computing** is also the **Concept of Zero-Touch Provisioning.** This applies to all the Layers of the Edge stack & requires **Full Management Automation & Service Assurance.**

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 3

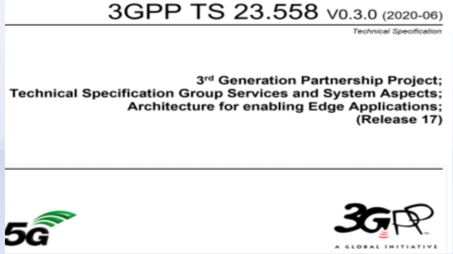
A GLOBAL INITIATIVE

3GPP TS 23.558 V0.3.0 (2020-06)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Architecture for enabling Edge Applications;
(Release 17)

5 3GPP Architecture enabling Edge Applications (EDGEAPP) requirements - 4


3GPP TS 23.558 V0.3.0 (2020-06)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Architecture for enabling Edge Applications;
(Release 17)

The application architecture for enabling Edge Applications is designed based on the following architecture principles:

- Application Client portability: Changes in logic of Application Clients to interact with Edge Application Servers, compared to existing cloud environment, are avoided.
- Edge Application Server's portability: Changes in logic of Application Servers when resident in Edge Hosting Environment, compared to existing cloud environment, are avoided. An Edge Application Server should be able to run in Edge Hosting Environments of multiple Edge Computing Service Providers, without any modification.
- Service differentiation: The mobile network operator is able to provide service differentiation (e.g. by enabling/disabling the Edge Computing features).
- Flexible deployment: There can be multiple Edge Computing Service Providers within a single PLMN operator network. The Edge Data Network can be a subarea of a PLMN.
- Interworking with 3GPP network: To provide Edge Computing features, already developed or to be developed in 3GPP network (such as location service, QoS, AF traffic influence), to Edge Application Servers, the application architecture supports interworking with 3GPP network using existing capability exposure functions such as NEF and PCF.

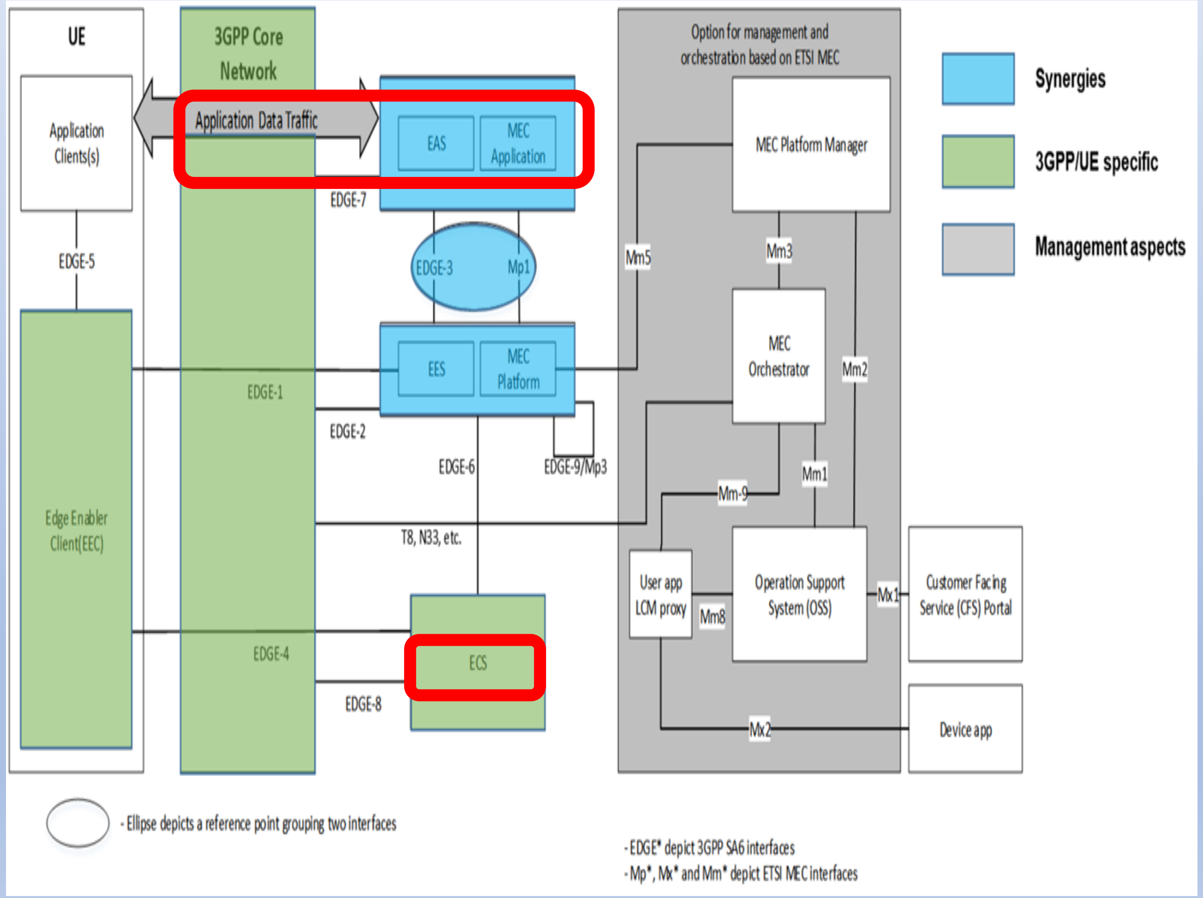


Figure C.2-1: Relationship between EDGEAPP and ETSI MEC Architectures

Release 17 15 3GPP TS 23.558 V0.3.0 (2020-06)

6.2 Architecture

The Figure 6.2-1 shows the architecture for enabling edge applications.

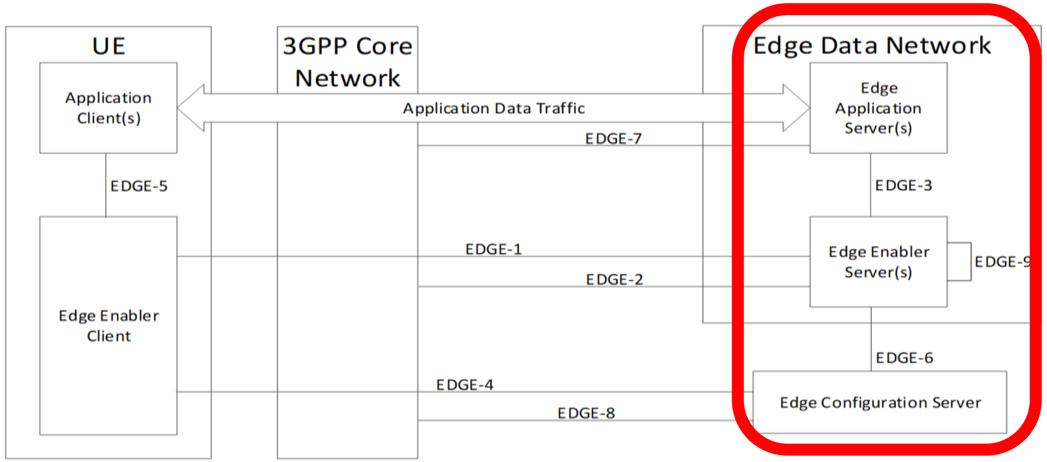


Figure 6.2-1: Architecture for enabling edge applications

The EDN is a local Data Network. EAS(s) & the EES are contained within the EDN.

The ECS provides Configurations related to the EES, including details of the EDN hosting the EES.

The UE contains Application Client(s) & the Edge Enabler Client.

The EAS(s), the EES & ECS may interact with the 3GPP Core Network.

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 5 MEC EAS/EES & 5G EPC/SBA

7.10.1.4 EES & EAS direct interaction with 3GPP Core Network(s)

As shown in Figure 7.10.1.4-1, the EES deployed with the PLMN Trust Domain can support Edge Application Server (owned by 3rd Party or by PLMN Operator) access to Northbound APIs exposed by SCEF/NEF by assuming the role of SCEF/NEF and the PLMN EAS can access the Network Capabilities via direct interaction with the 3GPP Core Network entities.

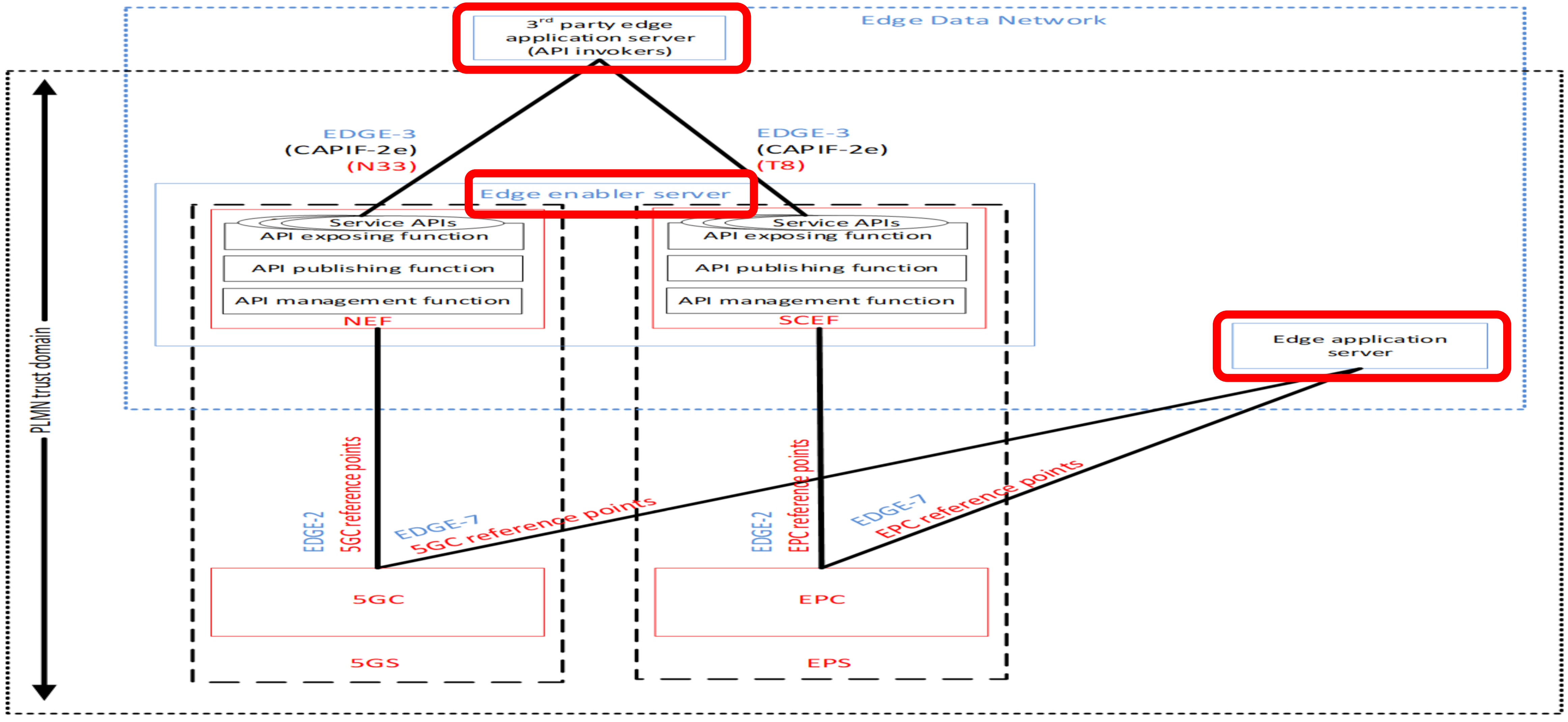


Figure 7.10.1.4.-1: EES and EAS direct interaction with 3GPP Core Network

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 6

The EES can support EAS (owned by 3rd party or by PLMN Operator) access to Northbound APIs exposed by SCEF/NEF by providing distributed CAPIF Functions as shown in Figure 7.10.1.2-1.

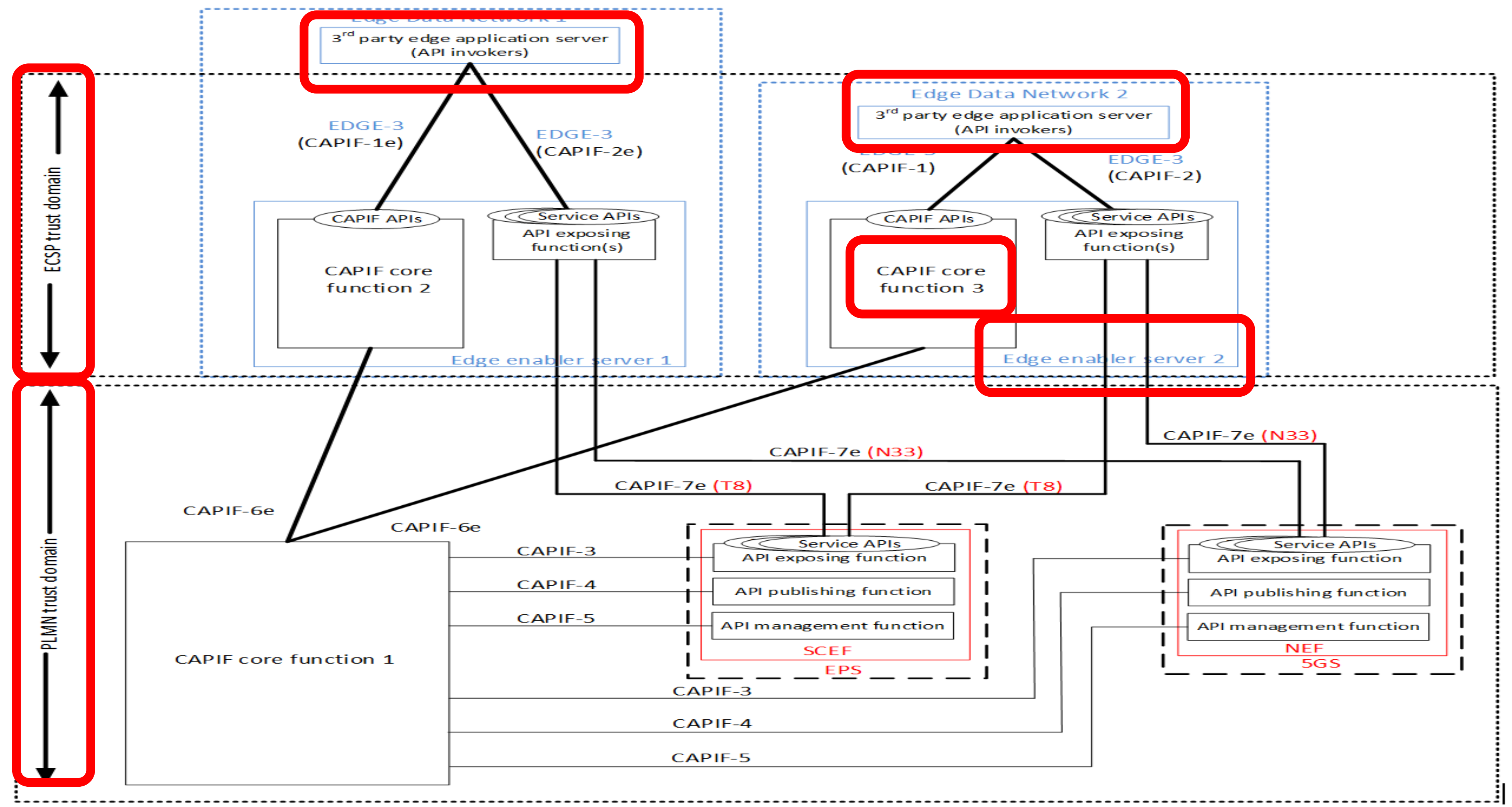


Figure 7.10.1.2-1: Edge Enabler Server supporting distributed CAPIF functions

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 7 MEC EES & CAPIF

7.10.1.3 Centralized CAPIF

The EES can support EAS (owned by 3rd party or by PLMN Operator) access to Northbound APIs exposed by SCEF/NEF by providing Centralized CAPIF Functions as shown in Figure 7.10.1.3-1.

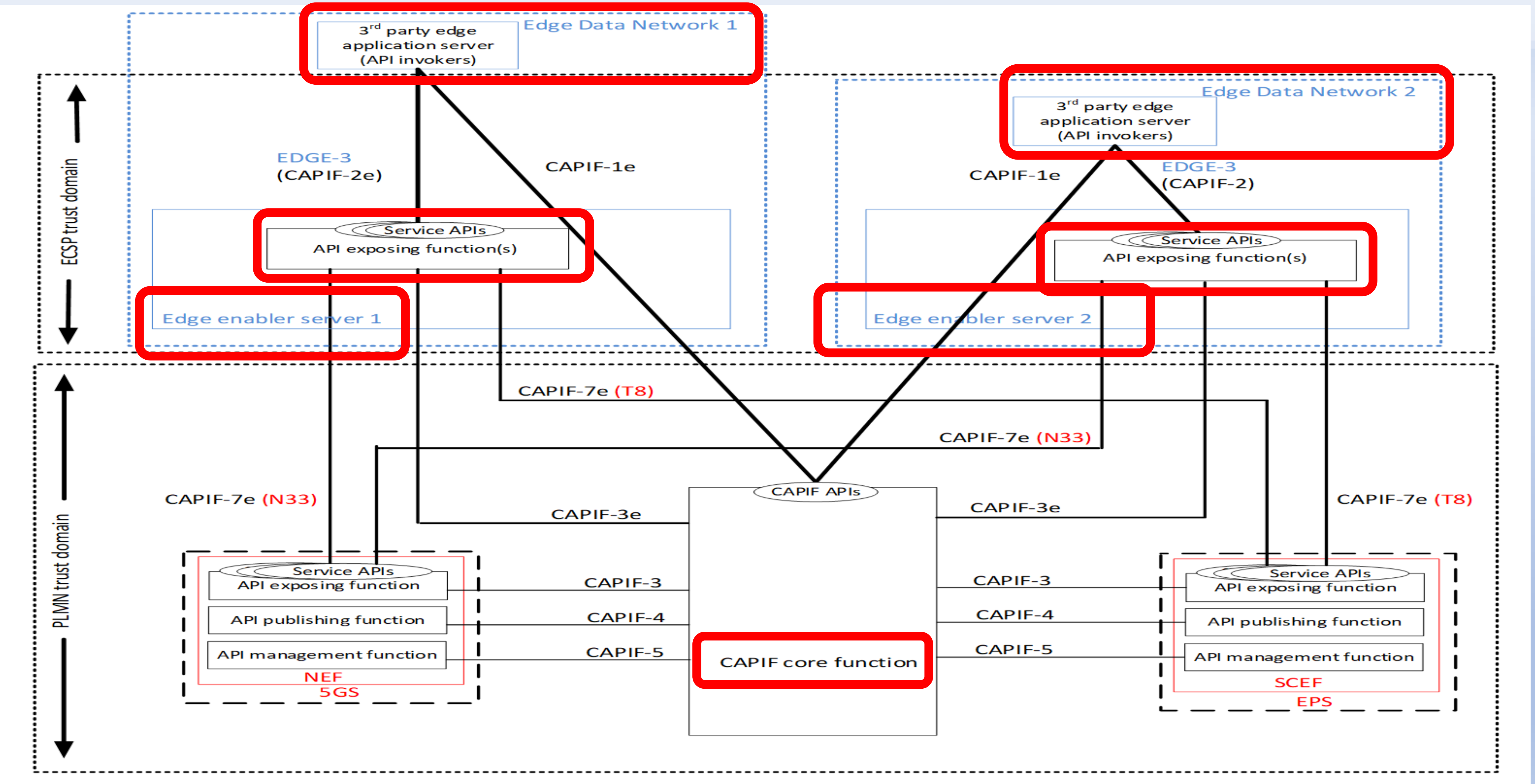


Figure 7.10.1.3.-1: Edge Enabler Server supporting centralized CAPIF functions

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 8 MEC in LADN

A.2.3 Option 3. Use of LADN

Edge computing services can be provided via Edge-dedicated Data Networks deployed as LADNs. The PLMN supports edge computing services in the EDN service areas which can be identified by the service area corresponding to the respective LADN DNNs or LADN DNN and subset of Tracking Areas corresponding to the LADN service area. The LADN service area is the service area that the Edge Computing is supported. Each individual EAS in the LADN may support the same or smaller service area than the LADN.

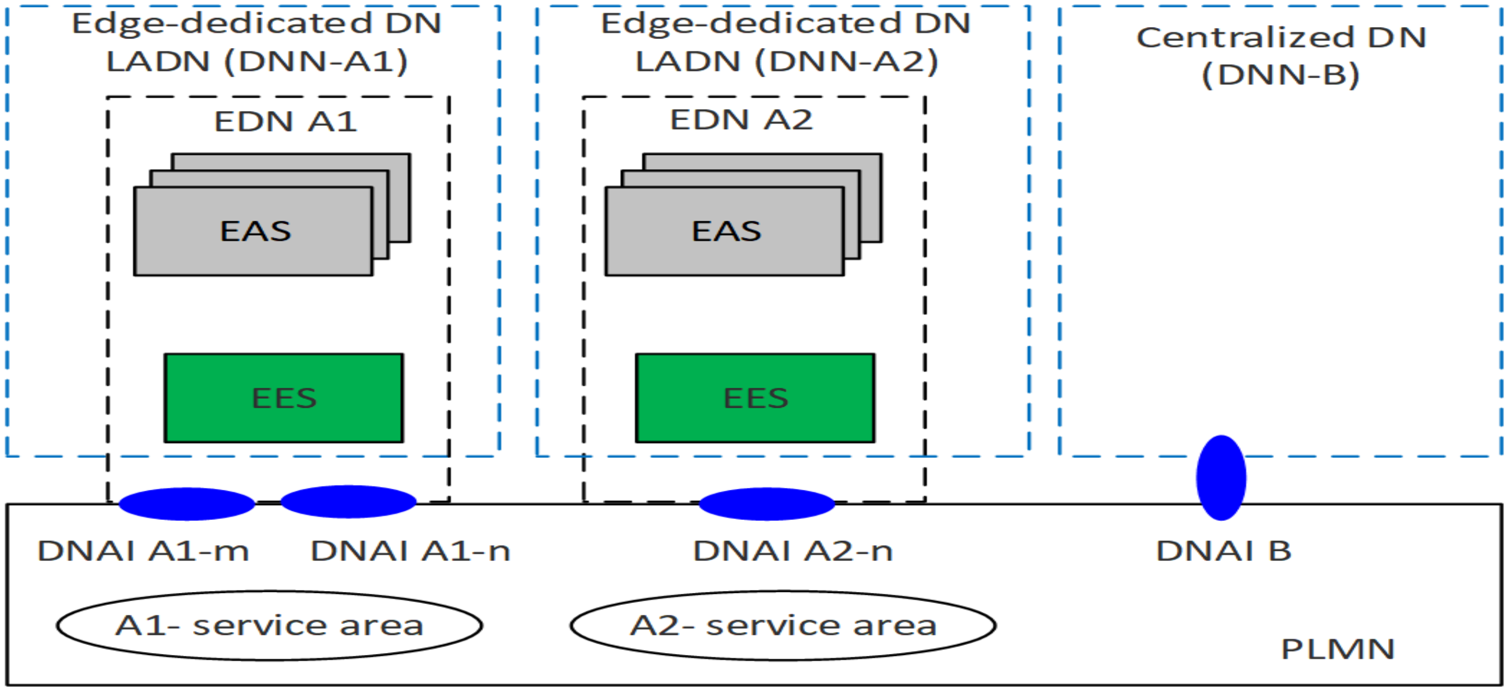


Figure A.2.3-1: Option 3: Use of LADN(s)

Annex 1 MEC V2X UC in MEC & 5G SST standard value - 1

ETSI GS MEC 030 V2.1.1 (2020-04)

Multi-access Edge Computing (MEC);
V2X Information Service API

Annex 1 MEC V2X UC in MEC & 5G SST standard value - 2

5.15.2.2 Standardised SST values

Standardized SST values provide a way for establishing global interoperability for slicing so that PLMNs can support the roaming use case more efficiently for the most commonly used Slice/Service Types.

The SSTs which are standardised are in the following Table 5.15.2.2-1.

Table 5.15.2.2-1 - Standardised SST values

Slice/Service type	SST value	Characteristics
eMBB	1	Slice suitable for the handling of 5G enhanced Mobile Broadband.
URLLC	2	Slice suitable for the handling of ultra- reliable low latency communications.
MIoT	3	Slice suitable for the handling of massive IoT.
V2X	4	Slice suitable for the handling of V2X services.

NOTE: The support of all standardised SST values is not required in a PLMN. Services indicated in this table for each SST value can also be supported by means of other SSTs.

5.15.3 Subscription aspects

The Subscription Information shall contain one or more S-NSSAIs i.e. Subscribed S-NSSAIs. Based on operator's policy, one or more Subscribed S-NSSAIs can be marked as a default S-NSSAI. If an S-NSSAI is marked as default, then the network is expected to serve the UE with a related applicable Network Slice instance when the UE does not send any permitted S-NSSAI to the network in a Registration Request message as part of the Requested NSSAI.

The Subscription Information for each S-NSSAI may contain:

- a Subscribed DNN list and one default DNN; and
- the indication whether the S-NSSAI is marked as default Subscribed S-NSSAI; and
- the indication whether the S-NSSAI is subject to Network Slice-Specific Authentication and Authorization and

Annex 1 MEC V2X UC in MEC & 5G SST standard value - 3

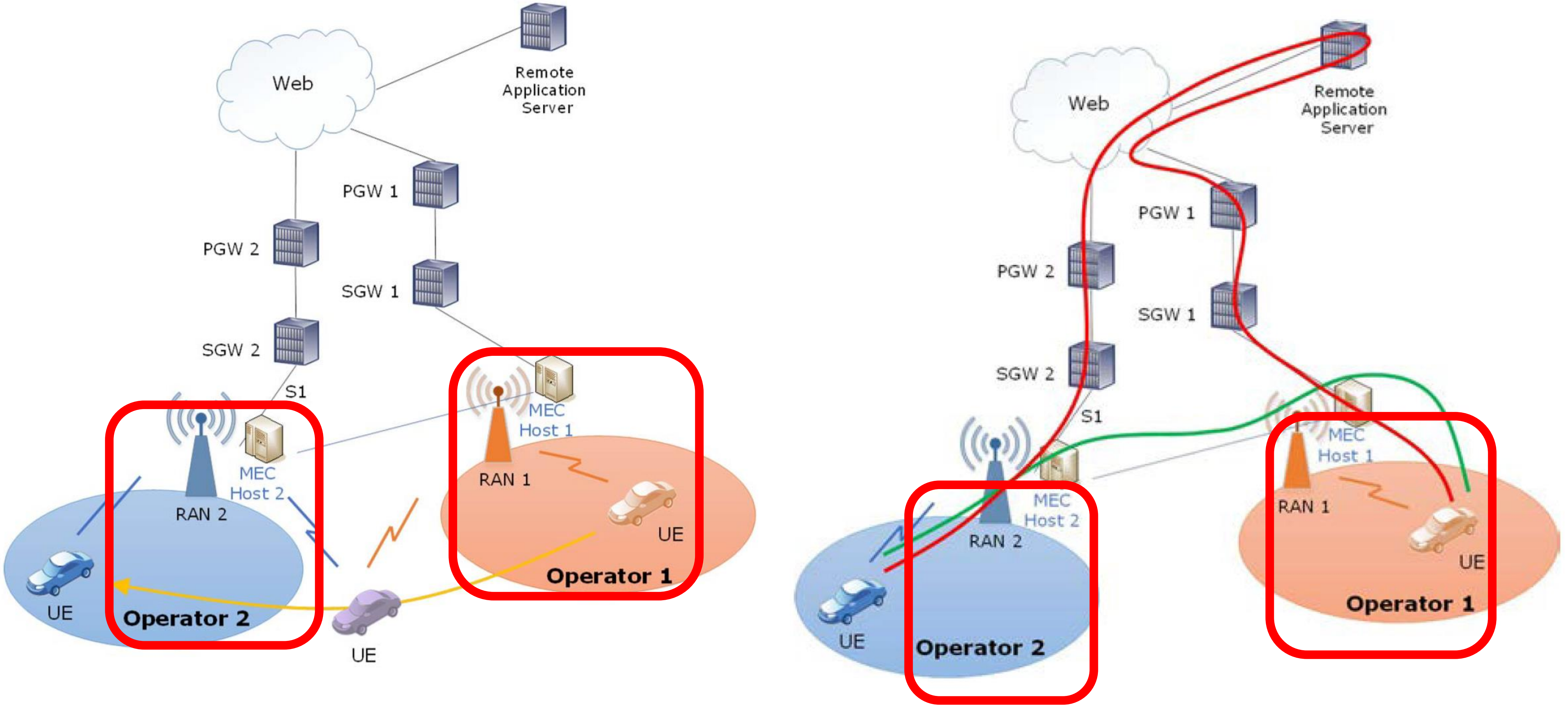


Figure 5.2-1: (left): Example of a multi-operator scenario for V2X services; (right): Example of path for data exchange without the VIS service (in red) and with the VIS service (in green)

Annex 1 MEC V2X UC in MEC & 5G SST standard value - 4

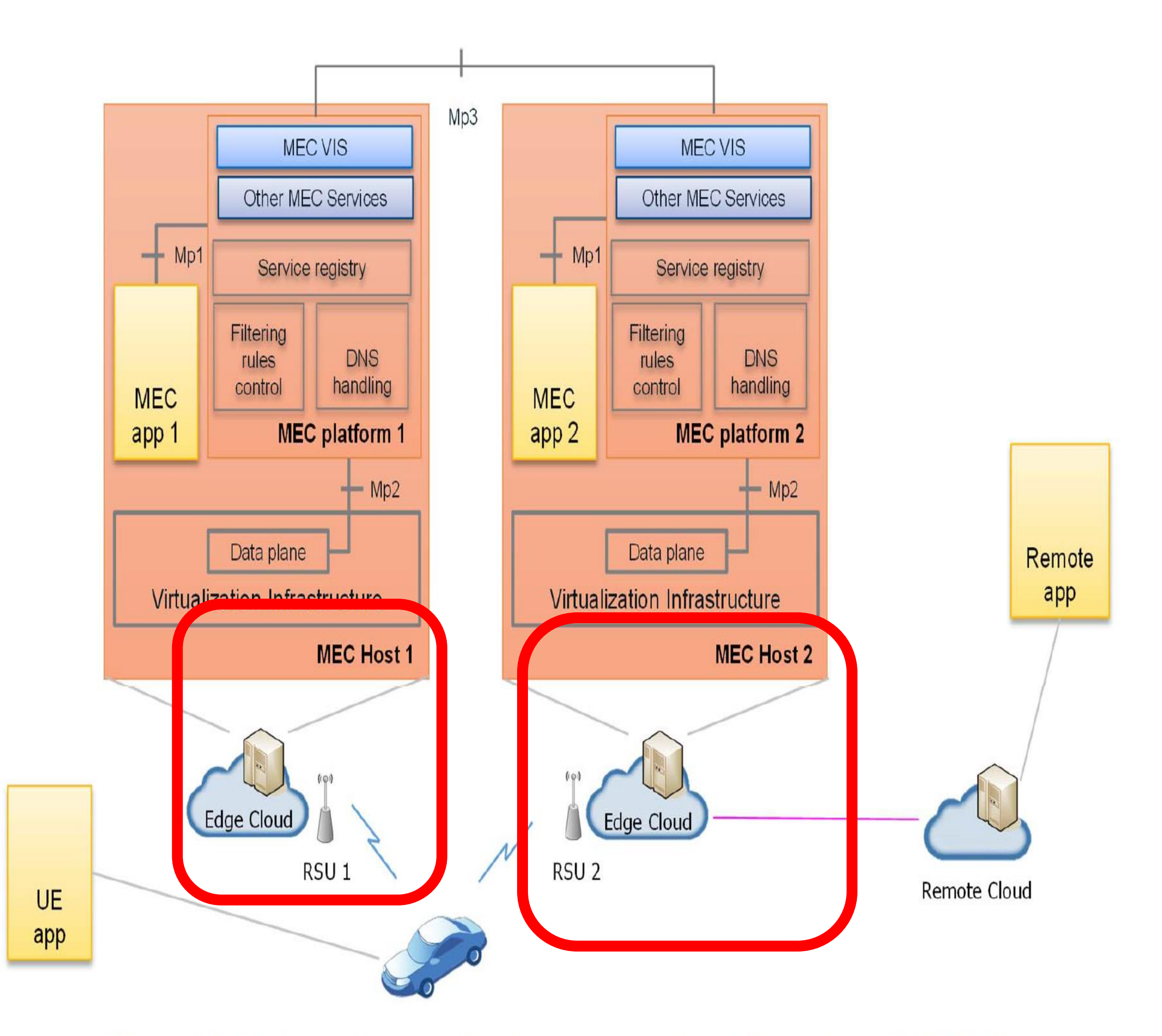


Figure 5.4.1-1: Example of application instances in a V2X service with VIS API

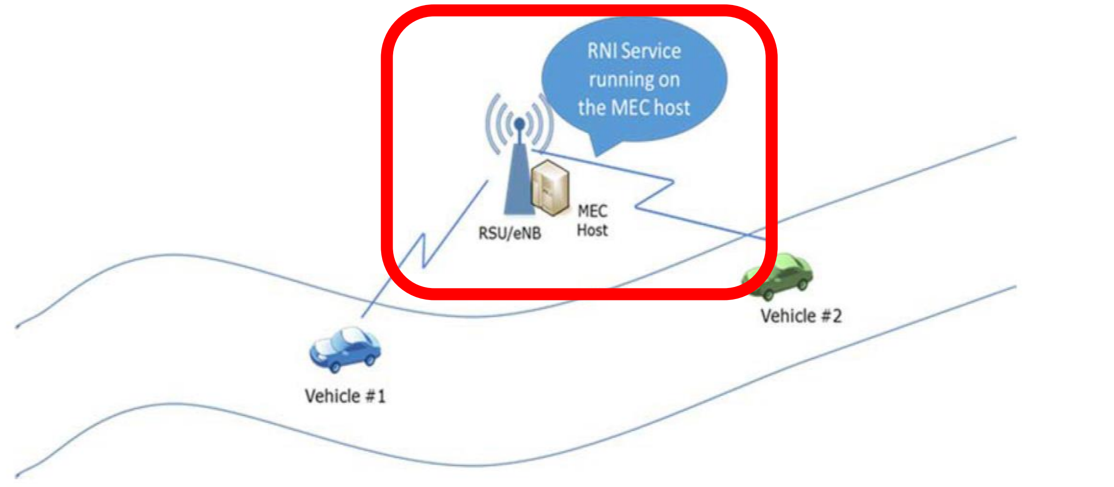


Figure 5.4.5-1: Exemplary V2X system scenario (see note)

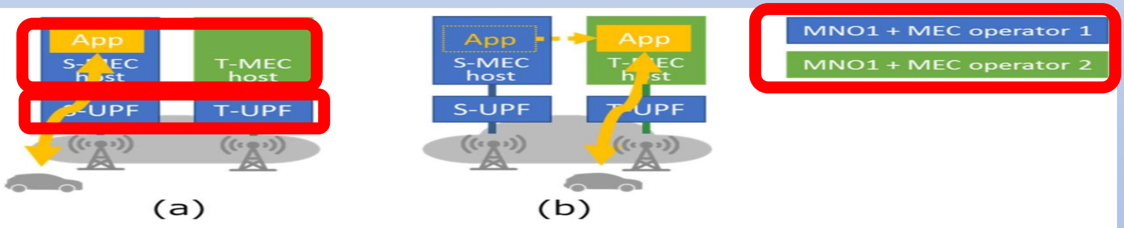


Figure 5.1.1.3-2: Inter-operator mobility support

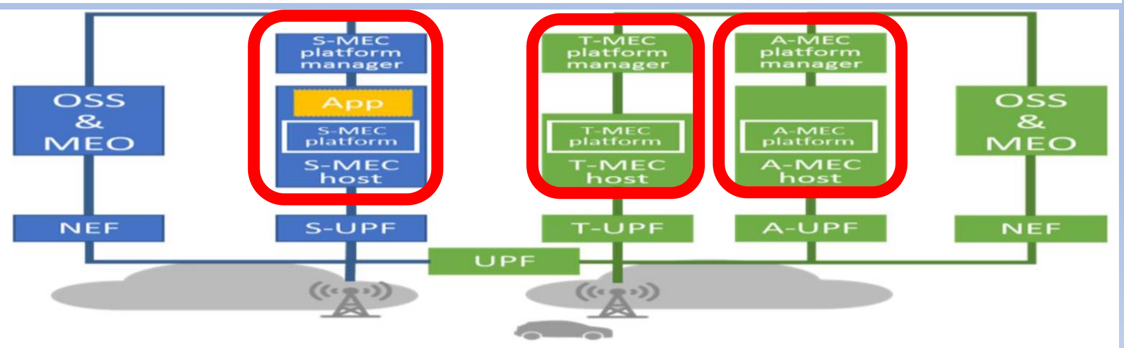


Figure 5.1.2.3-1: Function blocks in inter-operator case

Annex 1 MEC V2X UC in MEC & 5G SST standard value - 5

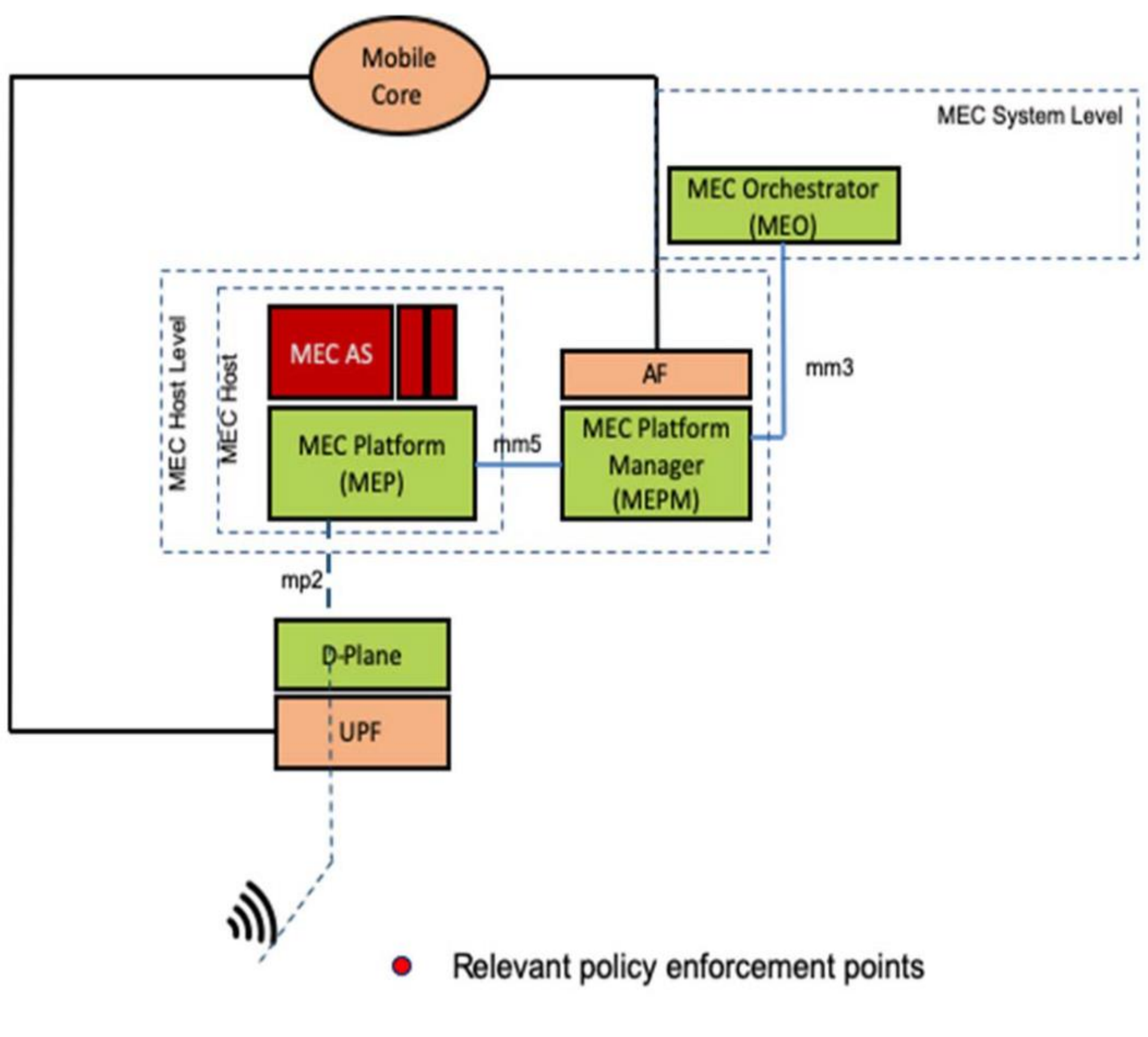


Figure 5.1.3.2-1 Policy enforcement architecture

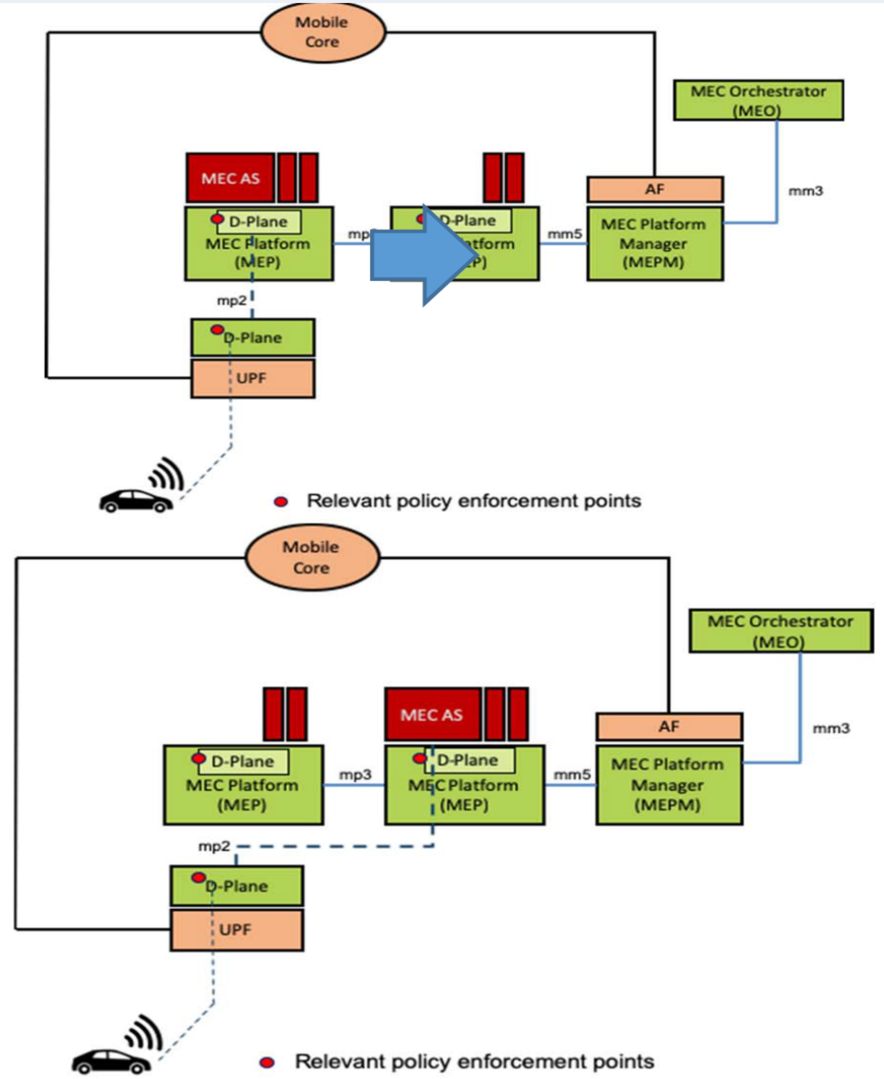


Figure 5.1.3.3-1: Traffic steering between UPF and MEC AS

Annex 2 - O-RAN & Radio Network Information Service RNIS

One of the Key Standardized Services that may be offered by the **Multi-access Edge Computing Platform (MEP) is the Radio Network Information Service (RNIS) as specified in ETSI GS MEC 012.**

The Service is provided **Northbound, i.e. from the MEP to Service Consuming Applications.**

The Southbound Interface from the MEP to the Entity providing Information, such as 3GPP UE Connection specific Radio Resource Control (RRC) Measurement Information, is not currently in scope of the RNIS specification, or the overall MEC System specifications.

What is of primary interest is the **Use and Availability of the O-RAN defined E2 Interface to provide a Source of Information to facilitate the RNIS.**

The open issue is that there is no 3GPP defined Entity that currently supports the E2 Interface for Radio Network Information exposure. This proposed solution would be bound by the requirement to only securely expose information to Authenticated & Authorized AF (directly to the AF or through the NEF). A diagram illustrating the architecture as described above can be found at https://www.o-ran.org/.

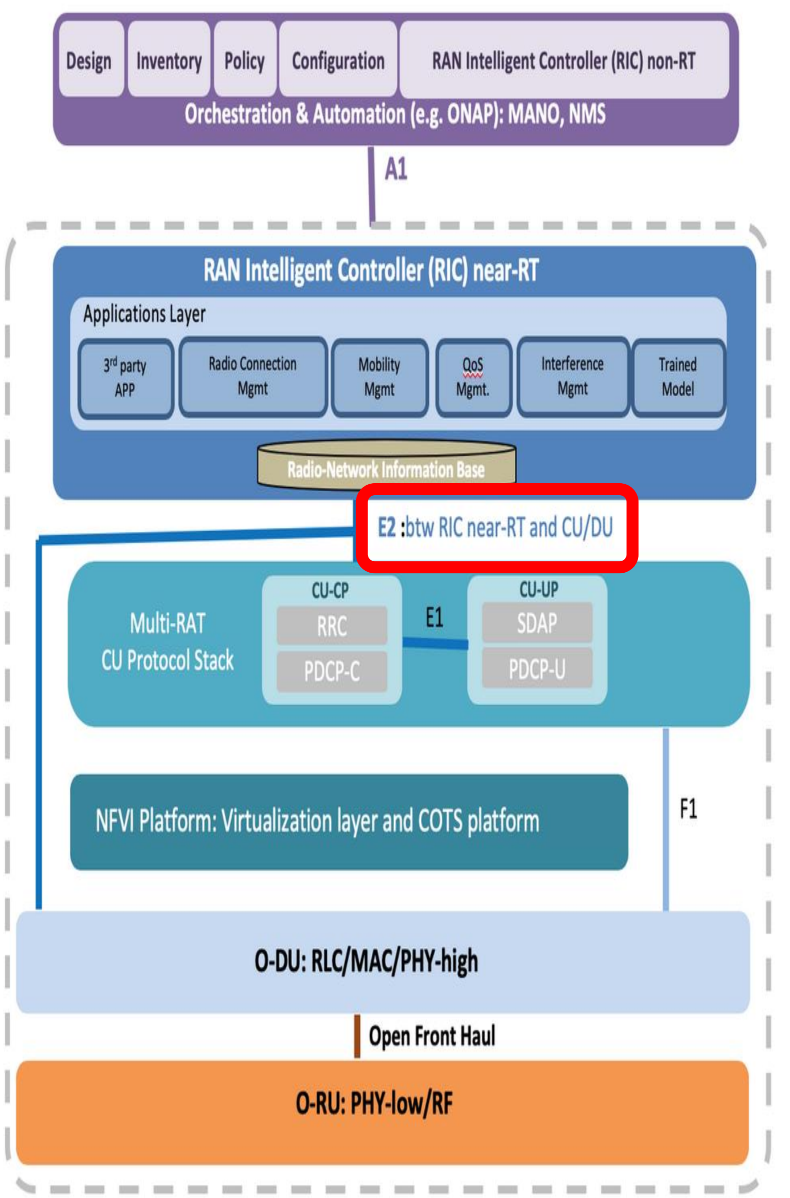


Fig. O-RAN Architecture

Annex 3 - 3GPP Rel. 16 NR Positioning - 1

Release 16 specifies **NR** to provide **Native Positioning** support by introducing **RAT-dependent Positioning Schemes** supporting **Regulatory & Commercial UCs** with more stringent Requirements on **Latency & Accuracy of Positioning**.

1. Downlink time difference of arrival (DL-TDOA). A new Reference Signal (Positioning Reference Signal (**PRS**) is introduced for the UE to perform DL RSTD measurements for each BTS's PRSs & **sends these measurements to Location Server.**

2. Uplink Time Difference of Arrival (UL-TDOA): Sounding Reference Signal (**SRS**) is enhanced to allow each BTS to measure the Uplink Relative Time of Arrival (UL-RTOA) and **report the measurements to the Location Server.**

3. Downlink Angle-of-Departure (DL-AoD): The UE measures the Downlink Reference Signal Receive Power **(DL RSRP) per beam/gNB**. Measurement reports are used to determine the AoD based on UE beam location for each gNB. **The Location Server then uses AoD to estimate the UE position.**

4. Uplink angle-of-arrival (UL-AOA): The gNB measures the angle-of-arrival based on the beam the UE is located in**. Measurement reports are sent to the Location Server.**

5. Multi-cell round trip time (RTT): The gNB and UE perform Rx-Tx Time Difference measurement for the Signal of each Cell. The measurement reports from the UE and gNBs **are sent to the location server to determine the round-trip time of each cell and derive the UE position.**

6. Enhanced cell ID (E-CID). This is based on RRM measurements (for example DL RSRP) of each gNB at the UE. The measurement **reports are sent to the Location Server. New LPP-a stack used for this.**

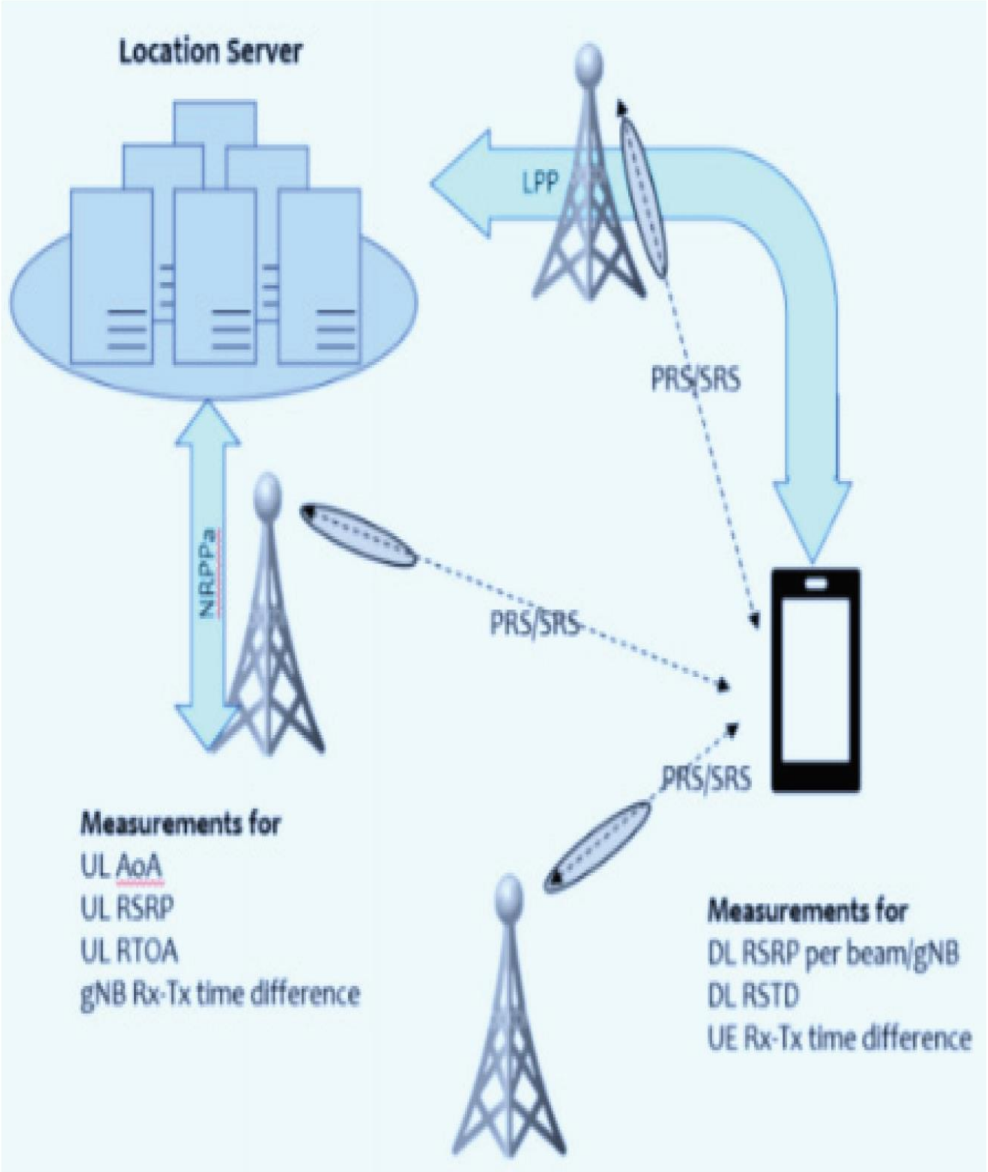


Figure 4-17 NR positioning key enablers

Annex 3 - 3GPP Rel. 16 NR Positioning - 2

For LCS client, it may indicate accuracy defined in TS 29.171 [34], table 7.4.7-1. For AF, it may either indicate the accuracy defined in TS 29.171 [34], table 7.4.7-1, or indicate a particular value e.g. PLMN ID defined in TS 29.122 [35], table 5.3.2.4.7-1.

4.2 Architectural Reference Model

4.2.1 Non-roaming reference architecture

Figure 4.2.1-1 shows an architectural reference model for 5GS LCS for a non-roaming UE in reference point representation.

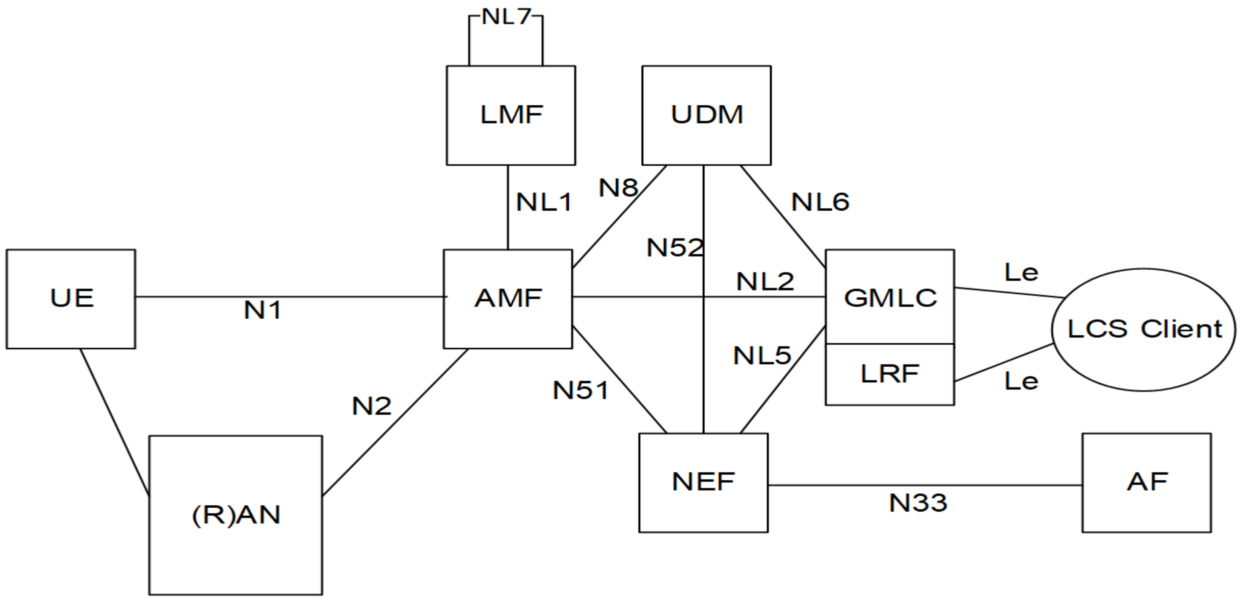


Figure 4.2.1-1: Non-roaming reference architecture for Location Services in reference point

3GPP TS 29.122 V16.7.0 (2020-09)
Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Core Network and Terminals;
T8 reference point for Northbound APIs;
(Release 16)

5.3.2.4.7 Enumeration: Accuracy

The enumeration Accuracy represents a desired granularity of accuracy of the requested location information. It shall comply with the provisions defined in table 5.3.2.4.7-1.

Table 5.3.2.4.7-1: Enumeration Accuracy

Enumeration value	Description
CGI_ECGI	The SCS/AS requests to be notified at cell level location accuracy.
ENODEB	The SCS/AS requests to be notified at eNodeB level location accuracy.
TA_RA	The SCS/AS requests to be notified at TA/RA level location accuracy.
PLMN	The SCS/AS requests to be notified at PLMN level location accuracy.
TWAN_ID	The SCS/AS requests to be notified at TWAN identifier level location accuracy.
GEO_AREA	The SCS/AS requests to be notified of the geographical area accuracy.

Annex 3 - 3GPP Rel. 16 NR Positioning - 3

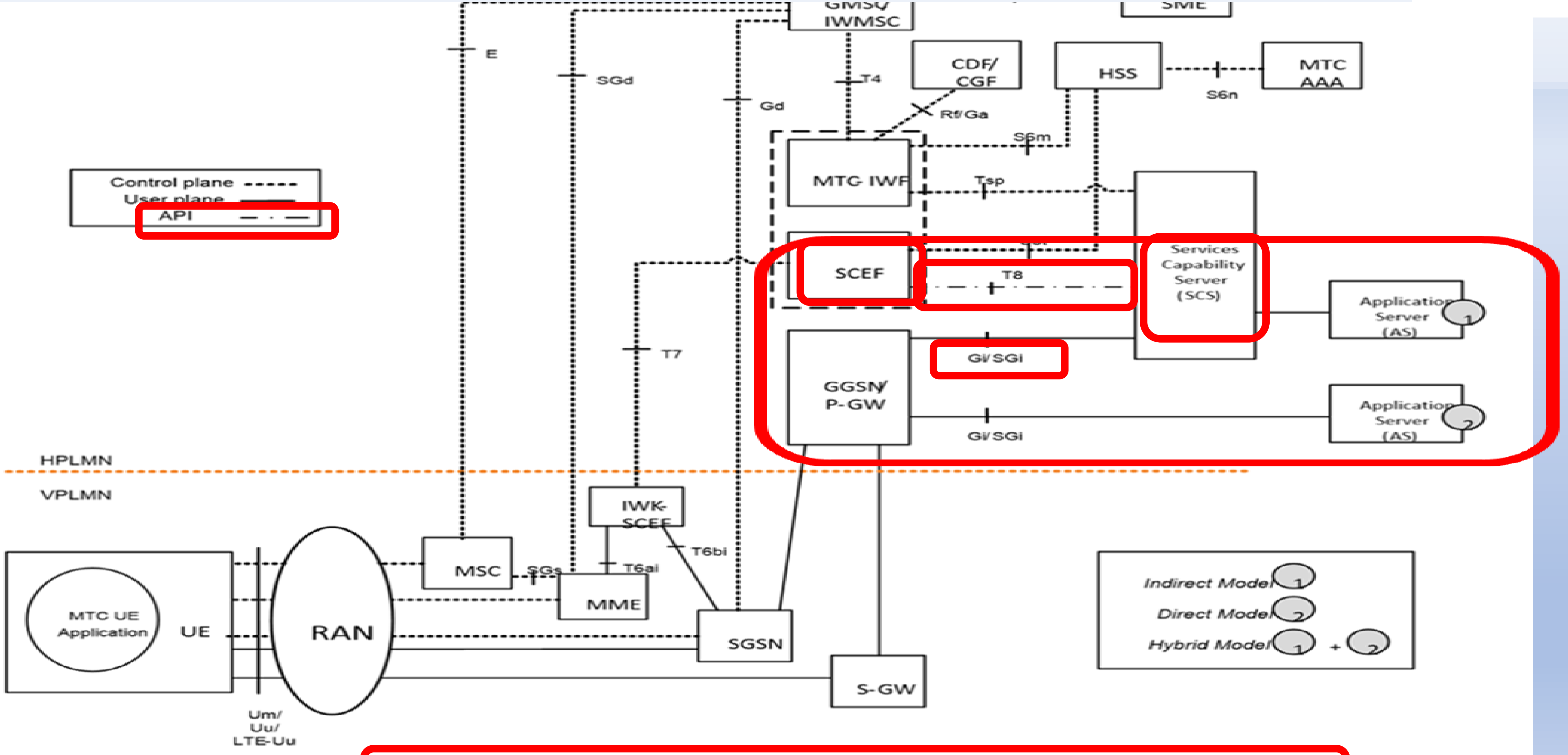


Figure 4.2-1b: 3GPP Architecture for Machine-Type Communication (Roaming)

Annex 3 - 3GPP Rel. 16 NR Positioning - 3x

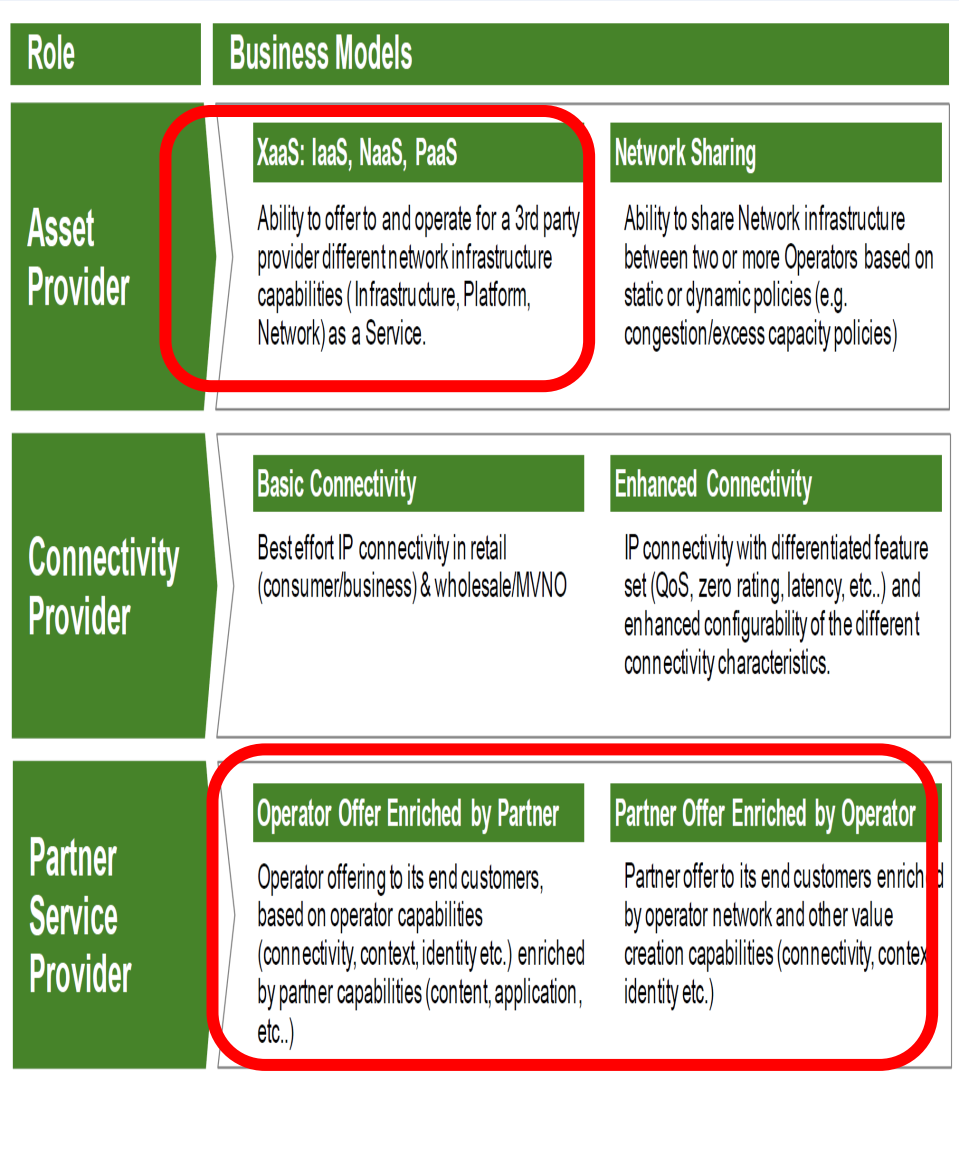


Figure 2: 5G Business models - Examples

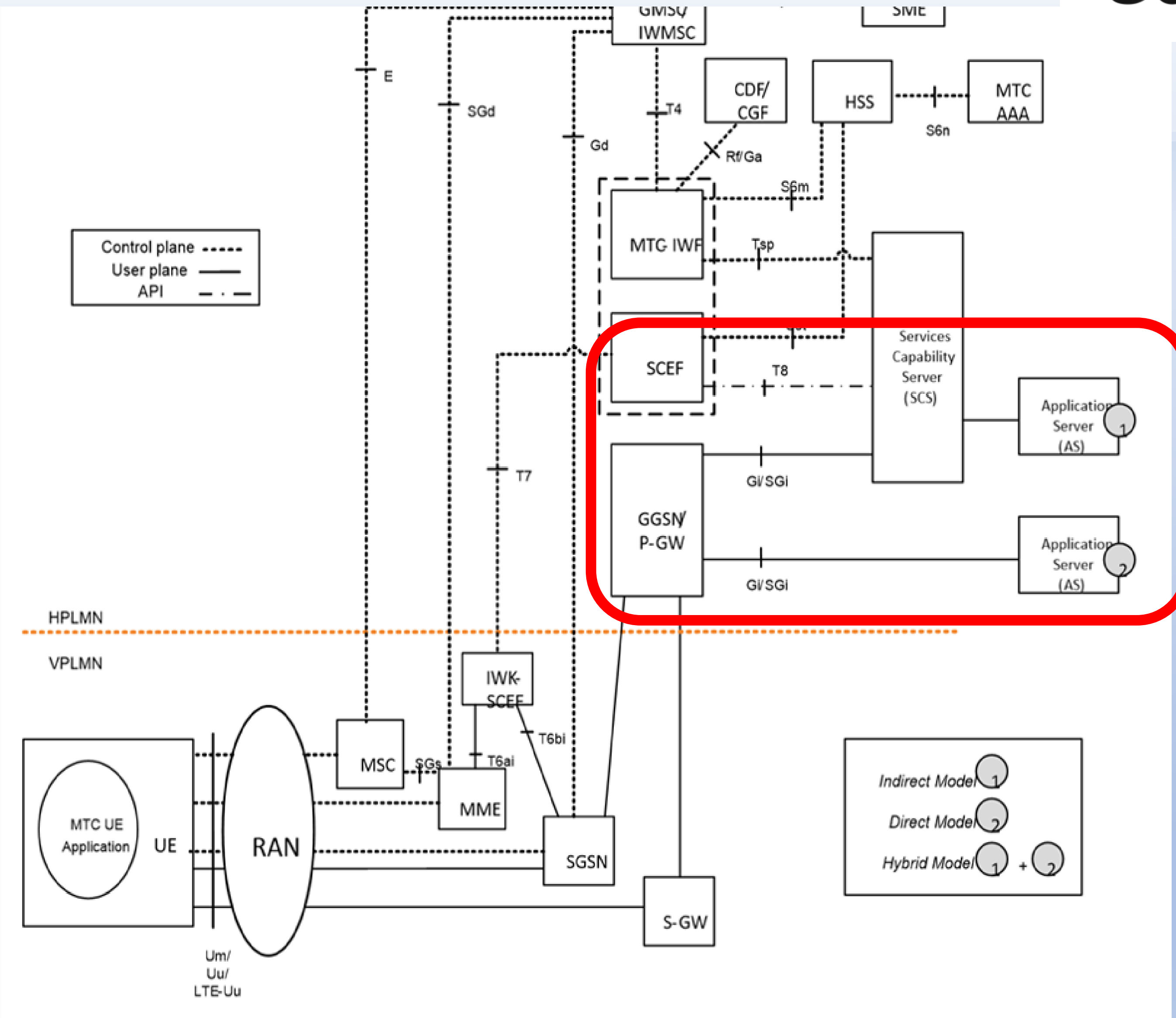


Figure 4.2-1b: 3GPP Architecture for Machine-Type Communication (Roaming)

Annex 4 - 3GPP 5G SCEF+NEF SCS/AS for oneM2M CIoT Platform integrated with IoT SL across 10 UCs - 1

5.2 Functional mapping between 3GPP and oneM2M

Figure 5.2-1 shows an Architecture and Functional mapping for the 3GPP Trust Domain which describes how oneM2M Functional Entities may access Features and Services that are exposed by 3GPP.

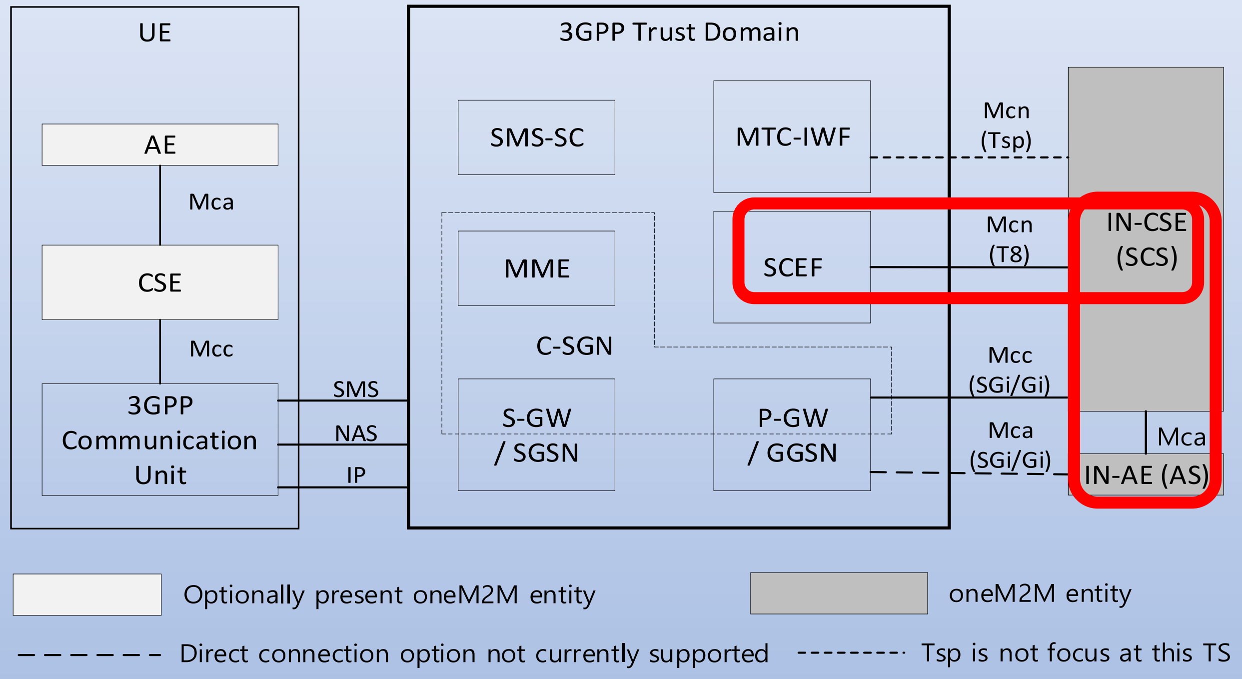


Figure 5.2-1: oneM2M Interfaces to the underlying 3GPP Network

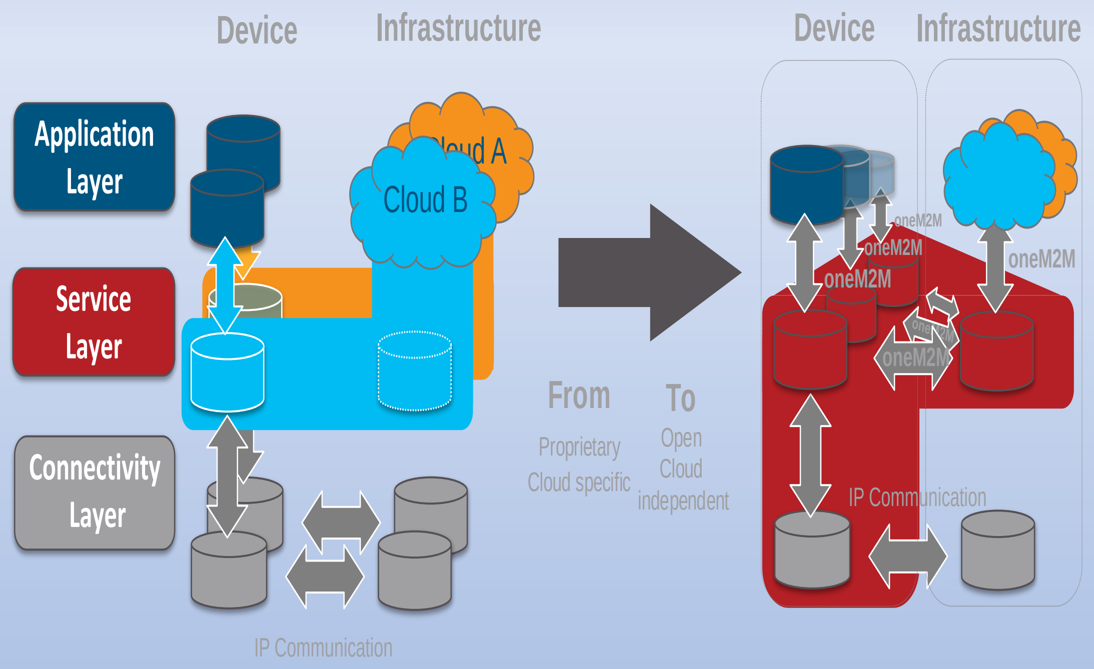


Figure 5.1.1-3: Cloud provider independent

Several implementation options for the placement of the oneM2M IN-CSE relative to the SCEF and the underlying 3GPP network are envisioned. In all implementations, the SCEF always resides within 3GPP domain.

In some options the IN-CSE and the SCEF are deployed by a MNO and are both part of the operator domain. In other options the SCEF is part of the 3GPP domain and the IN-CSE is not part of the operator domain.

In all options, services within the IN-CSE may access the network services that are exposed by the SCEF via the T8 reference point APIs.

Annex 4 - 3GPP 5G SCEF+NEF SCS/AS for oneM2M CIoT Platform integrated with IoT SL across 10 UCs - 2

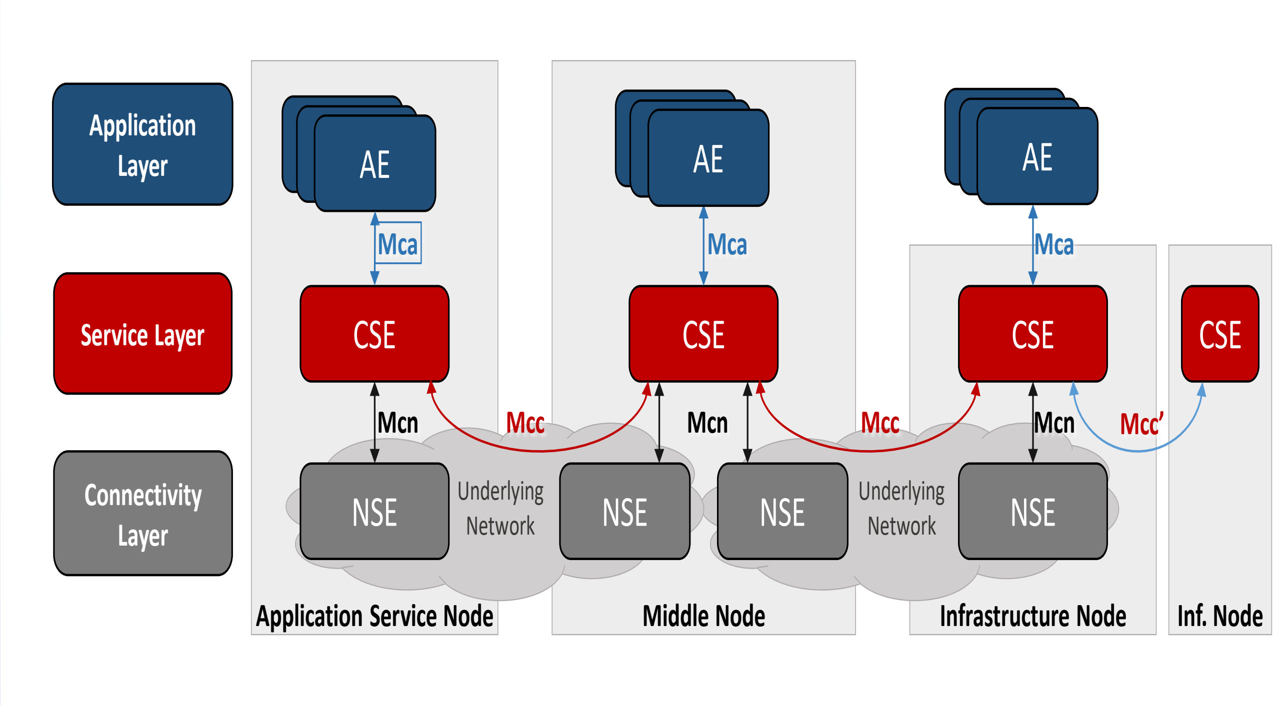


Figure 5.1.2-1: oneM2M Layered Model

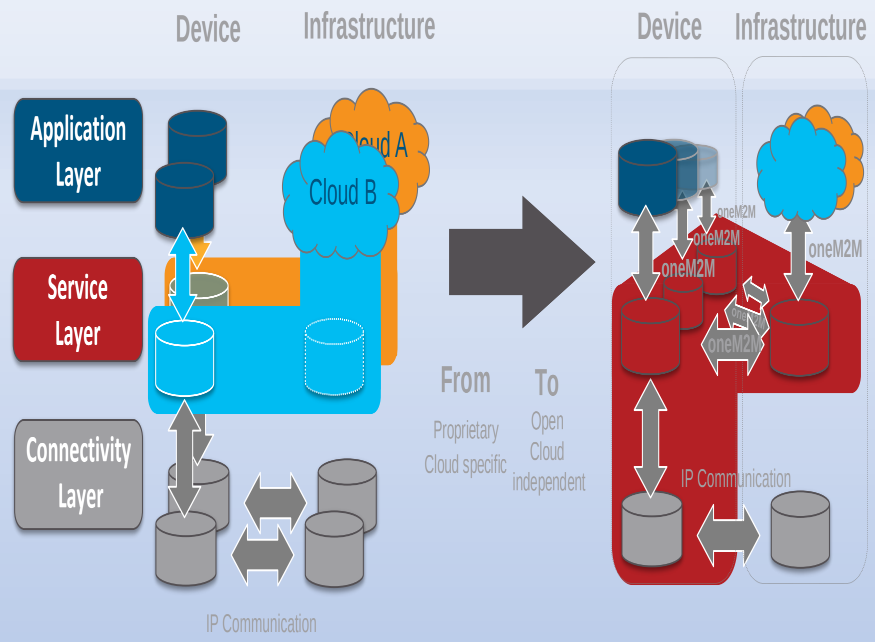


Figure 5.1.1-3: Cloud provider independent

Application Entity (AE): The Application Entity is an entity in the Application Layer that implements an M2M Application Service Logic.

Common Services Entity (CSE): A Common Services Entity represents an instantiation of a set of "Common Service Functions" of the oneM2M Service Layer (SL).

Network Services Entity (NSE): A Network Services Entity provides Services from the underlying Network to the CSEs. Examples of such Services include Location Services, Device Triggering, certain Sleep Modes like **PSM in 3GPP** based Networks or Long Sleep Cycles.

Annex 4 - 3GPP 5G SCEF+NEF SCS/AS for oneM2M CIoT Platform integrated with IoT SL across 10 UCs - 3

oneM2M Service Layer (SL) - Horizontal Architecture providing a Common Framework for IoT,

oneM2M has identified a **Set of Common Functionalities**, that are **applicable to all the IoT Domains (SAREF)**.

Think of these functions as a large toolbox with special tools to solve a number of IoT problems across many different domains. The oneM2M CSFs are applicable to different IoT UCs in different industry domains.

oneM2M has standardized how these Functions are being executed, i.e. is has defined Uniform APIs to access these Functions.

Figure 5.3.1-1 shows a grouping of these Functions into a few different scopes.

Figure 5.1.3-1: Common Service Functions

SAREF - Smart Applications REFerence Ontology

SAREF is the Reference Ontology for Smart Applications and contains recurring concepts that are used in several Domains.
SAREF has a close relation with the oneM2M Base Ontology, for which a mapping is defined in oneM2M TSs.

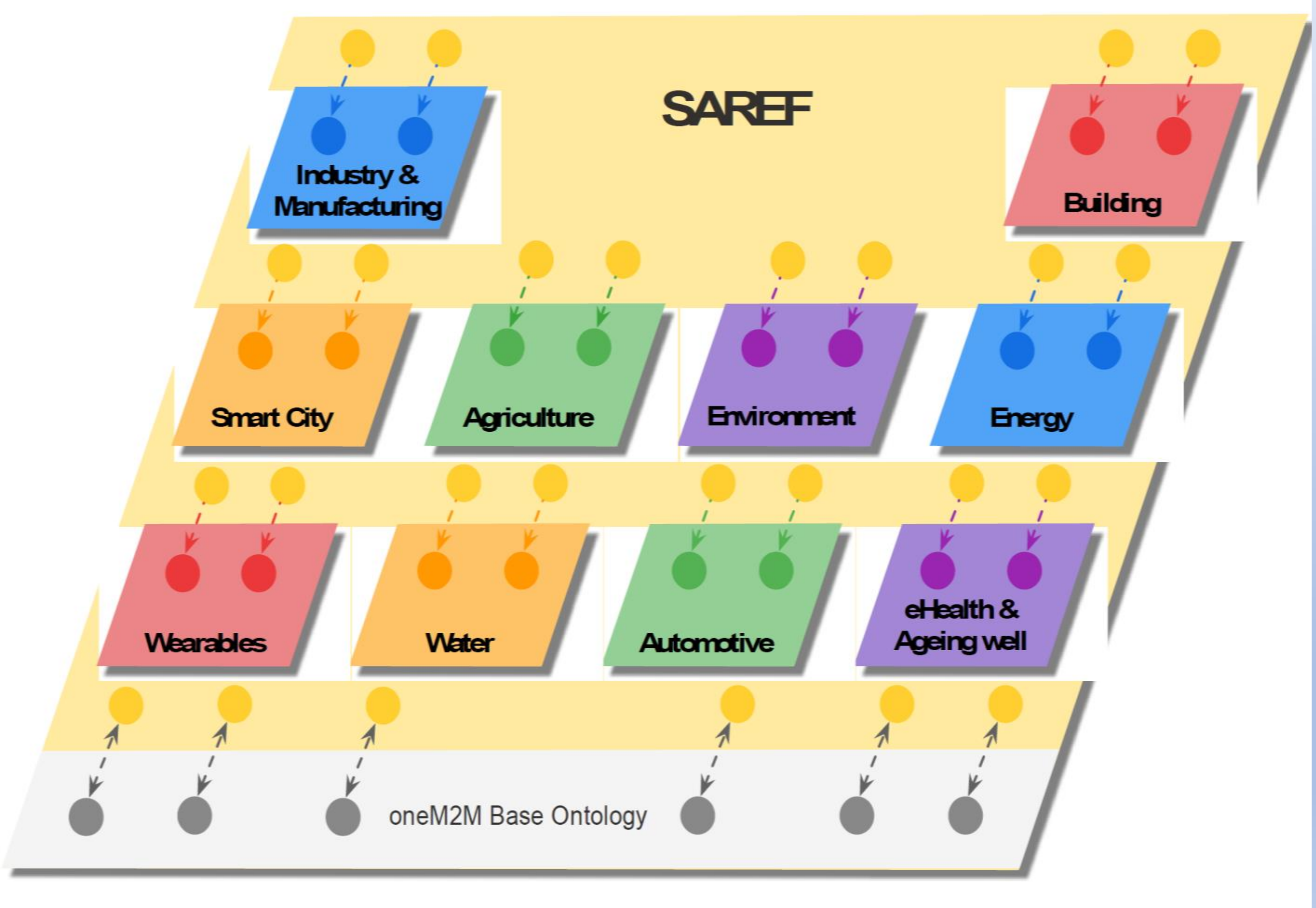


Figure 11: SAREF and its extensions

5.2 Mapping between SAREF and oneM2M Base Ontology

Figure 12 shows the mapping between SAREF and the oneM2M Base Ontology.

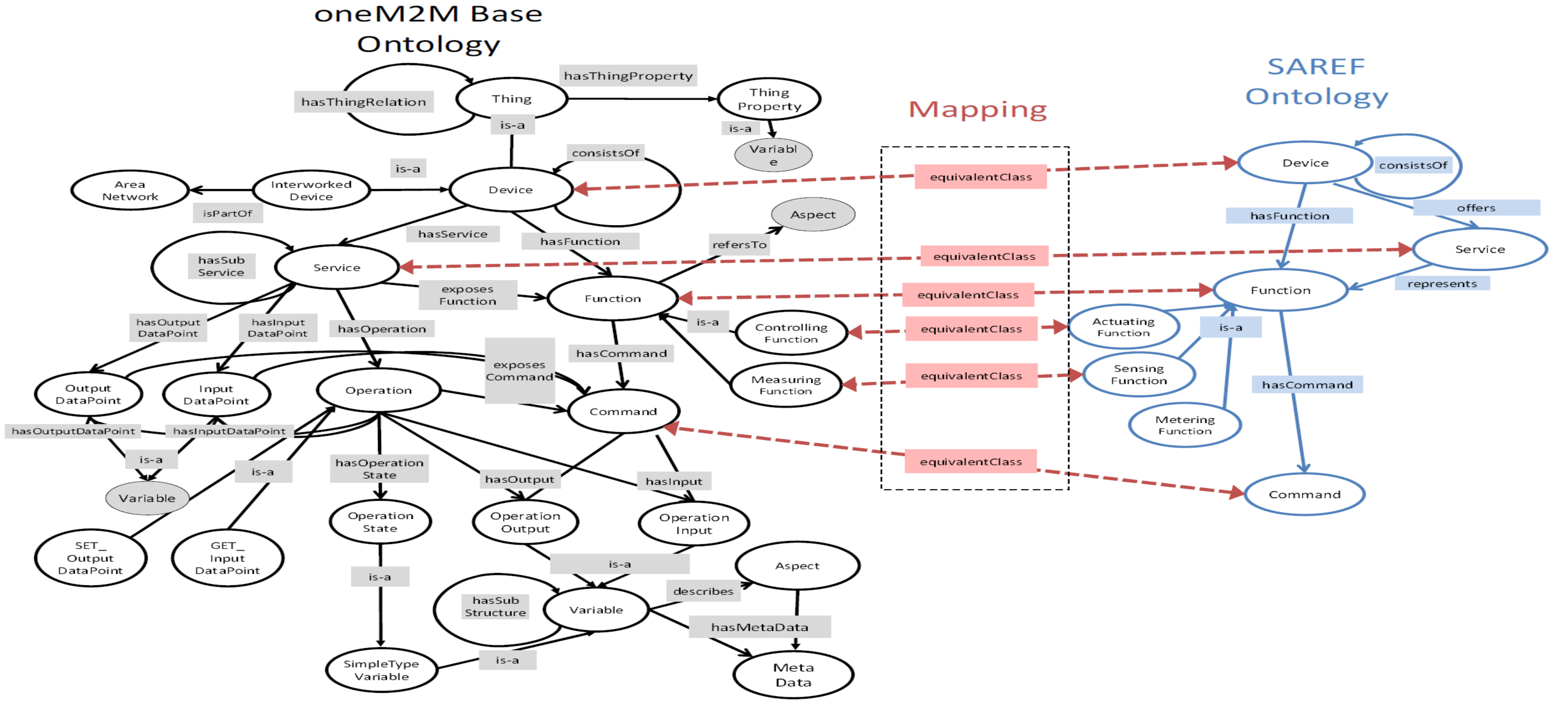


Figure 12: Mapping between SAREF and the oneM2M Base Ontology

Annex 4 - 3GPP 5G SCEF+NEF SCS/AS for oneM2M CIoT Platform integrated with IoT SL across 10 UCs - 4

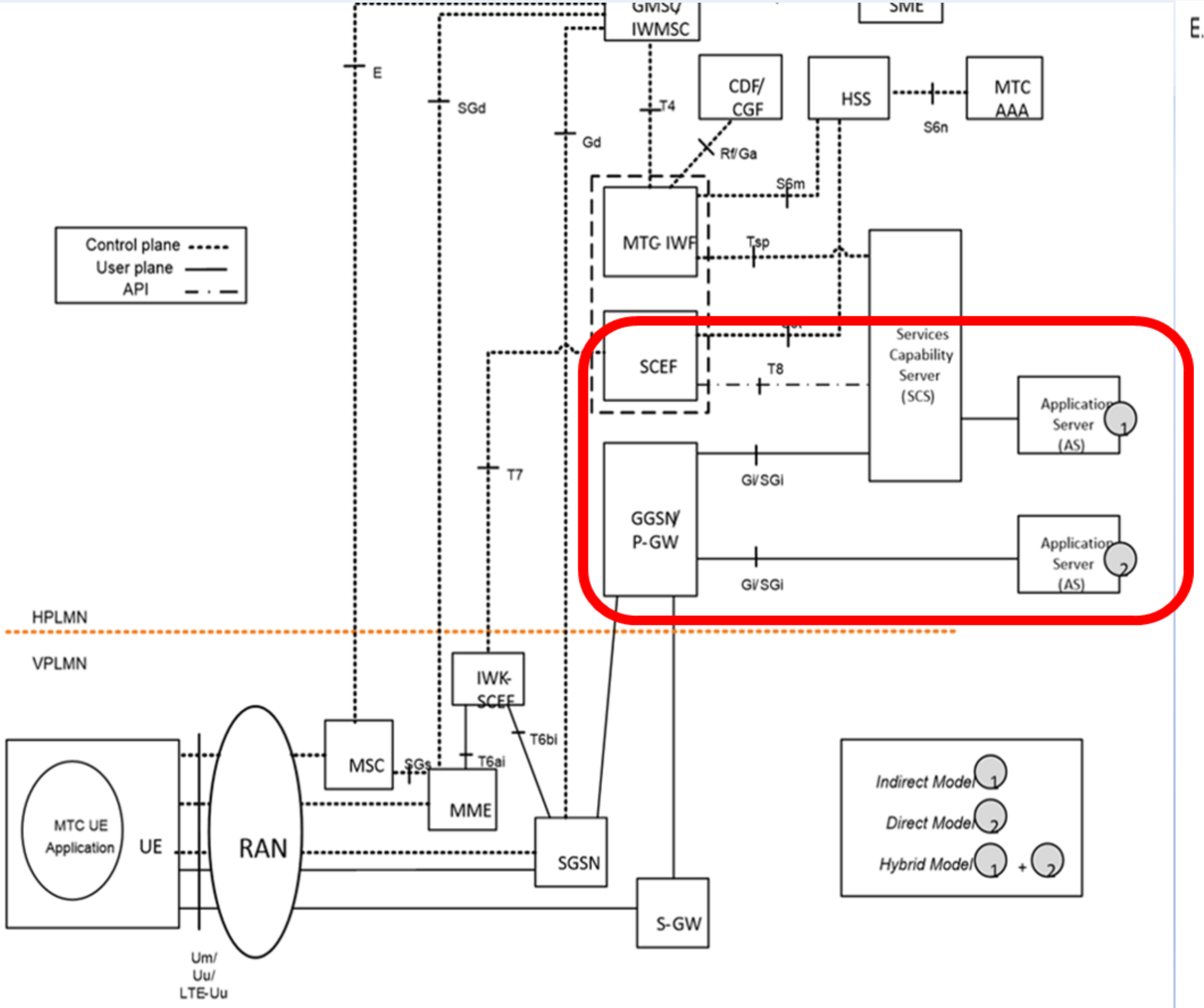


Figure 4.2-1b: 3GPP Architecture for Machine-Type Communication (Roaming)

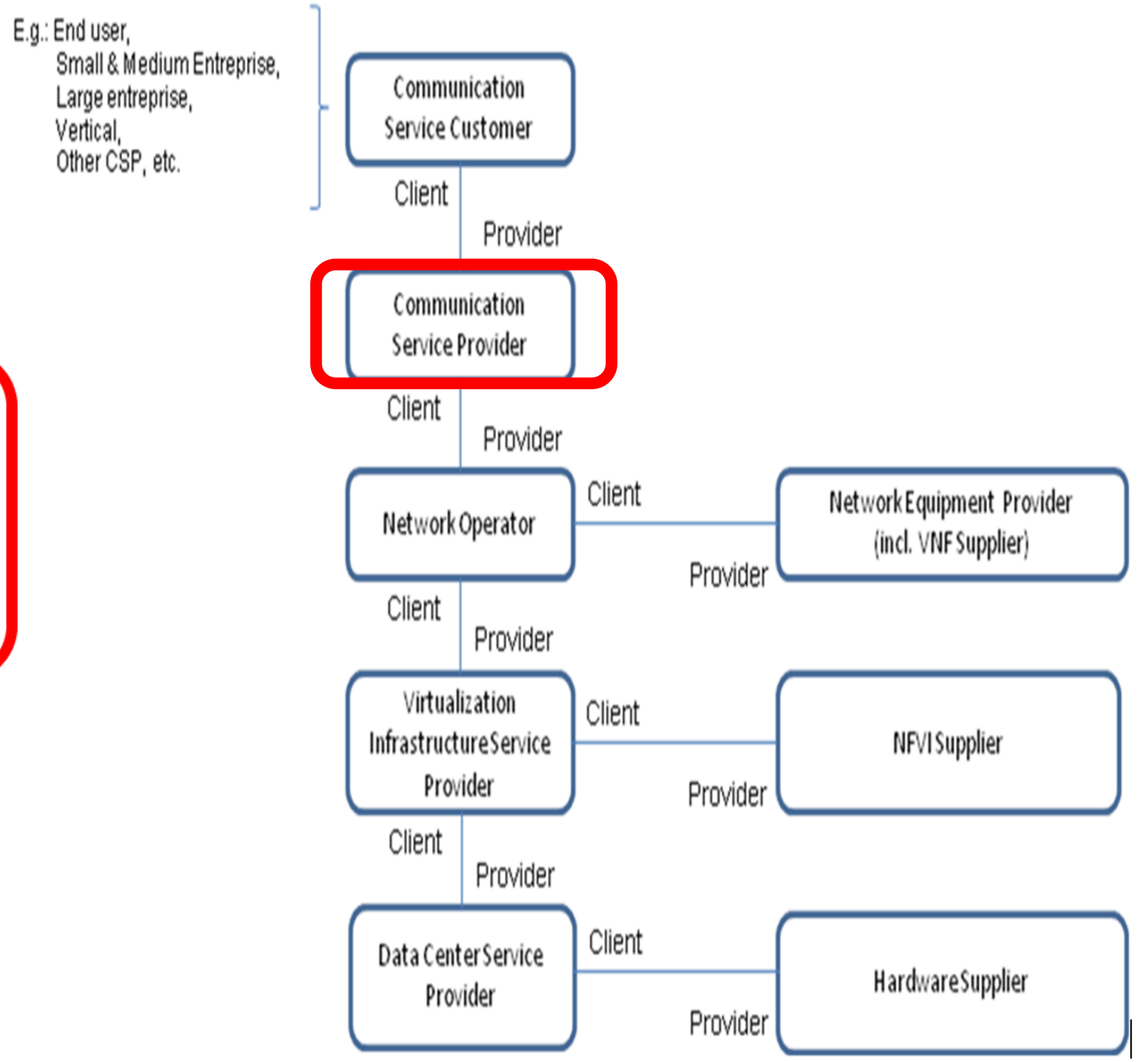


Figure 4.8.1: High-level model of roles

Annex 4 - 3GPP 5G SCEF+NEF SCS/AS for oneM2M CIoT Platform integrated with IoT SL across 10 UCs - 5

When a UE is capable of switching between EPC and 5GC, it shall only be associated with combined SCEF+NEF node(s) for Service Capability Exposure. The SCEF+NEF hides the underlying Network Topology from the AF (i.e. SCS/AS) and hides whether the UE is served by 5GC or EPC. Figure 6.13.2-1 shows the SCEF+NEF Architecture.

In the case of **Architecture without CAPIF** support, the AF is locally configured with the **API Termination Points for each Service**.
In case of **Architecture with CAPIF** support, the AF obtains the service API information from the CAPIF Core Function (CCF) via the Availability of Service APIs event notification or Service Discover Response as specified in 3GPP CAPIF TS.
For each UE, a service API may become unavailable because the UE is being served by a node (e.g. MME) or NF (e.g. AMF) even if the service is exposed by SCEF+NEF.

If a service API provided by SCEF+NEF becomes unavailable or its level of support changes because of the change of CN Type serving the UE, the SCEF+NEF node may inform the change to the related AF per the **AF's Subscription to the API supported Change event.**

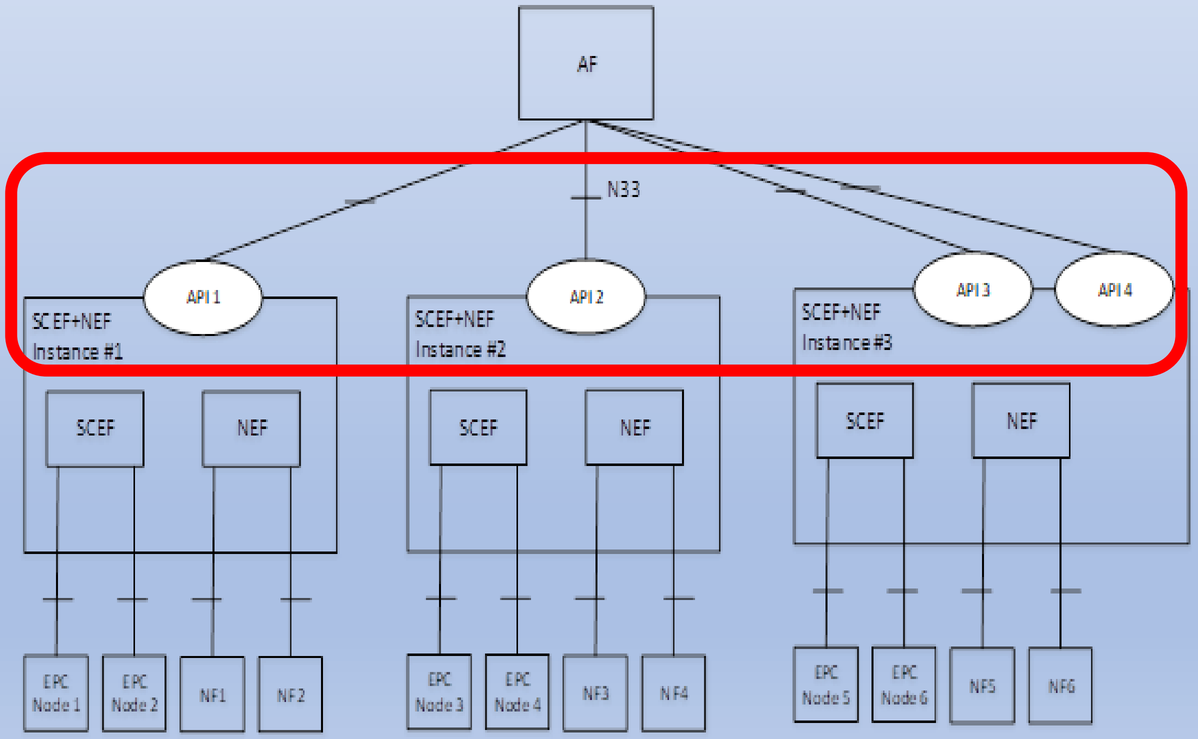


Figure 6.13.2-1: Architecture view of the SCEF+NEF node

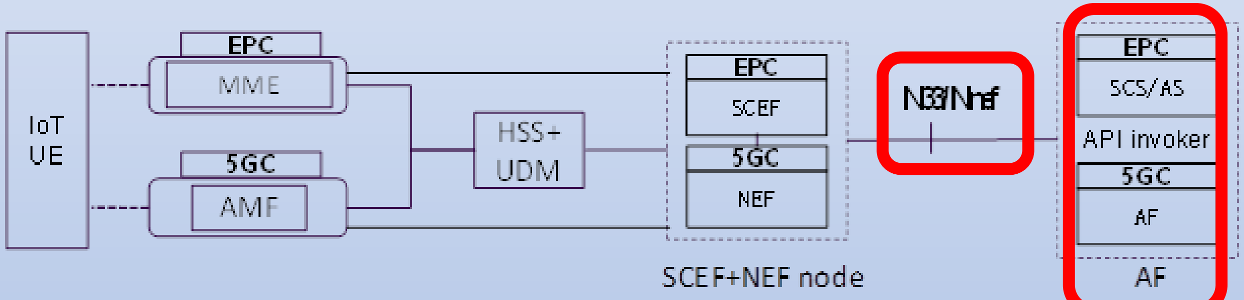


Figure 6.14.2-1: Combined NEF+SCEF NF without CAPIF support

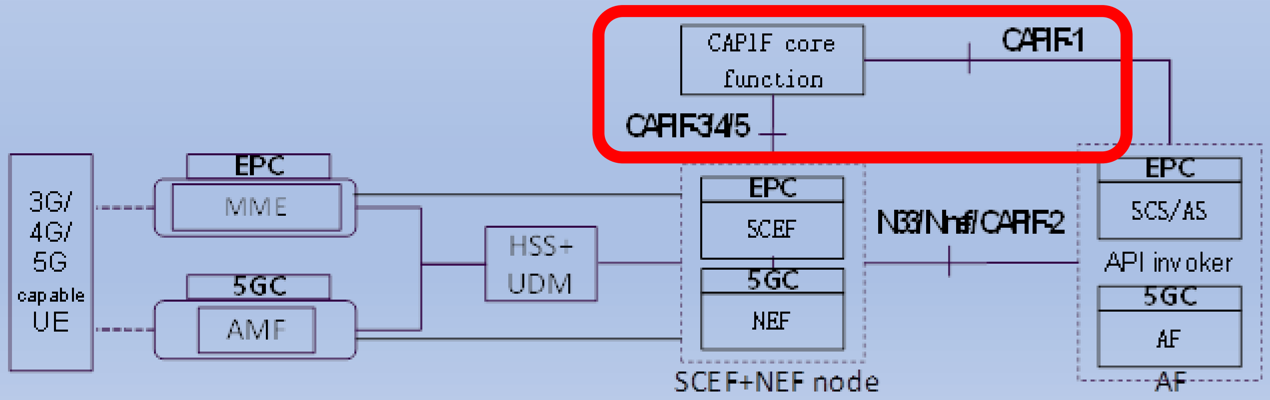


Figure 6.14.2-2: Combined NEF+SCEF NF with CAPIF support

NGMN 5G Partner & evolved CSP roles

Role	Business Models	
Asset Provider	**XaaS: IaaS, NaaS, PaaS** Ability to offer to and operate for a 3rd party provider different network infrastructure capabilities (Infrastructure, Platform, Network) as a Service.	**Network Sharing** Ability to share Network infrastructure between two or more Operators based on static or dynamic policies (e.g. congestion/excess capacity policies)
Connectivity Provider	**Basic Connectivity** Best effort IP connectivity in retail (consumer/business) & wholesale/MVNO	**Enhanced Connectivity** IP connectivity with differentiated feature set (QoS, zero rating, latency, etc..) and enhanced configurability of the different connectivity characteristics.
Partner Service Provider	**Operator Offer Enriched by Partner** Operator offering to its end customers, based on operator capabilities (connectivity, context, identity etc.) enriched by partner capabilities (content, application, etc..)	**Partner Offer Enriched by Operator** Partner offer to its end customers enriched by operator network and other value creation capabilities (connectivity, context, identity etc.)

Figure 2: 5G Business models - Examples

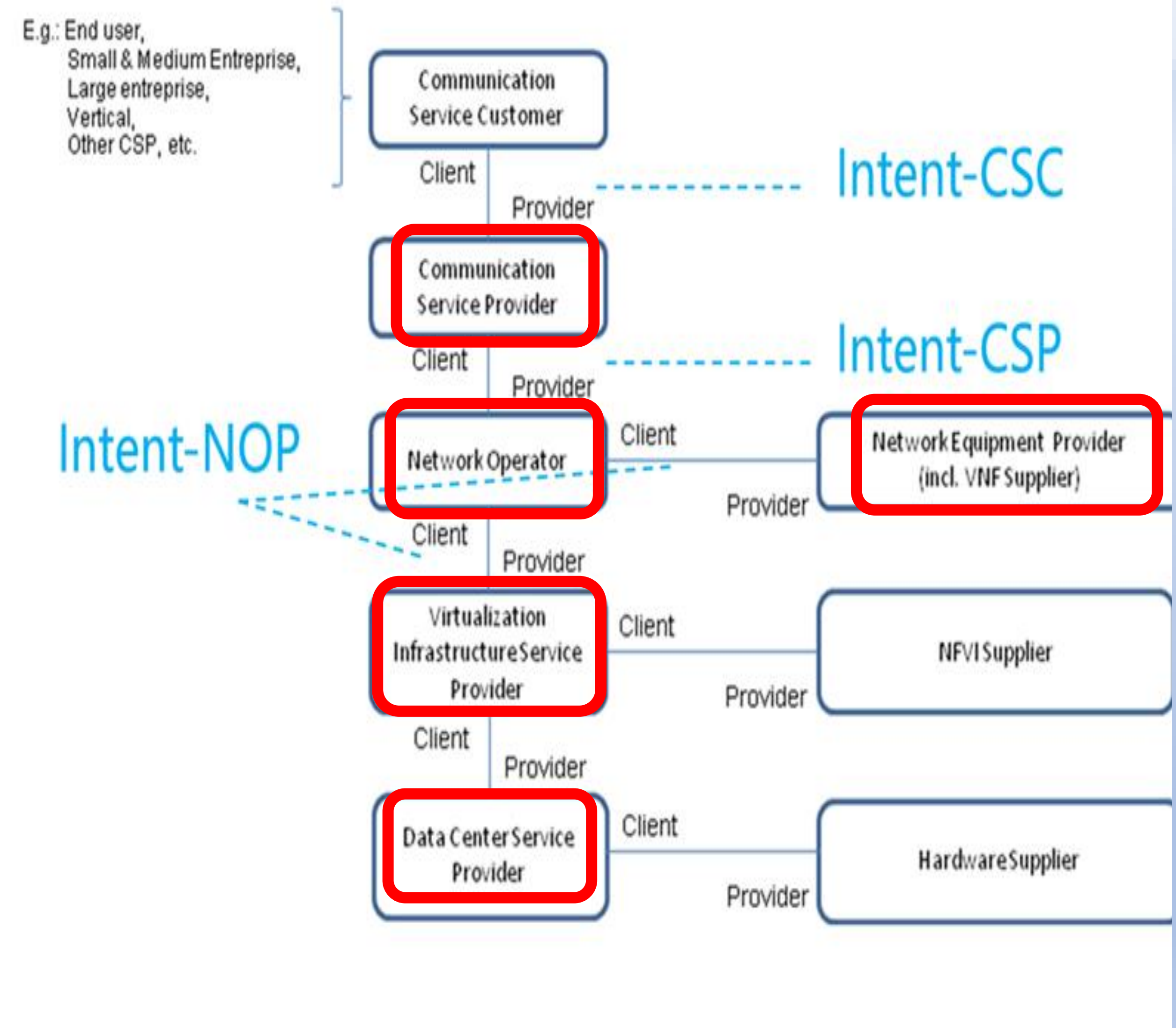


Figure 4.1.2.4-1: Concept for utilization of intent

Intent driven Management Service (**Intent driven MnS**) in 5GS is introduced to reduce the Complexity of Management emerged from the introduction of Service-based Architecture (SBA) in 5G which, in combination with the 5G Functional Model of Business Roles, exceeds the Level of Complexity, both in a Single & Multivendor Network. The relation between the **Policy driven Management** (Rule based) & **intent driven Management** is described in terms of "What-How" (cfi Fig. 4.6.1). The Systems are mainly focused on "How" & "less on "What". The Networks like 5G brings more Operational Complexities, which is driving Systems to shift the focus from "How" to "What". The 1st step towards that shift, has been "Policy driven Management", with more focus on "How" & less on "What" covering Domain specific Issues/Aspects. As Technologies are evolving & the Level of Complexity exceeds, the **Need for an Abstraction Level (Intent)** becomes more apparent. **An Intent driven System will be able to Learn the Behaviour of Networks & Services** & allows an Operator to provide the desired state, without detailed Knowledge of How to get to the desired state. The **Intent driven MnS** could in principle, be specified for deployment over the same set of standardized reference interfaces, as a replacement of or as an addition to the **deployed MnS**, where the **Consumer focuses on the 'What' and the Producer is concerned about the 'How'.** The Technological Evolution has enabled Operated System (**OS**) to become more Complex through the introduction of **AI & ML**. While Previous Generations of OS are classified as simple (& maybe not as Open as today's OS), the introduction of "Virtualization" has made OS more flexible as various System Functions can be co-ordinated in an agile sort of way. The Co-ordinated System is generally the Current State of the Technology, while **Complex System with AI & ML** are there, but not on a ubiquitous scale. These **Complex Systems will require Governance by Intents & Policies**.

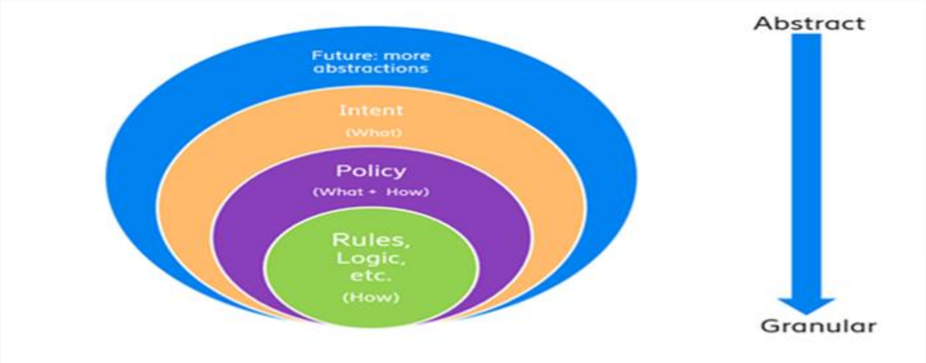


Figure 4.6.1: Intent driven management vs Policy driven management

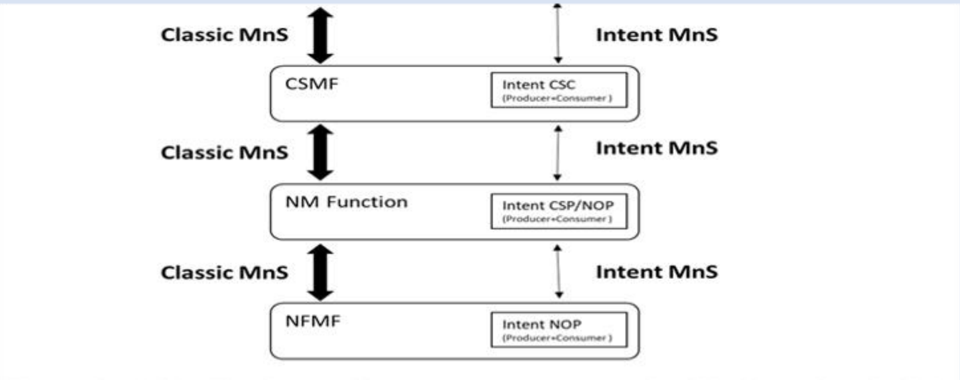


Figure 4.1.2.5.1: The intent driven management service (MnS) vs classic MnS

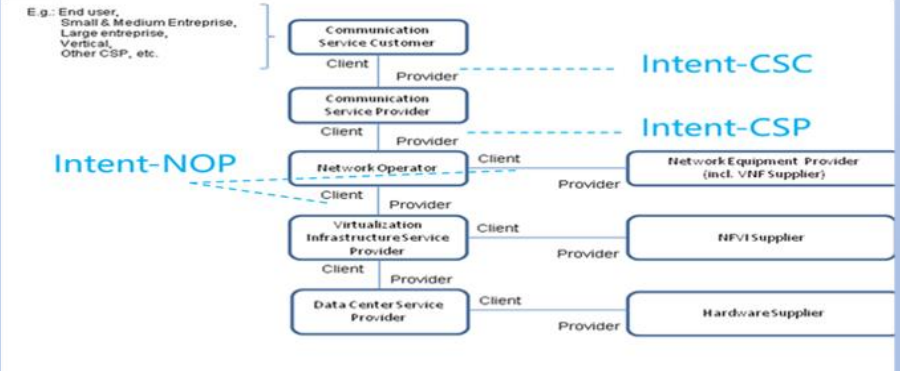


Figure 4.1.2.4-1: Concept for utilization of intent

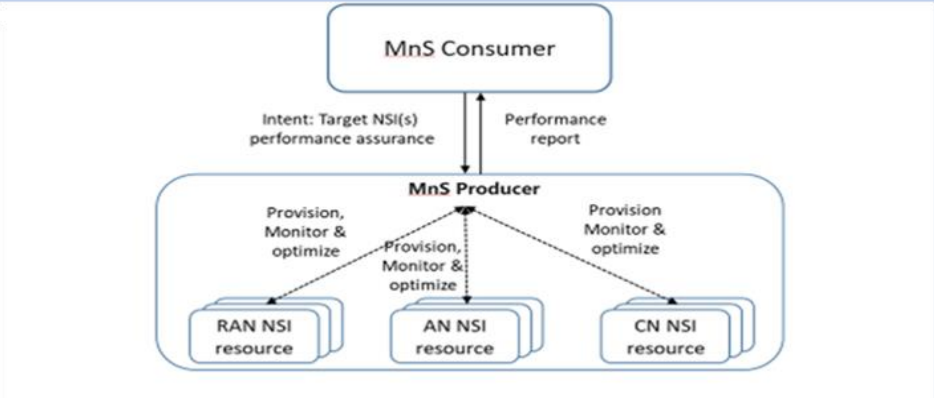


Figure 5.2.4.2-1: An example of intent driven NSI performance assurance scenario

Intent driven Management Service Roles for utilization of Intent are defined as: Communication Service Customer (**CSC**), Communication Service Provider (**CSP**), Network Operator (**NOP**). Based on the Intent expression, the **MnS Producer** decides on necessary Configurations & Monitoring for **NSI** (**Network Slice Instance**) Components. Handling the complexity of the optimization process is the responsibility of the MnS Producer, which simplifies the process from the perspective of the MnS Consumer. MnS Producer can utilize SON (Self Organizing Networks) & MDA (Model Driven Architecture) Services to Monitor & Predict the Performance of Each Component, & take some actions to fulfil the intent received from the operator.

Questions?