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Mobile Edge Computing (MEC); Deployment of Mobile Edge Computing in an NFV environment

Disclaimer

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Foreword

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

Modal verbs terminology

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1 Scope

The present document describes solutions that allow the deployment of MEC in a NFV environment. For each solution, it describes the motivation for the solution, its architectural impacts and the necessary work to enable it. The document provides recommendations as for where the specification work needs to be done.

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.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GS NFV-MAN 001: "Network Functions Virtualisation (NFV); Management and Orchestration".

[i.2] ETSI GS NFV-INF 003: "Network Functions Virtualisation (NFV); Infrastructure; Compute Domain".

[i.3] ETSI GS NFV-INF 004: "Network Functions Virtualisation (NFV); Infrastructure; Hypervisor Domain".

[i.4] ETSI GS NFV-INF 005: "Network Functions Virtualisation (NFV); Infrastructure; Network Domain".

[i.5] ETSI GS MEC 003: "Mobile Edge Computing (MEC); Framework and Reference Architecture".

[i.6] ETSI GS NFV-IFA 013: "Network Functions Virtualisation (NFV); Management and Orchestration; Os-Ma-Nfvo reference point - Interface and Information Model Specification".

[i.7] ETSI GS NFV-IFA 011: "Network Functions Virtualisation (NFV); Management and Orchestration; VNF Packaging Specification".

[i.8] 3GPP TR 32.842: "Telecommunication management; Study on network management of virtualised networks".

[i.9] ETSI GS NFV-IFA 009: "Network Functions Virtualisation (NFV); Management and Orchestration; Report on Architectural Options".

[i.10] ETSI GS MEC 010-2: "Mobile Edge Computing (MEC); Mobile Edge Management; Part 2: Application lifecycle, rules and requirements management".

[i.11] ETSI GS NFV-IFA 014: "Network Functions Virtualisation (NFV); Management and Orchestration; Network Service Templates Specification".

[i.12] ETSI GS NFV-IFA 008: "Network Functions Virtualisation (NFV); Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".

[i.13] ETSI GS MEC 010-1: "Mobile Edge Computing (MEC); Mobile Edge Management; Part 1: System, host and platform management".

[i.14] ETSI GS NFV-SOL 002: "Network Functions Virtualisation (NFV); Protocols and Data Models; RESTful protocols specification for the Ve-Vnfm Reference Point".

[i.15] IETF RFC 6241: "Network Configuration Protocol (NETCONF)".

[i.16] IETF RFC 8040: "RESTCONF Protocol".

[i.17] ETSI GS MEC 002: "Mobile Edge Computing (MEC); Technical Requirements".

[i.18] ETSI GS NFV-IFA 006: "Network Functions Virtualisation (NFV); Management and Orchestration; Vi-Vnfm reference point - Interface and Information Model Specification".

[i.19] ETSI GS NFV-IFA 007: "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".

[i.20] ETSI GS NFV-IFA 018: "Network Functions Virtualisation (NFV); Acceleration Technologies; Network Acceleration Interface Specification; Release 3".

[i.21] OpenStack documentation, Service function chaining.

NOTE: Available at: https://docs.openstack.org/newton/networking-guide/config-sfc.html.

[i.22] ETSI GS NFV-SOL 005: "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; RESTful protocols specification for the Os-Ma-nfvo Reference Point".

3 Definitions and abbreviations

3.1 Definitions

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

ME app VNF: mobile edge application that appears like a VNF towards the ETSI NFV MANO components

3.2 Abbreviations

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

DNS Domain Name System
DOPFR Dynamic Optimization of Packet Flow Routing
EM Element Manager
ETSI European Telecommunications Standards Institute
GS Group Specification
GTP GPRS Tunnelling Protocol
HOT Heat Orchestration Template
IP Internet Protocol
LCM Life Cycle Management
MANO Management and Orchestration
ME Mobile Edge
MEAO Mobile Edge Application Orchestrator
MEC Mobile Edge Computing
MEO Mobile Edge Orchestrator
MEPM Mobile Edge Platform Manager
MEPM-V Mobile Edge Platform Manager - NFV
NFP Network Forwarding Path
NFV Network Functions Virtualisation
NFVI Network Functions Virtualisation Infrastructure
NFVO Network Functions Virtualisation Orchestrator

NS	Network Service
NSD	Network Service Descriptor
OASIS	Organization for the Advancement of Structured Information Standards
OSS	Operations Support System
PM	Performance Management
PNF	Physical Network Function
PNFD	Physical Network Function Descriptor
PoP	Point of Presence
QCI	Quality Class Indicator
SFC	Service Function Chaining
SPID	Subscriber Profile ID
TEID	Tunnel Endpoint ID
TOSCA	Topology and Orchestration Specification for Cloud Applications
UE	User Equipment
VIM	Virtualised Infrastructure Manager
VL	Virtual Link
VM	Virtual Machine
VNF	Virtualised Network Function
VNFC	VNF Component
VNFD	VNF Descriptor
VNFFG	VNF Forwarding Graph
VNFM	Virtual Network Function Manager
YAML	YAML Ain't Markup Language

4 Introduction

Mobile network operators are expected to virtualise their networks using Network Functions Virtualisation (NFV), and want to use the introduced virtualisation infrastructure to consolidate network elements (Virtualised Network Functions - VNFs), Mobile Edge Computing (MEC) components and Mobile Edge (ME) applications on top of that infrastructure. Sharing the introduced elements (infrastructure, but also management functions) to the maximum possible degree allows to make maximum use of the investments into virtualisation. The present document will analyse different scenarios of MEC deployments in NFV environments w.r.t. their architectural impact and the needed specification work. The present document will help to identify normative specification work to enable MEC deployments in NFV environments. It will also help operators that plan to deploy MEC and NFV feature at the same time, to make the right decision by providing detailed information around solution aspects.

5 Reference Architecture

5.1 Overview and assumptions

This clause defines a reference architecture of how ETSI MEC can be deployed in a NFV environment. The basic assumptions are:

1) The ME platform is deployed as a VNF. For that purpose, the procedures defined by ETSI NFV are used. It is not expected that these procedures need to be modified for use with ETSI MEC. Clause 5.2 further elaborates on this.

2) The ME applications appear like VNFs towards the ETSI NFV MANO components. This allows re-use of ETSI NFV MANO functionality. It is, however, expected that ETSI MEC might not use the full set of MANO functionality, and requires certain additional functionality. Such a specific ME application is denoted by the name "ME app VNF" in the remainder of the present document.

3) The virtualisation infrastructure is deployed as a NFVI and its virtualised resources are managed by the VIM. For that purpose, the procedures defined by ETSI NFV Infrastructure specifications, i.e. ETSI GS NFV-INF 003 [i.2], ETSI GS NFV-INF 004 [i.3], ETSI GS NFV-INF 005 [i.4], can be used. It is not expected that these procedures need to be modified for use with ETSI MEC.

5.2 MEC reference architecture in NFV environments

It is assumed that the ME app VNFs will be managed like individual VNFs, allowing that a MECinNFV deployment can delegate certain orchestration and Life Cycle Management (LCM) tasks to the NFVO and VNFM functional blocks, as defined by ETSI NFV MANO.

One goal of the present study is to describe that actual mapping, to elaborate on a high level how MEC orchestration procedures and ME application LCM procedures can be realized in such an environment.

The Mobile Edge Platform Manager (MEPM), as defined in the MEC reference architecture ETSI GS MEC 003 [i.5], is transformed into a "Mobile Edge Platform Manager - NFV" (MEPM-V) that delegates the LCM part to one or more VNFM(s). The Mobile Edge Orchestrator (MEO), as defined in the MEC reference architecture ETSI GS MEC 003 [i.5], is transformed into a "Mobile Edge Application Orchestrator" (MEAO) that uses the NFVO for resource orchestration, and for orchestration of the set of ME app VNFs as one or more NFV Network Services (NSs).

Figure 5.2-1 illustrates the realization of the ETSI MEC reference architecture in an ETSI NFV environment.

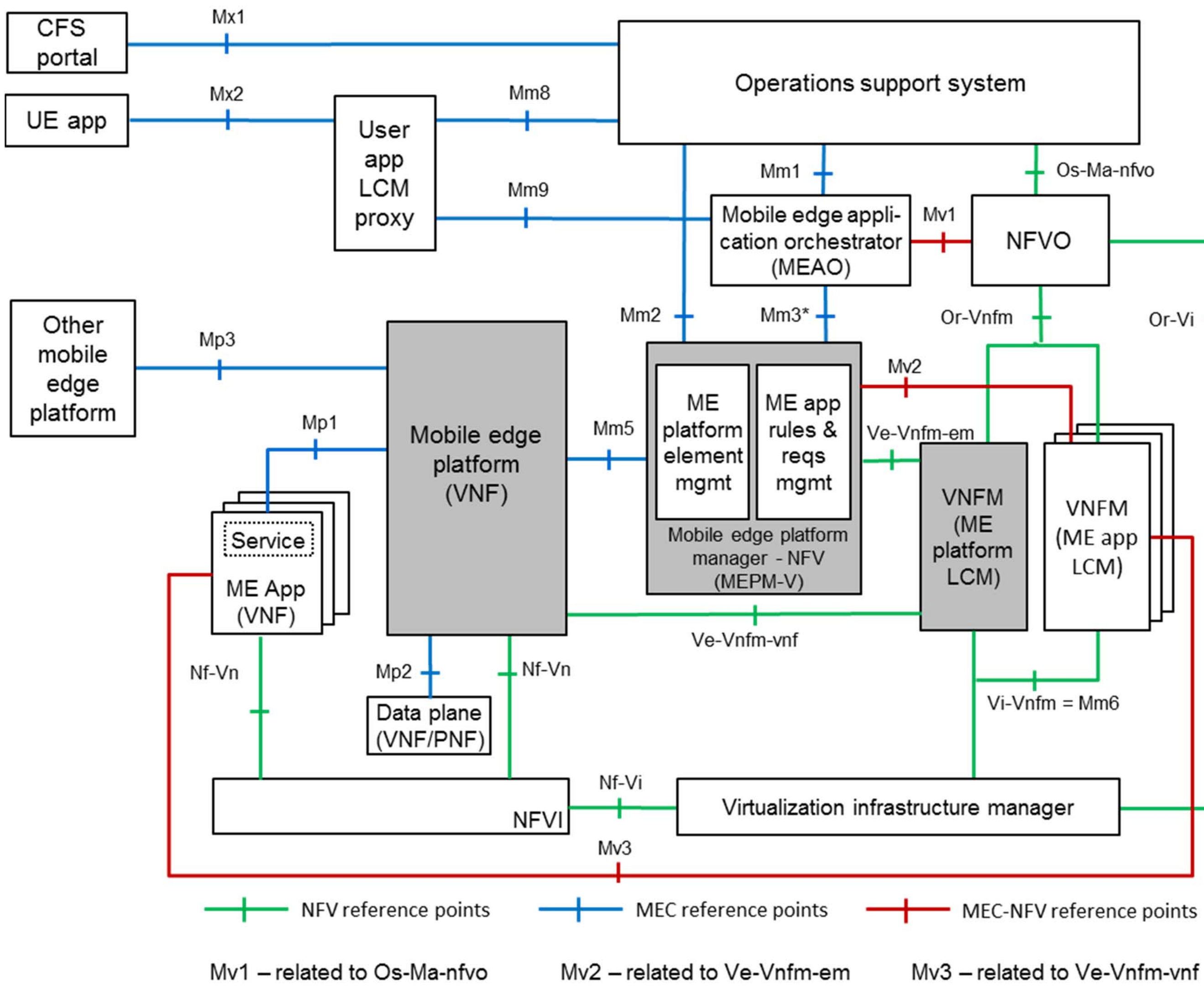

Figure 5.2-1: MEC reference architecture in a NFV environment

NOTE 1: It is assumed that the Mobile Edge Platform VNF, the MEPM-V and VNFM (ME platform LCM) will be deployed as a single package as per the ensemble concept in 3GPP TR 32.842 [i.8], or that the VNFM is a Generic VNFM as per ETSI GS NFV-IFA 009 [i.9] and the Mobile Edge Platform VNF and the MEPM-V are provided by a single vendor.

NOTE 2: The Mp1 reference point between an ME application and the ME platform is optional for the ME application, unless it is an application that provides and/or consumes a ME service (ETSI GS MEC 003 [i.5], Figure 6-1).

NOTE 3: The Mm3* reference point between MEAO and MEPM-V is based on the Mm3 reference point, as defined by ETSI GS MEC 003 [i.5]. Changes will be needed to this reference point to cater for the split between MEPM-V and VNFM (ME applications LCM).

The following new reference points (Mv1, Mv2 and Mv3) are introduced between elements of the ETSI MEC architecture and the ETSI NFV architecture to support the management of ME app VNFs. These are related to existing NFV reference points, but it is expected that only a subset of the functionality will be used for ETSI MEC, and that extensions may be necessary:

- **Mv1:** This reference point connects the MEAO and the NFVO. It is related to the Os-Ma-nfvo reference point, as defined in ETSI NFV.
- **Mv2:** This reference point connects the VNF Manager that performs the LCM of the ME app VNFs with the MEPM-V to allow LCM related notifications to be exchanged between these entities. It is related to the Ve-Vnfm-em reference point as defined in ETSI NFV, but will possibly include additions, and might not use all functionality offered by Ve-Vnfm-em.
- **Mv3:** This reference point connects the VNF Manager with the ME app VNF instance, to allow the exchange of messages e.g. related to ME application LCM or initial deployment-specific configuration. It is related to the Ve-Vnfm-vnf reference point, as defined in ETSI NFV, but will possibly include additions, and might not use all functionality offered by Ve-Vnfm-vnf.

The following reference points are used as they are defined by ETSI NFV:

- **Nf-Vn:** This reference point connects each ME app VNF with the NFVI.
- **Nf-Vi:** This reference point connects the NFVI and the VIM.
- **Os-Ma-nfvo:** This reference point connects the OSS and the NFVO. It is primarily used to manage NSs, i.e. a number of VNFs connected and orchestrated to deliver a service.
- **Or-Vnfm:** This reference point connects the NFVO and the VNFM. It is primarily used for the NFVO to invoke VNF LCM operations.
- **Vi-Vnfm:** This reference point connects the VIM and the VNFM. It is primarily used by the VNFM to invoke resource management operations to manage the cloud resources that are needed by the VNF. It is assumed in a NFV-based MEC deployment that this reference point corresponds 1:1 to Mm6.
- **Or-Vi:** This reference point connects the NFVO and the VIM. It is primarily used by the NFVO to manage cloud resources capacity.

5.3 Realization of the mobile edge platform as a VNF

It is assumed that the ME platform will be realized as a VNF and will be managed according to ETSI NFV procedures. It is not assumed that ETSI MEC needs to define any modification to this.

This means:

- the MEPM-V will act as the Element Manager (EM) of the ME platform VNF;
- a VNF Manager, according to ETSI NFV (e.g. Specific VNFM, Generic VNFM), is used to perform LCM of the ME platform VNF;
- the scope of the Mp2 reference point will need to be redefined. ETSI GS MEC 003 [i.5] states that this reference point is considered outside the scope of standardization but the introduction of the ME platform as a VNF introduces a potential multivendor deployment of the ME Platform VNF and the NFVI, which contains the Data Plane.

Figure 5.3-1 illustrates this set-up, mapping the applicable components into the ETSI NFV MANO architecture defined in ETSI GS NFV-MAN 001 [i.1].

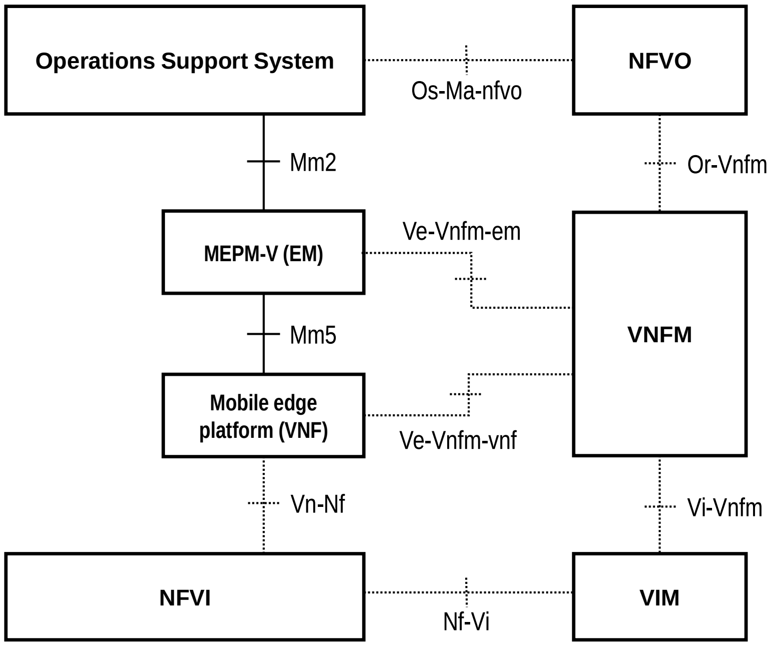

Figure 5.3-1: Management of the ME platform as a VNF

The following reference points are used as they are defined by ETSI NFV:

- **Ve-Vnfm-em:** This reference point connects the VNF Manager (VNFM) that manages the lifecycle of the ME platform with the Mobile Edge Platform Manager - NFV (MEPM-V). It is the Ve-Vnfm-em reference point as defined in ETSI NFV. Since the Mobile Edge Platform VNF is considered as a network function, it is not expected that there are any impacts to the Ve-Vnfm-em procedures as defined by ETSI NFV.
- **Ve-Vnfm-vnf:** This reference point connects the VNFM that manages the lifecycle of the ME platform with the Mobile Edge Platform VNF. It is the Ve-Vnfm-vnf reference point as defined in ETSI NFV. Since the Mobile Edge Platform VNF is considered as a network function, it is not expected that there are any impacts to the Ve-Vnfm-vnf procedures as defined by ETSI NFV.
- **Nf-Vn:** This reference point connects the Mobile Edge Platform VNF and the NFVI.
- **Nf-Vi:** This reference point connects the NFVI and the VIM.
- **Os-Ma-nfvo:** This reference point connects the OSS and the NFVO. It is primarily used to manage NSs, i.e. a number of VNFs connected and orchestrated to deliver a service.
- **Or-Vnfm:** This reference point connects the NFVO and the VNFM that manages the lifecycle of the ME platform. It is primarily used for the NFVO to invoke VNF LCM operations.
- **Vi-Vnfm:** This reference point connects the VIM and the VNFM that manages the lifecycle of the ME platform. It is primarily used by the VNFM to invoke resource management operations to manage the cloud resources that are needed by the VNF.
- **Or-Vi:** This reference point connects the NFVO and the VIM. It is primarily used by the NFVO to manage cloud resources capacity.

5.4 Realization of the Data Plane

When MEC is deployed in a NFV environment, there are two different possibilities to realize the Data Plane, both are valid and need to be supported.

Option 1: Realize the Data Plane as a PNF or VNF or combination thereof, and connect it to the NS that contains the ME app VNFs. In this option, Mp2 is kept as a MEC-internal reference point also in the NFV-based deployment of MEC; the option is agnostic to the way MEC is deployed.

Option 2: For performance enhancements, it can make sense to re-use the SFC functionality provided by the underlying NFVI for traffic routing. In such a deployment, the Data Plane as a dedicated component is not needed, and consequently, also the Mp2 reference point does not exist. The SFC functionality in the NFVI will be configured by the NFVO in the VIM based on the NFP of the NFV NS, using the Or-Vi reference point. The MEAO will need to translate the traffic rules into an NFP and send it to the NFVO. The ME platform will not control the traffic redirection directly via Mp2 will pass requests to activate / deactivate / update for traffic rules to the MEPM-V which will forward them to the MEAO. When receiving such a request, the MEAO will request the NFVO to update the NFP accordingly.

6 Key issues

6.1 Issue #1: Mapping of ME app VNFs to Network Services

6.1.1 Problem description

As indicated in point 2 of clause 5.1, the ME applications appear like VNFs towards the ETSI NFV MANO components. As stated in clause 5.2:

- The Mobile Edge Orchestrator (MEO), as defined in the MEC reference architecture ETSI GS MEC 003 [i.5], is transformed into a "Mobile Edge Application Orchestrator" (MEAO) that uses the NFVO for resource orchestration, and for orchestration of the set of ME app VNFs as one or more NFV NSs.

This is consistent with how NFV conceptualizes NFVO: as an entity that operates on NSs. For example, ETSI GS NFV-IFA 013 [i.6], Annex A states as "Principle #3":

- With respect to the Os-Ma-nfvo reference point, any interaction concerning a VNF is associated with at least one NS instance.

The issue is related to the mapping of ME app VNFs to NFV NSs. The MEAO would need to have a mapping from ME app VNFs to NSs.

The assumption is that Mv1 looks similar to Os-Ma-nfvo and that MEAO is creating the needed NSs for the ME app VNFs.

This assumption should be clearly stated in the document and the mapping of NS to ME app VNFs be explained. Functional blocks of the architecture request the creation/LCM of ME app VNF instances from the MEAO using the 2 reference points Mm1 and Mm9.

The Mm1 reference point between the MEO and the OSS is used for triggering the instantiation and the termination of ME app VNFs in the ME system.

The Mm9 reference point between the user application LCM proxy and the MEO of the ME system is used to manage ME applications requested by UE application.

None of those 2 reference points are dealing with services, while the MEAO would need NS knowledge, as well as the mapping of ME app VNF to NS.

6.1.2 Solution(s)

It is assumed that the MEAO would perform the following tasks:

1) Request the NFVO to set one or more NSs to manage the ME app VNFs, which includes:

   Generation and onboarding of an NSD

   Requesting the instantiation of a NS

2) When a new ME app VNF package is onboarded:

   Updating of the NSD to reference the new package, and onboarding of the updated NSD

3) When the instantiation of a ME app VNF is requested (see also key issue #13):

Request the NFVO to perform the UpdateNs operation, adding a new ME app VNF instance, and possibly, if the ME app VNF package was not included in the NSD on which the NS is built, updating the NS to use the new updated NSD

Once this was successful, trigger the MEPM-V to perform additional configuration

4) When the termination of a ME app VNF is requested (see also key issue #14):

Request the NFVO to perform the UpdateNs operation, removing the ME app VNF instance

The MEAO would need to track for every ME app VNF instance the following information:

1) Identifier NS instance of which the ME app instance is part
2) Identifier of the ME app VNF instance
3) Responsible MEPM-V instance
4) Responsible MEC Platform instance

This information can be obtained for various sources:

- 1) is available to the MEAO as part of managing the NSs
- 2) is available via notifications on Mv1 regarding the result of the UpdateNs operation
- 3) can be derived from 4)
- 4) is configured into the ME app VNF instance upon instantiation, as per decision of the MEAO

6.1.3 Evaluation

The solution described above allows to manage a ME app VNF instance as part of a NS. Creating and terminating ME app VNF instances always includes the NFVO in the path that the request travels, thereby mixing aspects of host-level management and system-level management. This is an inherent consequence of the choice to manage ME app VNFs as VNFs, which means that they have to be part of a NS when using ETSI NFV. As NSs are managed in NFV by the orchestration layer, the orchestrator needs to be involved in every single ME app instantiation, and there is not much that can be done about it in the chosen "MECinNFV" architectural framework.

6.1.4 Proposal

It is suggested that the MEAO arranges with the NFVO via Mv1 to manage the ME app VNF instances as part of one or more NSs.

6.2 Issue #2: Usage of NFV Network Service

6.2.1 Problem description

NFV decouples software implementations of Network Functions from the computation, storage, and networking resources they use. The virtualisation insulates the Network Functions from those resources through a virtualisation layer. VNFs can be chained with other VNFs and/or Physical Network Functions (PNFs) to realize a NS.

As defined in the ETSI GS NFV-IFA 014 [i.11], the NS describes the relationship between VNFs and possibly PNFs that it contains and the links needed to connect VNFs that are implemented in the NFVI network. Besides the VNF information, the NS information element also includes PNF information element, Virtual Link (VL) information element and VNF Forwarding Graph (VNFFG) information element. The VNFFG describes the topology of the NS by referencing VNFs and PNFs and VLs that connect them.

The Network Service Descriptor (NSD) can also be used to describe dependencies between VNFs, e.g. to ensure the ME Platform VNF is instantiated before any ME App VNF that uses it is instantiated.

In the present document, the concept of NS needs to be considered to deploy MEC in a NFV environment. Besides describing the dependencies between VNFs, it also defines the topology of the connections between the VNFs using the VNFFG.

6.2.2 Solution(s)

It is recommended to introduce the NS concept in support of MEC deployment in NFV environment, while keeping the assumptions that both ME platform and ME applications are considered VNFs. The set of ME platform VNF and ME app VNFs can be grouped into one or more (possibly nested) NSs. In an example deployment, a NS could contain a ME platform VNF and one or more ME app VNFs, with which the following scenarios can be addressed:

- the dependency between a ME app VNF and the ME platform VNF serving it are defined in the NSD;
- the connectivity between ME app VNFs, and/or between ME app VNFs and the ME platform VNF, are defined in the VNFFG.

The service chaining aspects between multiple ME app VNFs are to be determined. It is further to be determined how to realize MEC in a NFV environment with multiple NFVI Points of Presence (PoPs), and how the service chaining works in such environment.

It is also to be determined whether or not additional functions would be needed for the NS defined in ETSI ISG NFV.

6.2.3 Evaluation

The conception of NS needs to be introduced to represent MEC in NFV. Further investigation should identify any additional functions needed for the NS defined in ETSI ISG NFV.

6.2.4 Proposal

Use the concept of NSs to represent the set of ME app VNFs and ME platform VNFs and their interconnection/dependency.

It is to be determined if updates to the NSD and to the NS LCM procedures in ETSI NFV are required to address specific MEC use cases such as mobility.

6.3 Issue #3: Communication between MEAO and NFVO via Mv1

6.3.1 Problem description

The Mv1 reference point needs to allow the MEAO to invoke operations towards the NFVO to manage ME app VNFs. It also needs to allow the MEAO to onboard ME application packages into the NFVO. According to ETSI NFV standards, VNFs are always included in NSs (see also key issues #1 and #2 defined in clauses 6.1 and 6.2).

6.3.2 Solution(s)

The following set of interfaces and operations is defined for the Os-Ma-nfvo reference point (see ETSI GS NFV-IFA 013 [i.6]).

Table 6.3.2-1: Interfaces of the Os-Ma-nfvo reference point between OSS/BSS and NFVO that are relevant for MEC [i.6]

Interface	Operation	Direction	Remarks
NSD Management	On-board NSD	OSS → NFVO	On-board an NSD
	Update NSD	OSS → NFVO	Update an on-boarded NSD (e.g. to add reference to a new VNFD)
	Delete NSD	OSS → NFVO	Delete a NSD
	Query NSD	OSS → NFVO	Query list of NSDs
	(PNFD Management operations)	OSS → NFVO	Manage PNFDs, probably not relevant for MEC
	Notify	NFVO→ OSS	Asynchronous notifications on NSD change events
	Manage subscription	OSS → NFVO	Subscribe to notifications on NSD change events
NS LCM	Create NS Identifier	OSS → NFVO	Create a new NS identifier
	Instantiate NS	OSS → NFVO	Instantiate an NS
	Scale NS	OSS → NFVO	Scale an NS (i.e. change number of VNF instances)
	Update NS	OSS → NFVO	Update an existing NS (e.g. add VNF)
	Query NS	OSS → NFVO	Query list of NSs
	Terminate NS	OSS → NFVO	Terminate an NS
	Delete NS identifier	OSS → NFVO	Delete an NS identifier
	Heal NS	OSS → NFVO	Heal a malfunctioning NS
	Get Operation Status	OSS → NFVO	Track progress of NS LCM operations
	Notify	NFVO→ OSS	Asynchronous notifications on NSD LCM events
	Manage subscription	OSS → NFVO	Subscribe to notifications on NSD LCM events
NS PM	CreatePmJob	OSS → NFVO	Instruct the NFVO to create a job to collect performance information related to a NS
	QueryPmJob	OSS → NFVO	Instruct the NFVO to query PM jobs.
	DeletePmJobs	OSS → NFVO	Instruct the NFVO to delete PM jobs
	CreateThreshold	OSS → NFVO	Instruct the NFVO to create a threshold on a certain performance measure related to an NS. A threshold will trigger a notification if crossed.
	QueryThreshold	OSS → NFVO	Instruct the NFVO to query thresholds.
	DeleteThresholds	OSS → NFVO	Instruct the NFVO to delete thresholds.
	Notify	NFVO → OSS	Asynchronous notifications on PM events related to NSs (performance report available, threshold crossed)
	Manage subscription	OSS → NFVO	Subscribe to PM notifications
NS Fault Management	Get Alarm List	OSS → NFVO	Read the alarm list
	Notify	NFVO → OSS	Asynchronous notifications on alarms related to NSs
	Manage subscription	OSS → NFVO	Subscribe to notifications on alarms
VNF Package Management	On-board VNF Package	OSS → NFVO	On-board a VNF package into the NFVO
	Enable/Disable VNF Package	OSS → NFVO	Enable/disable an on-boarded VNF package
	Delete VNF Package	OSS → NFVO	Delete an onboarded VNF package
	Query On-boarded VNF Packages	OSS → NFVO	Obtain the list of on-boarded VNF packages base on certain criteria
	Fetch VNF package	OSS → NFVO	Obtain a copy of the VNF package content
	Fetch VNF Package Artifacts	OSS → NFVO	Obtain a copy of individual files from the VNF package
	Abort VNF Package Deletion	OSS → NFVO	Revoke a pending deletion request
	Notify	NFVO → OSS	Asynchronous notifications on events related to VNF Package changes
	Manage subscription	OSS → NFVO	Subscribe to notifications on events related to VNF Package changes

6.3.3 Evaluation

The VNF Package management interface can be used by the MEAO to onboard ME application packages as a special kind of VNF packages (see also key issue #9 in clause 6.9), or to be informed by notification if a ME application package was onboarded directly by the OSS into the NFVO.

The MEAO should request to the NFVO the management of one or more NSs that contain the ME app VNFs and the ME platform VNFs. For that purpose, the MEAO should onboard ME application descriptors (using NSD format) into the NFVO, and should update these each time a new ME app VNF is intended to be instantiated that has been on-boarded in a package which is not yet referenced in the NS descriptor.

Instantiating or terminating ME app VNF instances can be performed by the MEAO by requesting NS updates towards the NFVO. Such updates may be based on an updated version of the NSD from which the original NS has been instantiated.

When instantiating a ME app VNF, it is recommended that the MEAO communicates towards the NFVO in which part of the NFVI the ME app is instantiated. The closest available NFV mechanisms to support this are affinity and location; it needs to be determined during the normative work whether these need to be extended. Such extensions would be in the scope of ETSI NFV.

Support for migrating a ME app VNF as part of NS update is not available. It needs to be discussed with ETSI NFV how such gap can be filled.

6.3.4 Proposal

Engage in discussion with NFV to determine if the proposed re-use of NS update for MEC is feasible, how to give the MEAO control on the place where a ME app VNF is instantiated, and on migration support.

6.4 Issue #4: Communication between VNFM and MEPM-V via Mv2

6.4.1 Problem description

In the MEC in NFV architecture, the MEPM is split into a MEC-specific part (MEPM-V) and a VNFM that is responsible for the LCM of the ME app VNF instances. Also, the orchestration flow is modified to take the NFVO into the loop (see key issue #3, clause 6.3). The MEPM-V needs to be able to communicate with the VNFM to keep track of LCM operations that were initiated by the NFVO. Also, as the MEPM-V has no longer access to the VIM, it may need to receive PM counters and alarms for the virtualised resources that are related to the ME app VNFs that are related to the ME platform instance which is managed by that MEPM-V.

6.4.2 Solution(s)

Mv2 is used for the communication between the VNFM that is responsible for the LCM of the ME app VNFs and the MEPM-V. In the ETSI NFV architecture, the reference point Ve-Vnfm-em (see ETSI GS NFV-IFA 008 [i.12]) is defined for the communication between the EM that manages the VNF instance and the VNFM that manages the VNF instance. In MEC, the MEPM-V is the EM of the ME platform, but also has certain management responsibilities also for the ME app instance (see ETSI GS MEC 010-1 [i.13]).

The following set of interfaces and operations is defined for the Ve-Vnfm-em reference point ETSI GS NFV-IFA 008 [i.12].

Table 6.4.2-1: Interfaces of the Ve-Vnfm-em reference point between VNF instance and EM [i.12]

Interface	Operation	Direction	Remarks
VNF LCM	CreateVnfIdentifier	EM → VNFM	Create an identifier for a new VNF instance
	InstantiateVnf	EM → VNFM	Instantiate a new VNF instance
	ScaleVnf	EM → VNFM	Scale a VNF instance
	ChangeVnfFlavour	EM → VNFM	Change VNF instance flavor
	TerminateVnf	EM → VNFM	Terminate a VNF instance
	DeleteVnfIdentifier	EM → VNFM	Delete a VNF identifier
	QueryVnf	EM → VNFM	Obtain VNF instance information
	HealVnf	EM → VNFM	Heal a VNF instance
	OperateVnf	EM → VNFM	Change the operational status of a VNF instance (started, stopped)
	ModifyVnfInformation	EM → VNFM	Modifies VNF information, including configurable properties.
	GetOperationStatus	EM → VNFM	Track progress of LCM operations
	Notify	VNFM → EM	Asynchronous notifications on LCM events
	Manage subscription	EM → VNFM	Subscribe to notifications on LCM events
VNF PM	CreatePmJob	EM → VNFM	Instruct the VNFM to create a job to collect virtualised resource performance information related to a (set of) VNF/VNFC instance(s)
	QueryPmJob	EM → VNFM	Instruct the VNFM to query PM jobs.
	DeletePmJobs	EM → VNFM	Instruct the VNFM to delete PM jobs
	CreateThreshold	EM → VNFM	Instruct the VNFM to create a threshold on a certain virtualised resource performance measure related to a (set of) VNF instance(s). A threshold will trigger a notification if crossed.
	QueryThreshold	EM → VNFM	Instruct the VNFM to query thresholds.
	DeleteThresholds	EM → VNFM	Instruct the VNFM to delete thresholds.
	Notify	VNFM → EM	Asynchronous notifications on PM events related to virtualised resource (performance report available, threshold crossed)
	Manage subscription	EM → VNFM	Subscribe to notifications on PM notifications
VNF Fault Management	Get Alarm List	EM → VNFM	Read the alarm list
	EscalatePerceivedSeverity	EM → VNFM	Propose an escalation of the severity of an alarm
	AcknowledgeAlarms	EM → VNFM	Acknowledge one or more alarms
	Notify	VNFM → EM	Asynchronous notifications on alarms related to virtualised resource
	Manage subscription	EM → VNFM	Subscribe to notifications on alarms
VNF Indicator	GetIndicatorValue	VNFM → EM	Read VNF-specific indicators
	Notify	EM → VNFM	Asynchronous notifications on Indicator event
	Manage subscription	VNFM → EM	Subscribe to notifications on Indicator changes

6.4.3 Evaluation

It appears that the MEPM-V can use the Performance and Fault management interfaces on Ve-Vnfm-em to access PM and fault information of virtualised resources related to a particular ME app VNF instance that is lifecycle-managed by the VNFM. The MEPM-V can further be informed about LCM operations by subscribing to notifications delivered via the VNF LCM interface. It can query information that the VNFM maintains about a ME app VNF instance using the QueryVnf operation, and can even modify selected parts of that information using the ModifyVnfInformation operation. Invoking LCM operations, such as InstantiateVnf, is possible but information about the operations would need to be synchronized with the higher-layer management entities. It is therefore not recommended, but instantiation is recommended to be triggered by the NFVO, as instructed by the MEAO, towards the VNFM.

6.4.4 Proposal

Certain functionalities, as provided by the Ve-Vnfm-em reference point, will be used between the MEPM-V and the VNFM that manages the lifecycle of the ME app VNFs, as discussed in clause 6.4.3.

6.5 Issue #5: Communication between VNFM and ME app instance via Mv3

6.5.1 Problem description

As defined in ETSI GS NFV-IFA 008 [i.12], the Ve-Vnfm-vnf reference point allows the VNF instance to interact with the VNFM in various ways. The reference point is optional for the VNF instance to support. It is proposed by the present document to add to the MEC architecture a reference point Mv3 that is considered similar to Ve-Vnfm-vnf, to allow the VNFM and the managed ME app VNF instance to interact directly. This key issue highlights the possible interactions between these two entities using Ve-Vnfm-vnf.

6.5.2 Solution(s)

The following set of interfaces and operations is defined for the Ve-Vnfm-vnf reference point.

Table 6.5.2-1: Interfaces of the Ve-Vnfm-vnf reference point between VNF instance and VNFM [i.12]

Interface	Operation	Direction	Remarks
VNF LCM	ScaleVnf	VNF → VNFM	"Scale Me" operation
	HealVnf	VNF → VNFM	"Heal" operation
	GetOperationStatus	VNF → VNFM	Track progress of scale and heal operations
	QueryVnf	VNF → VNFM	Obtain VNF instance information
	Notify	VNFM → VNF	Asynchronous notifications on LCM events
	Manage subscription	VNF → VNFM	Subscribe to notifications on LCM event
VNF PM	Notify	VNFM → VNF	Asynchronous notifications on PM events related to virtualised resource (performance report available, threshold crossed)
	Manage subscription	VNF → VNFM	Subscribe to notifications on PM notifications
VNF Fault Management	Get Alarm List	VNF → VNFM	Read the alarm list
	EscalatePerceivedSeverity	VNF → VNFM	Propose an escalation of the severity of an alarm
	AcknowledgeAlarms	VNF → VNFM	Acknowledge one or more alarms
	Notify	VNFM → VNF	Asynchronous notifications on alarms related to virtualised resource
	Manage subscription	VNF → VNFM	Subscribe to notifications on alarms
VNF Indicator	GetIndicatorValue	VNFM → VNF	Read VNF-specific indicators
	Notify	VNF → VNFM	Asynchronous notifications on Indicator event
	Manage subscription	VNFM → VNF	Subscribe to notifications on Indicator changes
VNF Configuration	SetConfiguration	VNFM → VNF	Set VNF configuration, e.g. during executing an LCM operation. The technology to be used on this interface is up to the VNF vendor to choose. ETSI GS NFV-SOL 002 [i.14] has defined a RESTful interface which is optional. ETSI GS NFV-IFA 008 [i.12] mentions cloud-init and HOT as possible technologies.

6.5.3 Evaluation

It needs to be determined which operations on this interface are required by the ETSI MEC. For instance, does a ME app VNF instance need information about virtual resource alarms/PM counters from the VNFM or is this information more relevant for the MEPM-V (see key issue #4 in clause 6.4)? Further, will a ME app VNF instance invoke "Heal me"/"Scale me"? Will it define VNF indicators? All these functionalities are not foreseen in non-NFV MEC deployments. Finally, the VNF configuration interface provides a means for the component that manages the lifecycle of the VNF instance to pass configuration parameters to provision the VNF instance, or to provision the VNFC instances added during LCM operations. This is a task that should be also undertaken in MEC if it is not deployed in NFV environments.

It appears that the configuration operations towards the ME app instance are today out of scope of MEC. However, as part of instantiating a VM, certain configuration parameters need to be provided. This can be done as "day-zero configuration" which passes a configuration data set to the VIM which, in turn, passes it on to the VM instance as pre-boot configuration (e.g. using cloud software technologies like cloud-init, config-drive, HOT), or the software in the VM can be provisioned by the lifecycle manager once it is up and running, using scripts or a configuration interface such as RESTConf IETF RFC 8040 [i.16], NetConf IETF RFC 6241 [i.15], ETSI GS NFV-SOL 002 [i.14].

MEC has so far not covered this topic (if MEC chooses to do so, it would be in the scope of ETSI GS MEC 010-2 [i.10]).

6.5.4 Proposal

It should be determined which subset, if any, of this reference point is required for deploying MEC in NFV. Most functionality can be seen as an add-on to required MEC functionality.

An important role is played by the VNF configuration interface. It needs to be determined how configuration needs to be done when a VNFM is used for LCM (e.g. using a configuration interface provided on Ve-Vnfm, or using a "day-zero" configuration technique where the VIM is the intermediary such as cloud-init or config-drive, or a combination of both). This may also affect the addition of this mechanism to the general MEC specifications.

No normative work in NFV is foreseen to extend this reference point, but a profiling of the reference point in MEC appears necessary.

The use of the configuration interface in MEC needs to be elaborated further. It needs to be determined how the necessary information is passed between the involved MEC and NFV MANO components, which may include requirements to NFV interfaces other than Ve-Vnfm.

6.6 Issue #6: AppD vs. VNFD for ME app VNFs

6.6.1 Problem description

It is assumed, in the present document, that the ME applications appear as VNFs so that ETSI NFV MANO functionality can be re-used. In addition, as specified in ETSI NFV, the VNF Descriptor (VNFD) is used in the VNF package management interface on the Or-Vnfm reference point. Information from the VNFD is used in VNF LCM procedures on the Or-Vnfm reference point. The same information is also used in the VNF LCM interface on the Ve-Vnfm reference point, but it is out of scope of ETSI NFV how this information is provisioned to the EM respectively the VNF.

From ETSI ISG MEC side, the application Descriptor (AppD) is defined in clause 6.2.1 of ETSI GS MEC 010-2 [i.10] that is a part of application package and describes the application requirements and rules required by the application provider.

It needs to be analyzed how these two descriptors can work together; whether or not there is any impact on ME application package on-boarding and LCM of a ME application instance and if this is the case, what are the impacts.

6.6.2 Solution(s)

Based on the proposed MEC reference architecture in NFV environments described in clause 5.2, the following reference points may be related to the LCM of a ME app VNF:

- Mm3* reference point between MEAO and MEPM-V, which is based on the Mm3 reference point defined in ETSI GS MEC 003 [i.5]. Changes will be needed to this reference point to cater for the split between MEPM-V and VNFM (ME app VNF LCM). Based on an initial estimate, in a MEC in NFV deployment, Mm3* will not be involved in LCM specific procedures, as LCM is delegated to the VNFM. It is, therefore, assumed that Mm3* will be a subset of Mm3, with the LCM functionality not present, which means that no information from the VNFD will be exchanged on this reference point.

- Mv2 reference point between the VNFM of the ME app VNF with the MEPM-V. It is related to the Ve-Vnfm-em reference point as defined in ETSI NFV, but will possibly include additions, and might not use all functionality offered by Ve-Vnfm-em. It is assumed that the MEPM-V would receive Lifecycle Operation Occurrence Notifications w.r.t. the ME app VNF LCM procedures that were delegated to the VNFM. From that perspective, information from the VNFD could flow on that reference point.

- Mv3 reference point between the VNFM that manages a ME app VNF and the ME app VNF instance, which is related to the Ve-Vnfm-vnf reference point as defined in ETSI NFV. It is to be determined what additional features would be required. This optional reference point allows the VNF to invoke LCM operations w.r.t. itself from the VNFM, to send indicator information to the VNFM, and selected configurable VNF properties to be modified by the VNFM. Therefore, information from the VNFD would flow on this reference point, but it is out of scope of NFV how this information is provisioned to the VNF.

Clause 6.8 describes two different options for the on-boarding:

- In the first option, the package passes through the MEAO, which further on-boards the package into the NFV. The MEAO could just receive a ME app VNF package that contains both AppD and VNFD, and pass it on to the NFVO. It should be determined if AppD needs to be passed to the NFVO;

- In the second option, the ME app VNF package is on-boarded like any other VNF package from the OSS into the NFVO, from where the MEAO can fetch it. This implies that the package on-boarded into the NFVO needs to contain both the VNFD and the AppD.

6.6.3 Evaluation

There are some open issues that should be determined:

VNFD and AppD data structures:

- A detailed comparison of the information model for AppD and VNFD is needed, to determine which attributes are common to both descriptors, or can be mapped.

NOTE: An initial comparison is provided in clause 6.10.

- It needs to be determined what is the minimum required set of information in the VNFD for a ME app.

- It needs to be determined if a VNFD can be generated from the information in the AppD, and which additional information, if any, is needed in this process.

VNF packaging:

- It needs to be determined how the AppD information is included in the ME app VNF package - as a separate file, or as an extension of the VNFD (stage 2), and how it is formatted and signalled in the package (stage 3).

On-boarding procedures:

- The process of onboarding a ME App VNF needs to be defined as part of ETSI MEC. It is not foreseen that changes to the ETSI NFV onboarding procedures are required.

6.6.4 Proposal

The open issues listed above need to be addressed at a high level in this study, sufficient to scope the normative work, and details will be addressed in the normative stage.

6.7 Issue #7: VNF Package vs. MEC application package

6.7.1 Problem description

To represent the AppD (see clause 6.6), but also to provide other artifacts required by MEC management entities, there may be the need to provide additional MEC-specific data structures/files in the VNF package. It needs to be analyzed how MEC-specific files can be carried in the VNF package without interfering with the existing package content, and how these can be identified by the MEC management and orchestration components.

6.7.2 Solution(s)

A possible solution is to make use of a VNF package extension mechanism. The following requirements need to be met by such a mechanism:

- It should allow to include files in the VNF package that are MEC-specific, without interfering with NFV-specific files, or file included based on other third party specifications.
- It should allow a MEC management entity to identify the entry point to the set of MEC-specific files in the VNF package.
- It should isolate the structure of the file set from other files in the package in a suitable way, allowing ETSI MEC to structure the file set in a way ETSI MEC sees necessary.

6.7.3 Evaluation

An extension mechanism for VNF packages that allows third party extensions would solve this issue.

6.7.4 Proposal

Identify with ETSI NFV whether an extension mechanism for VNF Packages exists that can be re-used, and what are the rules for re-use. If it does not exist, suggest to ETSI NFV to specify such a mechanism.

6.8 Issue #8: VNF package onboarding

6.8.1 Problem description

When deploying MEC in the NFV environment, ME applications appear as VNFs towards the ETSI NFV MANO components. ETSI GS NFV-IFA 013 [i.6] defines the on-boarding procedures of VNF packages into the NFVO. It is assumed that the VNF package (including the MEC specific descriptors) will be made available to the NFVO using the onboarding procedures in ETSI GS NFV-IFA 013 [i.6]. Two different deployment options are possible w.r.t. which component (NFVO or MEAO) is the master of the onboarding procedure, based on the existing mechanism defined in ETSI GS NFV-IFA 013 [i.6].

6.8.2 Solution(s)

Solution 1: If the MEAO is the master, the ME app package would first be provided by the OSS to the MEAO via Mm1, and onboarded to the NFVO by the MEAO via Mv1, using procedures defined in ETSI GS NFV-IFA 013 [i.6]. In that case, the MEC specific extensions of the VNF package are directly available to the MEAO, as the package passes through the MEAO.

Solution 2: If the NFVO is the master, the ME app package would be onboarded directly into the NFVO by the OSS via Os-Ma-nfvo. Via Mv1, the MEAO would be notified about package onboarding, and would be able to subsequently fetch whole packages or the needed package parts (so called package artifacts), using procedures defined in ETSI GS NFV-IFA 013 [i.6]. This would allow the MEAO to access the MEC specific extensions of the VNF package.

6.8.3 Evaluation

Both solutions are technically feasible based on existing interfaces. Solution 1 is "MEC-centric", whereas solution 2 is "NFV-centric".

- For solution 1, the ME app package is onboarded to the MEAO first and then to NFVO. The onboarding time would be longer than solution 2 if the software image is included in the application package. However the MEAO can check the package before passing it to the NFVO. If there are any issues in the MEC-related extensions, the MEAO could reject the software package.
- For solution 2, the software image is made available only to the NFVO. The MEAO can fetch the needed package parts, thus the onbarding time would be shorter than in solution 1. However, the NFVO will not be able to detect errors in MEC-specific extensions. Therefore, it would onboard a package that is faulty from a MEAO point of view.

It requires further elaboration in the normative phase if there is a preferred solution or whether both solutions support valid deployments.

6.8.4 Proposal

ETSI MEC to evaluate as part of the normative work whether one solution will be selected, or both will be specified to cater for different deployments the message flow of on-boarding of the ME Application Package. No changes to the ETSI NFV procedures for package onboarding are foreseen.

6.9 Issue #9: Managing traffic redirection

6.9.1 Problem description

The Mp2 reference point is used by the ME platform to control the Data Plane (also known as forwarding plane) to configure the routing of traffic flows which will allow applications to originate, terminate or modify user plane traffic. The MEC requirements also include chaining multiple ME app VNFs to one chain through which the traffic is passed sequentially (see ETSI GS MEC 002 [i.17], clause 6.2.4). ETSI MEC is considering the Mp2 reference point to be based on vendor-specific solutions, and has not specified any technical solution for it.

The requirements for traffic routing from ETSI GS MEC 002 [i.17] are replicated below:

- [Routing-01] The mobile edge platform should provide functionality to allow authorized mobile edge applications to send user plane traffic to UEs.
- [Routing-02] The mobile edge platform should provide functionality to allow authorized mobile edge application to receive user plane traffic from UEs.
- [Routing-03] The mobile edge platform should provide functionality to route selected uplink and/or downlink user plane traffic from the network to authorized mobile edge applications.
- [Routing-04] The mobile edge platform should provide functionality to route selected uplink and/or downlink user plane traffic from authorized mobile edge applications to the network.
- [Routing-05] The mobile edge platform should provide functionality to allow authorized mobile edge applications to inspect selected uplink and/or downlink user plane traffic.
- [Routing-06] The mobile edge platform should provide functionality to allow authorized mobile edge applications to modify selected uplink and/or downlink user plane traffic.
- [Routing-07] The mobile edge platform should provide functionality to allow authorized mobile edge applications to shape selected uplink and/or downlink user plane traffic.
- [Routing-08] The mobile edge platform should provide functionality to route selected uplink and/or downlink user plane traffic from an authorized mobile edge application to another authorized mobile edge application.

- [Routing-09] The mobile edge platform should be able to select one or more applications to which the same traffic will be routed and assign priorities to them. The selection, prioritization and routing of traffic should be based on traffic rules defined per mobile edge application.

NOTE 1: The prioritization is used to determine the routing order between the mobile edge applications.

- [Routing-10] The mobile edge management should allow the configuration of the traffic rules.
- [Routing-11] The traffic rules should allow setting packet filters based on network address and/or IP protocol.
- [Routing-12] The traffic rules may allow setting packet filters based on the Tunnel Endpoint ID (TEID) and/or the Subscriber Profile ID (SPID) and/or the Quality Class Indicator (QCI) value(s).
- [Routing-13] When the user plane traffic is encapsulated, then:
    - the mobile edge host should support the de-capsulation of the encapsulated (uplink) IP traffic and its routing to the authorized mobile edge applications;
    - the mobile edge host should support the encapsulation of (downlink) IP traffic received from authorized mobile edge applications before routing it to the network.

NOTE 2: IP traffic for example can be encapsulated with GTP header.

- [Routing-14] The mobile edge host should support routing user plane traffic to/from authorized mobile edge applications according to configurable parameters received from the mobile edge platform.

In the MEC architecture, traffic rules are received by the MEPM via Mm3 from the MEO, and passed via Mm5 towards the ME platform, which then configures the Data Plane based on these rules. Applications request the ME platform (via Mp1) to modify/activate/deactivate the traffic rules. Such changes would be communicated by the ME platform via Mp2 to the Data Plane.

6.9.2 Solution(s)

The following solutions for traffic routing need to be further evaluated.

Solution 1: The Data Plane is realized as a PNF or VNF and exposes the Mp2 reference point towards the Mobile Edge Platform VNF.

Solution 2: NFV MANO can provide NFVI network resource management for the VNF to achieve certain traffic engineering without application level visibility, e.g. creating/updating NFP (Network Forward Path) rules. A NFP is defined as part of the VNFFG which is managed by the NFVO as part of the NS and can be modified via the Os-Ma-nfvo reference point as defined in ETSI GS NFV-IFA 013 [i.6]. The NFVO can configure an NFP into the VIM via the Or-Vi interface as defined in ETSI GS NFV-IFA 006 [i.18]. The concept of the NFP has been introduced in ETSI GS NFV-MAN 001 [i.1].

Solution 3: The NFV architectural framework also enables a VNF to provide instructions to a dedicated switch on how to process the traffic. This is known as the DOPFR (Dynamic Optimization of Packet Flow Routing) feature as defined in ETSI GS NFV-IFA 018 [i.20]. The concept of DOPFR has been introduced in ETSI GS NFV-INF 005 [i.4], clause 10.1.

6.9.3 Evaluation

Solution 1 does not have any impact on the standardization of MEC deployments in NFV. Both Data Plane and Mp2 reference point are proprietary.

Solution 2 would re-use SFC functionality available in the NFVI, and would be compatible with the assumption that ME app VNFs are managed the same way as VNFs in a NS. It would, however, require changes to the roles of the components and flows in the MEC architecture. Such modifications are solely in the realm of ETSI MEC and would re-use the NFP management functionality provided on the Os-Ma-nfvo reference point. The needed modifications are as follows:

- The ME platform does not use Mp2.

- If the ME app VNF requests the update / activation / deactivation of traffic rules via Mp1, the ME platform forwards this information to the MEPM-V via Mm5. Mm5 is an unspecified reference point, but this additional functionality may need to be defined in the "MEC in NFV" architecture work. This information is further forwarded via Mm3* to the MEAO. Such extension of Mm3* needs to be specified by ETSI MEC.
- The MEAO creates a NFP based on the traffic rules in the application package(s), and updates the NFP each time it receives information that a ME app VNF has updated / activated / deactivated a traffic rule.

The NFVO would control the SFC functionality in the VIM based on the NFP. For OpenStack used as the VIM, the SFC functionality is defined in OpenStack documentation [i.21].

According to a preliminary evaluation of ETSI GS NFV-INF 005 [i.4] and ETSI NFV-IFA 018 [i.20], solution 3 (DOPFR) would fulfil the requirement that the Mobile Edge Platform VNF instance can talk directly to the underlying infrastructure to perform reconfigurations of the routing, if the Data Plane is realized as part of the NFVI. Within the timeline available for creating the present document, not all open questions regarding DOPFR could be answered. The following open questions remain:

1) The DOPFR stage 2 is provided by ETSI NFV IFA018. It needs to be evaluated what is the status/timeline of stage 3 specifications of DOPFR, and whether implementations exist.
2) It needs to be understood whether DOPFR can route traffic to VNF instances other than the one that has requested the routing/redirection, and how access control/authorization is achieved.

It is proposed not to consider solution 3 in the normative work.

6.9.4 Proposal

The Data Plane in a MEC in NFV deployment may be realized by means outside the scope of the ETSI MEC specifications (solution 1). It may also be realized based on the NFP mechanism defined in ETSI NFV (solution 2).

For the former case, no specification is foreseen. For the latter case, no interaction with ETSI NFV is needed as the NFV mechanism is re-used as is, however, specification work in ETSI MEC is required to modify Mm3* and to re-use the NFP from ETSI NFV. It is suggested to define this as an optional mechanism.

6.10 Issue #10: Comparison of AppD and VNFD data structures

6.10.1 Problem description

ETSI NFV has defined the VNFD (ETSI GS NFV-IFA 011 [i.7]), which has certain overlaps with the MEC AppD (ETSI GS MEC 010-2 [i.10]). The mapping of the two needs to be analyzed.

6.10.2 Solution(s)

Table 6.10.2-1: High-level comparison of VNFD and AppD

VNFD attribute	AppD attribute
vnfdId	appDId
vnfProvider	appProvider
vnfProductName	appName
vnfSoftwareVersion	appSoftVersion
vnfdVersion	appDVersion
	mecVersion
vnfProductInfoName	appInfoName
vnfProductInfoDescription	appDescription
vnfmInfo	
localizationLanguage	
defaultLocalizationLanguage	
vdu	

VNFD attribute	AppD attribute
>swImageDescriptor	swImageDescriptor
virtualComputeDesc	virtualComputeDescriptor
virtualStorageDesc	virtualStorageDescriptor
intVirtualLinkDesc	
vnfExtCpd	appExtCpd
	appServiceRequired
	appServiceOptional
	appServiceProduced
	appFeatureRequired
	appFeatureOptional
	transportDependencies
	appTrafficRule
	appDNSRule
	appLatency
deploymentFlavour	
>vnfLcmOperationsConfiguration	
	terminateAppInstanceOpConfig
	changeAppInstanceStateOpConfig
configurableProperties	
modifiableAttributes	
lifeCycleManagementScript	
elementGroup	
vnfIndicator	
autoScale	

6.10.3 Evaluation

This comparison provides a first high-level indication of the similarities and differences; a much more detailed analysis is needed.

The AppD models much more detailed requirements to the infrastructure and service availability than the VNFD. It needs to be determined how such requirements can be considered when choosing the placement of the new ME app instance, and how they would flow in the system to configure other items such as traffic redirection.

Notably, the AppD can only model a single virtual compute resource for a ME app, whereas the VNFD can define templates for multiple virtual compute resources per VNF to support scalability. Scalability of ME apps is out of scope of ETSI MEC at the time of producing the present document.

The stage 3 for the VNFD is currently being built by ETSI NFV and OASIS TOSCA based on the TOSCA Simple Profile (YAML). It still needs to be determined what format will be used for the AppD stage 3.

6.10.4 Proposal

Perform a more detailed analysis, considering the items set out in clause 6.6.

6.11 Issue #11: NFV construct that corresponds to Mobile Edge Host

6.11.1 Problem description

In the MEC architecture, the ME host contains an instance of a NFVI and runs an instance of the ME platform. When virtualising this architecture, the concept of a ME host becomes obsolete.

In MEC, the concept of a ME host is used mainly in ME application instantiation and in mobility, as follows:

1) Prior to application instantiation, the MEO selects an appropriate ME host to instantiate the ME application, fulfilling constraints of the ME application (such as e.g. latency requirements).

2) If a UE is moving, the ME host that serves the UE may need to change to meet the constraints of the service e.g. w.r.t. latency. To compensate for changes incurred by UE mobility, either another ME app instance in another ME host serves the UE (session mobility), or the ME app that serves the UE is handed over to another ME host (application mobility, SmartRelocation).

With dissolving the ME host in a NFV deployment, it is still necessary to understand what will be the counterpart of a ME host in a NFV based deployment to fulfil the mobility use cases.

6.11.2 Solution(s)

ETSI ISG NFV has defined several constructs to structure a NFVI, such as NFVI-PoP (basically, a data center) and Zone (a set of co-located and well-connected physical resources which is a subset of a NFVI-PoP).

6.11.3 Evaluation

It is currently not well-defined how an edge cloud would be structured. It depends on the structure of the edge cloud to determine whether a handover from one "part" of the cloud to another "part" is necessary to keep fulfilling the constraints that have been defined by the ME application.

6.11.4 Proposal

It is suggested to keep the mapping open until there is a better understanding of edge cloud structures.

6.12 Issue #12 : ME App VNF Instance Relocation

6.12.1 Problem description

As part of the optional MEC feature "SmartRelocation", a ME application instance (VNF) needs to be re-located from one location to another, while preserving current state of the application instance.

6.12.2 Solution(s)

ETSI ISG NFV has defined VNF migration in ETSI GS NFV-MAN 001 [i.1]. However, the VNF LCM interface defined in ETSI GS NFV-IFA 007 [i.19] does not offer any operation(s) enabling this use case. Further, the Os-Ma-nfvo reference point as defined in ETSI GS NFV-IFA 013 [i.6] does not offer any operation(s) that allows requesting the NFVO to initiate VNF migration.

6.12.3 Evaluation

This can be considered a gap in ETSI NFV. Based on the current ETSI NFV specifications, the optional MEC feature "SmartRelocation" cannot be enabled in a NFV-based MEC deployment.

6.12.4 Proposal

VNF migration has been considered in the informative ETSI NFV-MAN 001 [i.1]. It should be explored with ETSI NFV whether there are plans to define support for VNF migration in the normative ETSI NFV specifications. ETSI MEC would need to provide requirements to such activity in ETSI NFV.

6.13 Issue #13: Application instantiation

6.13.1 Problem description

The ME app VNF instantiation procedure includes two parts. The procedure is successful only when the two parts are executed successfully:

1) The first part is to deploy the ME app VNF, which includes creation of the necessary virtualised resources and initial configuration of the ME app VNF.

2) The second part is to send configuration to the ME platform by MEPM-V. According to ETSI GS MEC 010-2 [i.10], this configuration includes the traffic rules, DNS rules, the required and optional services, and services produced by the application instance, etc. The MEPM-V needs to be triggered to send the configuration.

6.13.2 Solution(s)

Solution 1: MEAO calls NFVO to deploy the ME app VNF. MEAO listens to the NS change notification to learn if ME app VNF was created successfully in the related NS, and then sends a request to the MEPM-V that registers the created ME app VNF instance with the MEPM-V, and passes the necessary configuration parameters. MEPM-V then sends configuration to the ME platform.

Solution 2: MEPM-V acts as EM and subscribes to VNF lifecycle change notifications sent by the VNFM. MEAO calls NFVO to deploy the ME app VNF. After the ME app VNF is deployed, a notification will be sent to MEPM-V. This notification will trigger the MEPM-V to obtain the configuration from the MEAO and to send it to the ME platform. A notification should be sent to MEAO to indicate the configuration result.

For both solutions, the configuration information comes from OSS via Mm2 reference point and/or from application descriptor via the MEAO.

6.13.3 Evaluation

For solution 1, the application instance instantiation operation interface in ETSI GS MEC 010-2 [i.10] can be reused in Mm3* reference point. The most parts of application instantiation message flow in ETSI GS MEC 010-2 [i.10] can also be reused except the resource allocation request between MEPM and VIM. The request that registers the instantiated ME app VNF and passes the configuration parameters, similar to the existing application instantiation operation, is a new request that needs to be added to Mm3*.

For solution 2, a configuration result notify operation needs to be added to the Mm3* reference point, as well as a request to obtain the configuration.

Both solutions have ETSI NFV impact, as there is the need for the MEAO to communicate to the ETSI NFV MANO entities the placement decision it has made, namely, it has to pass placement constraints towards the NFVO via Mv1, and these may further need to be passed by the NFVO towards the VNFM.

6.13.4 Proposal

ETSI MEC to evaluate as part of the normative work to select one solution. Collaboration with ETSI NFV is required for these solutions.

6.14 Issue #14: Application instance termination

6.14.1 Problem description

The ME app VNF instance termination procedure includes two parts:

1) The first part is to remove the configuration in ME platform and Data Plane.

2) The second part is to terminate the ME app VNF.

The MEPM-V needs to be triggered to remove the configuration.

6.14.2 Solution(s)

Solution 1: MEAO sends an application instance termination request to MEPM-V. If graceful termination is requested, MEPM-V first indicates the ME platform to give time to the ME app for application level termination, and wait until successful or timeout. MEPM-V then requests ME platform to remove the configuration. After having received the application instance termination response, the MEAO requests NFVO to terminate the ME app VNF. NFVO then requests VNFM to shut down the ME app VNF and release the resources.

Solution 2: MEPM-V acts as EM and subscribes to VNF lifecycle change notifications sent by the VNFM. MEAO calls NFVO to terminate the ME app VNF. In case of graceful termination, the VNFM first arranges to take the ME app VNF out of service by interacting with MEPM-V. MEPM-V needs to indicate to the ME platform to give time to the ME app for application level termination. Once this is successful, or after a timeout, the VNFM shuts down the ME app VNF and releases the resources. After the ME app VNF has been terminated, a notification will be sent to MEPM-V. The MEPM-V will request ME platform to remove the configuration after receiving the notification.

6.14.3 Evaluation

For solution 1, the application instance terminate operation interface in ETSI GS MEC 010-2 [i.10] can be reused in Mm3* reference point. The most parts of application termination message flow in ETSI GS MEC 010-2 [i.10] can also be reused except the resource deletion request between MEPM and VIM.

In ETSI GS NFV-IFA 007 [i.19], referring to termination VNF operation, graceful termination is described as such: *"In case of graceful termination, the VNFM first arranges to take the VNF out of service (by means out of scope of the present specification, e.g. involving interaction with EM, if required). Once this was successful, or after a timeout, the VNFM shuts down the VNF and releases the resources"*.

Consequently, for solution 2, an interface should be defined in Mv2 reference point to support ME app VNF graceful termination. The definition of such interface may require coordination with ETSI NFV.

6.14.4 Proposal

ETSI MEC to evaluate as part of the normative work to select one solution. Collaboration with ETSI NFV is required for solution 2.

7 Recommendation

7.1 Way forward

The following items need to be addressed in follow-up work:

1) Allow the MEAO to map a ME app VNF instance to a NS (key issue #1).

2) Define how the dependency between a ME app VNF and the serving ME platform VNF are defined in the NSD, and define how the ME app VNFs and the ME platform VNF are connected using the VNFFG. The service chaining aspect of ME app VNFs is for further elaboration (key issue #2).

3) Define the re-use of Os-Ma-nfvo for communication between the MEAO and the NFVO, and determine how to signal placement constraints for ME app VNF instances to the NFVO (key issue #3).

4) Determine which subset of the Ve-Vnfm-em reference point is required to be used on Mv2. No additions to this reference point are foreseen, rather subsetting (key issue #4).

5) Determine which subset of the Ve-Vnfm-vnf reference point is required to be used on Mv3. Particular attention needs to be paid to the VNF Configuration interface in that reference point. Also, it needs to be determined if there is an influence of this on the generic MEC architecture. No additions to this reference point are foreseen, rather subsetting (key issue #5).

6) Compare VNFD and AppD data structures, and determine if and how certain attributes can be mapped to each other. Also, determine whether the AppD can provide the minimum information set required for a VNFD, and what information needs to be added if it cannot (key issues #6 and #10).

7) Determine how MEC-specific information can be included in a VNF package (key issues #6 and #7).

8) Determine how the ETSI NFV onboarding procedures can be re-used for MEC in NFV (key issues #6 and #8).

9) Determine which NFV construct corresponds to the ME host in the generic MEC architecture (key issue #11).

10) Support for ME app VNF instance relocation is currently not available in ETSI NFV, consider addition of VNF migration (key issue #12).

11) Define the flows of ME app VNF instantiation and termination when deploying ETSI MEC in a NFV environment (key issues #13 and #14).

7.2 Architecture impact

It is foreseen that the architecture defined in clause 5 of the present document needs to be documented in a normative MEC work item.

For the generic MEC architecture as defined in ETSI GS MEC 003 [i.5], it should be determined during the normative specification of Mv3 if the LCM part of the MEPM needs to apply configuration parameters to the ME app instance via an interface similar to Mv3. In this case, the addition of such an interface to ETSI GS MEC 003 [i.5] would be required.

7.3 Needed normative work

7.3.1 General

In order to address the key issues identified in the present document, extensions to the MEC architecture and certain reference points are required, as well as the definition of three new reference points Mv1, Mv2 and Mv3. Collaboration with ETSI NFV is required to address some of the issues; most issues, however, can be tackled directly in the scope of ETSI MEC.

The following two clauses list those issues that require collaboration with ETSI NFV, as well as those that can be foreseen to be tackled in ETSI MEC.

7.3.2 Normative work suggested to be performed in ETSI NFV

The following items need to be addressed in ETSI NFV specifications. It is suggested that this work is performed by ETSI NFV.

NFV-01: Generic VNF package extension mechanism: As defined in key issue #6, an extension mechanism is needed in an ETSI NFV VNF package that ETSI MEC can use to specify a MEC-specific VNF package extension.

NFV-02: Enhancements on the Os-Ma-nfvo reference point: As defined in key issue #3, the Os-Ma-nfvo reference point is foreseen to be used by the MEAO to trigger operations in the ETSI NFV MANO system. It is foreseen that the MEAO may need to pass finer-granular parameters to the NFVO to control the placement of the ME app VNF instances to be created that this can currently be achieved based on ETSI GSs NFV-IFA 013 [i.6] and ETSI GS NFV-SOL 005 [i.22]. It is for discussion with ETSI NFV whether NFV deployments would also benefit from such a parameter set, or whether these parameters would constitute MEC-specific interface extensions, in which case it may be sufficient to define an extension mechanism in ETSI NFV, and leave it to ETSI MEC to define the necessary parameters.

NFV-03: Enhancements on the Ve-Vnfm reference point: Solution 2 in key issue #14 requires to specify an operation on the Ve-Vnfm reference point that allows the VNFM to inform that MEPM-V (i.e. a specific kind of EM) of the upcoming graceful termination of a ME app VNF instance. Such exchange is left out of scope of ETSI NFV so far, however, is required for interworking of the MEPM-V with a standardized generic VNFM.

NFV-04: Enhancements to the NSD: Key issue #2 defines how the NS is re-used to model the set of VNFs involved, such as ME platform VNFs and ME app VNFs, as part of the NS. It needs to be defined whether or not additional functions would be needed for the NS defined in ETSI ISG NFV, such as modelling the association between each ME app VNF and the associated (serving) ME platform VNF.

NFV-05: VNF migration to support Smart Relocation: Currently, ETSI NFV does not support VNF migration. This means that the optional MEC feature "Smart Relocation" is not available when MEC is deployed in a NFV environment. See key issue #12.

7.3.3 Normative work suggested to be performed in ETSI MEC

The following topics need to be addressed in normative follow-up work in ETSI MEC.

NOTE: Certain items (such as the profiling of Os-Ma-nfvo and Ve-Vnfm) could also be done collaboratively with ETSI NFV.

MEC-01: Normative Architecture: The architecture of MEC deployments in NFV environments needs to be defined, including the roles of the new functional blocks MEAO and MEPM-V, and re-use of ETSI NFV functionality.

MEC-02: NS re-use: It needs to be defined how MEC re-uses the concept of a NFV NS and how key concepts of MEC such as ME host and serving ME platform are mapped to it.

MEC-03: Reference points: The new reference points (Mv1, Mv2, Mv3) need to be specified, including the necessary profiling of the re-used underlying ETSI NFV reference points: Os-Ma-nfvo and Ve-vnfm. Modifications to existing MEC reference points need to be specified, including Mm3*. The necessity of adding a reference point between MEPM and ME app in the general MEC architecture needs to be evaluated (to reflect the procedures performed on Mv3 towards the ME app), and, if needed, that reference point needs to be specified.

MEC-04: VNF Package extensions: Based on a generic VNF package extension mechanism requested to be developed by ETSI NFV, a VNF package extension for ETSI MEC needs to be developed.

MEC-05: VNFD for ME app VNF: It needs to be specified how the VNFD for a ME app VNF is to be built, and what is the relationship to the AppD (in particular, what information can be shared between both).

MEC-06: ME app VNF package management: The procedures for re-using VNF Package management (in particular ME app VNF package onboarding) need to be defined. These procedures involve OSS, MEAO and NFVO, i.e. these are procedures that cover more than one reference point.

MEC-07: ME app VNF lifecycle management: The procedures for re-using NS and VNF LCM need to be defined. These procedures involve OSS, MEAO, NFVO, MEPM-V, VNFM and ME platform, i.e. these are procedures that cover more than one reference point. This also includes defining how the ETSI NFV NS is re-used for MEC.

MEC-08: Traffic routing: Traffic routing can be realized in a NFV environment either by a dedicated VNF/PNF or combination thereof, or by the re-use of the NFP mechanism. If the re-use of the NFP mechanism is decided, such re-use needs to be specified. If a combination of VNF/PNF is to be used, this needs to be reflected in the NS model for MEC.

MEC-09: Smart relocation: Given ETSI NFV has defined support for VNF migration, ETSI MEC has to specify how this mechanism is re-used to support the optional "SmartRelocation" feature.

7.4 Items that require further study

The following items have been defined to require further elaboration and resolution during the normative phase. For each item, it is indicated whether it can be solved in ETSI MEC or whether collaboration with ETSI NFV is required. It is assumed that these items are performed as part of the related normative work:

OPEN-01: Select one solution for application instantiation and termination (see key issues #13 and #14; MEC).

OPEN-02: Determine if updates to the NSD and to the NS LCM procedures in ETSI NFV are required to address specific MEC use cases such as mobility (see key issue #2, MEC and NFV).

OPEN-03: Determine whether the NFV concepts of affinity and location are sufficient to define the placement of ME app VNF instances (see key issue #3, MEC and NFV).

OPEN-04: Decide whether both solutions for ME app VNF package onboarding are valid to be supported, or select one of the solutions otherwise (see key issue #8; MEC).

OPEN-05: A more detailed comparison of AppD and VNFD is needed as part of the VNFD modelling work (see key issue #10; MEC)

OPEN-06: Determine which NFV construct maps to the concept of a "Mobile Edge Host" in the virtualised environment. This may also require knowledge about edge cloud structures (see key issue #11, MEC).

NOTE: It is assumed that this will mainly be done in MEC, but information from ETSI NFV about possible NFVI structures, and maybe 3GPP on 5G edge cloud structures, is needed.

8 Conclusion

The present document has defined an architecture how to deploy MEC in a NFV environment, allowing to run ME applications alongside VNFs on the same NFVI. In order to allow re-use of ETSI NFV MANO, ME apps appear as VNFs towards the ETSI NFV MANO building blocks.

Also, the present document has identified key issues that need to be resolved in order to be able to deploy MEC in a NFV environment based on the defined architecture.

Last but not least, the present document has derived items of normative work to address the key issues. Even though this analysis has been performed carefully, there is the possibility that during the normative work additional gaps and aspects that require resolution may be discovered.

Some items of the normative work require modifications to ETSI NFV specifications. Possible work modes to develop such modifications include (not limited to) collaborative work between ETSI MEC and ETSI NFV, as well as development of the extensions in ETSI NFV based on requirements from ETSI MEC, and will be discussed separately.

History

Document history		
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