7. Example of IETF Network Slice request through IETF Network Slice NBI

As discussed in [I-D.ietf-teas-ietf-network-slices], to fulfill 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 8 shows the NSC and its NBI interface for 5G. Draft [I-D.ietf-teas-ietf-network-slice-nbi-yang] a addresses the service yang model of the NSC NBI interface for all network slicing use-cases.

+------------------------------------------+

| 5G Customer (Tenant) |

+------------------------------------------+

A

|

V

+------------------------------------------+

| 5G E2E Network Slice Orchestrator |

+------------------------------------------+

A

| NSC NBI

V

+------------------------------------------+

| IETF Network Slice Controller (NSC) |

+------------------------------------------+

A

| NSC SBI

V

+------------------------------------------+

| Network Controller(s) |

+------------------------------------------+

Figure 8: 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 undelay 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.

| (1) NBI: Request to create/modify/delete

| 5G IETF Network Slice

V

+----------------------+

| IETF Network Slice | (2) Mapping between technology

| Controller (NSC) | agnostics NBI to technology

+----------------------+ specific SBI

^ ^ ^

| | |

|---| | |---| (3) SBI: Realize 5G IETF Network Slice

| | | by using various IETF models for

V V V services, tunnels and paths

+----------------------+

| Network |-+

| Controller(s) | |-+

+----------------------+ | |

+----------------------+ |

+----------------------+

Figure 9: Relationship between transport slice interface and IETF

Service/Tunnels/Path data models

**Refer to our current Figure 8**

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).

┌────────────────────────┐ ┌────────────────────────┐

│3GPP or ORAN subsystem │Provider Provider│3GPP or ORAN subsystem │

│(e.g. (O)-DU) │Edge 1 Edge 2 │(e.g. (O)-CU-UP) │

│┌──────────────────────┐│ ┌──┐ ┌──┐ │┌──────────────────────┐│

││Bearer ││ │ │ │ │ ││Bearer ││

││ ┌──────┐┌───────┐││ ││ ═════ ││ ││┌───────┐┌──────┐ ││

││ │EP\_RP ││EP\_Tran│││ │PE│ │PE│ │││EP\_Tran││EP\_RP │ ││

││ │EP\_F1U├┤ sport X┼┼──┼┤ ═════ ├┼──┼┼X sport ├┤EP\_F1U├ ││

││ └──▲───┘└───▲───┘││ │ │ │ │ ││└───▲───┘└──▲───┘ ││

│└────────┼────────┼────┘│ │└──┘ └──┘│ │└────┼───────┼──────────┘

└─────────┼────────┼─────┘ └─────┼───────┼──────────

│ │ │ │ │ │

(2) (1) AC AC (1) (2)

Customer Edge 1 Customer Edge 2

Figure X 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.

**Summarize gaps in one single section at the end**

Gap analysis (<- to be summarized later on in a dedicated sub-section)

(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 X1.

+-----+ Association between X and Y +-----+

| | according to 3GPP (i.e., NgU/N3 interface) | |

| gNB |<----------------------------------------------->| UPF |

| | | |

+-----+ +-----+

+-----+ Association between DU and CU-UP +-----+

| | according to O-RAN (i.e., F1-U interface) | |

| DU |<----------------------------------------------->|CU-UP|

| | | |

+-----+ +-----+

\\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_/

\/

SDP1 SDP2

(with CE1 parameters) (with CE2 parameters)

o<----------------- IETF Network Slice ---------------->o

+ +

+|<------------------------- S1 ---------------------->|+

+| |+

+| |<------- T1 ----->| |+

+| v v |+

+v +----+ +----+ v+

+--+--+ | | PE1|==================| PE2| | +-+---+

| + | | | | | | | | + |

| o X----------X | | X----------X o |

| | | | | | | | | |

+-----+ | | |==================| | | +-----+

AC +----+ +----+ AC

Customer Provider Provider Customer

Edge 1 Edge 1 Edge 2 Edge 2

Legend:

O: 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 X 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 X2 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 X2 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 X3.

+---------------------------------+

| 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 X3 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 X2.

SDP1 SDP2

(100.1.1.2) (1.1.1.2)

o<----------------- IETF Network Slice ---------------->o

+ +

+|<------------------------- S1 ---------------------->|+

+| |+

+| EP\_Transport EP\_Transport |+

+| (1.1.1.1) |<------ T1 ---->| (100.1.1.1) |+

+| / v v \ |+

+v / +-----+ +-----+ \ v+

+--+--+ / | PE1 |================| PE2 | \ +-+---+

| + |/ | | | | | | \| + |

| o X----------X | | X----------X o |

| | | |\ | | /| | | |

| | | | \ | | / | | | |

| | | Peer SAP| | Peer SAP | | |

| | | (1.1.1.254)|================|(100.1.1.254) | |

| | | | | | | | | |

+-----+ | +-----+ +-----+ | +-----+

Customer | Provider Provider | Customer

Edge 1 | Edge 1 Edge 2 | Edge 2

| |

AC (vlan 100) AC (vlan 100)

Figure X2 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.

**Consolidate gaps discussion**

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-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 [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 PE-mode as described in Figure X1.

+-----+ Association between X and Y +-----+

| | according to 3GPP (i.e., NgU/N3 interface) | |

| gNB |<----------------------------------------------->| UPF |

| | | |

+-----+ +-----+

+-----+ Association between DU and CU-UP +-----+

| | according to O-RAN (i.e., F1-U interface) | |

| DU |<----------------------------------------------->|CU-UP|

| | | |

+-----+ +-----+

\\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_/

\/

SDP1 SDP2

(With PE1 parameters) (with PE2 parameters)

o<--------- IETF Network Slice 1 ------->o

+ | | +

+ |<----------- S1 ----------->| +

+ | | +

+ | |<------ T1 ------>| | +

+ v v v v +

+ +----+ +----+ +

+-----+ | | PE1|==================| PE2| +-----+

| | | | | | | | | |

| |----------X | | X----------| |

| | | | | | | | | |

+-----+ | | |==================| | | +-----+

AC +----+ +----+ AC

Customer Provider Provider Customer

Edge 1 Edge 1 Edge 2 Edge 2

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 X PE-mode slice realization – **OPTION 2**

The resulting mapping is summarized in Figure X2b.

SDP1 SDP2

(With PE1 parameters) (with PE2 parameters)

(1.1.1.254) (100.1.1.254)

o<--------- IETF Network Slice 1 ------->o

+ | | +

+ |<----------- S1 ----------->| +

+ | | +

+ | |<------ T1 ------>| | +

+ v v v v +

+ +----+ +----+ +

+-----+ | | PE1|==================| PE2| +-----+

| |----------X | | | | | |

| | | | | | X----------| |

| |----------X | | | | | |

+-----+ | | |==================| | | +-----+

| +----+ +----+ |

Customer | Provider Provider | Customer

Edge 1 | Edge 1 Edge 2 | Edge 2

| |

AC (vlan 100) AC (vlan 100)

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": "DU1",~~ /\* not available \*/

"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", /\* NextHopInfo 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": "CU-UP1",

"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-construct": [

{

"cc-id": 1,

"a2a-sdp": [ /\* not available \*/

{

"sdp-id": "01"

},

{

"sdp-id": "02"

},

]

}

]

}

]

}

}

]

}

}

}