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Technical Report

O-RAN Working Group 1
Study on O-RAN Slicing

Revision History

Date	Revision	Author	Description
2019.12.16	02.00.01	Arda Akman (Netsia)	Initial version of v2.0 (and deletion of v1.0 revision history)
2019.12.26	02.00.02	Arda Akman (Netsia), Tuğba Arıcı (Netsia)	Update to SDO Mapping table to add - Fault Management - Security Aspects
2019.12.29	02.00.03	Arda Akman (Netsia), Tuğba Arıcı (Netsia)	Updates to GSMA section to reflect the latest GSMA specs
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2020.03.01	02.00.05	Arda Akman (Netsia)	Updated references, abbreviations, deployment options and other editorial updates
2020.03.09	02.00.06	Arda Akman (Netsia)	Updates to various sections based on review feedback during WG1 approval process

Contents

Chapter 1 Introduction

1.1 Scope

This Technical Report has been produced by O-RAN Alliance.

The contents of the present document are subject to continuing work within O-RAN WG1 Slicing Task Group and may change following formal O-RAN approval. In the event that O-RAN Alliance decides to modify the contents of the present document, it will be re-released by O-RAN Alliance with an identifying change of release date and an increase in version number as follows:

Release x.y.z

where:

x the first digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc. (the initial approved document will have x=01).

y the second digit is incremented when editorial only changes have been incorporated in the document.

z the third digit included only in working versions of the document indicating incremental changes during the editing process.

This document provides common terminology for slicing, an overview of slicing activities in different SDOs (3GPP, ETSI, ONAP, GSMA, etc.) and provides the high level view of O-RAN slicing framework and architecture along with different deployment options.

1.2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document in Release 16.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 23.501: "System Architecture for the 5G System", Release 16, December 2019

[3] 3GPP TR 28.801: "Study on management and orchestration of network slicing for next generation network", Release 15, January 2018.

[4] 3GPP TS 28.530: "Aspects; Management and orchestration; Concepts, use cases and requirements", Release 16, January 2020.

[5] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3", Release 16, January 2020.

[6] 3GPP TS 38.300: "NR and NG-RAN Overall Description", Release 16, January 2020.

[7] ETSI GR NFV-EVE 012: "Report on Network Slicing Support with ETSI NFV Architecture Framework", Release 3, December 2017.

[8] ETSI GS NFV-IFA 008: "Ve-Vnfm reference point - Interface and Information Model Specification", Release 2, February 2018.

[9] ETSI GS NFV-IFA 013: "Os-Ma-Nfvo reference point - Interface and Information Model Specification", Release 2, February 2018.

[10] GSMA: "An Introduction to 5G Network Slicing", 2017.

[11] GSMA: "From Vertical Industry Requirements to Network Slice Characteristics", August 2018.

[12] GSMA: "Network Slicing, Use Case Requirements", April 2018.

[13] GSMA: "Generic Network Slice Template", Release 2, October 2019

[14] ETSI GS ZSM 003: "Zero-touch Network and Service Management (ZSM); End to end management and orchestration of network slicing".

1.3 Definitions and Abbreviations

1.3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

A1: Interface between non-RT RIC and Near-RT RIC to enable policy-driven guidance of Near-RT RIC applications/functions, and support AI/ML workflow.

E2: Interface connecting the Near-RT RIC and one or more O-CU-CPs, one or more O-CU-UPs, and one or more O-DUs.

FCAPS: Fault, Configuration, Accounting, Performance, Security.

Intents: A declarative policy to steer or guide the behaviour of RAN functions, allowing the RAN function to calculate the optimal result to achieve stated objective.

near-RT RIC: O-RAN near-real-time RAN Intelligent Controller: a logical function that enables near-real-time control and optimization of RAN elements and resources via fine-grained data collection and actions over E2 interface.

non-RT RIC: O-RAN non-real-time RAN Intelligent Controller: a logical function that enables non-real-time control and optimization of RAN elements and resources, AI/ML workflow including model training and updates, and policy-based guidance of applications/features in near-RT RIC.

NMS: A Network Management System.

O-CU: O-RAN Central Unit

O-CU-CP: O-RAN Central Unit – Control Plane: a logical node hosting the RRC and the control plane part of the PDCP protocol.

O-CU-UP: O-RAN Central Unit – User Plane: a logical node hosting the user plane part of the PDCP protocol and the SDAP protocol.

O-DU: O-RAN Distributed Unit: a logical node hosting RLC/MAC/High-PHY layers based on a lower layer functional split.

O-RU: O-RAN Radio Unit: a logical node hosting Low-PHY layer and RF processing based on a lower layer functional split. This is similar to 3GPP's "TRP" or "RRH" but more specific in including the Low-PHY layer (FFT/iFFT, PRACH extraction).

O1: Interface between management entities (NMS/EMS/MANO) and O-RAN managed elements, for operation and management, by which FCAPS management, Software management, File management shall be achieved.

RAN: Generally referred as Radio Access Network. In terms of this document, any component below near-RT RIC per O-RAN architecture, including O-CU/O-DU/O-RU.

1.3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

eNB	eNodeB (applies to LTE)
gNB	gNodeB (applies to NR)
KPI	Key Performance Indicator
KQI	Key Quality Indicator
Near-RT RIC	Near-RT RIC
Non-RT RIC	Non-Real-Time RIC
NS	Network Service
O-CU	O-RAN Central Unit
O-DU	O-RAN Distributed Unit
O-RU	O-RAN Radio Unit
PNF	Physical Network Function
PRB	Physical Resource Block
RIC	O-RAN RAN Intelligent Controller
RRM	Radio Resource Management
SDO	Standards Developing Organizations (For ex: 3GPP, ETSI, ONAP, O-RAN)
SMO	Service and Management Orchestration
VNF	Virtual Network Function
NSD	NFV Network Service Descriptors
NST	Network Slice Templates

Chapter 2 Objective

The current document aims to define the common terminology for slicing, captures slicing activities in different SDOs (3GPP, ETSI, ONAP, GSMA, etc.) and provides the high level view of O-RAN slicing framework and architecture, with the purpose of helping identify requirements for O-RAN defined interfaces and functions, eventually leading to formal drafting of interface specifications.

Chapter 3 Common Terminology

In this chapter, it is aimed to list slice specific definitions to agree on a common terminology.

Network slice instance: a set of network functions and the resources for these network functions which are arranged and configured, forming a complete logical network to meet certain network characteristics. [3]

Network slice subnet instance: a set of network functions and the resources for these network functions which are arranged and configured to form a logical network. [3]

Network slice subnet template: description of the structure (and contained components) and configuration of the network slice subnet. [3]

Network slice template: description of the structure (and contained components) and configuration of a network slice. [3]

Physical resource isolation: regime of resource management when a physical resource used by one network slice instance cannot be shared with another network slice instance. [3]

Chapter 4 Slicing in SDOs

4.1 Slicing in 3GPP

Architecture Including Network Slicing

Network slicing concept is considered as one of the key feature of 5G networks. Service-based 5G architecture including network slicing is defined in 3GPP TS 23.501 [2]. Figure 4.1-1 represents the non-roaming reference architecture and interfaces utilised in control plane.

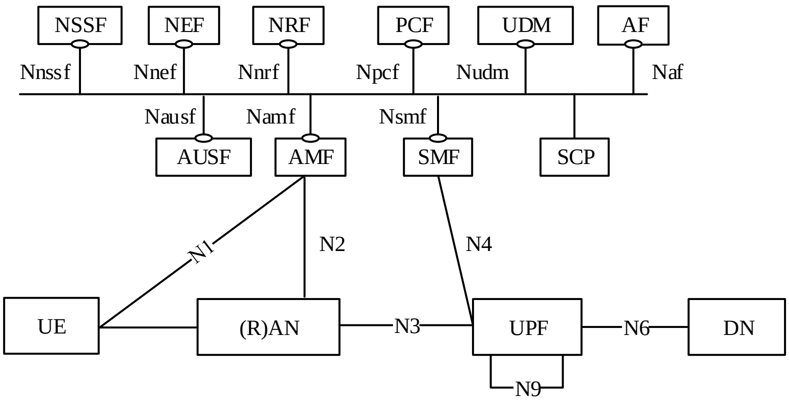

Figure 4.1-1: Reference architecture

Network Slice Identification and Service Types

A network slice is always defined with RAN part and CN part in a PLMN (see Clause 5.15.1 in [2]). The network slicing support is based on the principle that flows of the different slices handled by different PDU sessions. Granularity of slice awareness is in PDU session level (see Clause 16.3.1 in [6]).

S-NSSAI is a unique identifier for each network slice. NSSAI (Network Slice Selection Assistance Information) includes one or a list of s-NSSAIs which is a combination of mandatary SST (Slice/Service Type) and an optional SD (Slice Differentiator). The operator may choose to serve same Slice/Service Type but using different s-NSSAIs in case of serving same features to different group of users.

To support roaming use cases more efficiently, some SST values are standardised for the most common service types as shown in the Table 4.1-2 defined as in 3GPP TS 23.501 [2].

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

Table 4.1-2: Standardized SST values

Key Principles of Network Slicing

A single UE can connect one or more Network Slice instances simultaneously. The maximum number of simultaneous connection is 8 per UE. If UE has multiple simultaneous connections to the different slices, only one signalling connection is used.

5G QoS model is based on QoS Flows. GBR QoS flows require guaranteed flow bit rate. Non-GBR QoS flows, by contrast, do not require guaranteed flow bit rate. QoS differentiation is supported within a network slice.

NG-RAN should support resource management between slices. SLA is provided between slices. Multiple slices could be supported on a single RAN and resource isolation is maintained between slices. Shared resources should be managed by RRM policies or other mechanisms to prevent SLA violations for other slices.

Slice availability depends on the deployment scenario. Some slices might be offered globally while some others might be only in a local area.

Selection of a Network Slice

AMF selection procedure is made based on NSSAI or Temp ID. NSSAI is used when UE does not have Temp ID. Otherwise, RAN uses the NSSAI reported by UE during initial access procedure to select appropriate AMF. If both of them is not available, RAN routes UE to a default AMF.

After RRC connection and AMF Selection are completed successfully, selected AMF sends Initial Context Setup Request message to RAN to complete UE context. This message includes allowed NSSAI, s-NSSAI for each PDU session. When required resources and policies for the selected slice(s) are ready, RAN side sends an Initial Context Setup Response message to AMF 3GPP TS 38.300 [6].

Management and Orchestration of Network Slicing

Network slice is a logical network that provides specific network capabilities and network characteristics. There are some aspects that a network slice includes. A deployed network slice forms a Network Slice Instance (NSI). An NSI has all the physical and logical resources and the functionalities to serve a business use case. The NSI contains Core Part and Access Part. To create an NSI, configurations and policies are required for each instance. The NSI lifecycle includes commissioning, operation and decommissioning phases as shown in Fig 4.1-2.

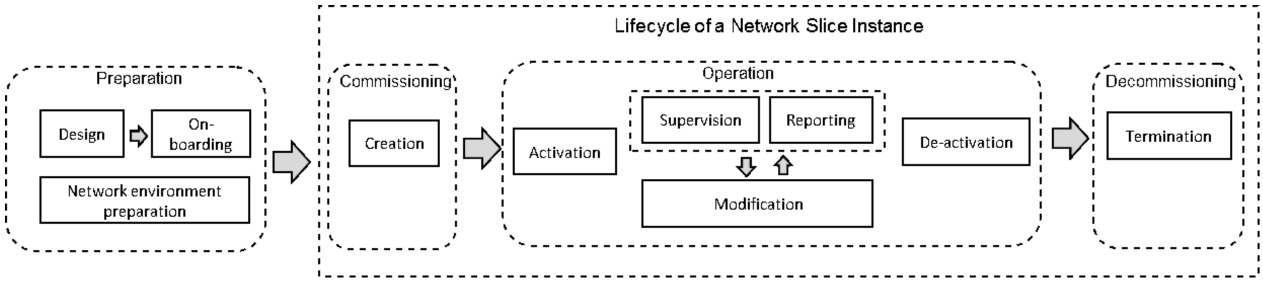

Figure 4.1-2: NSI lifecycle

In the preparation phase NSI does not exist and necessary preparations are handled, such as network slice design, capacity planning and on-boarding. Commissioning phase includes the creation of the NSI where all needed resources are allocated and configured per slice requirements. Operation phase is the state that NSI is operating and supporting services to the specified types. In the activation step, any action required to make NSI active is included. Supervision, reporting and modification steps are involved in operation phase. To illustrate, KPI reporting, reconfiguration of NSI or scaling are used in these phases. Decommissioning phase involves termination of the NSI and releasing of the resources assigned to it (see Clause 4.3.1 in [4]).

Network Resource Model and RRM Slice Policies

3GPP TS 28.541 [5] has introduced the Information Model in the Network Resource Model (NRM) to fulfill management and orchestration of 5G networks. Regarding the network slicing feature modeling at the NRCellCU level, the model basically lists the s-NSSAI(s) supported in the cell and RRM policy to share resources among listed slices. RRMPolicyType attribute is used to describe RRM policy to be applied.

4.2 Slicing in ONAP

ONAP 5G slicing activity is ongoing in Frankfurt R6 release. ONAP R5 includes the feature of Network Slicing modeling as a prerequisite for Slicing orchestration that is work in progress in R6. The Network Slice model leverages the shared service/resource approach that is essential for modeling the network slice where VNF's/PNF's may be shared by several slices.

The shared service approach is similar to ETSI NFV nested services approach, so its TOSCA implementation may be easily translated into Network Service descriptors defined by the ETSI NFV-SOL001 specification for TOSCA based NFV descriptors.

The graphical representation of the example of modelling the eMBB Network Slice having 3 slice segments (RAN, transport and core) is shown below in Figure 4.2-1.

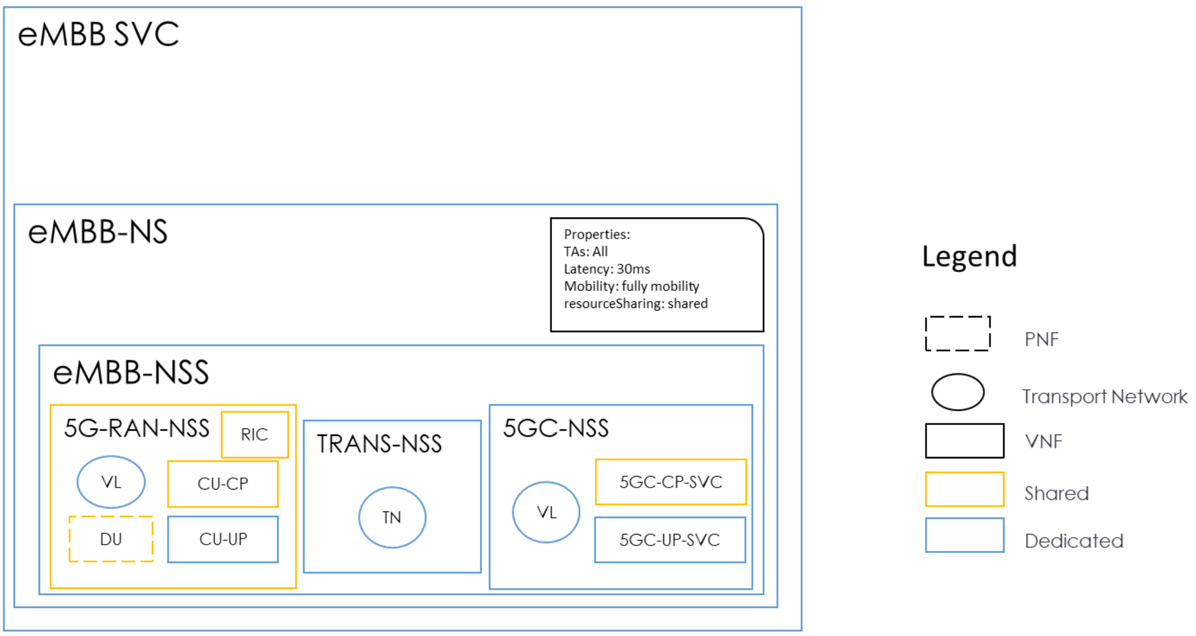

Figure 4.2-1: Example model of eMBB Network Slice

Nested Network Service is the approach for shared resources (VNF/NS)

- Nested network service TOSCA implementation in ETSI NFV-SOL001
- PNFD may be part of Nested Service

Sharing of Network Slice resources (PNF's and VNF's) for ONAP release 6 is proposed using Nested services approach (based on work done for Release 5) including wrapping PNFs/VNF's within Network Services and defining operations and properties on Service level. The Network slicing orchestration in ONAP R6 will include assigning workflows to the operations.

Following this approach, the topology model for O-RAN segment would be as shown below in Figure 4.2-2:

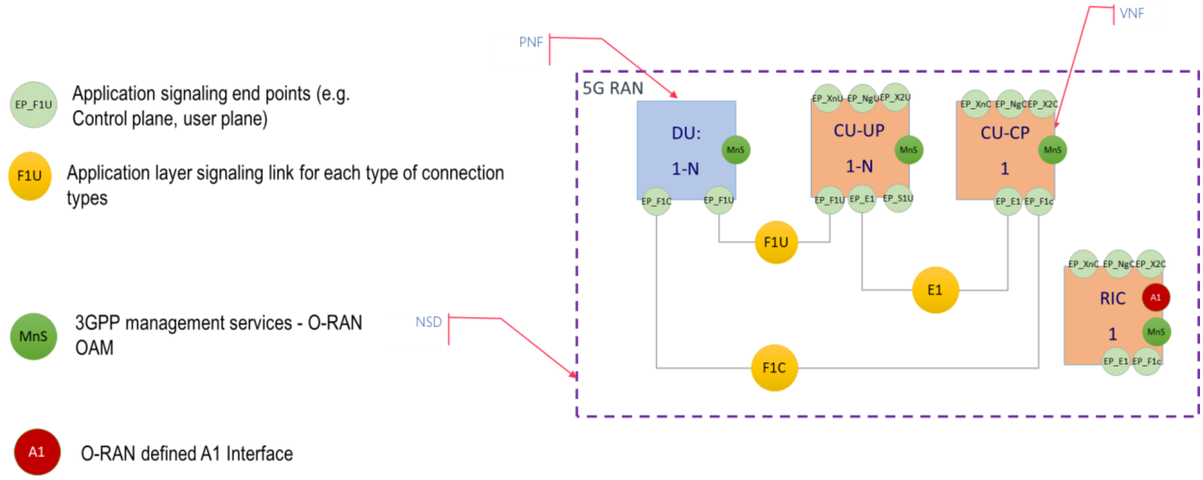

Figure 4.2-2: High level O-RAN topology model

4.3 Slicing Orchestration in 3GPP SA5 and ETSI NFV MANO

According to ETSI NFV Network Slicing Report [7], network slicing has been defined by different SDOs, there is no common definition for network slicing. Therefore, understanding of network slicing is different from each other. Nonetheless, the report does not introduce use cases or features but analyses network slicing in external SDOs. In this report, how these external use cases should be mapped to NFV and the ETSI NFV architecture is explained.

As stated in 3GPP TR 28.801 [3], a network slice may contain one or more network slice subnets and each of them includes one or more network functions. VNFs and PNFs are managed as these network functions in the ETSI NFV architecture. Related to network slicing management, there are three different management functions identified in 3GPP TR 28.801 [3]:

- Communication Service Management Function (CSMF): translates the communication service related requirement to network slice related requirements.
- Network Slice Management Function (NSMF): responsible for management and orchestration of NSI. Provides communication with the Network Slice Subnet Management Function (NSSMF) and Communication Service Management Function.
- Network Slice Subnet Management Function (NSSMF): responsible for management and orchestration of NSSI.

As shown in the Figure 4.3-1, Os-Ma-nfvo reference point is used for interaction between 3GPP slice management functions and NFVO. Similarly, Ve-Vnfm-em reference point is used for exchanges between NFMF and VNF Manager. Further analysis is required on these reference points to apply deployment scenarios including 3GPP network slicing related management functions and NFV-MANO. Further details are available in ETSI GS NFV-IFA 008 [8] and ETSI GS NFV-IFA 013 [9].

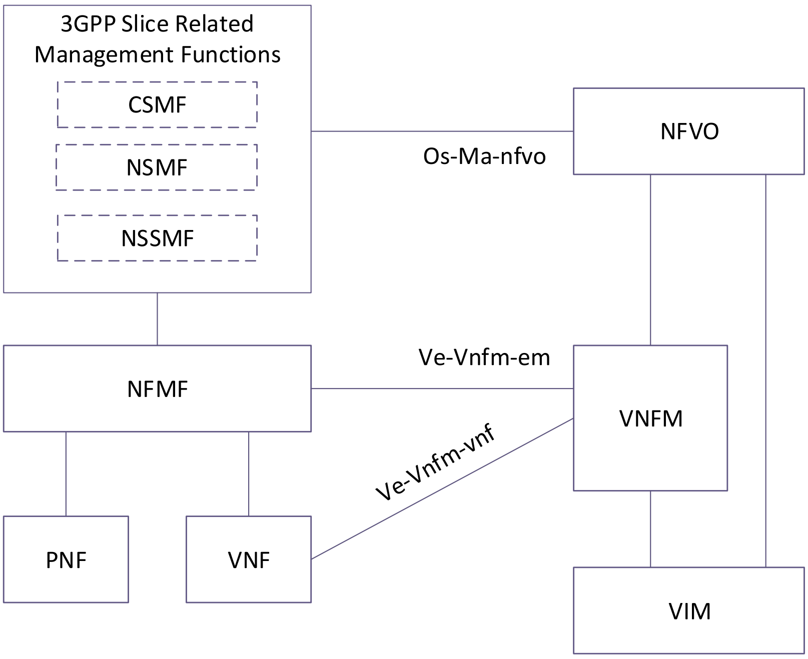

Figure 4.3-1: Network slice management in an NFV framework

Figure 4.3-2 shows an example of a 5G network realized by an end-to-end network slice, consisting of network slice subnet #1 for 5G core networks and network slice subnet #2 for 5G radio networks (see Clause 4.1.3 in TS 28.530 [4]).

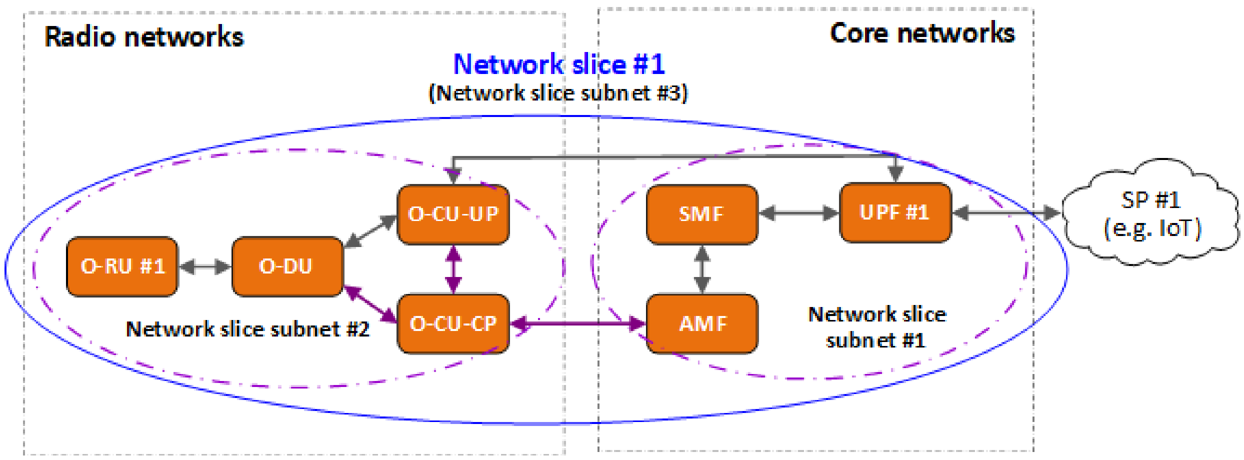

Figure 4.3-2: 5G network with network slicing

The following diagram (Figure 4.3-3) shows the interaction between 3GPP and ETSI NFV to create a network slice subnet instance for RAN network functions.

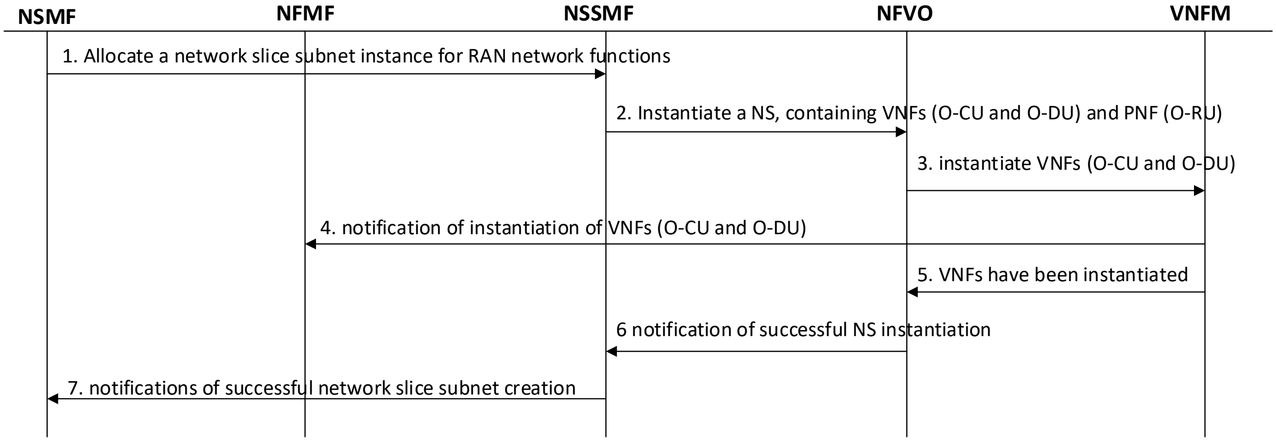

Figure 4.3-3: High level view of network slice subnet instance creation

1. NSMF sends request to allocate a network slice subnet instance for RAN network functions, e.g. O-CU, O-DU, and O-RU.
2. NSSMF decides to instantiate a Network Service (NS) instance for a new network slice subnet instance.
3. NFVO sends request to instantiate the VNFs for O-CU, O-DU.
4. VNFM instantiates VNFs and notifies NFMF that VNFs have been instantiated.
5. VNFM responds to NFVO informing that VNFs have ben instantiated.
6. NFVO notify NSSMF that NS has been instantiated.
7. NSSMF responds to NSMF with status equals to successful for the operation of network slice subnet instance creation.

4.4 Slicing in ETSI ZSM

The management services (MnSs) for end-to-end network slicing are provided by a set of management domains (MDs). Including that for network slicing defined by 3GPP SA5 and that for NFV defined by ETSI NFV, provides various MnSs as shown in Figure 4.4-1 [14].

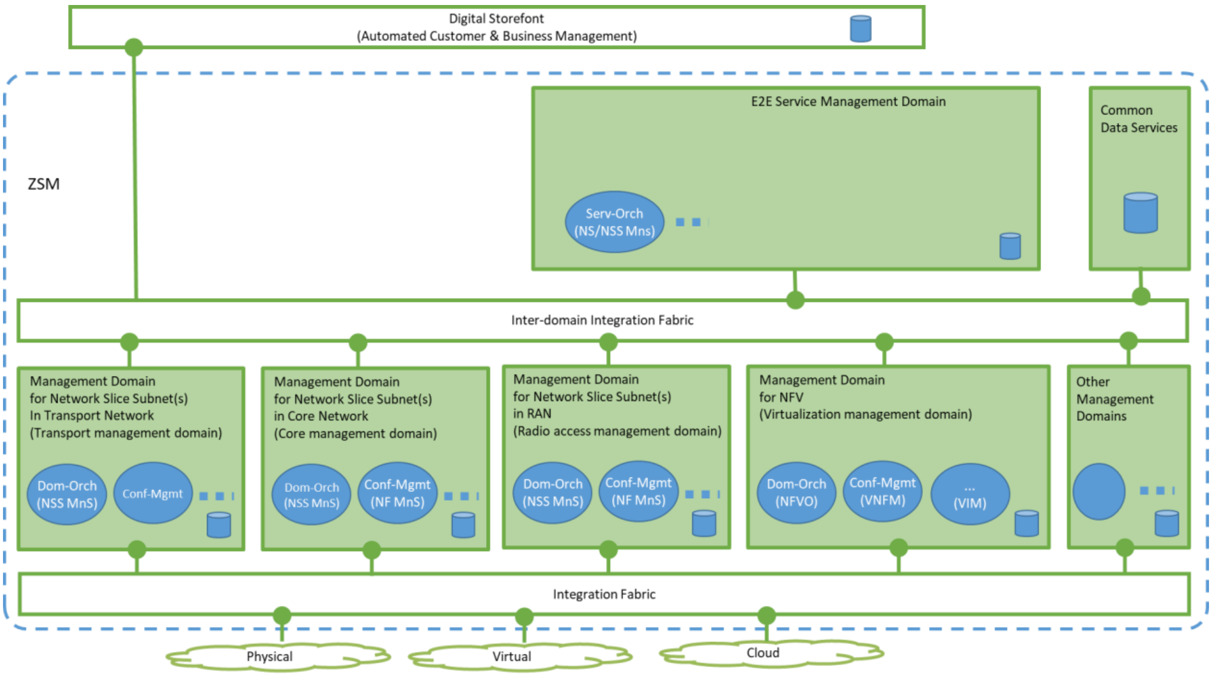

Figure 4.4-1: Example of MDs to support network slicing using NFV

In this operator deployment example:

- E2E Service MD provides MnSs for E2E network slices/network slice subnets, e.g. Service Orchestration service (Serv-Orch), which orchestrates the individual network slice subnets (NSSs) provided by Radio Access Network (RAN), Transport Network (TN) and Core Network (CN), and stitches them into a E2E network slice subnet being exposed as a network slice. The MnSs in this MD may also manage NSSs of Data Network (aka. SGi Network) using MD for NFV. It is expected that parts of specifications developed by 3GPP SA5 are re-used for the MnSs in this MD. This MD exposes e.g. management capabilities of E2E network slices (provisioning, performance assurance, fault supervision, etc.).
- MD for NSS in TN provides MnSs for NSSs of TN, e.g. Dom-Orch service. This MD may consume TN resources outside of ZSM supported by e.g. Configuration Management service(s) (Conf-Mgmt). It is expected that parts of specifications developed by e.g. BBF, MEF, IETF and/or ETSI NFV are re-used for the MnSs in this MD. This MD exposes e.g. management capabilities of NSS of TN (provisioning, performance assurance, fault supervision, etc.).
- MD for NSS in RAN provides MnSs for NSSs of RAN, e.g. Dom-Orch service. This MD may consume application level RAN resources (i.e. application part of RAN Network Functions) outside of ZSM supported by e.g. Conf-Mgmt, and it may also consume MnSs for Network Services which include virtualized resources from MD for NFV. It is expected that parts of specifications developed by 3GPP SA5 are re-used for the MnSs in this MD. This MD exposes e.g. management capabilities of NSS of RAN (provisioning, performance assurance, fault supervision, etc.).
- MD for NSS in CN provides MnSs for NSSs of CN, e.g. Dom-Orch service. This MD may consume application level CN resources outside of ZSM (i.e. application part of CN Network Functions) supported by e.g. Conf-Mgmt, and it may also consume MnSs for Network Services which include virtualized resources from MD for NFV. It is expected that parts of specifications developed by 3GPP SA5 are re-used for the MnSs in this MD. This MD exposes e.g. management capabilities of NSS of CN (provisioning, performance assurance, fault supervision, etc.).
- MD for NFV provides MnSs for NFV Network Service(s) (at resource level), e.g. Dom-Orch service (NFV Orchestrator). This MD may also have Conf-Mgmt (VNF Manager) and MnSs for managing compute/network/storage resources (Virtualized Infrastructure Manager). It is expected that parts of specifications developed by ETSI NFV are re-used for the MnSs in this MD. This MD exposes e.g. management capabilities related to NFV Network Services (Create/Read/Update/Delete of the Network Services, on-boarding of catalogues for those, etc.).

Using the operator deployment scenario in Figure 4.4-1, a service over an E2E network slice instance comprising of RAN access + virtualized application can be deployed. Figure 4.4-2 describes the particular instance of service consumption across the domains.

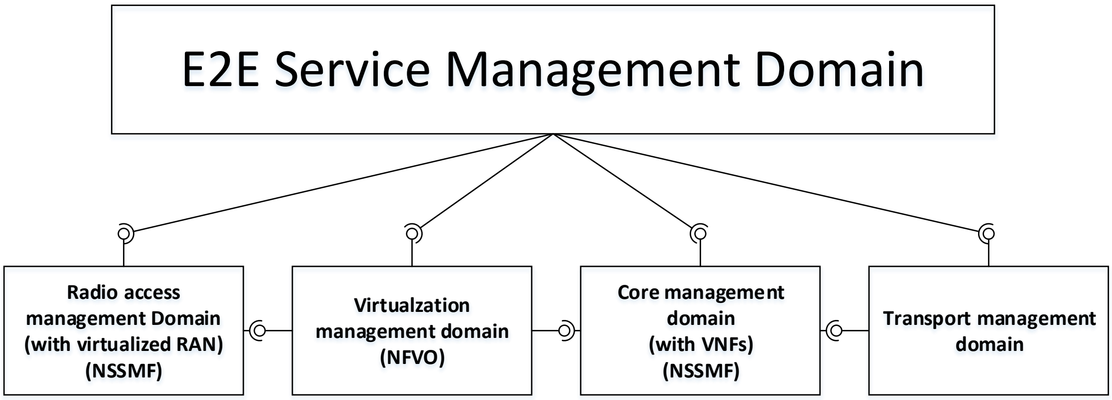

Figure 4.4-2: Example management services' consumption to show E2E slice deployment.

The steps of deployment are:

1) The E2E service breaks up the E2E network slicing deployment requests into
   a) Part of the E2E network slice (for fixed users and Transport) + 3GPP Core Part of the E2E network slice (for Mobile users) + 3GPP RAN part of the E2E network slice + application service (Virtualized)
2) A part of the E2E network slice is handed over to the TN management domain using the appropriate management services exposed by the transport management domain.
3) The 3GPP core part (CP: AMF/SMF, UPF, N1,N6) goes to the core management system
   a) The core management domain requests the connectivity (N1, N6) to the transport management domain
   b) The Core management domain hands over the VNFs (AMF/SMF, UPF…) to the virtualization management domain
4) The access part goes to radio access service management domain
   a) The radio access management domain uses the management services of the virtualization management domain to deploy the virtualized RAN part
5) The virtualized application AS is handed over to be deployed by the virtualization management system.

4.5 Slicing in GSMA

GSMA published a document [10] which aims to provide an introduction to network slicing functionality. It shows how network slicing can be used by business customers. Business customers are referred as users of the 5G services which could be enterprises, specialized industries or individuals. Network slicing is analyzed from the business customers' point of view in addition to set of use cases.

It is highlighted that different business customers has various requirements like ultra-reliable services, ultra-high-bandwidth communication or extremely low latency. Running multiple logical networks on a common physical infrastructure is enabled by network slicing. Network slice contained 5G networks allow business customers to have connectivity having different business requirements which are governed by SLAs.

Network slicing provides ability to customize capabilities and functionality of the mobile network offered to business customers. Customized services are classified as Network Connection Service and Network Resource Service. The first one indicates the connectivity functionalities of the customer e.g. near real-time latency, guaranteed SLA, seamless mobility and energy efficiency. The second one describes the case that customers are granted access to the operator network resources to run their proprietary applications. In addition to network resource services, the network is able to provide additional services i.e. big data analytics, cloud computing, edge computing and positioning.

GSMA lists some use cases for the business customers to underline potential of network slicing. Industry sectors including automotive, logistic, healthcare, government are indicated as potential application of the network slicing.

As the successor of the previous document, GSMA conducted a study on the service requirements expressed by various business customers. In addition to detailed analysis of the service requirements, recommendations for the industry has been provided. Finally, a generic slice template has been introduced and all the attributes a network slice could have, has been discussed [12]. Generic Slice Template (GST) lists set of attributes with names and units that characterise a network slice (e.g. throughput, supported functionalities). GST categorises the attributes into character attributes and scalability attributes. Former defines generic slice attributes independent from the NSC and NSP (e.g. latency, throughput), while latter provides information about scalability of the slice e.g. number of terminals, area of the service.

Another concept defined to represent network slices with a common language is Network Slice Type (NEST). The NEST is a GST filled with proper values based on a specific business use case. Moreover, NEST is the input for the network slice preparation phase which leads to service profile definition in 3GPP.

GSMA Network Slicing Taskforce (GSMA-NEST) has two main objectives which are defining the GST [13] and identifying set of slices whose characteristics are accepted by the industry. GSMA-NEST aims to deliver NESTs with industry approved slice characteristics which could be used by the operators [11].

Chapter 5 O-RAN Slicing Framework

5.1 O-RAN Slicing Architecture

5.1.1 Non-RT RIC

The fundamental role of the Non-RT RIC in O-RAN architecture is to apply AI/ML based algorithms to provide innovative RAN use cases. Hence, Non-RT RIC is a key component to allow advanced RAN slicing technology to be applied in O-RAN framework. For this purpose, Non-RT RIC should be aware of RAN slices and related slice properties/configurations as well as slice performance metrics to actively assist slice assurance through optimization methods, including AI/ML models.

To generate AI/ML models to be deployed in the Near-RT RIC, Non-RT RIC retrieves slice specific PMs and configuration parameters of the slices and optionally external enrichment information from external servers. Complex problems for Near-RT RIC e.g. applying RRM policies can be tackled by learning capabilities of AI/ML. Training models enable non-real-time optimization of the slice specific parameters over O1 interface. Moreover, these performance, configuration and other data are used to assist Near-RT RIC to provide dynamic slice optimization. Appling dynamic slice optimization in the Near-RT RIC is used to prevent SLA violations between the slices.

5.1.2 Near-RT RIC

Near-RT RIC enables xApps to control RAN elements and their resources through the E2 interface in near real-time (sub second). Similar to Non-RT RIC, Near-RT RIC xApps should be aware of RAN slices and can utilize slice aware algorithms for slice SLA assurance purposes. Once the slices are up and running, slice specific PMs from E2 nodes will be gathered and sent to Near-RT RIC and Near-RT RIC will use these PMs and the slice configuration data to apply dynamic slice optimization to assure slice SLAs, through E2 interface (to be discussed).

These dynamic slice optimization algorithms can be built into the Near-RT RIC, can be guided from Non-RT RIC through A1 policies, or can be sent down as AI/ML models from Non-RT RIC.

5.1.3 O-RAN Central Unit (O-CU)

In order to apply RAN slicing in O-RAN framework, both O-CU and O-DU needs to support slicing features as defined by 3GPP. Furthermore slicing can be enhanced with the assistance of O-RAN specific Near-RT RIC dynamic slice optimization through E2 interface.

O-CU is the O-RAN entity which runs the upper layer protocols of the RAN stack, such as Radio Resource Management. Since RRM is responsible for managing resources, and in case of slicing – the allocation of resources between slices, O-CU needs to execute slice specific resource allocation strategies and drive O-DU(s) similarly. O-CU will interact with Near-RT RIC to provide slice specific PMs as well as getting dynamic guidance through E2 interface.

5.1.4 O-RAN Distributed Unit (O-DU)

O-DU is the O-RAN entity which runs the lower layer protocols of the RAN stack, including MAC layer which is the layer that schedules Physical Resource Blocks to UEs. As part of slicing, MAC layer needs to allocate PRBs according to the RRM strategies provided by the Operator and slice management entities. O-DU will receive the slice configuration parameters from O1 interface, and dynamic slice optimization guidance from RIC through E2 interface and will provide slice specific PMs through O1 interface to SMO and E2 interface to Near-RT RIC.

5.1.5 A1 Impact

A1 interface will be used to support policy based guidance for slicing use cases, such as SLA assurance. In addition to policy guidance towards Near-RT RIC, Non-RT RIC should be able to receive feedback related to deployed policies over A1 interface. In case of external data enrichment, Non-RT RIC should be able to transfer slice specific enrichment data to Near-RT RIC over A1 interface as well.

5.1.6 E2 Impact

E2 interface will be used to drive E2 nodes' slice configuration and behaviour, such as slice based radio resource allocations, scheduling policies, and configuration policies that may affect performance characteristics of the corresponding network slice. Near-RT RIC should be able to configure and receive slice specific performance data from the E2 nodes over the E2 interface for near real-time optimization (as compared to PMs collected over the O1 interface, which is a slower loop). Slice specific PMs can include PRB utilization, average delay and DRB related measurements that are already defined in 3GPP. However, E2SM(s) can be extended to support non-3GPP slice specific PM collection so that policy control algorithms running on the Near-RT RIC are improved to meet the slice SLA requirements.

5.1.7 O1 Impact

The primary role of O1 interface is to enable slice specific configuration of O-RAN nodes based on the service requirements. 3GPP 28.541 [5] has defined the Information Models to list attributes of the slice profiles with the slice specific requirements, including RRM policy attributes to provide ratio of radio resources to split among the supported slices. In addition to slice specific configuration capabilities, O1 interface is used to gather slice specific performance metrics and fault information from O-RAN Nodes. As extensions to O-RAN specific slicing configuration and performance measurement attributes are defined, these information will be sent over O1 interface as well.

5.1.8 O2 Impact

O2 is the interface used for life cycle management of virtual O-RAN network functions. In case of network slicing, after the preparation phase, SMO might instantiate necessary O-RAN network functions (such as Near-RT RIC, O-CU-CP, O-CU-UP, O-DU) through instantiation procedures as part of the RAN NSSI creation and provisioning, NSSI modification and NSSI deletion. It is expected that Non-RT RIC is instantiated as part of SMO and does not require any lifecycle management activities.

Chapter 6 Deployment Options

This section provides possible deployment options with respect to network slice management topology and their possible effects on O-RAN slicing architecture. Based on 3GPP specifications Network Slice Management Function (NSMF) and Network Slice Subnet Management Function (NSSMF) are responsible for end-to-end slice management and slice subnet management respectively. Within the scope of O-RAN, RAN slice subnet management function is the primary focus including but not limited to its interactions with the Service Management and Orchestration Framework. Possible architectural impacts of different deployment options are planned to be investigated and captured in O-RAN Slicing Architecture Specification document.

In the following sub sections, four possible deployment options are presented. Please note that while ETSI based NFVO/VNFM interface types are depicted as examples, depending on SMO type these interfaces and NFVO/VNFM components can be different. As other SMOs (such as ONAP) make progress with RAN slicing, the relevant interfaces can be captured in the next iterations of this document.

Option 1

In this option, both NSMF and NSSMF are deployed within the SMO.

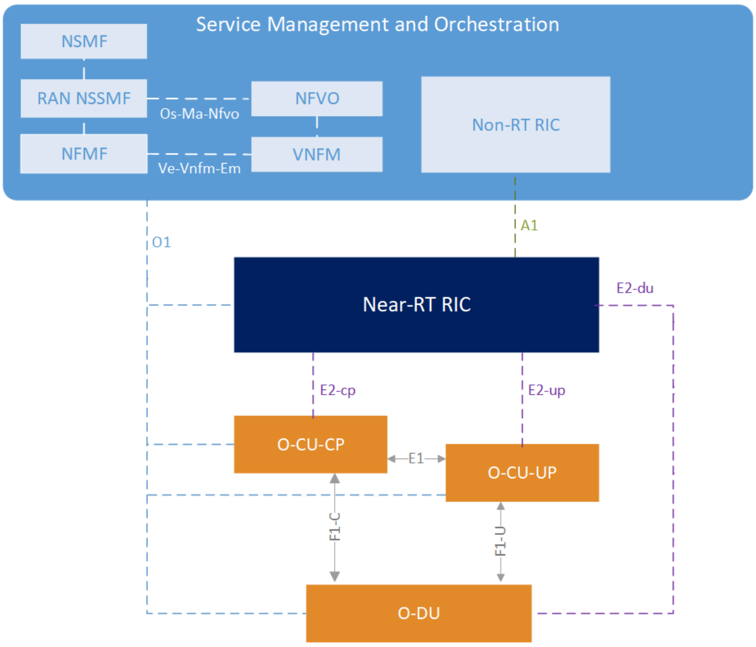

Figure 3: NSMF and NSSMF are deployed within the SMO

Option 2

In this case, both NSMF and NSSMF are deployed outside the SMO.

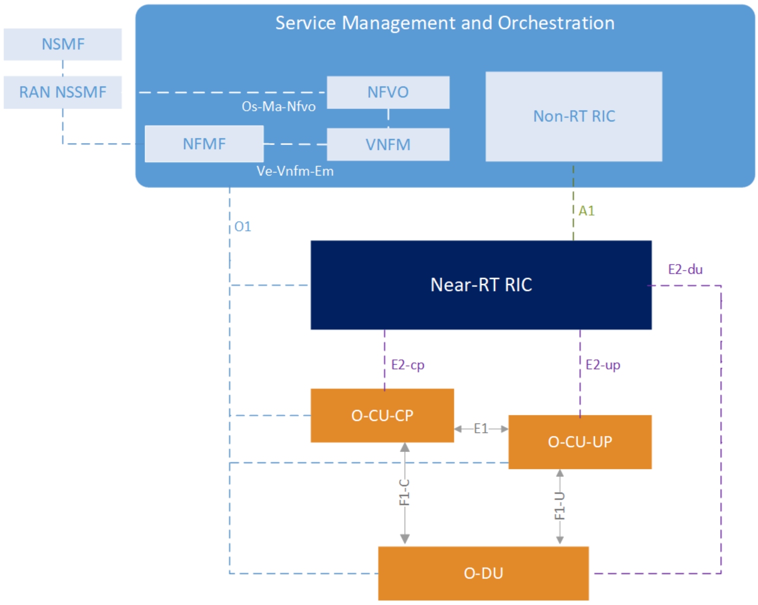

Figure 4: External deployment of NSMF and NSSMF

Option 3

In this option, NSMF is placed within SMO. However, NSSMF is deployed outside the SMO.

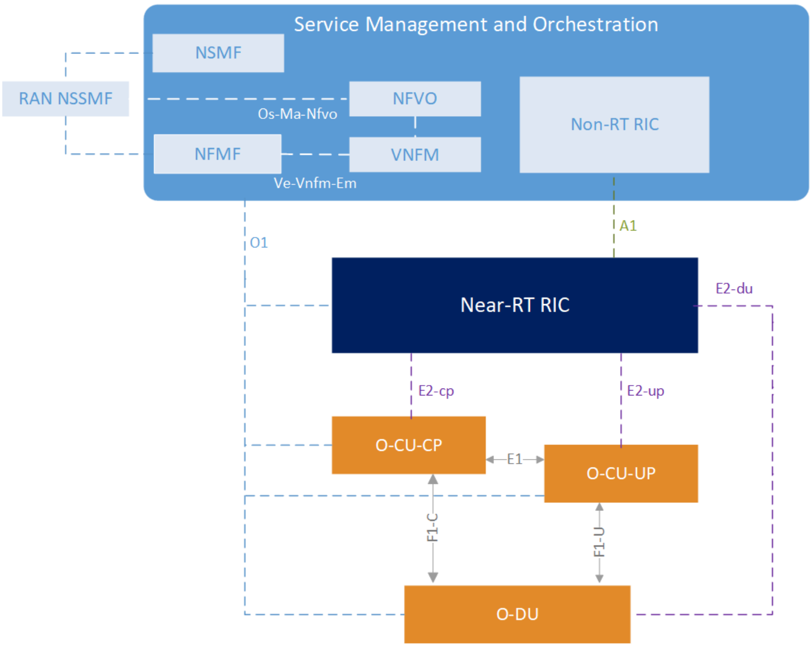

Figure 5: External NSSMF deployment

Option 4

In this case, NSMF is in the outside of SMO while NSSMF is deployed within SMO.

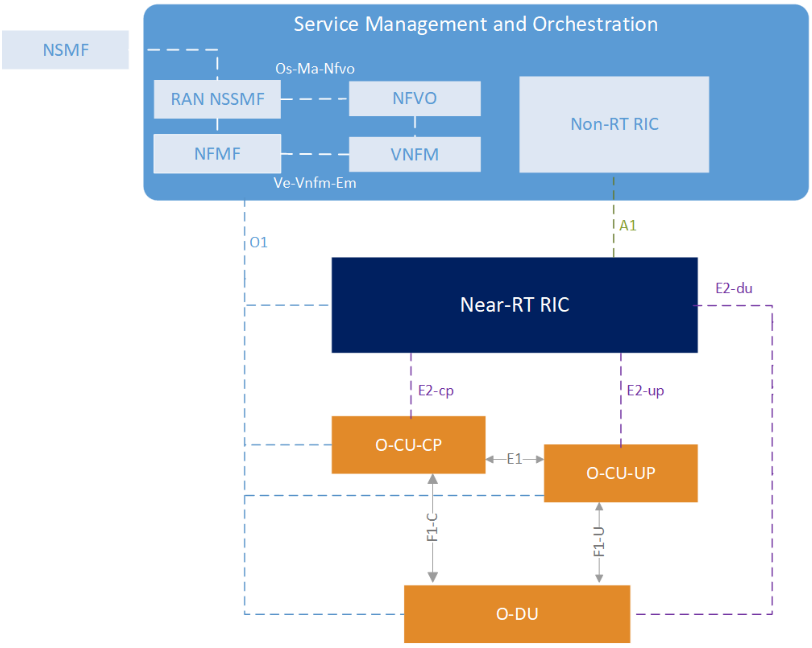

Figure 6: NSSMF within the SMO

Annex A (informative): Additional Information

A.1 Slicing SDO Mapping Table

Areas	**3GPP**	**ONAP**	**ETSI OSM**	**GSMA**	**ETSI ZSM**
Use cases and high level requirements	3GPP TS 22.261			Network Slicing Use Case Requirements GSMA-NEST (Network Slicing Task Force)	
Architectural requirements	3GPP TS 23.501 3GPP TS 23.502 (Procedures involving slicing) 3GPP TR 28.801				
Management and orchestration	3GPP TS 28.531 3GPP TS 28.530 3GPP TS 28.541 3GPP TR 28.801	R4 (Dublin) for Network Slice Model, R5 (El Alto) for Orchestration of Network Slicing Model	ETSI GS NFV-IFA 014 ETSI GS NFV-IFA 013 (Os-Ma-nfvo) ETSI GS NFV-IFA 008 (Ve-Vnfm)		ETSI GS ZSM 002 (Reference Architecture)
Slice Configuration	3GPP TS 28.531 3GPP TS 28.541	TOSCA based service and network slice modelling	ETSI GS NFV-IFA 014 (Network Service Templates Specification)	NG.116 - Generic Network Slice Template (attributes are listed)	
Security aspects of network slicing	3GPP TR 33.811				
Slice specific Performance Management (PM), KPIs	3GPP TS 28.552 3GPP TS 28.554				
Fault Management	3GPP TS 28.801 3GPP TS 28.530 3GPP TS 28.515-517 3GPP TS 32.111 3GPP TS 28.545 (Fault Supervision) 3GPP TS 28.545				

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