ETSI GR MEC 035 V3.1.1 (2021-06)

Multi-access Edge Computing (MEC); Study on inter-MEC systems and MEC-Cloud systems coordination

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Multi-access Edge Computing (MEC).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document studies the applicability of MEC specifications to inter-MEC systems and MEC-Cloud systems coordination that supports e.g. application instance relocation, synchronization and similar functionalities. Another subject of this study is the enablement and/or enhancement of functionalities for application lifecycle management by third parties (e.g. application developers).

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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[i.1] ETSI GS MEC 001: "Multi-access Edge Computing (MEC); Terminology".

[i.2] ETSI GS MEC 003: "Multi-access Edge Computing (MEC); Framework and Reference Architecture".

[i.3] ETSI GS MEC 030: "Multi-access Edge Computing (MEC); V2X Information Service API".

[i.4] GSMA White Paper: "Operator Platform Concept - Phase 1: Edge Cloud Computing", Jan. 2020.

NOTE: Available at https://www.gsma.com/futurenetworks/resources/operator-platform-concept-whitepaper/.

[i.5] XW2-200048, Huawei, Intel: "High-level Architectural Considerations on MEC in Multi-MNO Scenarios", Attachment for LS to GSMA on High-level Architectural Considerations on MEC in Multi-MNO Scenarios (XW2-200047), presented at 5GAA 'F2F'/Virtual WG Meeting Week #14 (11 - 15 May 2020).

[i.6] ETSI GS MEC 010-2: "Multi-access Edge Computing (MEC); MEC Management; Part 2: Application lifecycle, rules and requirements management".

[i.7] ETSI GS MEC 016: "Multi-access Edge Computing (MEC); Device application interface".

[i.8] ETSI GS MEC 021: "Multi-access Edge Computing (MEC); Application Mobility Service API".

[i.9] ETSI GS MEC 002: "Multi-access Edge Computing (MEC); Phase 2: Use Cases and Requirements".

[i.10] ETSI TS 122 186: "5G; Service requirements for enhanced V2X scenarios (3GPP TS 22.186)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

MEC federation: federated model of MEC systems enabling shared usage of MEC services and applications

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GS MEC 001 [i.1] and the following apply:

API	Application Programming Interface
APP	APPlication
AR	Augmented Reality
CAPEX	CAPital EXpenditure
DNS	Domain Name System
FOTA	Firmware Over The Air
GSMA	Global System for Mobile Communications Association
IMA	Intersection Movement Assist
IP	Internet Protocol
LBO	Local Break Out
LCM	Life Cycle Management
MEO	MEC Orchestrator
MEP	MEC Platform
MEPM	MEC Platform Manager
MNO	Mobile Network Operator
NEF	Network Exposure Function
NF	Network Function
OEM	Original Equipment Manufacturer
OSS	Operations Support System
PDU	Protocol Data Unit
QoE	Quality of Experience
RNIS	Radio Network Information Service
SMF	Session Management Function
SOTA	Software Over The Air
UE	User Equipment
UPF	User Plane Function
V2X	Vehicle-to-everything

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4 Overview

4.1 Introduction

The present document studies the applicability of MEC specifications to inter-MEC systems and MEC-Cloud systems coordination. Firstly, the study analyses the current ETSI MEC specifications (clause 4). Secondly, the study documents the use cases that require inter-system coordination, including those in multi-MNO environments (clause 5). Thirdly, the study clarifies the requirements and any missing parts (clause 5). Finally, the study indicates possible solutions to close the gaps (clause 6). The document considers the relevant work of other industry bodies relating to inter system coordination and all relevant work done in ETSI.

4.2 Inter-MEC system communication

Inter-MEC system communication has been identified by ETSI ISG MEC as an important technical topic, primarily impactful to Mobile Network Operators (MNOs). ETSI GS MEC 003 [i.2] specifies three high-level requirements for inter-MEC system communication, along with a hierarchical framework for inter-MEC system discovery and communication as described by the following excerpt (clause 9 of [i.2]):

"Inter-MEC system communication addresses the following high-level requirements:

1) A MEC platform should be able to discover other MEC platforms that may belong to different MEC systems.

2) A MEC platform should be able to exchange information in a secure manner with other MEC platforms that may belong to different MEC systems.

3) A MEC application should be able to exchange information in a secure manner with other MEC applications that may belong to different MEC systems.

To enable the inter-MEC system communication, the following hierarchical inter-MEC system discovery and communication framework is assumed:

- *MEC system level inter-system discovery and communication.*
- *MEC host level inter-system communication between the MEC platforms.*

NOTE: It is for further study if MEC platforms in different MEC systems should be able to discover each other without the involvement of the MEC system level functional elements."

In parallel, driven by the MNOs' interest to form federated MEC environments, e.g. to achieve V2X service continuity in multi-operator operation scenarios, as per ETSI GS MEC 030 [i.3], clauses 5.1 to 5.3, ETSI ISG MEC has introduced the present document on "Study on Inter-MEC systems and MEC-Cloud systems coordination".

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At the same time, GSMA has published a White Paper on the "Operator Platform" concept with focus on "Phase 1" of Edge Cloud Computing in January 2020 [i.4]. In this White Paper, GSMA envisages that "operators will collaborate to offer a unified "operator platform". In Phase 1, the Operator Platform will federate multiple Operators' edge computing infrastructure to give application providers access to a global edge cloud to an innovative, distributed and low latency services through a set of common APIs".

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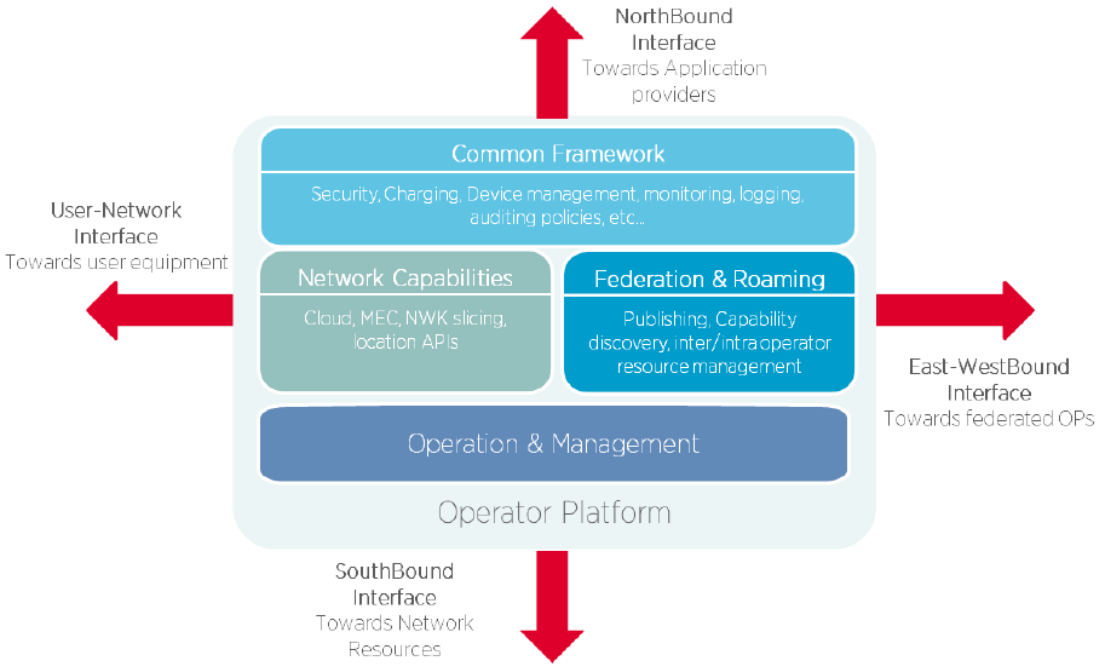

Figure 4.2-1: High level GSMA Operator Platform building blocks (source: [i.4])

From all the above, it is concluded that inter-MEC system communication is an imperative need in today's as well as future's edge computing industry and ecosystem. However, to unlock the full potential of federated MEC environments (as the exemplary one in Figure 4.2-1), an effective and well-defined signalling framework among MEC system entities, is needed, both at system level and at host level. Such a framework has not yet been proposed so far, and the present document is the appropriate place to discuss this topic.

4.3 MEC-Cloud system communication

MEC-Cloud communication is recognized as another important technical topic. ETSI GS MEC 003 [i.2], has referred to application instance relocation between the MEC system and an external cloud environment, (clause A.4.2.2.4 of [i.2]), which is applicable in the context of MEC applications sensitive to UE mobility. According to that, the application instance relocation is conducted under the supervision of MEO.

In some cases, and when it is supported, the UE can request the MEC system to move application instances out of the MEC system to an external cloud environment, or from an external cloud environment to the MEC system. In that case, the application instance relocation is triggered between the MEC system and the external cloud environment under the supervision of MEO.

Furthermore, OSS is responsible for receiving requests from device applications for relocating applications between external clouds and the MEC system (clause 7.1.4.2 of [i.2]) and for receiving a request to run applications from the third parties. In the case of relocation between MEC and Cloud systems, it may include a request from the third parties. Virtualization infrastructure manager is expected to interact with external cloud manager to perform the application relocation (clause 7.1.5.2 of [i.2]). As for the interfaces, ETSI GS MEC 003 [i.2] specifies the reference points connecting to external entities, i.e. Mx1 and Mx2 (clause 6.1 of [i.2]).

As a summary, MEO supervises the application relocation between external cloud and MEC system. For that purpose, OSS interacts with external Cloud system via Mx1 or the combination of Mx2 and Mm8.

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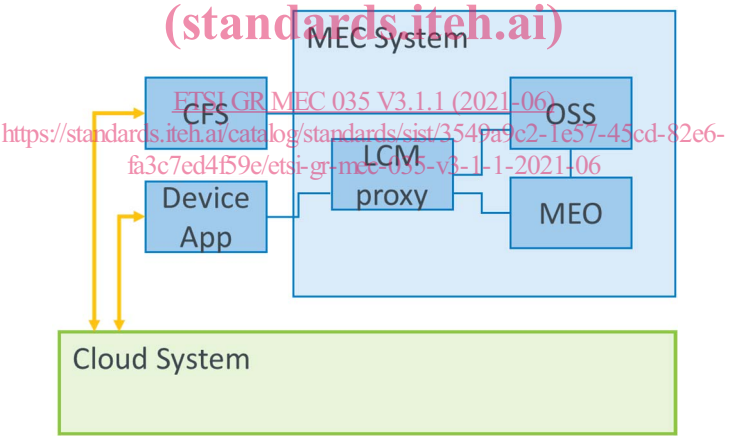

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NOTE: The blue-coloured reference points are specified by ETSI GS MEC 003 [i.2].

Figure 4.3-1: Interactions between a MEC and a Cloud system

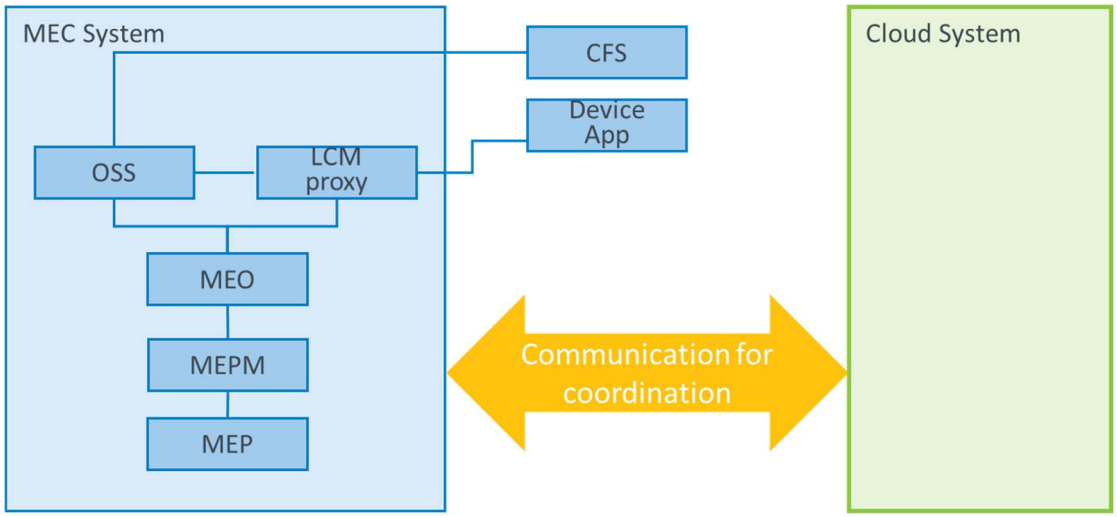
Application mobility is a unique feature of MEC system, which supports relocation of user context and/or application instance from one MEC host to another, or between a MEC host and a Cloud system.

In the present document, all the works should align with the current ETSI MEC specifications. The further recommendations should be clarified based on the use case. Then, the gap from the current ETSI MEC specifications will be clarified as well. Then, solutions will be introduced.

As a matter of fact, there exist many de-facto specifications for cloud systems. Therefore, proposing recommendations for the operation of the cloud system is outside the scope of the present document. The intention is to rather clarify the involved reference points and functional entities in the MEC system. Figure 4.3-2 illustrates the high-level architecture.

NOTE 1: Infrastructure level communication is out of scope in the present document.

NOTE 2: An architecture of Cloud system is out of scope of the present document.



NOTE: The blue-coloured reference points are specified by ETSI GS MEC 003 [i.2].

Figure 4.3-2: High-level architecture view of MEC-Cloud system communication

4.4 Patterns of Business relationship between MEC and external systems

In this study, the following patterns of relationship between MEC and external systems in Business and service layer are considered as illustrated in Figure 4.4-1. Business and service layer is referred to a level of communication among functions belonging to different MEC systems, which may need an agreement between MEC system providers. For the purpose of MEC federation, communication with the external system should be taken into account, which needs to extend the current concept of the system level management:

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1) MEC system and MEC system/Edge Cloud:
As a main pattern of this category, one MEC system is in MNO 1's network and the other is in MNO 2's network. Both systems are located in the different MNOs' networks but those systems are structured with the same functions that are specified in ETSI GS MEC 003 [i.2]. This category includes the following subcases relating to Edge Cloud. Here, "Edge Cloud" is referred to a cloud point-of-presence on the same "operator's premises" as the MNO but which is outside the MNO's control and therefore trust space. For practical purposes the difference may be understood as one of interconnections: the Edge Cloud is connected to the MEC System via a high-performance L2 interconnect over which the MNO can enforce L2-like strict SLAs on throughput, latency, etc.; whereas Private Cloud and Public Cloud do not presume such an interconnect (although it may presume other interconnects with their own SLAs):

    1') MEC system and Edge Cloud in different MNO's network:
    This pattern is also considered as a subcase of 1). Edge Cloud is located inside the MNO's network but the associating MNO is different from that of MEC system. It shares the virtualized infrastructure with the centralized cloud system.

    1") MEC system and Edge Cloud in the same MNO's network:
    This pattern is considered as a subcase of 1). Edge Cloud is located inside the same MNO's network as MEC system. It shares its virtualized infrastructure with the centralized cloud system. but its resources are distributed in the associating MNO's network.

2) MEC system and Public/Private Cloud system:
Public Cloud system is located out of MNO's network. Architecture of Public Cloud system is out of scope of the present document.

    2') MEC system and Private Cloud system in an application provider's own environment:
    This pattern is considered as a subcase of 2). Private Cloud system is located in the application provider's environment. It can be just an application server or an on-premise Cloud system. Architecture of Private Cloud system is also out of scope of the present document.

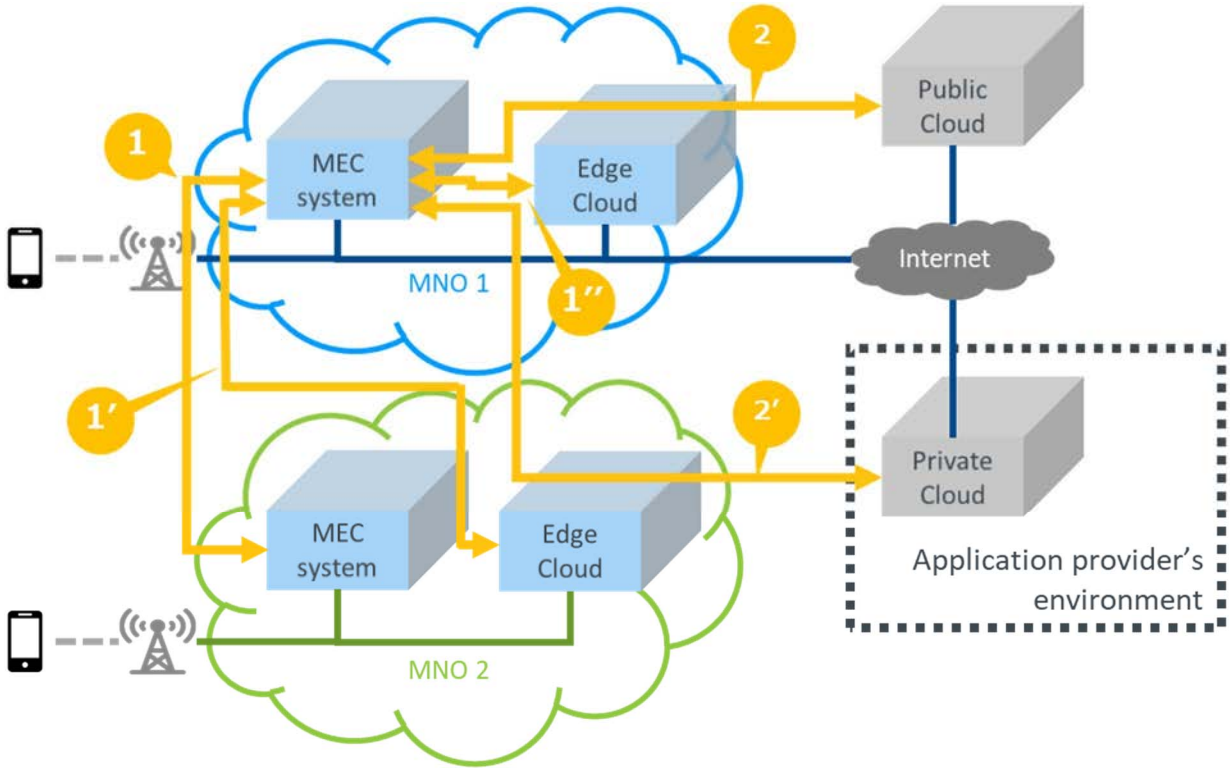

Figure 4.4-1: Patterns of relationship in Business and service layer

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The use cases and key issues in the following clauses cover the patterns of relationship in Business and service layer.

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5 Use cases

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5.1 Use case #1: MEC federation scenario of V2X services

5.1.1 Description

A typical MEC federation scenario of V2X services (i.e. multi-MNO, multi-OEM, multi-MEC) is considered, as the one illustrated in Figure 5.1.1-1.

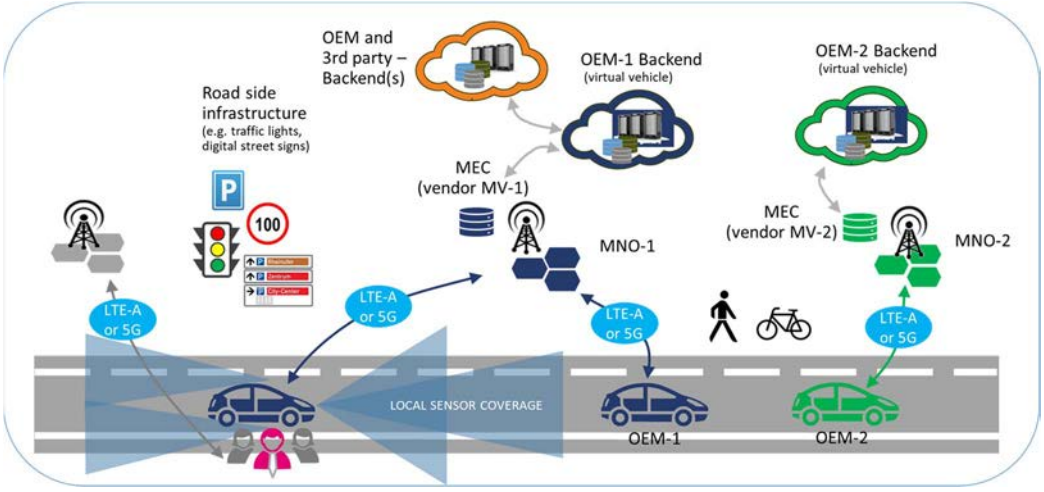

Figure 5.1.1-1: Typical V2X multi-stakeholder scenario (source: 5GAA member's symposium in Turin, November 2019)

In this scenario, a V2X application instance may be running on a car connected to MNO 1 which is equipped with a MEC system from vendor 1, and communicating with another V2X application instance, running on a server, or, in general, on a second car connected to MNO 2, which, in its turn, is equipped with a MEC system from vendor 2.

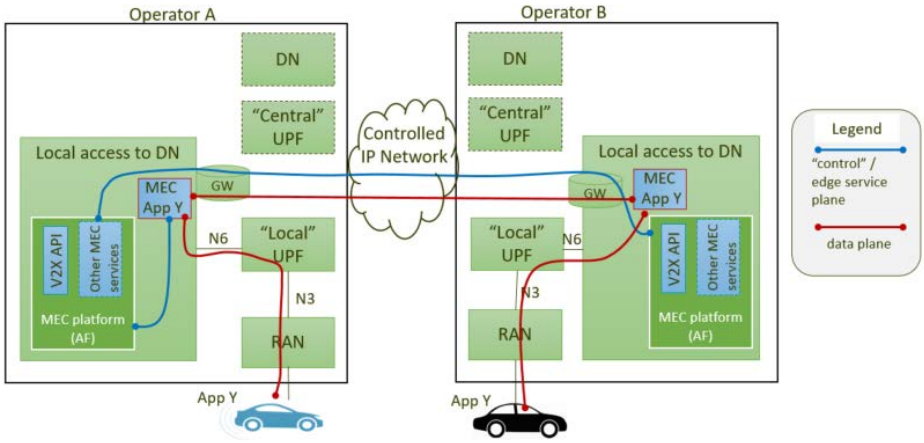

Figure 5.1.1-2: Illustration of a MEC federation reference scenario where both MNOs have MEC platforms and a MEC application Y ("MEC App Y") is instantiated (Multiple OEM vehicle use case) (source: 5GAA document XW2_200048, May 2020) [i.5]

From an architectural point of view, this scenario is also depicted in Figure 5.1.1-2, where a certain V2X service is implemented with two instances of the "MEC App Y", each of which communicates with its corresponding Client App, i.e. "App Y", and is also connected with a MEC platform in each respective MEC system (domain). The "MEC App Y" instances may need to directly communicate with each other and/or consume platform services of the other MEC system.

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5.1.2 Recommendations

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To enable a MEC federation, the following hierarchical inter-MEC system communication levels should be introduced:

1) MEC system (i.e. below business level) discovery, including security (authentication/authorization, system topology hiding/encryption), charging, identity management and monitoring aspects as an essential prerequisite to form a MEC federation.

2) MEC platform discovery, by means of the MEC systems exchanging information about their MEC platforms, i.e. their identities, a list of their shared services, as well as authorization and access policies.

3) Information exchange at MEC platform level, for the needs of MEC service consumption, or for MEC app-to-app communication.

The ultimate goal is to address the needs of information exchange for MEC/edge service consumption and MEC app-to-app communication, which is related to the third item in the above list. Such information exchange refers to either a MEC application in need of consuming a MEC platform service, or a MEC application in need of communicating with other (e.g. service-producing) MEC applications.

NOTE: Identifiers for MEC platforms and MEOs may need to be defined.

5.1.3 Evaluation

Recommendations of clause 5.1.2 are technically feasible, provided that ETSI ISG MEC will introduce a proper hierarchical signalling framework needed to realize a MEC federation constituting of MEC systems, possibly owned and operated by different parties (e.g. MNOs).

Clause 6 includes the related key issues and proposed solutions.

5.2 Use case #2: multi-operator agreements enabling MEC Federation for V2X services

5.2.1 Description

Some federation use cases are described below:

TYPE-1 USE CASE

- A possible use case for federation can be associated to a national roaming like scenario where customers of an MNO#1 could access the edge infrastructure of MNO#2 if this operator has a complementary footprint. An end-user is a customer of MNO#1 but the best edge location for the MEC App to be used is in the edge infrastructure of MNO#2. When triggering the app in his device, the MEC system of MNO#1, through its federation agreement, identifies that the best edge location is in MNO#2. Then, the edge system of MNO#1 redirects the App to the MEC system of MNO#2 to ensure the best possible service.

TYPE-2 USE CASE

- An application developer has a commercial relationship with MNO#1. Through his federation agreements MNO#1 allows also the application developer to deploy its App in the MEC systems of MNO#2, MNO#3 to access their respective subscribers. Through its existing federation agreements MNO#1 provides visibility of the availability zones that can be used in MNO#1, MNO#2, MNO#3 networks. The app developer then decides on its deployment approach based upon his commercial strategy.

TYPE-3 USE CASE

- MNO#1 wants to reach the maximum possible number of federation agreements with other MNOs. To achieve this goal MNO#1 decides to make use of a federation broker who has a pre-established set of agreements with a large number of MNOs. Then MNO#1 offers to his App developers/customers the possibility to deploy in the availability zones of the MEC systems of all the MNOs part of the direct federation agreement of MNO#1 but also to the MNOs part of the federation broker portfolio.

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5.2.2 Recommendations

The corresponding recommendations are described in clause 5.1.2.

5.2.3 Evaluation

The corresponding evaluation is described in clause 5.1.3.

5.3 Use case #3: Application instance transfer between MEC and Cloud systems

5.3.1 Description

For the better QoS or cost efficiency, the application instances serving the device are possibly changed from the one on the cloud system to another on MEC host, e.g. in cases of shortage of backhaul network resources, activation of the MEC host, or entering the coverage of the MEC host. The current MEC specifications support the on-boarding of the application package and the instantiation of the application instance based on the request from outside. Other relevant functions are not fully specified. Furthermore, regarding the other way, in the case where the serving MEC application instance is changed from the one on the MEC system to another on the Cloud system, e.g. in the case of leaving the coverage of the corresponding MEC host, the shortage of computing resource on MEC host, or service down due to hardware errors, the endpoint of the communication is changed from the MEC host to the Cloud system. High level behaviour is illustrated in Figure 5.3.1-1. Note that regarding the second application transfer that is from MEC system to Cloud system, the application instance on Cloud system is stopped and deleted during the device connects to the application instance on MEC system, e.g. in the case where the application instance on Cloud system does not serve any other devices. Therefore, Cloud system needs to start the application instance again when the device comes back to Cloud system. Since Cloud system keeps the application package, the application package transfer is not necessary. If the application instance stays active on Cloud system after the first application transfer, the second transfer will not happen.

After the second transfer, an application instance on Cloud system may need to continue using MEC services on the MEC system, e.g. RNIS, location service, etc. In this case, the relevant information maintained by the MEC system may need to be transferred to the Cloud system for the purpose of MEC service remote consumption or equivalent service continuity.

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As shown in Figure 5.3.1-2, there are two operations for application transfer between MEC system and cloud system:

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1) distribution of the application that includes check of the platform service availability, dissemination of application package, instantiation of application instance, and synchronization of the application data;

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2) switch communication path that includes the continuity of the application and checks availability of the physical resource.

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Recommendations are introduced based on these processes:

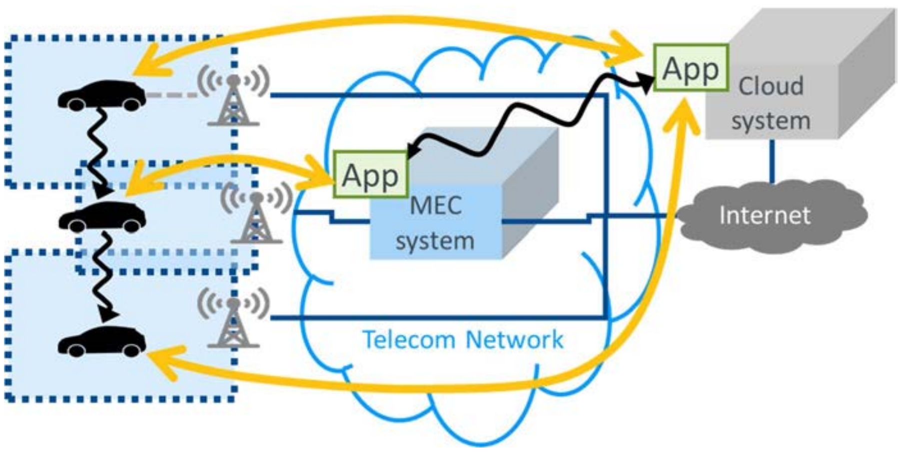

Figure 5.3.1-1: Abstract level of the behaviour

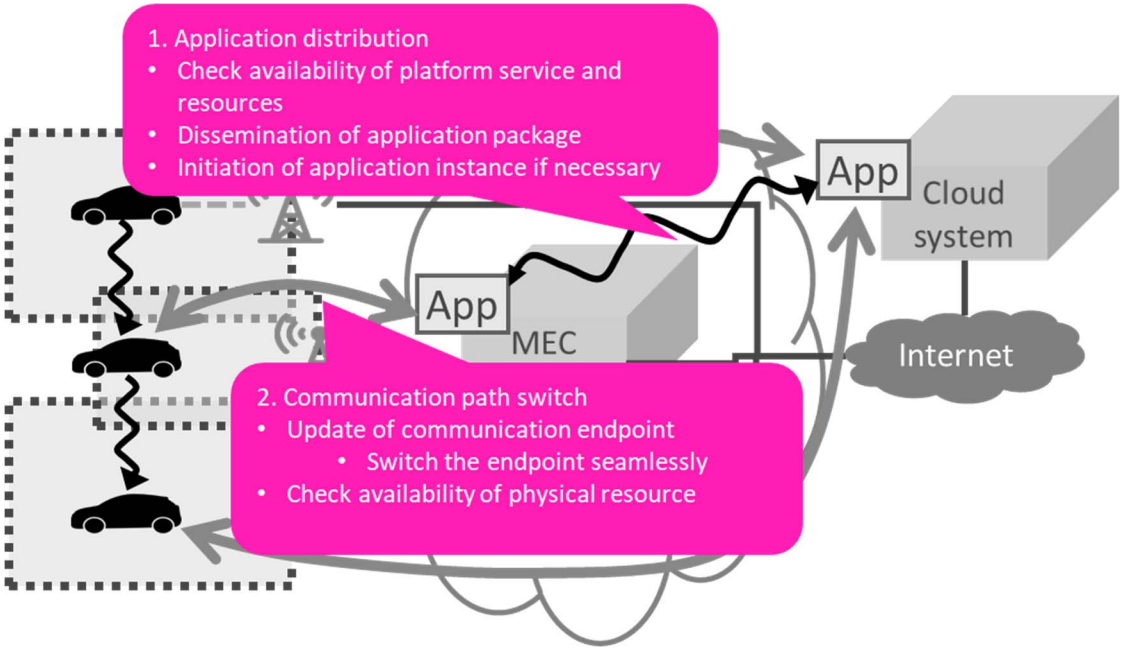

Figure 5.3.1-2: Corresponding operations

With regard to the business relationship described in clause 4.4, the same example can be applicable to the following systems:

- MEC system to Private Cloud in the application provider's environment (as illustrated in Figure 5.3.1-3).

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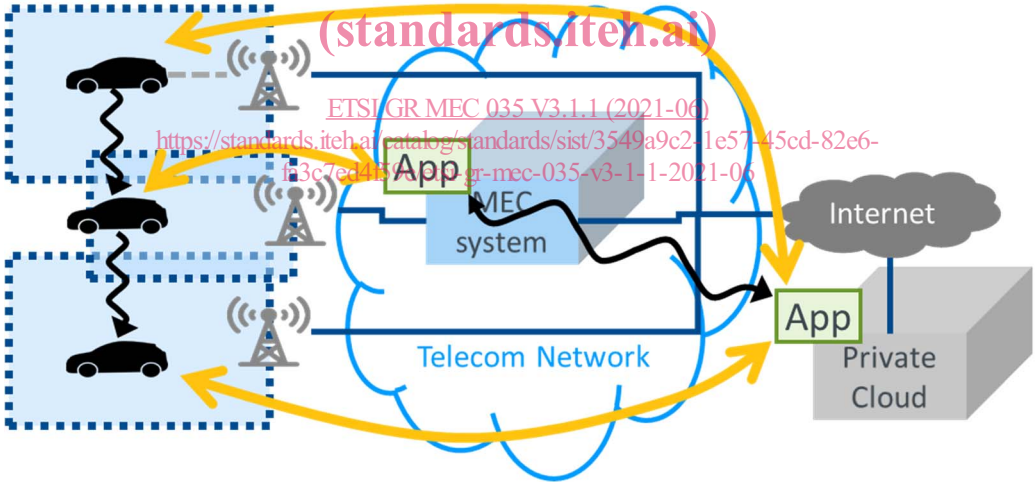

Figure 5.3.1-3: Abstract level behaviour in the case of MEC system to Private Cloud

5.3.2 Recommendations

The list of recommendations for relocating application between Cloud system and MEC system are as follows.

[Recommendation 5.3.2-1]

In order to distribute the application package to the appropriate MEC host, MEC system should support Cloud system or application instance on the cloud to discover the appropriate MEC host.

[Recommendation 5.3.2-2]

In the case of transfer from Cloud system to MEC system, MEC system should support the Cloud system to check if the availability of MEC system prior to the application instance transfer/distribution. The relevant information is provided if needed. In the case of transfer from MEC to the Cloud system, the MEC system should support to confirm the availability of the Cloud system if needed.