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X. Geng
Huawei Technologies
L. M. Contreras
Telefonica
R. Rokui
Ciena
J. Dong
Huawei Technologies
I. Bykov
Ribbon Communications
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**IETF Network Slice Application in 3GPP 5G End-to-End Network Slice
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Abstract

Network Slicing is one of the core features of 5G defined in 3GPP, which provides different network service as independent logical networks. To provide 5G network slices services, an end-to-end network slices have to span three network segments: Radio Access Network (RAN), Mobile Core Network (CN) and Transport Network (TN). This document describes the application of the IETF network slice framework in providing 5G end-to-end network slices, including network slice mapping in management plane, control plane and data plane.

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1. Introduction

Driven by the new applications, 3GPP introduced the concept of network slicing as a feature of its 5G specification. Such a concept is meant to provide a customized connectivity service with specific capabilities and characteristics. A network slice may include a set of network functions and resources (e.g. computation, storage and network resources). The RFC XXXX Network Slice Services is defined in [[I-D.ietf-teas-ietf-network-slices](#)] as a set of connections between a number of SDPs (e.g., CE, NF), where these connections having specific Service Level Objectives (SLOs) and Service Level Expectations (SLEs) over a common underlay network, with the traffic of one customer being separated from another. The concept of RFC XXXX Network Slice Service is conceived as technology agnostic.

Note to the RFC Editor: Please update "RFC XXXX Network Slice" with the RFC number assigned to I-D.ietf-teas-ietf-network-slices.

The RFC XXXX Network Slice Services is specified in terms of the set of service delivery endpoints connected to the slice, the type of connectivity among them, and a set of SLOs and SLEs for each connectivity construct.

In [[I-D.ietf-teas-ietf-network-slice-nbi-yang](#)], the endpoints are identified by an identifier, with some metrics associated to the connections among them as well as certain policies (e.g., rate limits for incoming and outgoing traffic).

The 5G network slice as defined in [[TS-23.501](#)] does not take the transport network slice into consideration. 3GPP introduces the concept of 5G end-to-end network slice service, which is built on top of three network segments: Radio Access Network (RAN), Transport Network (TN) and Core Network (CN). Transport network provides the required connectivity between RAN and CN or inside RAN/CN, with specific performance commitment. The 5G end-to-end network slice

services may have distinct topology and performance requirements on the underlying transport network. The transport network should have thus capability to support multiple IETF network slices. The decision about the number of such IETF network slices is deployment specific.

This document focuses on the mapping between 5G Slices and underlying Transport Networks. Specifically, the document describes how RFC XXXX Network Slice Services can be derived in the context of a 3GPP Slice Service. To that aim, the document explores how and whether 3GPP Slice Service parameters are mapped to parameters that are exposed in IETF service data models (mainly, IETF Network Slice Service Model, Attachment Circuits'-as-a-Service (ACaaS), and bearers). It is out of scope of this document to elaborate on the realization of RFC XXXX Network Slices. These considerations are discussed in [[I-D.ietf-teas-5g-ns-ip-mpls](#)].

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

This document uses the terms defined in [[I-D.ietf-teas-ietf-network-slices](#)].

The following abbreviations are used in this document:

NSC: IETF Network Slice Controller

NSI: Network Slice Instance

NSSI: Network Slice Subnet Instance

S-NSSAI: Single Network Slice Selection Assistance Information

RAN: Radio Access Network

TN: Transport Network

CN: Mobile Core Network

DSCP: Differentiated Services Code Point

CSMF: Communication Service Management Function

NSMF: Network Slice Management Function

NSSMF: Network Slice Subnet Management Function

IOC: Information Object Class model, defined in 3GPP

3. 5G End-to-End Network Slice

The scope of a 5G End-to-End Network Slice service discussed in this document is shown in Figure 1. The transport networks (TN) provide the connectivity between and within RAN and CN. To support automated enablement of 5G E2E network slices, multiple controllers are likely to manage 5G E2E network slices across RAN, CN and TN. In addition, a 5G E2E network slice orchestrator is used to coordinate and control the overall creation and life cycle management of 5G E2E network slices across RAN, TN and CN.

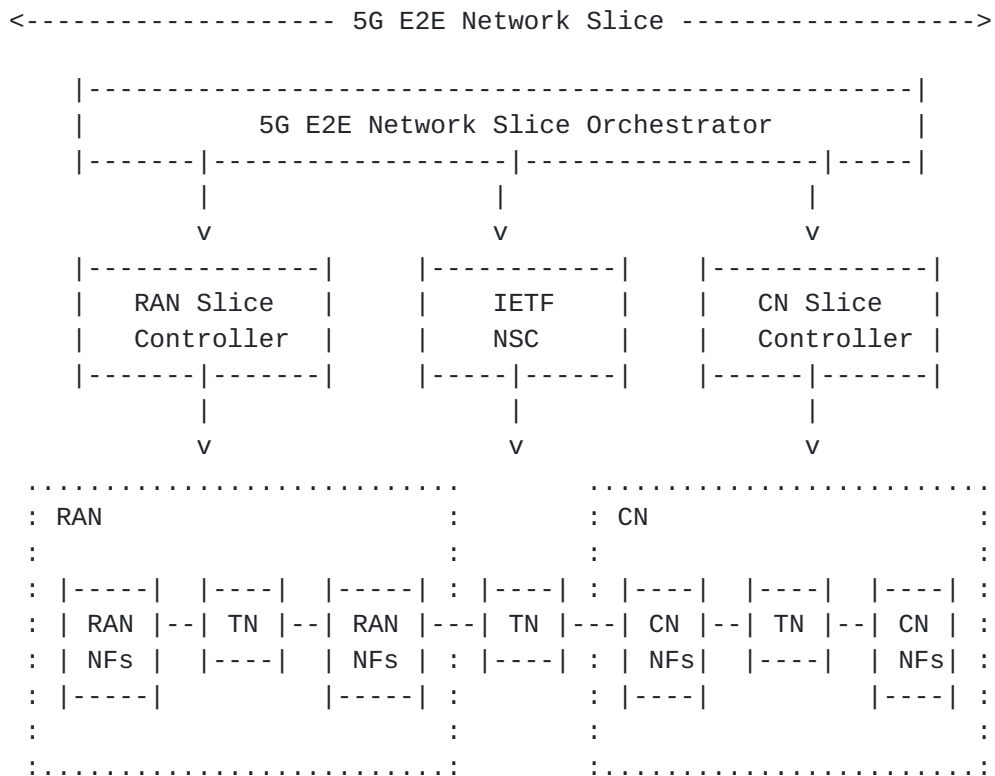


Figure 1: Scope of 5G End to End Network Slice

Depending on RAN deployment, a single 5G E2E network slice might have one or more IETF network slices. Depends on the operator's networks, one or more of the following RAN deployments might be used. These RAN deployments are discussed in the following sections:

- * Distributed RAN
- * Centralized RAN
- * Cloud RAN (C-RAN)

3.1. IETF Network Slices in Distributed RAN Deployment

Distributed RAN is the most common deployment of 3GPP RAN networks as shown in Figure 2. RAN is connected to CN using a transport network (TN1). In this deployment a single 5G E2E network slice might have one or more IETF network slices between E2E and CN networks. In addition, one or more IETF network slices might be present inside the CN network to provide the connectivity between CN network functions (e.g., AMF, CMF and UPF).

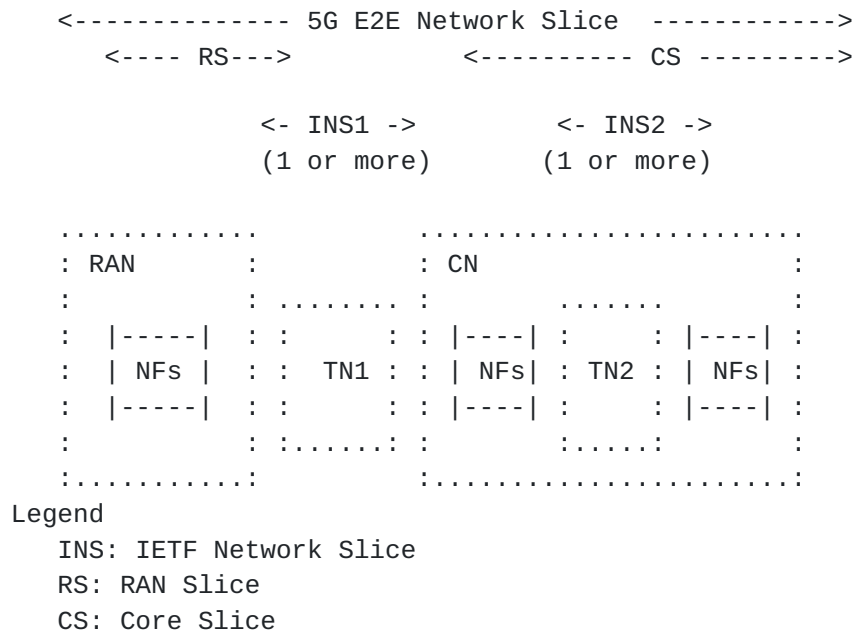


Figure 2: IETF network slices in distributed RAN deployment

3.2. IETF Network Slices in Centralized RAN Deployment

In general, the RAN network consists of network functions for processing the radio signal and transmit/receive the radio signal. As shown in Figure 3, in Centralized RAN deployment, two groups of network functions exist; NFs1 and NFs2 where NFs2 processes the radio signal and is connected to the transport network and NFs1 transmits and receives the carrier signal that is transmitted over the air to the end user equipment (UE). In Centralized RAN, network functions NFs1 and NFs2 are separated by a transport network TN3 called fronthaul network (FH). In this deployment a 5G E2E network slice contains RAN and CN slices and one or more IETF network slices INS1, INS2 and INS3. INS1 and INS2 are identical to the IETF network slices shown in Figure 2. However, the IETF network slices INS3 are needed across the RAN network to provide the connectivity among NFs1 and NFs2.

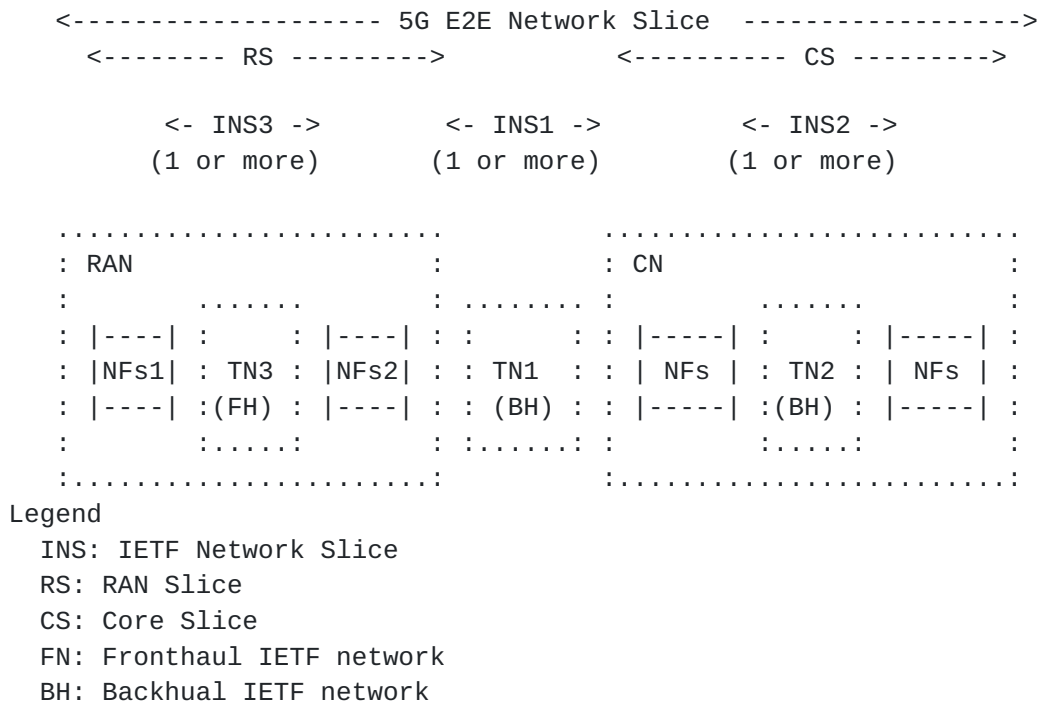


Figure 3: IETF network slices in centralized RAN deployment

3.3. IETF Network Slices in Cloud RAN deployment (C-RAN)

In a Cloud RAN deployment, the network function NF2 is further disaggregated into real-time and non-real-time components. As shown in Figure 4, these disaggregated components are called CU (Central Unit) and DU (Distributed Unit) where they are connected by a new network called Midhaul network (MH).

In this deployment 3GPP network slice contains not only RAN and Core slices but IETF network slices INS1, INS2, INS3 and INS4. IETF network slices INS1, INS2 and INS3 are similar to those in Figure 3. An additional IETF network slice INS4 is used to connect the DUs to CUs through F1 interfaces.

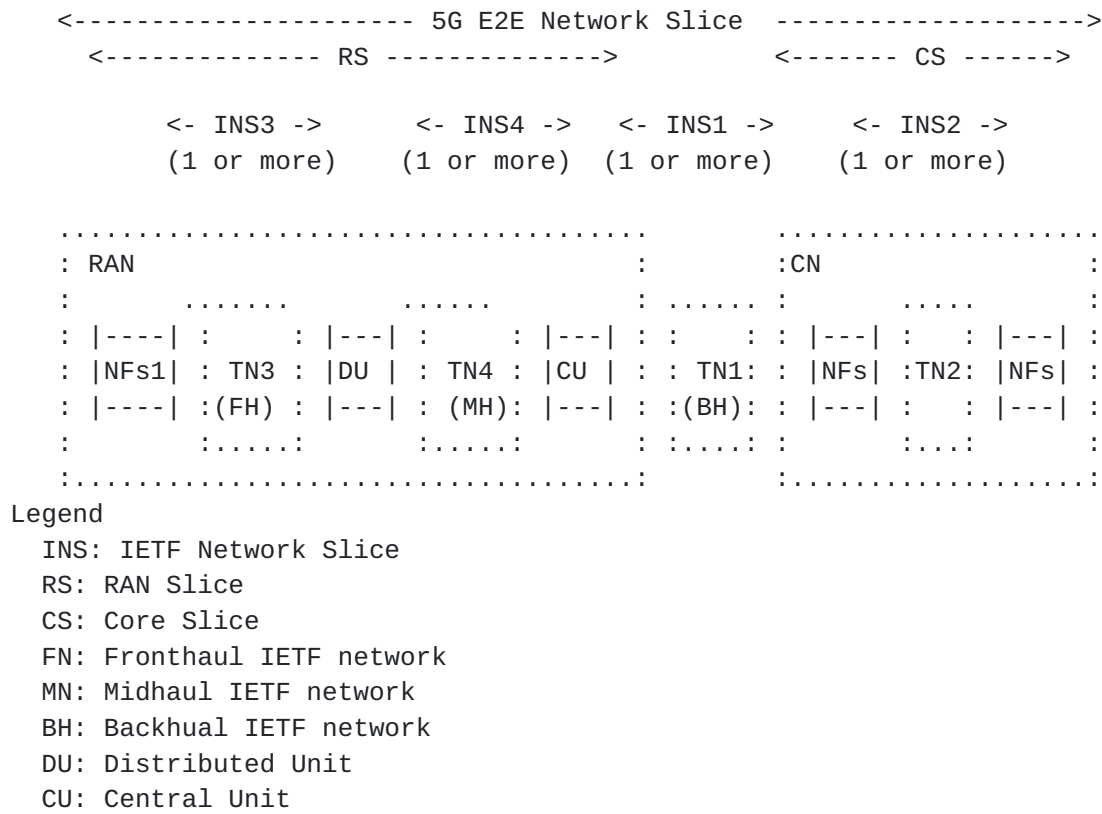


Figure 4: IETF network slices in cloud RAN deployment (C-RAN)

3.4. Relationship Between IETF Network Slices and 3GPP Network Slices

For the sake of illustration, the descriptions below all take the TN slice between RAN and CN as an example, and the other cases are similar. Figure 5 shows the correspondence between network entities in 5G slices and IETF slices respectively

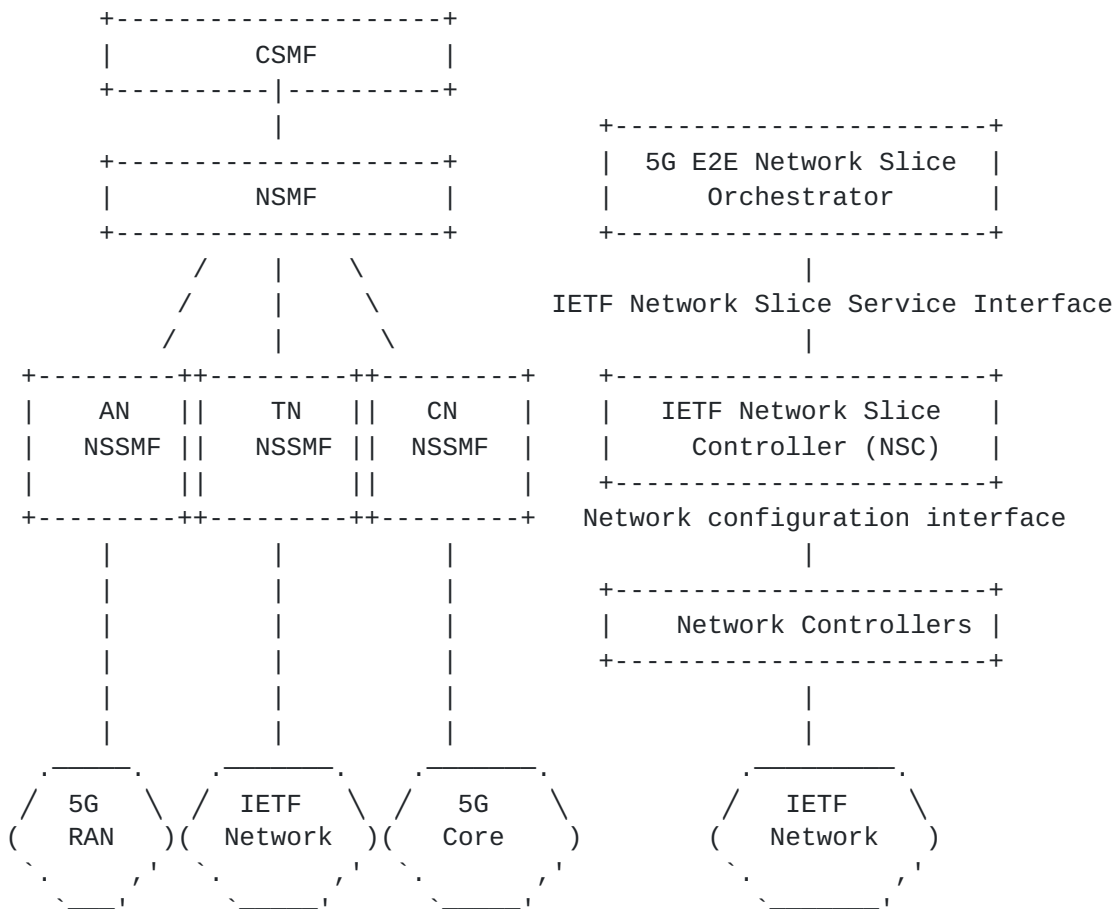


Figure 5: Relationship between 3GPP domain controllers and IETF Network Slice Controller

An example of 5G E2E Network Slice is shown in Figure 6. Each e2e network slice contains RAN slice, CN slice and one or more IETF network Slices. 3GPP identifies each e2e network slice using an integer called S-NSSAI. In Figure 6 there are three instances of e2e network slices which are identified by S-NSSAI 01111111, 02222222 and 02333333, respectively. Each instance of e2e network slice contains AN slice, CN Slice and one or more IETF network slices. For example, e2e network slice 01111111 has AN Slice instance 4, CN Slice instance 1 and IETF network slice 6. Note that 3GPP does not cover the IETF network slice. See [\[\[I-D.ietf-teas-ietf-network-slices\]\]](#) for details of IETF network slice.

Note that 3GPP uses the terms NSI and NSSI which are a set of network function and required resources (e.g. compute, storage and networking resources) which corresponds to network slice Instance, whereas S-NSSAI is an integer that identifies the e2e network slice.

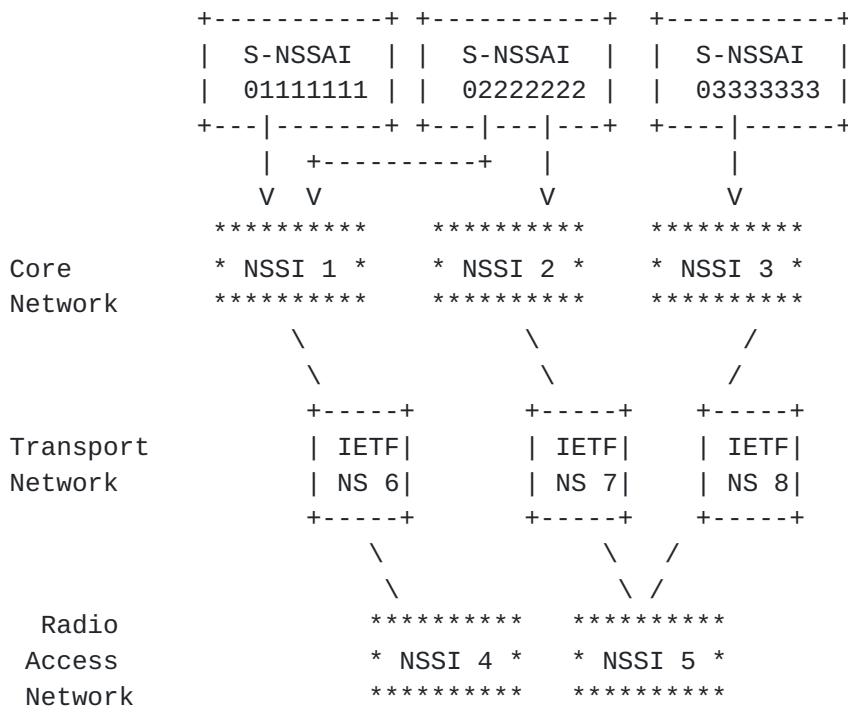


Figure 6: 5G End-to-End Network Slice and its components

The following network slice related identifiers in management plane, control plane and data(user) plane play an important role in end-to-end network slice mapping

- * Single Network Slice Selection Assistance Information (S-NSSAI): The end-to-end network slice identifier, which is defined in [\[TS-23.501\]](#); S-NSSAI is used during 3GPP network slice signalling process.
- * IETF Network Slice Identifier: An identifier allocated by IETF Network Slice Controller (NSC) in management plane. In data plane, IETF Network Slice Identifier may be instantiated with existing data plane identifiers and doesn't necessarily require new encapsulation.
- * IETF Network Slice Interworking Identifier: Data-plane network slice identifier which is used for mapping the end-to-end network slice traffic to specific IETF network slice. The IETF Network Slice Interworking Identifier is a new concept introduced by this draft, which may be instantiated with existing data plane identifiers and doesn't necessarily require new encapsulation.

*Note: the term "IETF Network Slice Interworking Identifier" is proposed but requires further discussion. The term "handoff" is used sometimes along the document with similar purpose. Alignment is needed. Todo by documents editors.

4. 5G E2E Network Slice Mapping Procedure

This section provides a general procedure of network slice mapping:

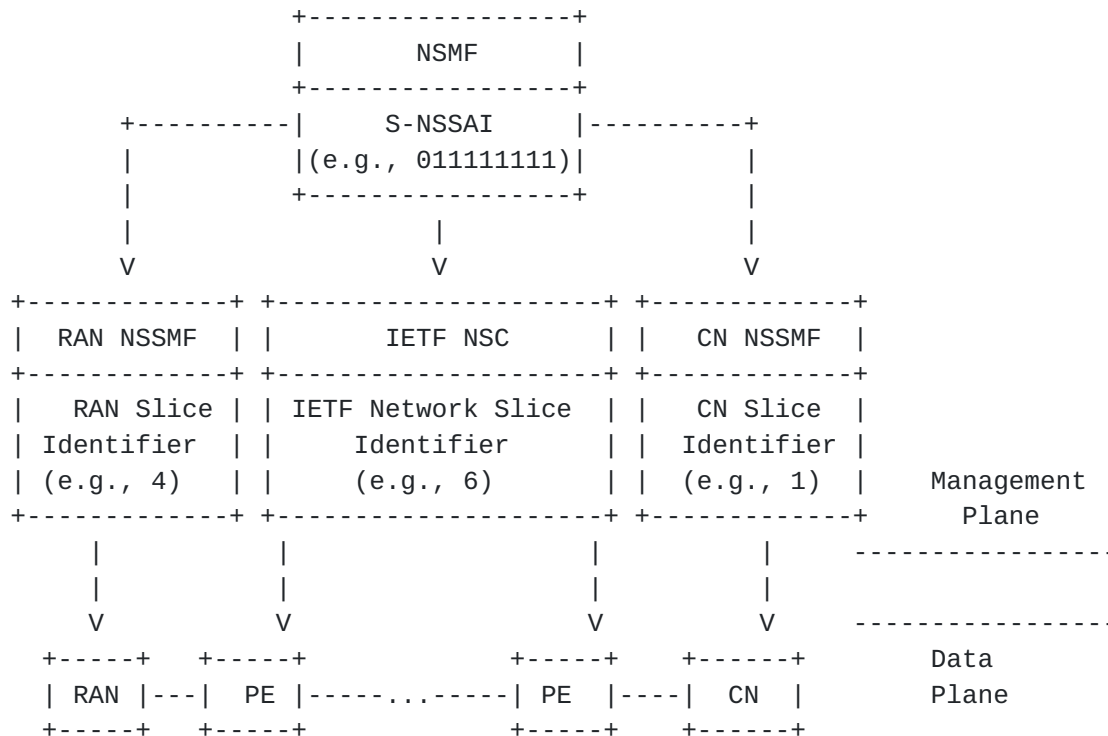


Figure 7: Relation between IETF and 3GPP Network Slice management

1. 3GPP NSMF receives the request from 3GPP CSMF for allocation of a network slice instance with certain characteristics.
2. Based on the service requirement, 3GPP NSMF acquires requirements for the end-to-end network slice instance, which is defined in Service Profile (section 6.3.3 of [TS-28.541]).
3. Based on Service Profile, 3GPP NSMF determines the network function and the required resources in AN, CN and TN networks. It also assigns the unique S-NSSAI ID.
4. 3GPP NSMF sends a request to AN NSSMF for creation of AN Slice, which is out of the scope of this document.

5. 3GPP NSMF sends a request to CN NSSMF for creation of CN Slice, which is out of the scope of this document.
6. 3GPP NSMF sends a request to an IETF NSC (acting as an NSSMF for transport network, from the perspective of the 3GPP Management System)) for creation of an RFC XXXX Network Slice Services. The request contains attributes such as endpoints (based on the information from EP_Transport IOC), required SLA along with other IETF network slice attributes. It also contains mapping information for IETF Network Slice Interworking Identifier.
7. The IETF NSC realizes the IETF Network Slice which satisfies the requirements of the RFC XXXX Network Slice Services requested between the specified endpoints (RAN/CN edge nodes). the IETF NSC might assign an IETF slice ID and send it to 3GPP NSMF.
8. The 3GPP NSMF could maintain the mapping relationship between S-NSSAI and RFC XXXX Network Slice Services ID.

5. 5G E2E Network Slice Mapping in Management and Control Planes

The transport network management Plane maintains the interface between 3GPP NSMF and TN NSSMF, which 1) in order to guarantees that IETF network slice could satisfy the requirements of connection between AN and CN, requirement parameters are necessary for ietf network slice northbound interface ; 2) builds up the mapping relationship between NSI identifier and RFC XXXX Network Slice Services ID.

Service Profile defined in [TS-28.541] represents the requirement of end-to-end network slice instance in 5G network. Parameters defined in Service Profile include Latency, resource sharing level, availability and so on. How to decompose the end-to-end requirement to the transport network requirement is one of the key issues in Network slice requirement mapping. GSMA (Global System for Mobile Communications Association) defines the [GST] to indicate the network slice requirement from the view of service provider.

[I-D.ietf-teas-ietf-network-slice-use-cases] analyzes the parameters of GST and categorize the parameters into three classes, including the attributes with direct impact on the IETF network slice definition. It is a good start for selecting the transport network relevant parameters in order to define Network Slice Profile for Transport Network. Network slice requirement parameters are also necessary for the definition of transport network northbound interface. NSMF delivers SLA/QoS related parameters and mapping related parameters to IETF NSC through the RFC XXXX Network Slice Services Interface.

3GPP TN NSSMF will request the RFC XXXX Network Slice Services adding in the RFC XXXX Network Slice Services request some slice identifier to the IETF NSC. The mapping relationship between NSI identifier and IETF Network Slice service identifier could be maintained in both 3GPP NSMF and IETF NSC.

Then, at the time of provisioning a 3GPP slice, it is required to provide slice connectivity constructs by means of IETF network slices. Then it is necessary to bind two different endpoints, as depicted in Figure 8:

- * Mapping of EP_Transport (as defined by [[TS-28.541](#)]) to the endpoint at the CE side of the IETF network slice. This is necessary because the IETF Network Slice Controller (NSC) will receive as input for the RFC XXXX Network Slice Services the set of endpoints at CE side to be interconnected
- * Mapping of the endpoints at both CE and PE side. The endpoint at PE side should be elicited by some means by the IETF NSC, in order to establish and set up the connectivity construct intended for the customer slice request, according to the SLOs and SLEs received from the higher level system.

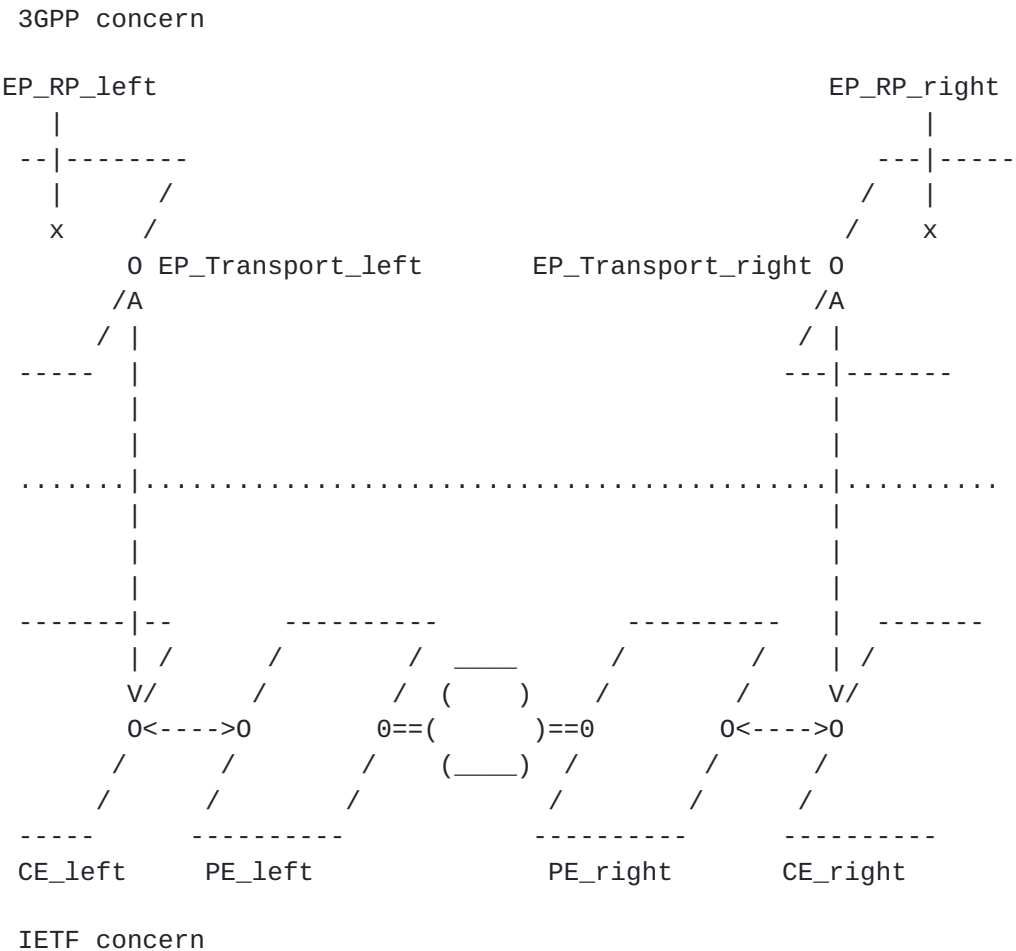


Figure 8: conceptual view on 3GPP and TN connectivity meeting points

The examples in [Section 7](#) will show how the endpoints at both 3GPP and IETF concerns can be bound.

5.1. Mapping EP_transport to IETF NS CE Endpoints

The 3GPP Management system provides the EP_Transport IOC to extend the slice awareness to the transport network. The EP_Transport IOC contains parameters as IP address, additional identifiers (i.e., vlan tag, MPLS label, etc), and associated QoS profile. This IOC is related to the endpoints of the 3GPP managed functions (detailed in the EP_Application IOC).

The information captured in the EP_Transport IOC (as part of the 3GPP concern) should be translated into the CE related parameters (as part of the IETF concern). There will be cases where such translation is straightforward, as for instance, when the 3GPP managed functions run on monolithic, purpose- specific network elements, in the way that the IP address attribute from the EP_Transport IOC directly

corresponds to the IP address of an interface of such network element. In this case, the information on EP_Transport IOC can be directly passed to the IETF NSC through the RFC XXXX Network Slice Services Interface, even though some additional information could be yet required, not being defined yet on 3GPP specifications (e.g., the mask applicable to the IP address field on EP_Transport). Note that information gaps are further detailed in a summary section at the end of this document.

However, there could be other cases where such a relationship is not straightforward. This could be the case of virtualized 3GPP managed functions that could be instantiated on a general-purpose bare-metal server or in a data center. In these other cases it is necessary to define additional means for eliciting the endpoint at the CE side corresponding to the endpoint of the 3GPP-related function.

With solely EP_Transport characterization in 3GPP (i.e., according to 3GPP Release 16 specifications), we could expect the NS CE endpoint being identified by a combination of IP address and some additional information such as vlan tag, MPLS label or SR SID that could discriminate against a certain logical interface. The next hop router information is related to the next hop view from the perspective of the 3GPP entity part of the slice, then providing hints for determining the slice endpoint at the other side of the slice boundary. Finally, the QoS profile, if present, helps to determine configurations needed at the PE side to respect the SLOs in the connection between CEs slice endpoints.

5.2. Mapping IETF NS CE to PE Endpoints

As described in [[I-D.ietf-teas-ietf-network-slices](#)], there are different potential endpoint positions for an IETF NS.

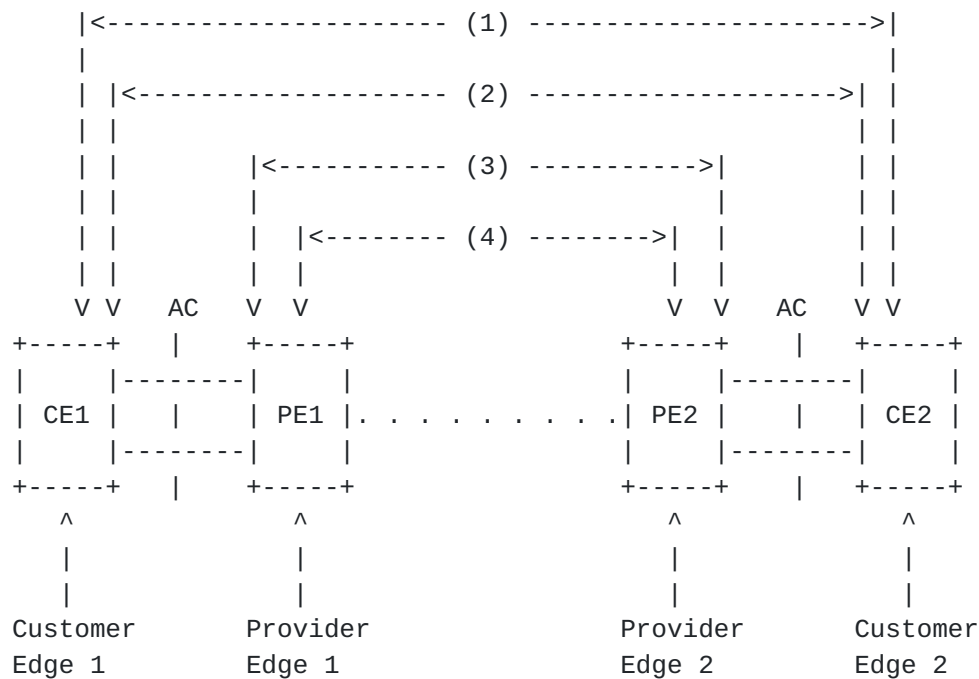


Figure 9: IETF Network Slice endpoints

The information that is passed to the IETF NSC in terms of endpoints is the information relative to the CE side, which is the one known by the slice customer (i.e., the 3GPP Management system, that corresponds to the 3GPP managed functions). From that information, the IETF NSC needs to infer the corresponding endpoint at the PE side, in order to setup the desired connectivity constructs with the SLOs indicated in the request.

Being the IETF slice request a technology-agnostic procedure, the identification of the slice endpoints at the PE side should leverage on generic information passed through the RFC XXXX Network Slice Services Interface to the IETF NSC.

5.3. 5G E2E Network Slice Mapping in Control Plane

There is no explicit interaction between transport network and AN/CN in the 3GPP control plane signalling, but the S-NSSAI defined in [TS-23.501] is treated as the end-to-end network slice identifier in the control plane of AN and CN, which is used in UE registration and PDU session setup. In this draft, it is assumed that there is a correspondence between S-NSSAI and the RFC XXXX Network Slice Services identifier in the management plane.

However, edge nodes between transport network and CN/AN may have IETF control plane protocol interactions, for example routing protocols.

ToDo: there is no direct relationship between 3GPP control plane signalling and IETF control plane. Add sentence on this respect to provide some description here (Xuesong).

Note: to ensure consistency with NBI YANG model (i.e., service tag)

6. 5G E2E Network Slice Mapping in Data Plane

If multiple 5G E2E network slices data flows are carried from one physical interface between AN/CN and TN, there should be a mechanism for provider edge (PE) nodes to distinguish between these flows in order to apply and to enforce the different SLO/SLE policy to each flow. In other words, a solution needed in order to define an IETF Network Slice Interworking in the data plane.

If different network slices are transported through different physical interfaces, 5G E2E network slices could be distinguished by the interface directly. However if all flows from different 5G network slice flows are transported through same interface, the PE nodes needs to be able to distinguish each flows.

6.1. Data Plane Mapping Considerations

The following picture shows the end-to-end network slice in data plane taking the IETF network slice between RAN and UPF as an example:

The mapping relationship between AN or CN network slice and an IETF Network Slice will be based on a IETF Network Slice Interworking identifier based on the information provided by the EP_Transport IOC. When the packet of an uplink flow goes from AN to TN, the packet is delivered according to the information provided by the EP_Transport IOC (e.g., the information provided in the logicalInterface field); then the encapsulation is read by the edge node of transport network, which maps the packet to the corresponding IETF network slice.

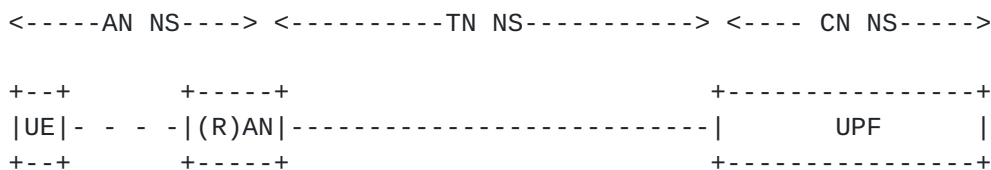


Figure 10: The mapping between 3GPP slice and transport slice

The mapping between 3GPP slice and transport slice in user plane could happens in: (R)AN: User data goes from (radio) access network to transport network

UPF: User data goes from core network functions to transport network

The following picture shows the user plane protocol stack in end-to-end 5G system.

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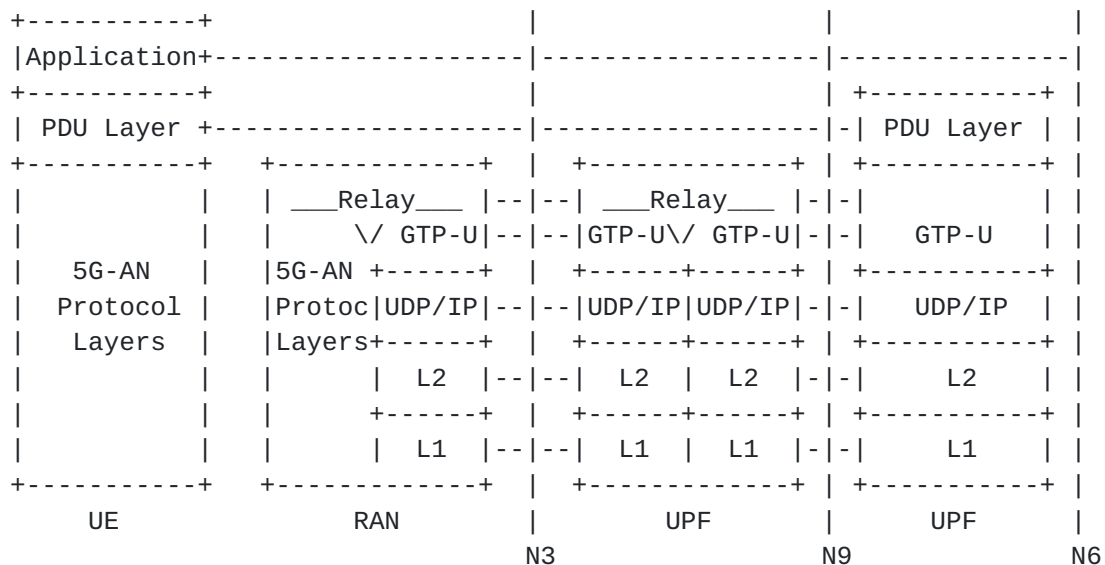


Figure 11: Packet encapsulation in UE/RAN/UPF

The following figure shows the typical encapsulation in N3 interface.

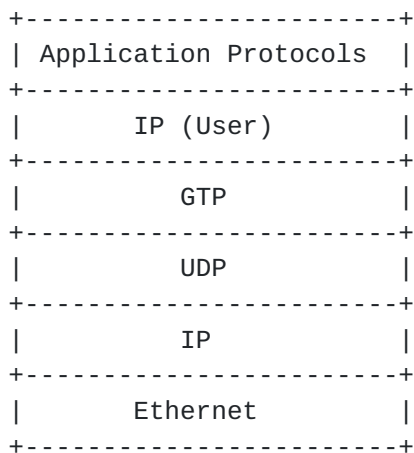


Figure 12: Typical packet encapsulation in N3 interface

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There are several options in the encapsulation that could be used in data plane of network slice mapping.

6.2. Methods for Mapping Between 3GPP E2E Network Slice and IETF Network Slice

Referring to Figure 2, Figure 3 and Figure 4, a 5G end-to-end network slice might have one or more IETF network slices. Figure 13 is a general representation of any of transport networks in 5G end-to-end network slice where the IETF network slice INS_a provides the connectivity between network functions NF1 and NF2 to satisfy the specific SLO/ SLE. For example, Figure 14 could represent IETF network slice INS1 of Figure 4 where connectivity needed between network functions CU and UPF or it could represent IETF network slice INS4 between network functions DU and CU.

Suppose the network function NF1 sends the traffic to NF2. The data plane mapping is mainly addresses how the identification of 3GPP network slice is conveyed and represented on data path, and how the provider network PE nodes map the traffic from context of 5G end-to-end network slice to the RFC XXXX Network Slice Services. It is crucial for PE nodes to be able to map the traffic to the appropriate IETF network slice so as to enforce the SLO/SLE policy.

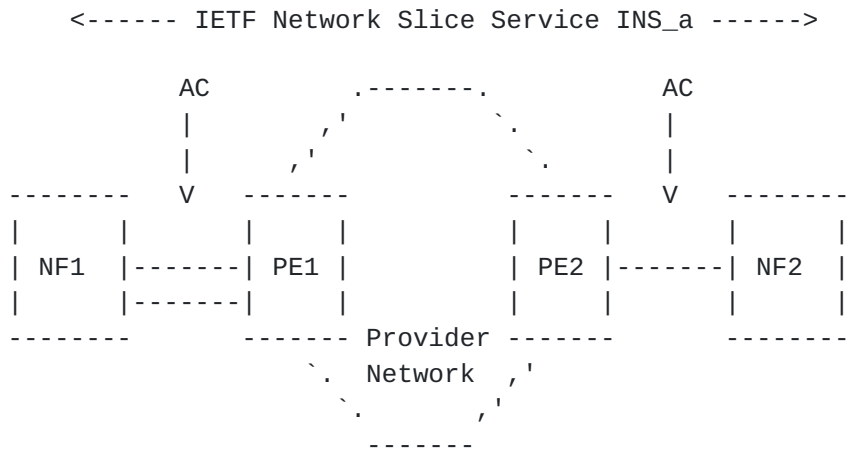
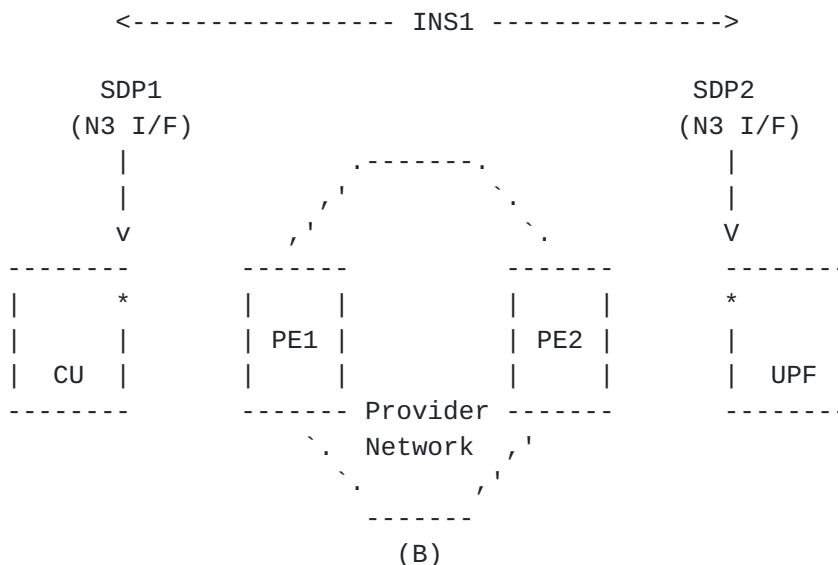
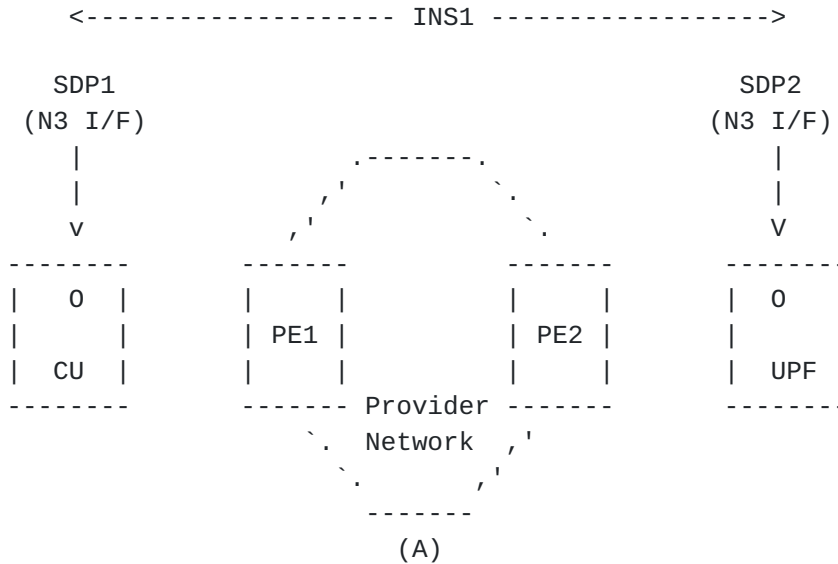


Figure 13: Typical IETF Network Slice in 3GPP Network

To provide an overview of various mechanisms of mapping 5G E2E network slice to IETF network slices, we focus on IETF network slice INS1 in Figure 4 where IETF network slice INS1 provides the connectivity between network functions CU and UPF. Figure 8 shows this scenario. Although the various mapping techniques considered in this section is for IETF network slice INS1, they are all applicable to other IETF network slices of Figure 2, Figure 3 and Figure 4, i.e., INS2, INS3 and INS4.

The IETF network slice INS1 provides the connectivity between service demarcation points SDP1 and SPD2. These SDPs are the N3 interfaces on CU and UPF, respectively. As shown in Figure 8(A) and Figure 8(B), the SDPs could be either loopback interfaces or a physical interfaces on CU and UPF network functions. For simplicity case (A) is considered in this section although the various mapping methods are identically applicable to both cases (A) and (B).



Legend:

- <---> IETF Network Slice Service between SDP1 and SDP2
- * SDP (N3 interface as CU IP interface)
- 0 SDP (N3 as CU loopback interface)

Figure 14: Representation of a Typical IETF Network Slice in 3GPP Network

Various techniques can be used to map the IETF network slice to 5G E2E network slice. The section covers the following techniques which can be used for mapping between 5G E2E network slice and RFC XXXX Network Slice Servicess. Note that these techniques might also be used by IETF network slice controller (NSC) to influence the realization of the IETF network slice services as well. The latter case is out of scope of the current draft:

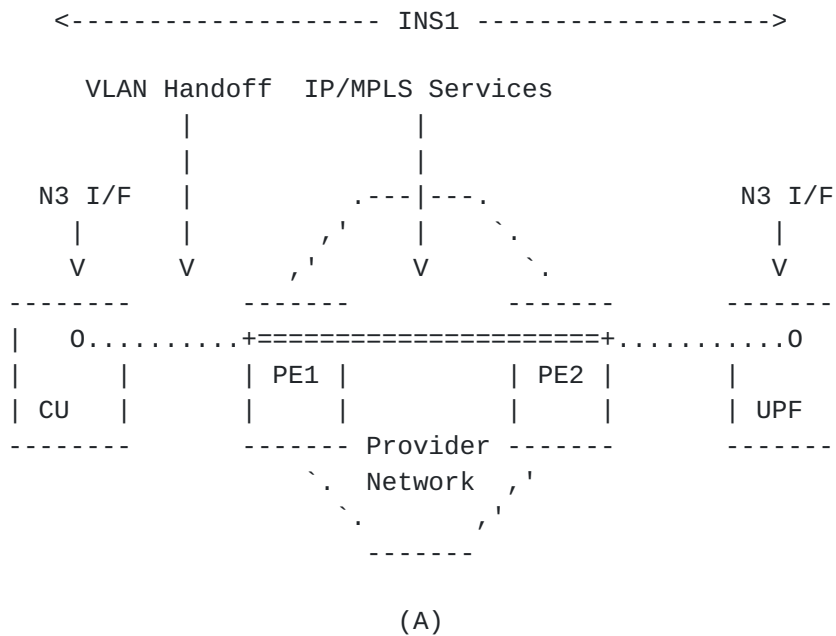
- * Mapping based on VLAN
- * Mapping based on MPLS label or SR-MPLS SID
- * Mapping based on SRv6 SID
- * Mapping based on Policy Based Routing (PBR)
- * Mapping based on UDP source port

It should be noted that the first three mapping mechanisms are briefly mentioned in [\[TS-28.541\]](#).

[6.2.1](#). Mapping based on VLAN ID

In some scenarios, it would be possible for provider edge (PE) nodes to infer the identification of the 5G E2E network slices from the VLAN ID carried in the data path traffic, and map the traffic to the corresponding IETF network slice. As shown in Figure 9, the IETF Network slice INS1 between network functions CU and UPF can be mapped using the VLAN ID. In this scenario, the VLANs assigned by network functions CU and UPF are used for the handoff to the provider network.

Refer to section 4.1 of [\[draft-srld-teas-5g-slicing\]](#) for details of this solution and how it is realized by provider network.



Legend:

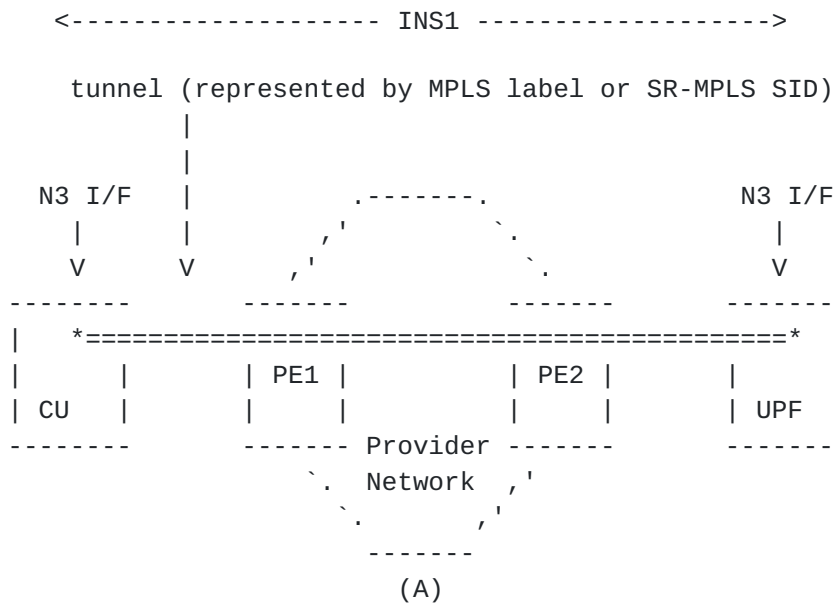
- 0 SDP (N3 interface)
- + Access points to provider network
- ... VLAN hand-off
- === IP/MPLS transport service in provider network (i.e., realization of INS1)

Figure 15: VLAN hand-off based for IETF Network Slice Realization

6.2.2. Mapping based on MPLS Label or SR-MPLS SID

This section describes another solution for mapping the 5G E2E network slice traffic to IETF network slices based on MPLS/SR-MPLS labels/SIDs. The labels/SIDs carried in the packets sent from CU to UPF can be used by the provider edge (PE) nodes to infer the identification of the 5G E2E network slices and map the packet to the corresponding IETF network slice. Figure 10 shows an example where the 5G E2E network slice is mapped to IETF network slice INS1 using the MPLS label or SR-MPLS SID. In this case, the MPLS label or SR-MPLS SID is used for the handoff to the provider network.

Refer to section 4.3 of [[draft-srld-teas-5g-slicing](#)] for details of this solution and how it is realized by provider network.



Legend:

* SDP1 and SPD2 (N3 Address)

=== tunnel between SDP1 and SDP2 (MPLS or SR-MPLS)

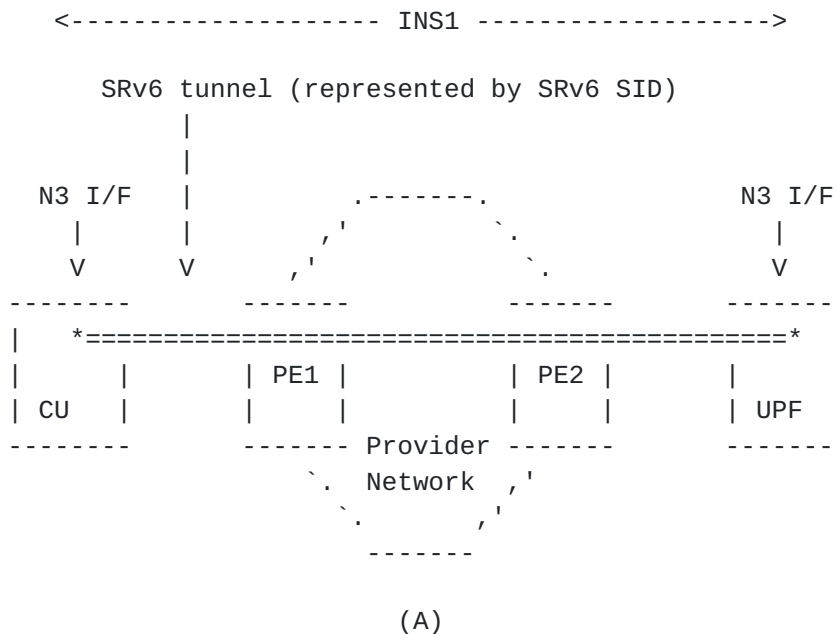
Figure 16: MPLS label or SR-MPLS SID based IETF Network Slice Mapping

6.2.3. Mapping based on SRv6 SID

This section describes a solution for mapping the 5G E2E network slice traffic to IETF network slices based on SRv6 SIDs. This solution is similar to the mapping based on MPLS label or SR-MPLS SID but using SRv6 tunnels. As shown in Figure 11, the SRv6 SIDs is added by CU or UPF to the data path traffic between SDP1 and SPD2. The SRv6 SIDs can be used by the provider edge (PE) nodes to infer the identification of the 5G E2E network slices and map the traffic to the corresponding IETF network slice.

In this solution, the identification of the 5G E2E network slice may be embedded into IPv6 SIDs, where the 32-bit 3GPP network slice identification is mapped into the 128-bit IPv6 SID, thus the SRv6 SID is used for the handoff to the provider network.

Refer to section 4.2 of [[draft-srld-teas-5g-slicing](#)] for details of this solution and how it is realized by provider network.



Legend:

- * SDP1 and SPD2 (N3 address)
- === SRv6 tunnel between SDP1 and SDP2

Figure 17: SRv6 hand-off based for IETF Network Slice Mapping

6.2.4. Mapping based on Policy Based Routing (PBR)

This section provides a solution for mapping the 3GPP E2E network slice traffic to IETF network slices. As shown in Figure 12, in some deployments of the 5G network slices, it would be possible for provider edge (PE) nodes to infer the identification of the 3GPP E2E network slice from the content of the IP data packet sent between CU and UPF. In these cases, the PE nodes can identify the 5G E2E network slice using any combination of the following attributes and then map them to RFC XXXX Network Slice Services:

- * Source N3 IP address
- * Destination N3 IP address
- * Ingress interface
- * DSCP
- * Other information in the packet (at IP/MPLS layer or upper layers such as UDP/TCP)

Once the PE nodes receives the IP packets, it may apply infer the conetext of the 5G E2E netweork slice and then apply a policy- based routing (PBR) to the packet to map the traffic of specific 5G E2E network slice to the corresponding IETF network slices in the provider network. The details of this solution is beyond scope of this draft.

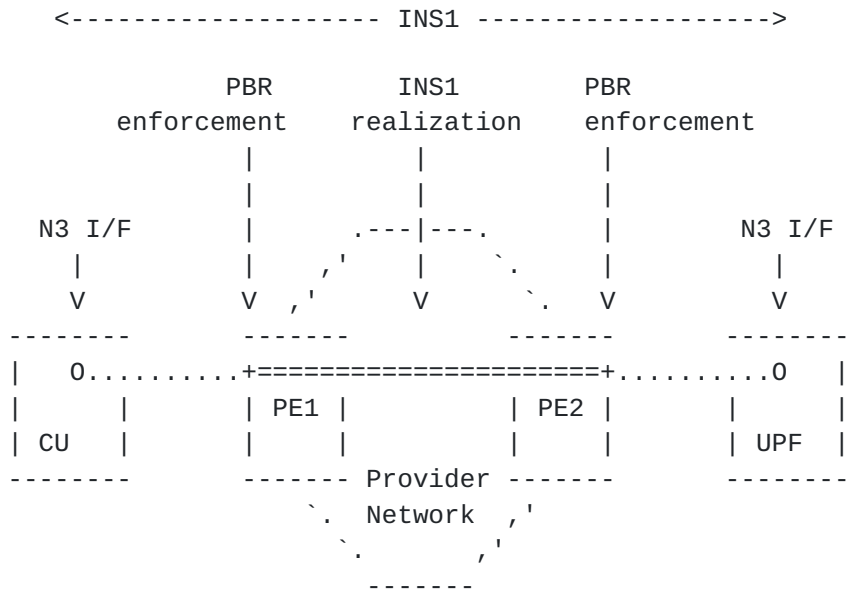
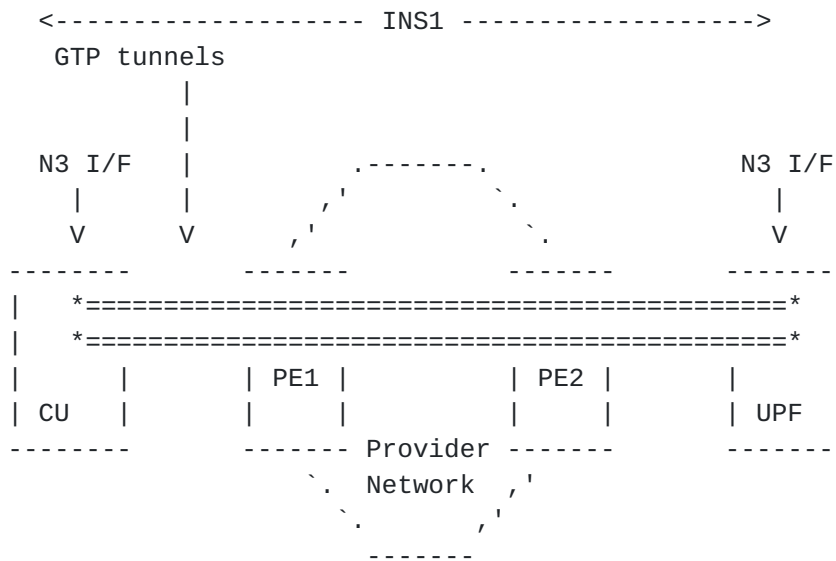


Figure 18: Policy Based Routing (PBR) based IETF Network Slice Mapping

6.2.5. Mapping based on UDP Source Port

This section provides another solution for mapping the 5G E2E network slice traffic to IETF network slices. In some deployments of the 5G E2E network slices, it might be possible for PE nodes to infer the identification of the 3GPP E2E network slice based on the information of the GTP tunnels. As shown in Figure 19, the source UDP port of the data packet may be used to infer the identification of 5G E2E network slices. In this case, a mapping table between the identification of 5G network slice and the source UDP port needs to be maintained by network functions CU, UPF and the PE nodes.

The details of this solution is described in [\[draft-ietf-dmm-tn-aware-mobility\]](#).



Legend:

* SDP (N3 address)

=== GTP tunnels in context of IETF network slice INS1

Figure 19: UDP source port solution for IETF Network Slice Mapping

7. IETF Network Slice request through IETF Network Slice NBI

As discussed in [[I-D.ietf-teas-ietf-network-slices](#)], to fulfil IETF network slices and to perform monitoring on them, an entity called IETF Network Slice Controller (NSC) is required to take abstract requests for IETF network slices and realize them using suitable underlying technologies. An IETF Network Slice Controller is the key building block for control and management of the IETF network slice. It provides the creation/modification/deletion, monitoring and optimization of transport Slices in a multi-domain, a multi-technology and multi-vendor environment.

Figure 20 shows the NSC and its NBI interface for 5G. Draft [[I-D.ietf-teas-ietf-network-slice-nbi-yang](#)] addresses the service yang model of the NSC NBI interface for all network slicing use-cases.

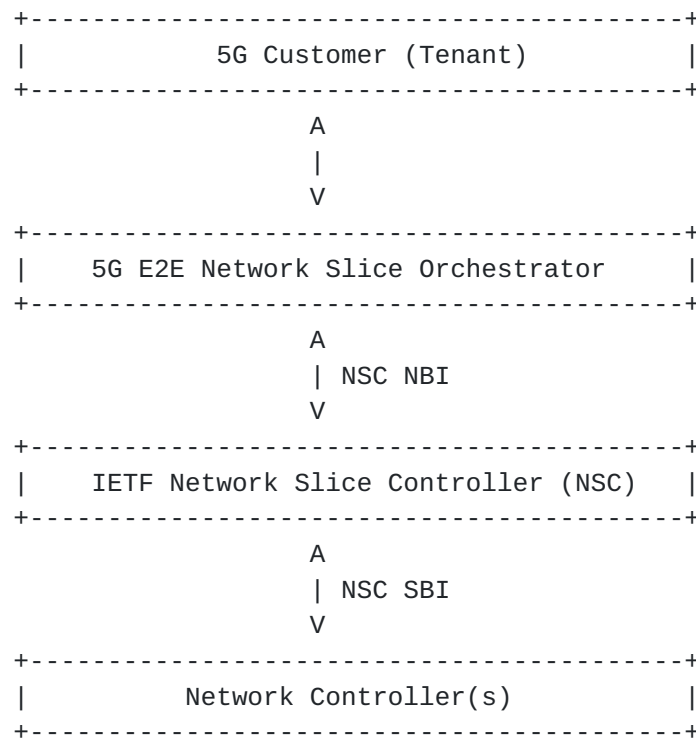


Figure 20: IETF Network Slice Controller NBI for 5G

As discussed in [[I-D.ietf-teas-ietf-network-slices](#)], the main task of the IETF Network Slice Controller is to map abstract IETF network slice requirements from NBI to concrete technologies on SBI and establish the required connectivity, and ensure that required resources are allocated to IETF network slice. There are a number of different technologies that can be used on SBI including physical connections, MPLS, TSN, Flex-E, PON etc. If the underlay technology is IP/MPLS/Optics, any IETF models can be used during the realization of IETF network slice.

There are no specific mapping requirements for 5G. The only difference is that in case of 5G, the NBI interface contains additional 5G specific attributes such as customer name, mobile service type, 5G E2E network slice ID (i.e. S-NSSAI) and so on (See [Section 6](#)). These 5G specific attributes can be employed by IETF Network Slice Controller during the realization of 5G IETF network slices on how to map NBI to SBI. They can also be used for assurance of 5G IETF network slices. Figure 9 shows the mapping between NBI to SBI for 5G IETF network slices.

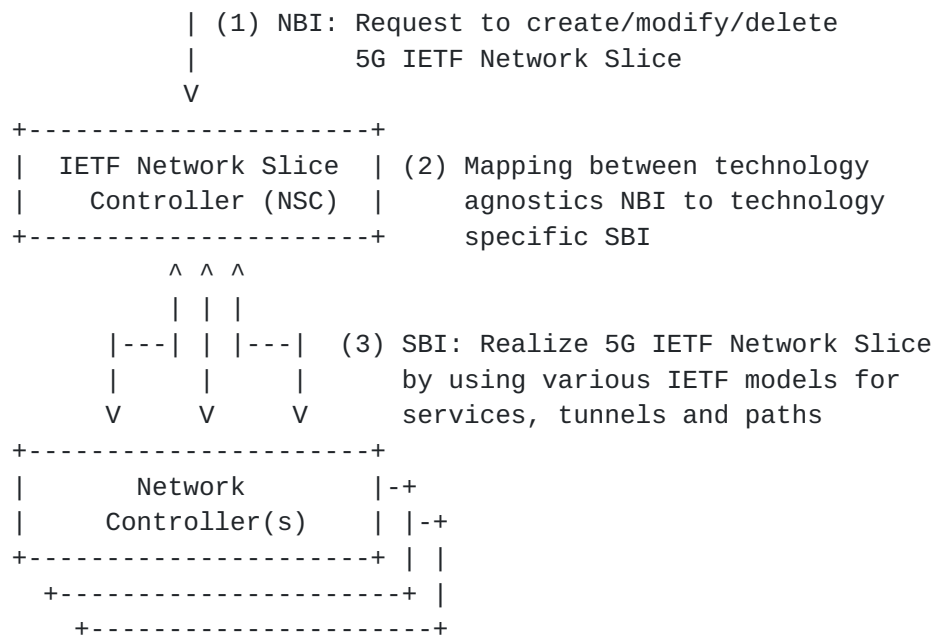


Figure 9: Relationship between transport slice interface and IETF Service/Tunnels/Path data models

The following figure illustrates the relationship between 3GPP or ORAN subsystems connected through IETF TN domain. After the analysis of 3GPP Generic Network Resource Models (NRM) of [TS-28.540] Rel 17, [TS-28.541] Rel 17 and [TS-28.622] Rel 16 the following objects have been identified as entities on which the decision of mapping to IETF TN slices can be made. These available delineators of network slices, represented by the arrows in the figure, are accessible in IETF domain and possible to be treated as triggers for decision of mapping 3GPP slice to IETF TN slice.

Option (1) - the object class of 3GPP/ORAN subsystem is EP_Transport, [TS-28.541] clause 6.3.18, representing a list of attributes including IETF-related parameters, directly exposed to transport network domain: * ipAddress - an IP address assigned on the 3GPP/ORAN subsystem side of the link to TN. * logicInterfaceType and logicInterfaceId - in current release it is an ID of the VLAN and encapsulation type is 802.1Q

These parameters can program the slice separation and be mapped to an IETF slice.

By instantiating EP_Transport per slice on 3GPP/ORAN subsystem the slicing may be implemented and mapped on slices in IETF TN domain. In this case EP_Transport parameters may be mapped to [draft-ietf-teas-ietf-network-slice-nbi-yang](#) data model objects. This option is described in the following example in [section 7.1](#) of current document.

Option (2) - the object class is EP_RP ([[TS-28.622](#)] clause 4.3.11), EP_F1U ([[TS-28.541](#)] clause 4.3.13), EP_NgU ([[TS-28.541](#)] clause 4.3.11), EP_N3 ([[TS-28.541](#)] clause 5.3.20), representing the 3GPP link and association between 3GPP/ORAN subsystems. These attributes are not exposed directly to IETF TN domain and can be treated as loopbacks behind the link, defined in EP_Transport object class. Instantiation and manipulation of EP_RPs per slice may be mapped on slices in IETF TN domain, while link defined by parameters of EP_Transport may remain the same. This delineation by loopbacks is adding secondary axis of flexibility to network slicing and needs to be mapped to [draft-ietf-teas-ietf-network-slice-nbi-yang](#) data model with different logic that delineation in option (1).

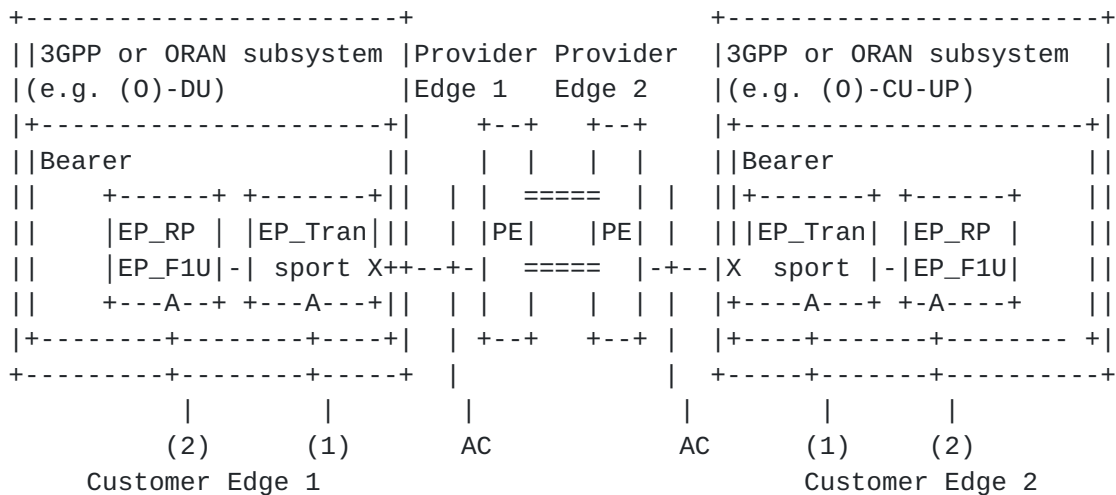


Figure 10: Slice mapping options analysis based on 3GPP NRM

These basic options represent possible implementation options of objects and parameters Operator may use to instantiate slices and correlate them with network slices in IETF TN domain to ensure SLA and SLO per slice.

Since 3GPP Generic Network Resource Models are not limiting use of these object classes and not mandating roles and mapping procedures, any combination of (1), (2) and (3) may be implemented in real slicing scenario.

(Editorial note: Summarize gaps in one single section at the end)

(1) The use of slicing based on EP_Transport instantiation may be favorable due to direct exposure of connectivity parameters to IETF TN domain. However, there are currently gaps in the NRM that may affect this option:

- * The NRM Rel. 17 lacks definitions and object class structures for DC or DC-fabric implementations of RAN or CN instances.
- * The attribute in EP_Transport qosProfile has no relation to clauses 5.3.84 QoSData and 5.3.79 FiveQiDscpMapping and cannot be extracted or mapped to SLO/SLE constructs as the information is not available in the IETF domain.
- * The destination of the traffic may potentially be extracted from EP_RP ([[TS-28.622](#)] clause 4.3.11), but this information is not accessible in the IETF domain, so it cannot be extracted or mapped to communication type and connectivity constructs.
- * Redundancy of EP_Transports is an open topic for failover and protection mechanisms

(2) The option of using a common EP_Transport and multiple EP_RP with unique IP addresses may be suitable for DC and DC-Fabric implementations where EP_Transport establishes connectivity to the IETF TN domain and EP_RPs serve as virtual instance loopbacks. However, the lack of direct exposure of IP addresses and slice demand parameters in the IETF domain may make this slicing option challenging to implement. Currently, the following gaps have been identified:

- * EP_Transport object class does not define a mechanism for active communication of EP_RP loopbacks to the IETF ingress PE device (e.g., no PE-CE protocols)
- * Redundancy for EP_Transports is still an open topic for failover and protection mechanisms, with the added complexity of EP_RP loopback switchover
- * Pre-installed policies in the IETF TN domain for pre-defined EP_RP loopbacks may result in network overprovisioning (e.g., PBR, policies, service-match-criteria)
- * The absence of a common toolset for monitoring the existence and activity of EP_RP loopbacks may hinder root cause analysis and troubleshooting.

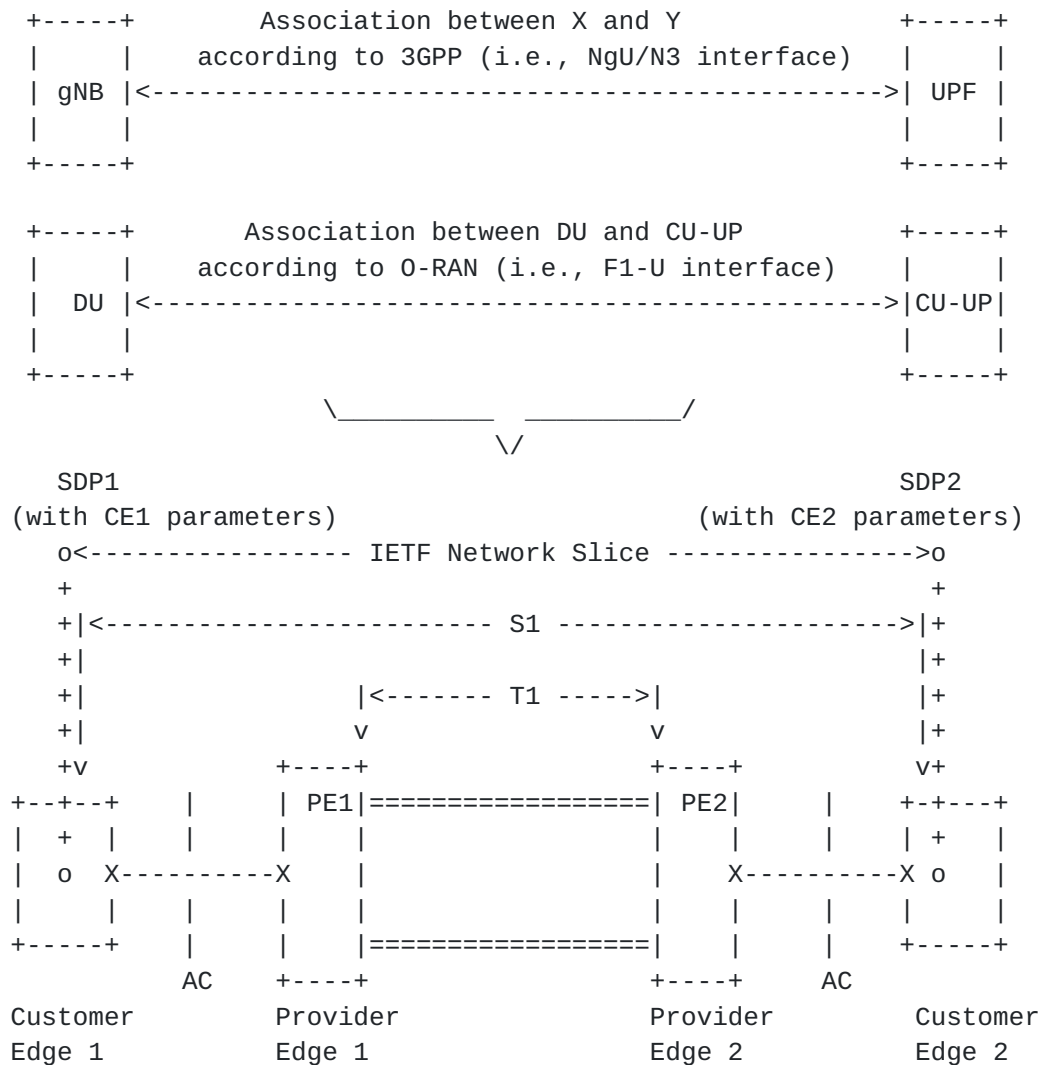
Following sub-sections present several examples for illustrating the mapping of 3GPP objects to IETF NBI YANG model.

Editorial note: further examples will be added in future versions of this document.

7.1. Example according to CE-mode (OPTION 1)

This example considers the request of a slice for realizing the F1-U [3GPP [\[TS-38.470\]](#) interface between a DU and a CU-UP elements (i.e., INS4 in previous Figure 4). Note that the example is equally valid for the realization of any other case.

The example follows the CE-mode as described in Figure 11.



Legend:

0: Representation of the IETF network slice endpoints (SDP) -

loopback interface in this example

+: Mapping of SDP to CE

X: Physical interfaces used for realization of IETF network slice

S1: L0/L1/L2/L3 services used for realization of IETF network slice

T1: Tunnels used for realization of IETF network slice

Figure 21: CE-mode slice realization example between DU and CU-UP -
OPTION 1

The 3GPP Management System is expected to handle different IOCs for both DU and CU-UP. For each of those 3GPP network entities, one of the IOCs is the EP_RP, which describes each of the end-points in the association between 3GPP core entities, and the other IOC is the EP_Transport, which provides information attributes about the point

of attachment of each 3GPP core entity to the transport network. Both objects are cross-referenced, so it is possible to get the information of one of them from the other.

Figure 12 shows the information provided at the DU side corresponding to the intended association with the CU-UP at the other end.

+-----+			
	EP_F1U CU-UP1		<---+
+-----+			
	Parameter	Value	
+-----+			
	localAddress	1.1.1.2	
+-----+			
	remoteipaddress	100.1.1.2	
+-----+			
	epTransportRef	EP_Transport 100	
+-----+			
	A		
	V		
+-----+			
	EP_Transport 100		
+-----+			
	Parameter	Value	
+-----+			
	ipAddress	1.1.1.1	
+-----+			
	logicInterfaceType	vlan	
+-----+			
	logicInterfaceId	100	
+-----+			
	NextHopInfo	1.1.1.254	
+-----+			
	qosProfile	5QI100	
+-----+			
	epApplicationRef	EP_F1U CU-UP1	<---+
+-----+			

Figure 22: 3GPP IOCs at DU side for the DU1 - CU-UP1 connection

Similarly, at CU-UP side the following objects are provided for setting up the network slice service towards DU, as represented in Figure 13.

+-----+			
EP_F1U DU1 <---+			
+-----+			
Parameter	Value		
+-----+			
localAddress	100.1.1.2		
+-----+			
remoteipaddress	1.1.1.2		
+-----+			
epTransportRef	EP_Transport 100		
+-----+			
A			
V			
+-----+			
EP_Transport 100			
+-----+			
Parameter	Value		
+-----+			
ipAddress	100.1.1.1		
+-----+			
logicInterfaceType	vlan		
+-----+			
logicInterfaceId	100		
+-----+			
NextHopInfo	100.1.1.254		
+-----+			
qosProfile	5QI100		
+-----+			
epApplicationRef	EP_F1U DU1	<---+	
+-----+			

Figure 23: 3GPP IOCs at CU-UP side for the DU1 – CU-UP1 connection

This is the basic information from where deriving the set of parameters feeding the NS NBI model.

According to this example, the following mapping could be performed.

- * SDPs: the SDPs in this example correspond to the IP addresses of the 3GPP core entities, thus 1.1.1.2 at the DU1 side and 100.1.1.2 at the CU-UP1 side, both contained in the EP_RP object.
- * SLO / SLE policy: the SLO policy can be derived from the QoS profile indicated in the EP_Transport object. SLE information are not directly expressed in 3GPP IOCs, then, if needed, SLE information should be complemented by other means (e.g., the 3GPP

Slice Profile could provide indication of high reliability which could be translated to SLE values in the NBI YANG model internally to the NSC).

- * Peer SAP: the Next Hop info parameter in EP_Transport object can provide information about the SAP at the PE side, based on the IP address provided.
- * AC: the conjugation of the IP address in the EP_Transport object, plus the information of the logical interface type and its identifier also in EP_Transport, can assist on determining the specific AC used for the network slice.

The resulting mapping is summarized in Figure 14.

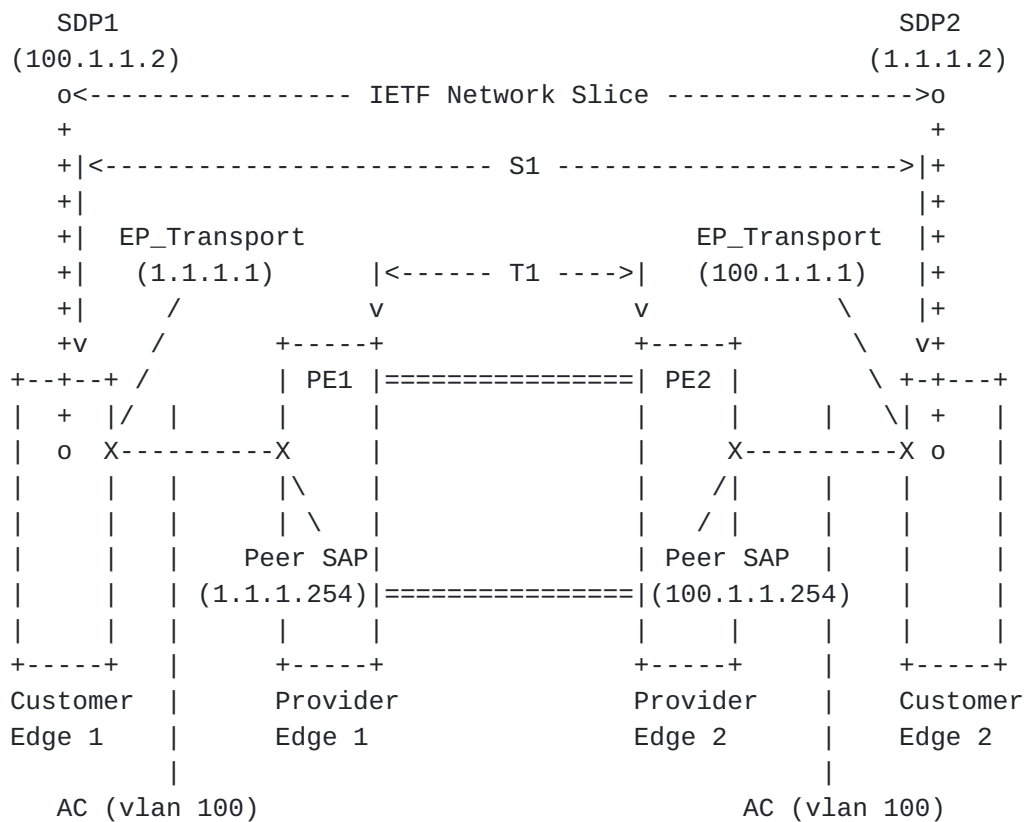


Figure 24: CE-mode slice realization example between DU and CU-UP with values

Further parameters can be filled in the NS NBI YANG model from the information provided. For instance, since there is one single pair of EP_Transport objects, one on each end of the intended slice service, the connectivity construct can be requested as p2p. Since the ranges of IP address of both DU1 and CU-UP1 could pertain to different block of prefixes, the NSC can take the decision of

realizing the network slice as a routed service. Here is important to remark that the IOCs from 3GPP do not provide any information regarding the mask applied to each prefix, so this can produce inconsistencies in the interpretation of the information received. Clearly this is a gap necessary to be solved.

In addition to that, the logical interface type and its identifier can be used as match criteria for mapping traffic between DU1 and CU-UP1 on the intended slice service.

As such, the NBI YANG model can result in something like:

```
{
  "data": {
    "ietf-network-slice-service:network-slice-services": {
      "slo-sle-templates": {
        "slo-sle-template": [
          {
            "id": "5QI100", /* QoS profile as in EP_Transport*/
            "template-description": "5QI100 description"
          },
        ]
      },
      "slice-service": [
        {
          "service-id": "5GSliceMapping",
          "service-description": "example 5G Slice mapping",
          "slo-sle-template": "5QI100",
          "status": {
          },
          "sdps": {
            "sdp": [
              {
                "sdp-id": "01",
                "node-id": "DU1",
                "sdp-ip": "1.1.1.2",
                "service-match-criteria": {
                  "match-criterion": [
                    {
                      "index": 1,
                      "match-type": "vlan-match",
                      "target-connection-group-id": "DU-CU"
                    }
                  ]
                }
              }
            ]
          },
          "attachment-circuits": {
            "attachment-circuit": [
              {
            
```



```

        "ac-id": "100",
        "ac-ip-address": "1.1.1.1",
        "ac-ip-prefix-length": "?",
        "peer-sap-id": "1.1.1.254"
      }
    ]
  },
  "status": {
  }
},
{
  "sdp-id": "02",
  "node-id": "CU-UP1",
  "sdp-ip": "100.1.1.2",
  "service-match-criteria": {
    "match-criterion": [
      {
        "index": 1,
        "match-type": "vlan-match",
        "target-connection-group-id": "DU-CU",
        "target-connectivity-construct-id": 1
      }
    ]
  },
  "attachment-circuits": {
    "attachment-circuit": [
      {
        "ac-id": "100",
        "ac-ip-address": "100.1.1.1",
        "ac-ip-prefix-length": "?",
        "peer-sap-id": "100.1.1.254"
      }
    ],
    "status": {
    }
  },
  "connection-groups": {
    "connection-group": [
      {
        "connection-group-id": "DU-CU",
        "connectivity-type": "ietf-vpn-common:any-to-any",
        "connectivity-construct": [
          {
            "cc-id": 1,
            "a2a-sdp": [

```

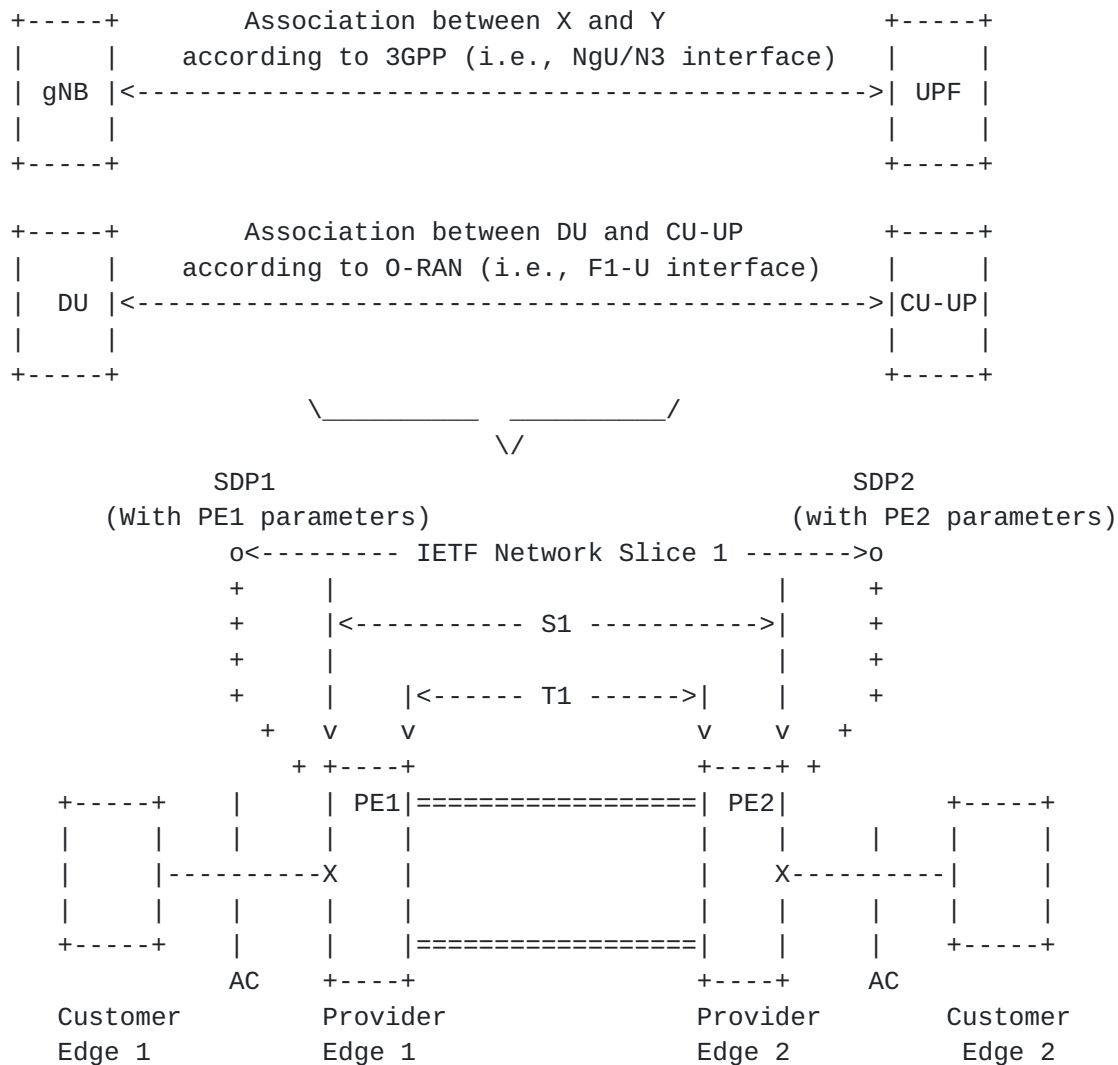


```
{
    {
        "sdp-id": "01"
    },
    {
        "sdp-id": "02"
    },
]
}
]
```

7.2. Example according to PE-mode (OPTION 2)

This example considers the request of a slice for realizing the F1-U [TS-38.470] interface between a DU and a CU-UP elements (i.e., INS4 in previous Figure 4). Note that the example is equally valid for the realization of any other case.

The example follows the PE-mode as described in Figure 15.



Legend:

- o: Representation of the IETF network slice endpoints (SDP)
- +: Mapping of SDP to customer-facing ports on the PE
- X: Physical interfaces used for realization of IETF network slice service
- S1: L0/L1/L2/L3 services used for realization of IETF network slice service
- T1: Tunnels used for realization of IETF network slice service

Figure 25: PE-mode slice realization - OPTION 2

The resulting mapping is summarized in Figure 16.

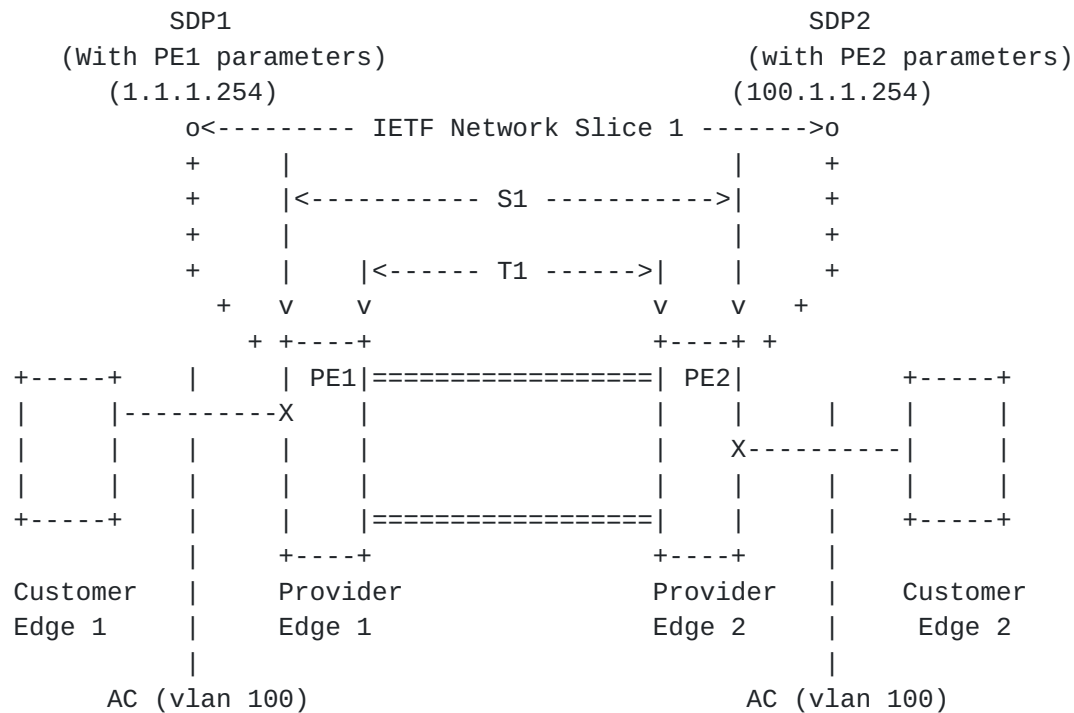


Figure 26: PE-mode slice realization - OPTION 2

From NBI YANG: "The IETF network slice controller (NSC) uses 'node-id' (PE device ID), 'attachment circuit' (ACs) to map SDPs to the customer-facing ports on the PEs"

Gap: no info received in regards PE device ID. However we can retrieve the PE port IP address from NextHopInfo parameter, as sdp-ip

```
{
  "data": {
    "ietf-network-slice-service:network-slice-services": {
      "slo-sle-templates": {
        "slo-sle-template": [
          {
            "id": "5QI100", /* QoS profile as in EP_Transport*/
            "template-description": "5QI100 description"
          }
        ]
      },
      "slice-service": [
        {
          "service-id": "5GSliceMapping-PE-mode",
          "service-description": "example 5G Slice mapping
following PE mode",
          "slo-sle-template": "5QI100", /* QoS profile as
in EP_Transport*/

```



```

    "status": {
    },
    "sdps": {
      "sdp": [
        {
          "sdp-id": "01",
          "node-id": "PE1",
          "sdp-ip": "1.1.1.254", /* NextHopInfo IP
address in EP_Transport */
          "service-match-criteria": {
            "match-criterion": [
              {
                "index": 1,
                "match-type": "vlan-match", /*logicInterfaceType*/
                "target-connection-group-id": "DU-CU"
              }
            ]
          },
          "attachment-circuits": {
            "attachment-circuit": [
              {
                "ac-id": "100", /*logicInterfaceId*/
                "ac-ip-address": "1.1.1.254", /* Next
HopInfo IP address in EP_Transport, redundant, can be removed */
                "ac-ip-prefix-length": ?, /* not available */
                "peer-sap-id": "1.1.1.254"
              }
            ]
          },
          "status": {
          }
        },
        {
          "sdp-id": "02",
          "node-id": "PE2",
          "sdp-ip": "100.1.1.254", /* NextHopInfo IP address
in EP_Transport */
          "service-match-criteria": {
            "match-criterion": [
              {
                "index": 1,
                "match-type": "vlan-match", /*logicInterfaceType*/
                "target-connection-group-id": "DU-CU",
                "target-connectivity-construct-id": 1
              }
            ]
          },
          "attachment-circuits": {

```



```
"attachment-circuit": [
    {
        "ac-id": "100", /*logicInterfaceId*/
        "ac-ip-address": "100.1.1.254", /* NextHopInfo
IP address in EP_Transport, redundant, can be removed */
        "ac-ip-prefix-length": ?, /* not available */
        "peer-sap-id": "100.1.1.254"
    },
]
},
"status": {
}
},
]
},
"connection-groups": {
    "connection-group": [
        {
            "connection-group-id": "DU-CU",
            "connectivity-type": "ietf-vpn-common:any-to-any",
** Note: there is a hint from NRM on {{TS-28.541}} Clause 4.3.11, 4.3.13,
5.3.20 relationship between 3GPP elements on the logical link connection with
attributes localAddress and remoteAddress. This information may be correlated
with the connectivity and analyzed to make a decision on the connectivity
type.**
            "connectivity-construct": [
                {
                    "cc-id": 1,
                    "a2a-sdp": [
                        {
                            "sdp-id": "01"
                        },
                        {
                            "sdp-id": "02"
                        }
                    ]
                }
            ]
        }
    ]
}
}
```


7.3. Example According to PE-mode with Meeting Point Extension of ACaaS (OPTION 3)

This example is based on the Option 2 when SDP is located on the PE and utilizing the same approach for the data model of the Network Slice Service, but "attachment-circuits" section of the model is referring to the identifiers that are created using the data models specified in [[I-D.boro-opsawg-teas-attachment-circuit](#)]

This example following the overall conception in [[ZSM-003](#)] of confederated data model approach and SDO Data Model cross-referencing in order to get quicker Service and Slice provisioning in multiple domains under various SDO areas of focus, fueling closed-loop automation direction in the Management lifecycle of Slices and Services.

3GPP NRM Rel 18 LogicalInterfaceInfo (Section 6.3.35 of [[TS-28.541](#)]) represents 3GPP IOC with TN-related parameters of the 3GPP subsystem interpreted in this example (Option 3) as CE network configuration of current model and may be referenced as a 'peer-sap-id' remote endpoint of the attachment circuit with parameters as 'nf-termination-ip' and 'nf-termination-vlan' (see more on SAPs at [[RFC9408](#)]; and parameters related to the physical connection and associated with Bearer Service "ietf-ac-svc:attachement-circuits:ietf-bearer-svc".

3GPP NRM ConnectionPointInfo (Section 6.3 of [[TS-28.541](#)]) represents 3GPP IOC with link to the external IETF data model [[I-D.boro-opsawg-teas-attachment-circuit](#)] in order to link the corresponding 3GPP subsystem Transport Network-related slice Meeting Point (Clause 6.3.18 of [[TS-28.541](#)], EP_Transport) to the IETF Network Slice attachment circuit.

As the [[I-D.ietf-teas-ietf-network-slices](#)] has flexibility of Network-Specific abstraction, a need for more attention to connectivity parameters was identified during collaboration activity in O-RAN Alliance Working Group 9 between the 3GPP SA5 representatives and IETF contributors.

[[I-D.boro-opsawg-teas-attachment-circuit](#)] is used jointly to the Network Slice Service YANG model to capture and reflect IETF PE connectivity to 3GPP subsystem parameters such as:

- * Physical parameters of the bearer, captured in the "ietf-bearer-svc" YANG Module of [[I-D.boro-opsawg-teas-attachment-circuit](#)], contains the physical connectivity parameters that the link is utilizing, site location, (3GPP) device information, the IETF PE is connected to, and administrative operational parameters as status and activation time constraints.
- * Location information, correlated with NRM [[TS-28.623](#)] in corresponding 3GPP element id in Clause A 2.2.2 IOC ManagedElement.locationName attribute.
- * Logical connectivity parameters: e.g., VLAN, IPv4, and IPv6.
- * Routing protocols

While 3GPP NRM Rel 17 (Section 6.3.18 of [[TS-28.541](#)]) EP_Transport Attribute "nextHopInfoList" from Clause 6.3.18.2 is associated with "ietf-network-slice-service:network-slice-services:slice-service:sdp:sdp-ip" value, in 3GPP NRM Rel 18 [[TS-28.541](#)] Clause 6.3.18 EP_Transport Attribute list no longer contains IP address of TN element, but a link to IETF meeting point with connectionPointId value of "ietf-ac-svc:attachement-circuits:ac:name".

Provisioning procedures of the 3GPP Elements are captured in [[TS-28.531](#)] where relationship between NRM leaf and IETF AC "ietf-ac-svc:attachement-circuits:ac:name" is depicted.

Note: Possible values of the attribute, specifying the type of the connection point identifier "connectionPointIdType" are VLAN, MPLS, Segment, IPv4, IPv6, and Attachment Circuit (AC). In current exmanple Option 3 "Attachment Circuit (AC)" is used.

Figure 21 captures Transport-related parameters.

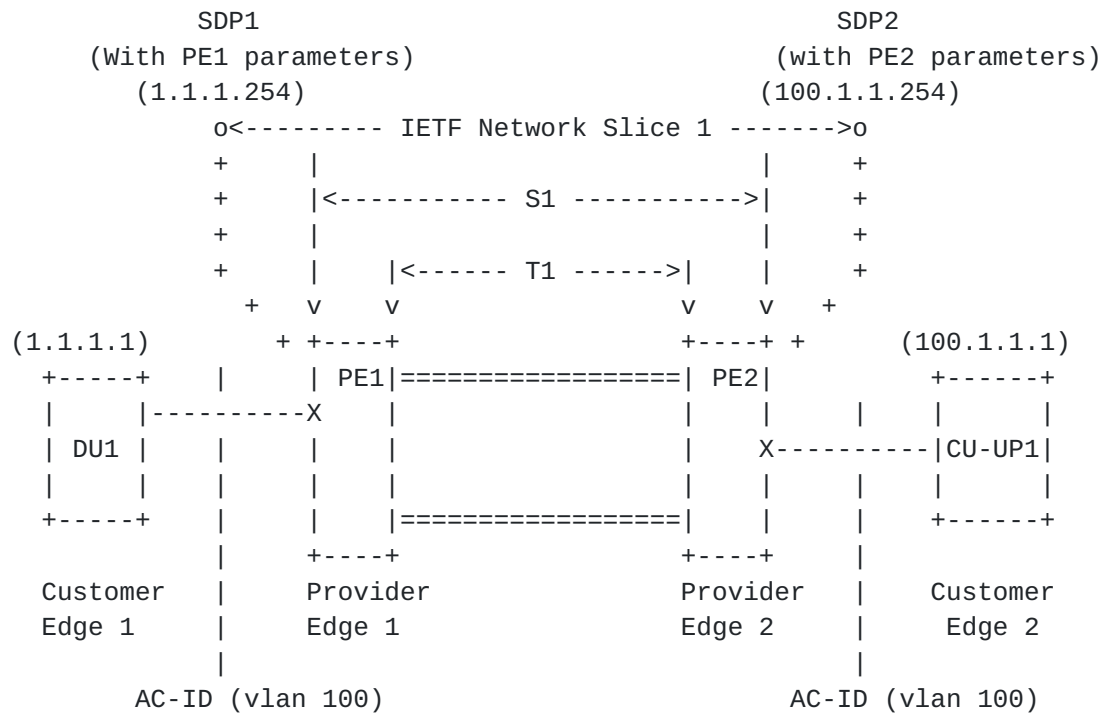


Figure 21

The following attributes mapping is assumed in this example:

---DU1---

3GPP NRM {{TS-28.541}} Clause 6.3.18 EP_Transport

ipAddress: '1.1.1.1/24'

localLogicalInterfaceInfo: "DU1_LogicalInterfaceInfo"

qosProfile: '5QI100'

connectionPointRefList: "DU1_Meeting_point"

3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35 LogicalInterfaceInfo:

"DU1_LogicalInterfaceInfo"

logicalInterfaceType: 'VLAN'

logicalInterfaceId: '100'

systemName: 'DU1'

portName: 'XE'

routingProtocol: 'Static'

** Note: LogicalInterfaceInfo.routingProtocol has Allowed values: RIP, IGMP, OSPF, EGP, EIGRP, BGP, IS-IS.**

** Identified gap: No Static or Direct_connect value is available.**

3GPP NRM {{TS-28.541}} Clause 6.3.41 ConnectionPointInfo:

"DU1_Meeting_point"

connectionPointId: 'ac01-DU1'

connectionPointIdType: 'Attachment_Circuit'

** Note: connectionPointIdType has Allowed values: VLAN, MPLS, Segment, IPV4, IPV6, Attachment Circuit (AC) with multiplicity: 1

3GPP NRM {{TS-28.623}} Clause A 2.2.2 IOC ManagedElement

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```
id: 'DU1'
```

```
locationName: 'Site1.AAA1.ZIP1'
```

**** Note:** The physical location (e.g., an address) of an 3GPP entity. It may contain no information to support the case where the derivative of ManagedElement needs to represent a distributed multi-location NE.*******

```
---CU-UP1---
```

```
3GPP NRM {{TS-28.541}} Clause 6.3.18 EP_Transport
```

```
ipAddress: '100.1.1.1/24'
```

```
localLogicalInterfaceInfo: "CU-UP1_LogicalInterfaceInfo"
```

```
qosProfile: '5QI100'
```

```
connectionPointRefList: "CU-UP1_Meeting_point"
```

```
3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35 LogicalInterfaceInfo: "CU-UP1_LogicalInterfaceInfo"
```

```
logicalInterfaceType: 'VLAN'
```

```
logicalInterfaceId: '100'
```

```
systemName: 'CU-UP1'
```

```
portName: 'XE'
```

```
routingProtocol: 'Static'
```

```
3GPP NRM {{TS-28.541}} Clause 6.3.41 ConnectionPointInfo: "CU-UP1_Meeting_point"
```

```
connectionPointId: 'ac01-CU-UP1'
```

```
connectionPointIdType: 'Attachment_Circuit'
```

```
3GPP NRM {{TS-28.623}} Clause A 2.2.2 IOC ManagedElement
```

```
id: 'CU-UP1'
```

```
locationName: 'Site1.AAA2.ZIP2'
```

```
----
```

```
{
```

```
  "data": {
```

```
    "ietf-network-slice-service:network-slice-services": {
```

```
      "slo-sle-templates": {
```

```
        "slo-sle-template": [
```

```
          {
```

```
            "id": "5QI100", /* QoS profile as in EP_Transport*/
```

```
            "template-description": "5QI100 description"
```

```
          },
```

```
        ]
```

```
      },
```

```
      "slice-service": [
```

```
        {
```

```
          "service-id": "5GSliceMapping-PE-mode",
```

```
          "service-description": "example 5G Slice mapping
```

```
following PE mode",
```

```
          "slo-sle-template": "5QI100", /* QoS profile as
```

```
in EP_Transport*/
```

```
"status": "active"  
"sdps": {  
  "sdp": [  
    {
```

```

        "sdp-id": "01",
        "node-id": "PE1",
        "ac-svc-name:ac-ref": [
            "ac01-DU1"
        ]
    ** 3GPP NRM {{TS-28.541}}
    DU1.ConnectionPointInfo."DU1_Meeting_point".connectionPointId **
        ]
        "status": "active"
    {
        "sdp-id": "02",
        "node-id": "PE2",
        "ac-svc-name:ac-ref": [
            "ac01-CU-UP1" **3GPP NRM {{TS-28.541}} CU-
    UP1.ConnectionPointInfo.
    "CU-UP1_Meeting_point".connectionPointId**
        ]
        "status": "active"
    },
    ],
    },
    "connection-groups": {
        "connection-group": [
            {
                "connection-group-id": "DU-CU",
                "connectivity-type": "ietf-vpn-common:any-to-any",
                "connectivity-construct": [
                    {
                        "cc-id": 1,
                        "a2a-sdp": [
                            {
                                "sdp-id": "01"
                            },
                            {
                                "sdp-id": "02"
                            },
                        ]
                    }
                ]
            }
        ]
    }
}

"ietf-ac-svc:attachment-circuits": {

```

```
"ac": [  
  {
```

```

        "name": "ac01-DU1",
** 3GPP NRM {{TS-28.541}} Clause 6.3.41 ConnectionPointInfo.connectionPointId
**
        "description": "meeting point DU1-PE1",
        "l2-connection": {
            "encapsulation": {
                "type": "ietf-vpn-common:dot1q",
** 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35
LogicalInterfaceInfo.logicalInterfaceType **
                logicalInterfaceType: 'VLAN'
                "dot1q": {
                    "cvlan-id": 100
** 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35
LogicalInterfaceInfo.logicalInterfaceId **
                }
            },
            "bearer-reference": "line-156"
        },
        "ip-connection": {
            "ipv4": {
                "local-address": "1.1.1.254",
                "prefix-length": 24,
                "address": [
                    {
                        "address-id": "1",
                        "customer-address": "1.1.1.1"
**3GPP NRM {{TS-28.541}} Clause 6.3.18 DU1.EP_Transport.ipAddress**
                    }
                ]
            },
            "routing-protocols": {
                "routing-protocol": [
                    {
                        "id": "1",
                        "type": "ietf-vpn-common:direct-routing"
** 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35
LogicalInterfaceInfo.routingProtocol **
                    }
                ]
            }
        },
        "name": "ac01-CU-UP1",
** 3GPP NRM {{TS-28.541}} Clause 6.3.41 ConnectionPointInfo.connectionPointId
**
        "description": "meeting point CU-UP1-PE2",
        "l2-connection": {
            "encapsulation": {
                "type": "ietf-vpn-common:dot1q",
** 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35

```

```
LogicalInterfaceInfo.logicalInterfaceType **
    "dot1q": {
        "cvlan-id": 100
    }
    ** 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35
LogicalInterfaceInfo.logicalInterfaceId **
    }
},
```



```
"bearer-reference": "line-345"
},
"ip-connection": {
    "ipv4": {
        "local-address": "100.1.1.254",
        "prefix-length": 24,
        "address": [
            {
                "address-id": "1",
                "customer-address": "100.1.1.1"
** 3GPP NRM {{TS-28.541}} Clause 6.3.18 CU-UP1.EP_Transport.ipAddress **
            }
        ]
    },
    "routing-protocols": {
        "routing-protocol": [
            {
                "id": "1",
                "type": "ietf-vpn-common:direct-routing"
** 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35 LogicalInterfaceInfo.routingProtocol **
            }
        ]
    }
}

"ietf-ac-svc:ietf-bearer-svc":{
    "bearers": [
        {
            "id": "line-156" //Note that bearer-reference is returned in the response
            "description": "link DU1-PE1"
            "customer-point": {
                "identified-by": "ietf-bearer-svc:site-and-device-id",
                "device": {
                    "device-id": "DU1"
** Either 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35 LogicalInterfaceInfo: "DU1_LogicalInterfaceInfo". systemName or 3GPP NRM {{TS-28.623}} Clause A 2.2.2 IOC ManagedElement.DU1.id **
                "site": {
                    "site-id": "Site1.AAA1.ZIP1"
** 3GPP NRM {{TS-28.623}} Clause A 2.2.2 IOC ManagedElement.DU1.locationName **
                }
            }
        }
    ],
    "id": "line-345"
    "description": "link CU-UP1-PE2"
```

```
"customer-point": {  
  "identified-by": "ietf-bearer-svc:site-and-device-id",  
  "device": {  
    "device-id": "CU-UP1"
```

```

** Either 3GPP NRM Rel 18 {{TS-28.541}} Clause 6.3.35 LogicalInterfaceInfo:
"CU-UP1_LogicalInterfaceInfo".
systemName or 3GPP NRM {{TS-28.623}} Clause A 2.2.2 IOC ManagedElement.CU-
UP1.id **
        "site": {
            "site-id": "Site1.AAA2.ZIP2"
** 3GPP NRM {{TS-28.623}} Clause A 2.2.2 IOC ManagedElement.CU-
UP1.locationName**
        }
    }
}
}
}
}
]
}
}

```

8. Gap Analysis

The way in which 3GPP is characterizing the slice endpoint (i.e., EP_Transport) is based on Layer 3 information (e.g., the IP Address). However the information provided seems not to be sufficient for instructing the IETF Network Slice Controller for the realization of the IETF Network Slice. For instance, some basic information such as the mask associated to the IP address of the EP_Transport is not specified, as well as other kind of parameters like the connection MTU or the connectivity type (unicast, multicast, etc). More sophisticated information could be required as well, like the level of isolation or protection necessary for the intended slice.

In the case in which the 3GPP managed function runs on a purpose-specific network element, the IP address specified in the EP_Transport IOC serves as reference to identify the CE endpoint, assuming the endpoint of the CE has been configured with that IP address. With that information (together with the logical interface ID) should be sufficient for the IETF NSC to identify the counterpart endpoint at the PE side, and configuring it accordingly (e.g., with a compatible IP address) for setting up the slice end-to-end. Similarly, the next hop information in EP_Transport can help validate the end-to-end slice between PE endpoints.

In the case in which the 3GPP managed function is instantiated as a virtualized network function, the direct association between the IP address of EP_Transport and the actual endpoint mapped at the CE is not so clear. It could be the case, for instance when the virtualized network function is instantiated at the internal of a data center, that the CE facing the PE is far from the point where the function is deployed, being that connectivity extended through

the internals of the data center (or by some internal configuration of a virtual switch in a server). In these situations additional information is needed for accomplishing the end-to-end connection.

At the same time, [TS-28.541] IOC contains useful parameters to be used in IETF Network Slice creation mechanism and enriching IETF Network Slice model. The following parameters may be suggested as a candidates to the correlation of the IETF Network Slice parameters and IETF Network Slice model enrichments:

- * For the latency, dLThptPerSliceSubnet, uLThptPerSliceSubnet, reliability and delayTolerance attributes, the following NRM apply (with reference to the section in that specification):
 - CNSliceSubnetProfile (section 6.3.22 in [TS-28.541])
 - RANSliceSubnetProfile (section 6.3.23 in [TS-28.541])
 - TopSliceSubnetProfile (section 6.3.24 in [TS-28.541])
- * For the qosProfile attribute, the NRM which applies is EP_Transport (detailed in section 6.3.18 in [TS-28.541])

9. IANA Considerations

This document makes no request of IANA.

Note to RFC Editor: this section may be removed on publication as an RFC.

10. Security Considerations

11. Evolution Considerations

3GPP NRM evolution to confiderated data model approach is considered for Rel. 18

12. Acknowledgments

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Thanks to Philip Eardley (philip.eardley@bt.com) for his contribution to this document.

13. Annex 1: 3GPP Network Slice Mapping Parameters

The network slice concept was introduced in 3GPP specifications from the first 5G release, corresponding to Release 15. As captured in [TS-23.501], a network slice represents a logical network providing specific network capabilities and network characteristics.

To make slicing a reality, every technical domain is split into one or more logical network partitions, each referred to as a network slice subnet. The definition of multiple slice subnets on a single domain allows each segment to provide differentiated behaviors, in terms of functionality and/or performance, tailored to some specific needs. The stitching of slice subnets across the RAN, CN and TN results in the definition of 5G network slices in 3GPP.

From a management viewpoint, the concept of network slice subnet represents an independently manageable yet composable portion of a network slice. The rules for the definition of network slice subnet and their composition into network slices are detailed in the 5G Network Resource Model (NRM) [[TS-28.541](#)], specifically in the Network Slice NRM fragment. This fragment captures the information model of 5G network slicing, which specifies the relationships between different slicing related managed entities, which is represented as Information Object Class (IOC). The IOC that have been defined including: NetworkSlice IOC, NetworkSliceSubnet IOC, ManagedFunction IOC and EP_Transport IOC.

Information Object Class EP_Transport [[TS-28.541](#)] Clause 6.3.18 represents logical interface parameters of 3GPP subsystems, providing specific network capabilities and network characteristics. Relationships of Transport slicing-related 3GPP IOCs and IETF domain represented on the Figure X for NgU/N3 slices with traffic between 3GPP CU-UP (or ORAN) CU-UP and 3GPP UPF, while the Figure Y similarly represents F1-U slices with traffic between 3GPP (or ORAN) DU and 3GPP (or ORAN) CU-UP.

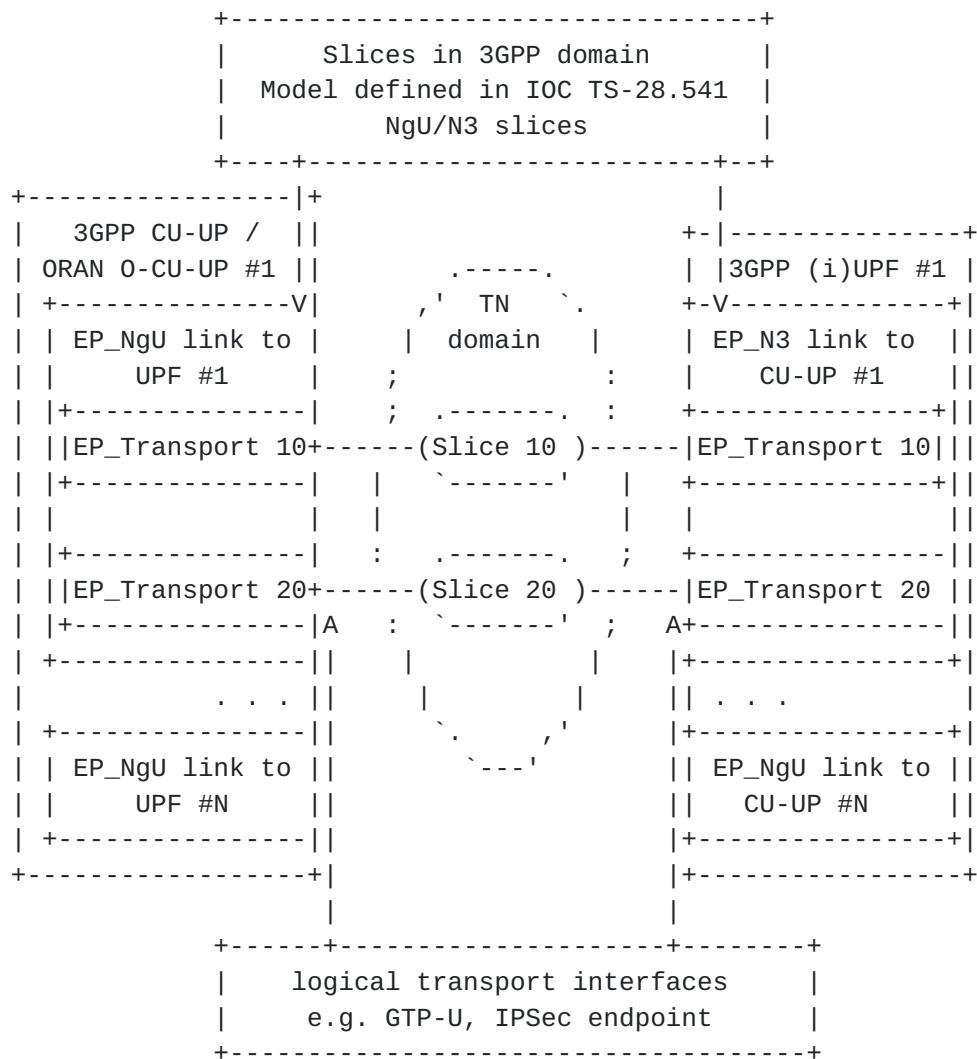


Figure 22: Slicing example realization between 3GPP subsystems and TN on the NgU/N3 interface

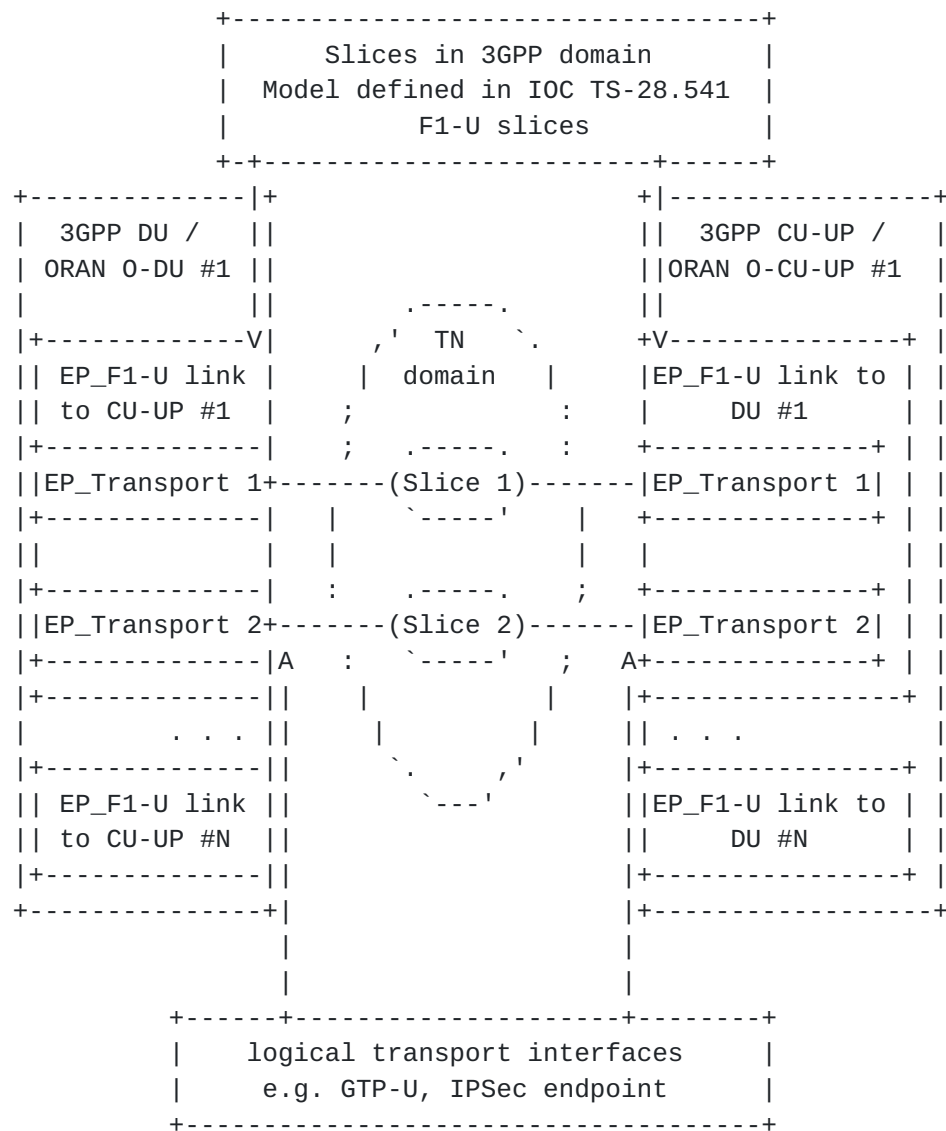


Figure 23: Slicing example realization between 3GPP subsystems and TN on the F1-U interface

For the transport (i.e., connectivity) related part of a network slice, the key focus is on the EP_Transport IOC. Instances of this IOC serves to instantiate 3GPP interfaces (e.g., N3) which are needed to support Network Slicing and to define Network Slice transport resources within the 5G NRM. In a nutshell, the EP_Transport IOC permits to define additional logical interfaces for each slice instance of the 3GPP user plane.

According to [TS-28.541], the EP_Transport construct on 3GPP side has the following attributes: ipAddress, logicaInterfaceInfo, nextHopInfo, qosProfile and epApplicationRef In which, nextHopInfo could be used for choosing PE node in transport network and LogicalInterfaceInfo could be used for Transport Network Slice mapping.

nextHopInfo (optional): identifies the ingress transport node. Each node can be identified by any combination of IP address of next-hop router of transport network, system name, port name and IP management addresses of transport nodes.

logicInterfaceInfo (mandatory): a set of parameters, which includes logicInterfaceType and logicInterfaceId. It specifies the type and identifier of a logical interface. It could be a VLAN ID, MPLS Tag or Segment ID. This is assigned uniquely per slice.

From the Transport Network domain side, these parameters assist on the definition of the CE transport interface configuration and shall be taken as an input to the transport service model to create coherent Network Slice transport service. Figure 17 illustrates how the EP_Transport parameters can relate to the IETF ones for determining the endpoint connectivity.

```

+-----+      .-----+      +-----+
| 3GPP CU-UP / |      , ' TN ` . | 3GPP (i)UPF #1 |
| ORAN O-CU-UP #1 |      | domain | | |
|+-----+      +-----+ : +-----+
||EP_NgU link to UPF #1 || PE 1 | : | EP_N3 link to ||
|| | | : | CU-UP #1 ||
||+-----+      +-----+||
||| EP_Transport for +---+(Slice 10 )+---+---| EP_Transport |||
||| S-NSSAI FWA | |A`-----' | ; +-----+||
|||logicInterfaceType = | +|-----+ ; +-----+||
||| Vlan ID | | : ; +-----+||
||| logicInterfaceId = | | | |
||| Vlan 200 | | | |
|||ipAddress = 20.2.2.2 | | ` . , '
||+-----+A-----| | `-----'
|+-----+|-----+ +-----+
+-----+|-----+ | nextHopInfoList |
| | |NextHopInfo = IP/mask|
+-----+|-----+ | of PE 1 |
| epApplicationRef = | | system name = PE 1 |
|EP_NgU link to UPF#1 | | port name = Gi1/1 |
+-----+ +-----+

```


Figure 24: Example of 3GPP EP_Transport IOC TS-28.541 parameters with correlation to IETF

Furthermore, that same parameters should be leveraged for constituting the connectivity construct allowing endpoint interconnection. That is, there is no additional information that could be leveraged at service level that the one provided by EP_Transport, which essentially reflects an endpoint view. Figure 18 represents this relationship between 3GPP and IETF parameters.



Representation of connectivity:
EP_NgU/N3, link between (0)-CU-UP and UPF
F1-U, link between (0)-DU and (0)-CU-UP

Figure 25: Relationships of the 3GPP parameters with the IETF parameters

Leveraging on the EP_Transport information, the IETF NSC should be instructed through its NBI on performing the slice connection. Figure 19 graphically represents the slice connection (e.g., for Ng-U/N3) as expected by 3GPP by using connectivity constructs (of a IETF Network Slice service) to be configured by the IETF Network Slice Controller.

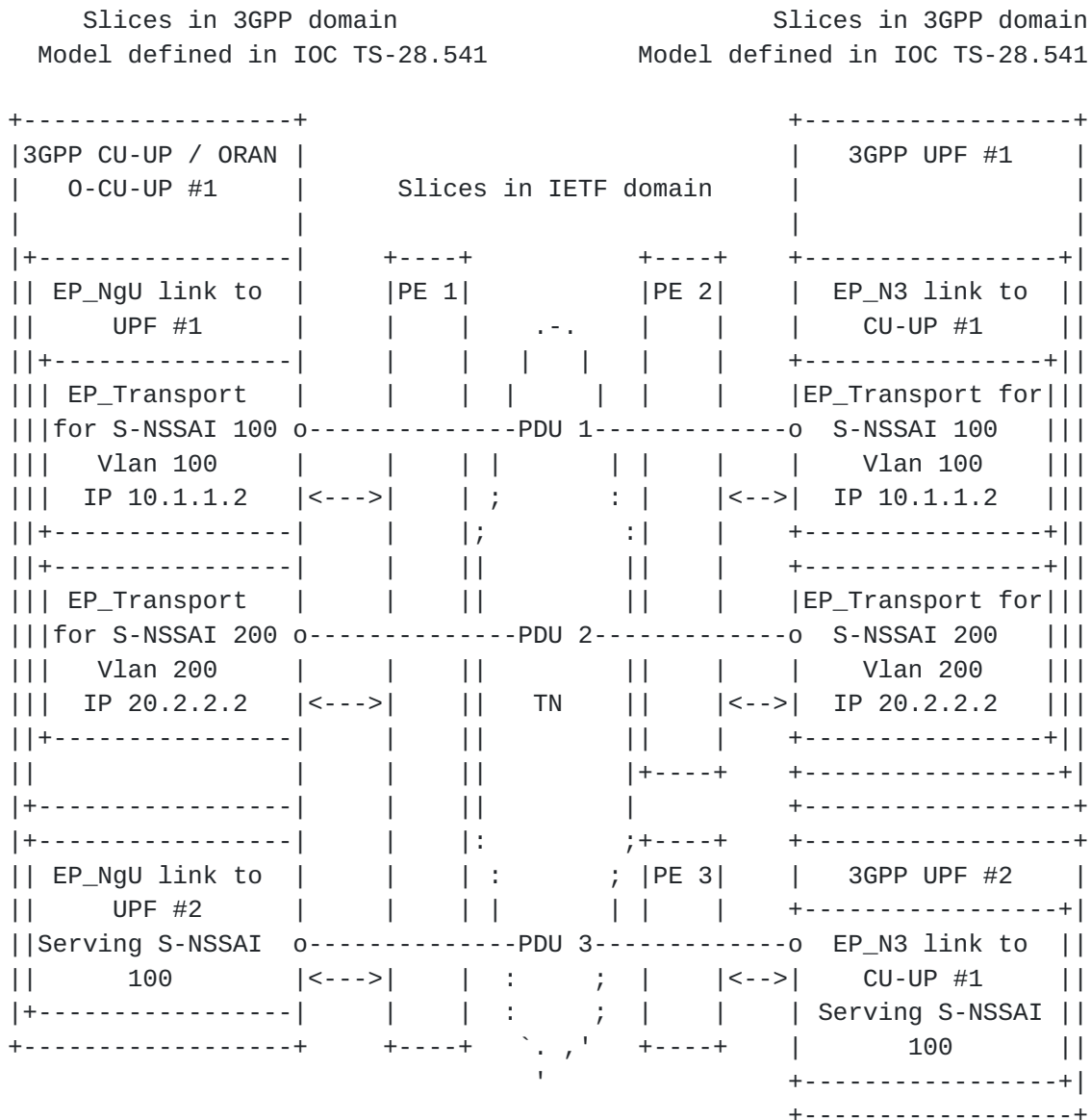


Figure 26: Example of CU-UP Slice in the 3GPP domain using an IETF Network Slice service

From the perspective of IETF Network Slice realization, some of these options could be realized in a straightforward manner while other could require of advanced features (e.g., PBR, SRv6, FlexE, etc). RFC XXXX Network Slice Services may be a set of techniques and underlaying technologies, so multiple models may be used to define slice.

According to the [TS-28.541] attributes in the EP_Transport, the IETF Network Slice may be defined by the following combination of the parameters:

EP_Transport attribute name			
ipAddress	logicInterfaceId	nextHopInfo	qosProfile
Different per slice		Same for all slices	
Same for all slices	Different per slice		Same for all slices
Different per slice	Same for all slices	Different per slice	Same for all slices
Same for all slices		Different per slice	Same for all slices
Different per slice			
Same for all slices	Different per slice		

Figure 27: Variations of Slice implementation options

From the perspective of IETF Network Slice realization, some of these options could be realized in a straightforward manner while other could require of advanced features (e.g., PBR, SRv6, FlexE, etc).

RFC XXXX Network Slice Services may be a set of techniques and underlaying technologies, so multiple models may be used to define slice.

14. Annex 2: Data Plane Mapping Options

The following picture shows the end-to-end network slice in data plane:

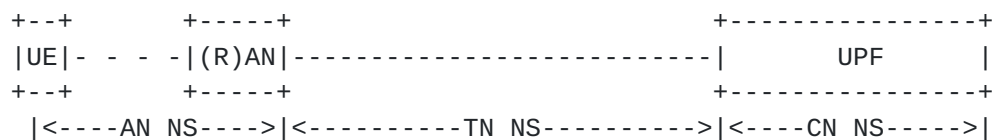


Figure 28: End-to-end network slice in data plane

The mapping between 3GPP slice and transport slice in user plane could happens in:

(R)AN: User data goes from (radio) access network to transport network

Editor's Note: As figure 4.7.1. in [\[TS-28.530\]](#) describes, TN NS will not only exist between AN and CN but may also within AN NS and CN NS. However, here we just show the TN between AN and CN as an example to avoid unnecessary complexity.

The following picture shows the user plane protocol stack in end-to-end 5G system.

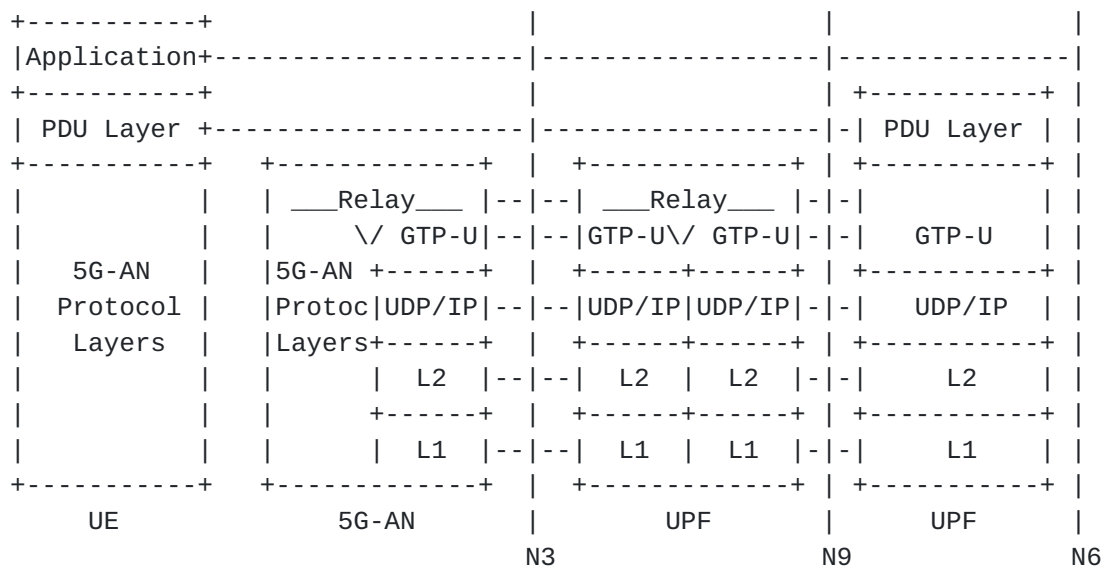


Figure 29: User plane protocol stack in end-to-end 5G system

The following figure shows the typical encapsulation in N3 interface.

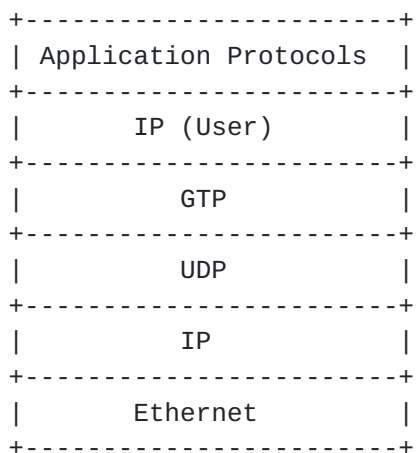


Figure 30: Typical encapsulation in N3 interface

14.1. Layer 3 and Layer 2 Encapsulations

If the encapsulation above IP layer is not visible to Transport Network, it is not able to be used for network slice interworking with transport network. In this case, IP header and Ethernet header could be considered to provide information of network slice interworking from AN or CN to TN.

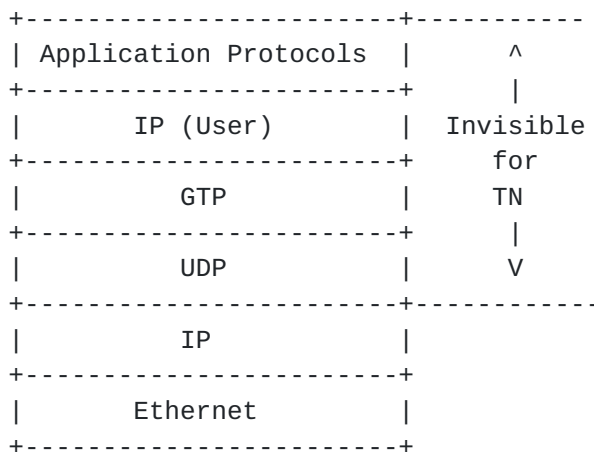


Figure 31: IP header for network slice interworking

The following field in IP header and Ethernet header could be considered:

IP Header:

- * DSCP: It is traditionally used for the mapping of QoS identifier between AN/CN and TN network. Although some values (e.g. The unassigned code points) may be borrowed for the network slice interworking, it may cause confusion between QoS mapping and network slicing mapping.;
- * Destination Address: It is possible to allocate different IP addresses for entities in different network slice, then the destination IP address could be used as the network slice interworking identifier. However, it brings additional requirement to IP address planning. In addition, in some cases some AN or CN network slices may use duplicated IP addresses.
- * Option fields/headers: It requires that both AN and CN nodes can support the encapsulation and decapsulation of the options.

Ethernet header

- * VLAN ID: It is widely used for the interconnection between AN/CN nodes and the edge nodes of transport network for the access to different VPNs. One possible problem is that the number of VLAN ID can be supported by AN nodes is typically limited, which effects the number of IETF network slices a AN node can attach to. Another problem is the total amount of VLAN ID (4K) may not provide a comparable space as the network slice identifiers of mobile networks. Two or more options described above may also be used together as the IETF Network Slice Interworking ID, while it would make the mapping relationship more complex to maintain.

In some other case, when AN or CN could support more layer 3 encapsulations, more options are available as follows:

If the AN or CN could support MPLS, the protocol stack could be as follows:

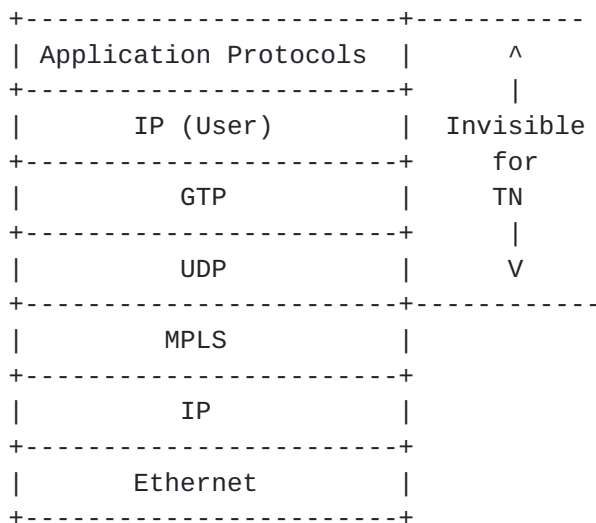


Figure 32: MPLS label for network slice interworking

A specified MPLS label could be used to as a IETF Network Slice Interworking ID.

If the AN or CN could support SRv6, the protocol stack is as follows:

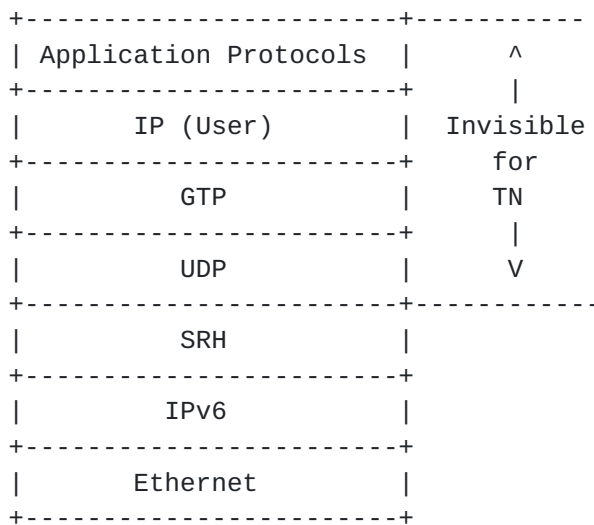


Figure 33: SRH for network slice interworking

The following field could be considered to identify a network slice:
SRH:

- * SRv6 functions: AN/CN is supposed to support the new function extension of SRv6.
- * Optional TLV: AN/CN is supposed to support the extension of optional TLV of SRH. ### Above Layer 3 Encapsulations If the encapsulation above IP layer is visible to Transport Network, it is able to be used to identify a network slice. In this case, UDP and GTP-U could be considered to provide information of network slice interworking between AN or CN and TN.

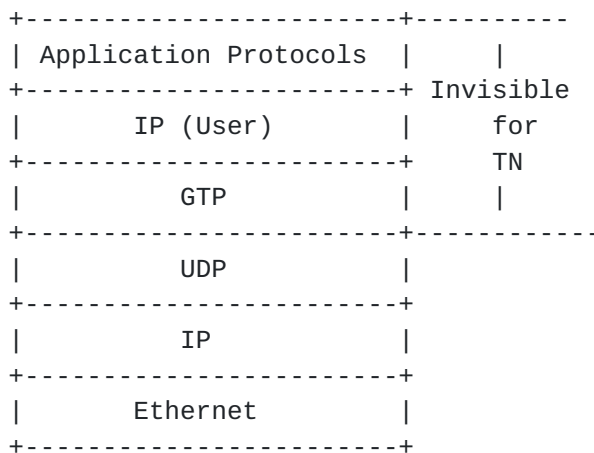


Figure 34: UDP Header for network slice interworking

The following field in UDP header could be considered:

UDP Header:

- * UDP Source port: The UDP source port is sometimes used for load balancing. Using it for network slice mapping would require to disable the load-balancing behavior.

A similar approach to this is followed in
[\[I-D.ietf-dmm-tn-aware-mobility\]](#)

14.1.1.1. Consideration of the Virtual Network Functions (VNF)

In some 5G network slice deployments, it might be beneficial to deploy RAN and Core network functions such as DU, CU and UPF as virtual network functions (VNF) inside a data center (DC). As an example, consider Figure 14 where the CU and UPF have been deployed as VNF. The definition of the RFC XXXX Network Slice Services INS1 stays identical to its PNF counterpart (physical network function) which are discussed in sections [7.2.1](#) to [7.2.5](#), i.e., INS1 is an IETF network slice service which provides the connectivity between SDP1 and SDP2 to satisfy certain SLO/SLE.

However, the mapping of INS1 might be different from previous use cases. Figure 14 shows one possible solution for mapping of INS1 where the 5G E2E network slice is first mapped inside the data center and then mapped to provider network PE nodes. One potential mapping in the data center is to use VxLAN ID to infer the identification of 5G E2E network slice inside the data center, and any of the options described in 7.2.1 to 7.2.5 in the provider network PE1 and PE2.

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Contributors

Jose Ordonez-Lucena
Telefonica
Ronda de la Comunicacion, s/n Sur-3 building, 3rd floor
Madrid, 28050
Spain
Email: joseantonio.ordonezlucena@telefonica.com

Ran Pang
China Unicom
Email: pangran@chinaunicom.cn

Liuyan Han
China Mobile
Email: hanliuyan@chinamobile.com

Jaehwan Jin
LG U+
Email: daenamu1@lguplus.co.kr

Jeff Tantsura
Microsoft
Email: jefftant.ietf@gmail.com

Shunsuke Homma
NTT
NTT 3-9-11, Midori-cho Musashino-shi,,
Japan
Email: shunsuke.homma.ietf@gmail.com

Xavier de Foy
InterDigital Inc.
Canada
Email: Xavier.Defoy@InterDigital.com

Kiran Makhijani
Futurewei Networks
United States of America
Email: kiranm@futurewei.com

Hannu Flinck
Nokia
Finland
Email: hannu.flinck@nokia-bell-labs.com

Rainer Schatzmayr
Deutsche Telekom
Germany
Email: rainer.schatzmayr@telekom.de

Ali Tizghadam
TELUS Communications Inc
Canada
Email: ali.tizghadam@telus.com

Christopher Janz
Huawei Canada
Canada
Email: christopher.janz@huawei.com

Henry Yu
Huawei Canada
Canada
Email: henry.yu1@huawei.com

Authors' Addresses

Xuesong Geng
Huawei Technologies
Email: gengxuesong@huawei.com

Luis M. Contreras
Telefonica
Email: luismiguel.contrerasmurillo@telefonica.com

Reza Rokui
Ciena
Email: rrokui@ciena.com

Jie Dong
Huawei Technologies
Email: jie.dong@huawei.com

Ivan Bykov
Ribbon Communications
Email: Ivan.Bykov@rbbn.com

