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## 5G End-to-end Network Slice Mapping from the view of Transport Network [draft-geng-teas-network-slice-mapping-01](#)

### Abstract

Network Slicing is one of the core features in 5G. End-to-end network slice consists of 3 major types of network segments: Access Network (AN), Mobile Core Network (CN) and Transport Network (TN). This draft describes the procedure of mapping relationship between 5G end-to-end network slice and transport network slice defined in IETF. This draft also intends to expose some gaps in the existing network management plane and data plane to support inter-domain network slice mapping. Further work may require cooperation between IETF and 3GPP (or other standard organizations). The definition of data model, signaling protocol extension and new encapsulation are out of the scope of this draft.

### Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[RFC2119](#)].

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## Table of Contents

<a href="#">1.</a>	<a href="#">Introduction</a>	<a href="#">3</a>
<a href="#">2.</a>	<a href="#">Terminologies</a>	<a href="#">3</a>
<a href="#">3.</a>	<a href="#">Network Slice Mapping Structure</a>	<a href="#">4</a>
<a href="#">3.1.</a>	<a href="#">Requirements Profile</a>	<a href="#">5</a>
<a href="#">3.2.</a>	<a href="#">Identifiers</a>	<a href="#">6</a>
<a href="#">3.3.</a>	<a href="#">Relevant functions</a>	<a href="#">6</a>
<a href="#">4.</a>	<a href="#">Network Slice Mapping Procedure</a>	<a href="#">7</a>
<a href="#">4.1.</a>	<a href="#">Network Slice Mapping in Management Plane</a>	<a href="#">8</a>
<a href="#">4.2.</a>	<a href="#">Network Slice Mapping in Control Plane</a>	<a href="#">9</a>
<a href="#">4.3.</a>	<a href="#">Network Slice Mapping in data plane</a>	<a href="#">9</a>
<a href="#">4.3.1.</a>	<a href="#">Data Plane Mapping Considerations</a>	<a href="#">10</a>
<a href="#">4.3.2.</a>	<a href="#">Data Plane Mapping Design</a>	<a href="#">10</a>
<a href="#">5.</a>	<a href="#">Network Slice Mapping Summary</a>	<a href="#">14</a>
<a href="#">6.</a>	<a href="#">IANA Considerations</a>	<a href="#">15</a>
<a href="#">7.</a>	<a href="#">Security Considerations</a>	<a href="#">15</a>
<a href="#">8.</a>	<a href="#">Acknowledgements</a>	<a href="#">15</a>
<a href="#">9.</a>	<a href="#">Normative References</a>	<a href="#">15</a>
	<a href="#">Authors' Addresses</a>	<a href="#">16</a>



## 1. Introduction

Driven by the new applications of 5G, the concept of network slicing is defined to provide a logical network with specific capabilities and characteristics. Network slice contains a set of network functions and allocated resources (e.g. Computation, storage and network resources). According to [TS28530], a 5G end-to-end network slice is composed of three major types network segments: Radio Access Network (RAN), Transport Network (TN) and Mobile Core Network (CN). Transport network is supposed to provide the required connectivity between AN and CN, which specific performance commitment. For each end-to-end network slice, the topology and performance requirement for transport network can be very different, which requires transport network to have the capability of supporting multiple different transport network slices.

A transport network slice is a virtual (logical) network with a particular network topology and a set of shared or dedicated network resources, which are used to provide the network slice consumer with the required connectivity, appropriate isolation and specific Service Level Agreement (SLA). A transport network slice could span multiple technology (IP, Optical) and multiple administrative domains. Depending on the consumer's requirement, a transport network slice could be isolated from other concurrent transport network slices, in terms of data plane, control plane and management plane. Transport network slice is being defined and discussed in IETF.

Editor's Note: The work of

The procedure of end-to-end network slice instance creation, network slice subnet instance creation and network slice instance termination in management plane are defined in [TS28531]. The end-to-end network slice allocation is defined in ETSI [ZSM003]. But there is no specifications about how to map end-to-end network slice in 5G system to transport network slice. This draft describes the procedure of mapping 5G end-to-end network slice into transport network slice in management plane, control plane and user plane.

## 2. Terminologies

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

The following terms are used in this document:

NS: Network Slice



NSI: Network Slice Instance

NSSI: Network Slice Subnet Instance

NSSAI: Network Slice Selection Assistance Information

S-NSSAI: Single Network Slice Selection Assistance Information

AN: Access Network

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

GST: General Slice Template

TNSII: Transport Network Slice Interworking Identifier

TNSI: Transport Network Slice Identifier

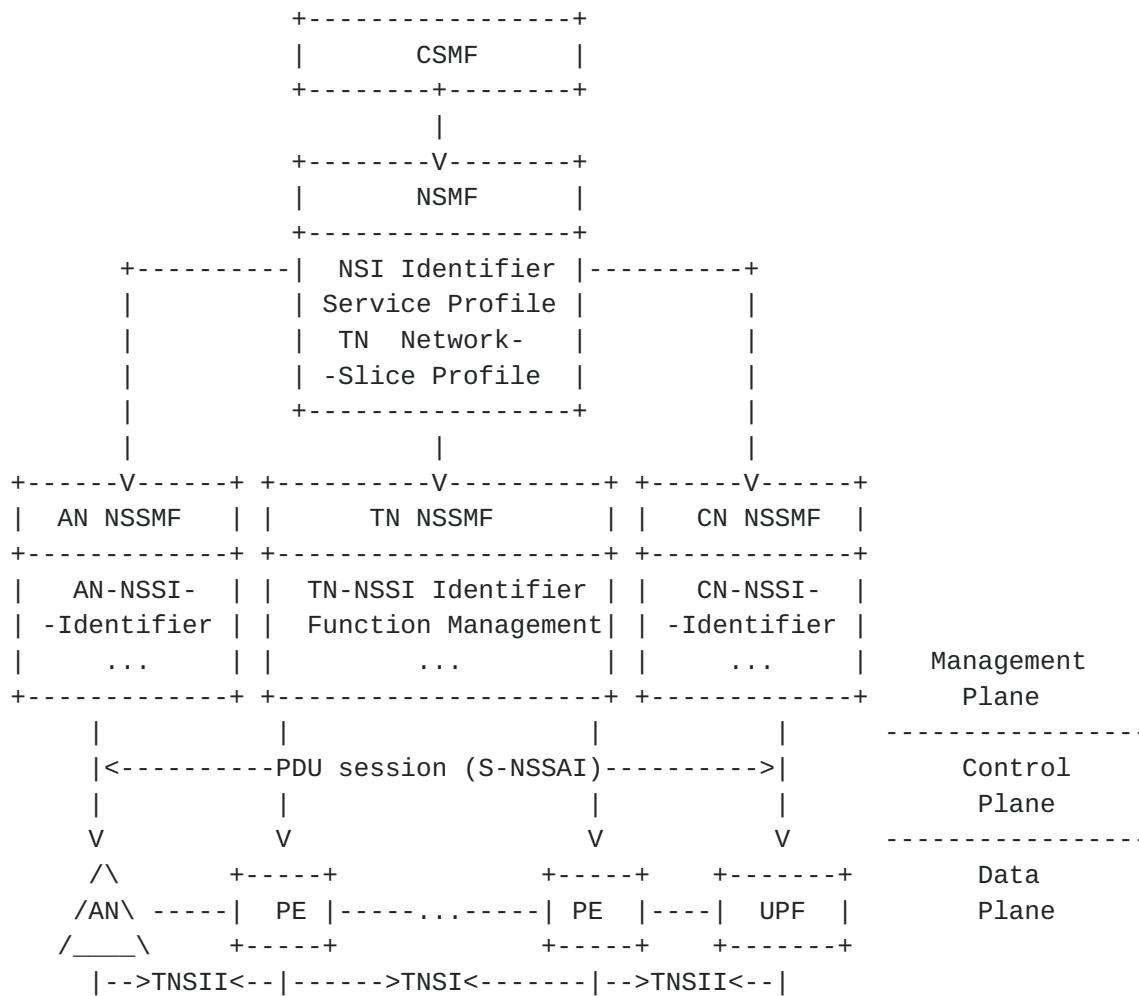
PDU: Protocol Data Unit

Editor's Note: Terminologies defined in 3GPP, e.g., Network Slice Subnet Management Function(NSSMF), Network Slice Subnet Instance(NSSI) and Network Slice Selection Assistance Information(NSSAI), is used in the end-to-end network slice mapping, which may not be used necessarily within the transport network.

### **3. Network Slice Mapping Structure**

The following figure shows the necessary elements for mapping end-to-end network slice into transport network slice. All these network slice elements are classified into three groups: requirements/capabilities, identifiers and relevant functions.





### 3.1. Requirements Profile

In order to satisfy a tenant's request for a network slice with certain characteristics, creating a new network slice or using existing network slice instance is constrained by the customer's requirement and the capability of the network slices.

- o Service Profile: represents the properties of network slice related requirement that should be supported by the network slice instance in 5G network. Service profile is defined in [\[TS28541\]](#) 6.3.3.
- o TN Network Slice Profile: represents the properties of transport network slice related requirement that should be supported by the transport network slice in a 5G network. Slice Profile is defined in [\[TS28541\]](#) 6.3.4. TN Network slice profile is newly defined in this draft.





### **3.2. Identifiers**

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

- o Single Network Slice Selection Assistance Information(S-NSSAI): end-to-end network slice identifier in control plane, which is defined in [[TS23501](#)];
- o Network Slice Instance(NSI) Identifier: end-to-end network slice identifier in management plane, which is created in NSMF; NSI is a set of Network Function instances and the required resources (e.g. compute, storage and networking resources) which form a deployed Network Slice, which is defined in [[TS23501](#)]; ;
- o Transport Network Slice Instance(TN-NSSI) Identifier: transport network slice identifier in management plane, which is created in TN NSMF; TN-NSSI is newly defined in this draft.
- o Transport Network Slice Interworking Identifier (TNSII): network slice identifier which is used for mapping end-to-end network slice into transport network slice in user plane. TNSII is newly defined in this draft.
- o Transport Network Slice Identifier(TNSI): transport network slice identifier in data plane(user plane). TNSI is newly defined in this draft.

The relationship between these identifiers are specified in the following sections.

### **3.3. Relevant functions**

There are a set of slice relevant functions that are necessary for transport network slice management:

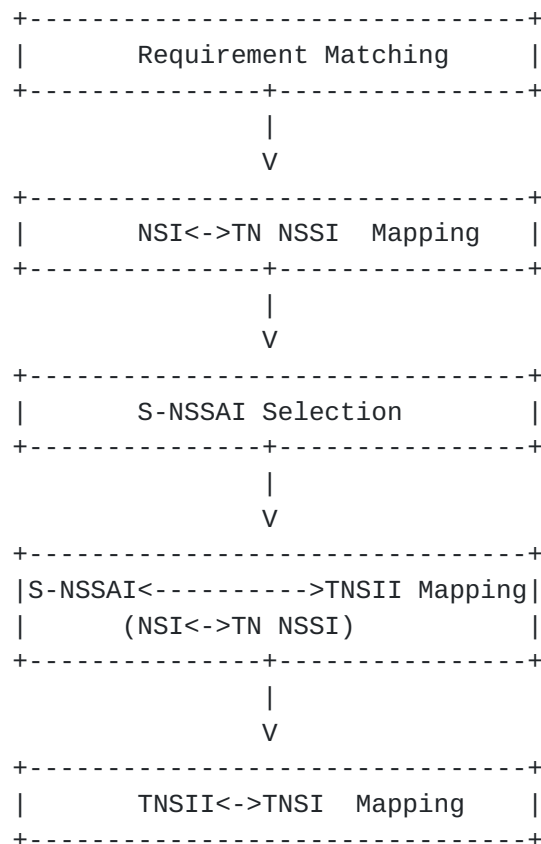
- o Topology management
- o QoS management
- o Resource management
- o Measurement management
- o ...



Some of these functions are implemented inside the transport network and independent from the end-to-end network slice, e.g., topology management, QoS management, resource management; Some of the functions are related to the end-to-end network slice and should cooperate with other network elements from other domain, e.g., Measurement management.

#### 4. Network Slice Mapping Procedure

This section provides a general procedure of network slice mapping:



1. NSMF receives the request from CSMF for allocation of a network slice instance with certain characteristics.
2. Based on the service requirement , NSMF acquires requirements for the end-to-end network slice instance , which is defined in Service Profile([TS28541] [section 6.3.3](#)).
3. NSMF derives transport network slice related requirements from the Service profile, and maintains them in Transport Network Slice Profile, So as to CN Slice Profile and AN Slice Profile, in order to decide on the constituent NSSIs(including AN NSSI, CN NSSI and TN



NSSI) of the NSI, based on the service profile and the endpoint information(AN/CN edge nodes).

4. NSMF sends the Transport Network Slice Profile to TN NSSMF for TN NSSI allocation.

5. TN NSSMF allocates TN NSSI which could satisfy the requirement of Transport Network Slice Profile between the specified endpoints (AN/CN edge nodes) and sends the TN NSSI Identifier to NSMF.

6. NSMF acquires the mapping relationship between NSI and TN NSSI.

7. NSMF maintains the mapping relationship between NSI and S-NSSAI and the mapping relationship between TN NSSI and TNSII, which could be used to set up mapping relationship between S-NSSAI and TNSII.

8. When a PDU session is set up between AN and CN, an S-NSSAI is selected for the PDU session.

9. AN/CN edge nodes encapsulate the packet using TNSII, according to the selected S-NSSAI. Network Slice could also be differentiated by physical interface, if different network slices are transported through different interface;

10. The edge node of transport network parses the TNSII from the packet and maps the packet to the corresponding transport network slice. It may encapsulate packet with TNSI. The nodes in transport network transit the packet inside the corresponding transport network slice according to TNSI.

The procedure of end-to-end network slice mapping involves the mapping in three network planes: management plane, control plane and data plane.

#### **4.1. Network Slice Mapping in Management Plane**

The transport network management Plane maintains the interface between NSMF and TN NSSMF, which 1) guarantees that transport network slice could connect the AN and CN with specified characteristics that satisfy the requirements of communication; 2) builds up the mapping relationship between NSI identifier and TN NSSI identifier; 3) maintains the end-to-end slice relevant functions;

Service Profile defined in[TS28541] 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.contreras-teas-slice-nbi] analysis the parameters of GST and categorize the parameters into three classes, including the attributes with direct impact on the transport 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.

Inside the TN NSSMF, it is supposed to maintain the attributes of the transport network slice. If the attributes of an existing TN NSSI could satisfy the requirement from TN Network Slice Profile, the existing TN NSSI could be selected and the mapping is finished. If there is no existing TN NSSI which could satisfy the requirement, a new TN NSSI is supposed to be created by the NSSMF with new attributes.

TN NSSI resource reservation should be considered to avoid over allocation from multiple requests from NSMF (but the detailed mechanism should be out of scope in the draft)

TN NSSMF sends the selected or newly allocated TN NSSI identifier to NSMF. The mapping relationship between NSI identifier and TN NSSI identifier is maintained in both NSMF and TN NSSMF.

#### **4.2. Network Slice Mapping in Control Plane**

There is no explicit interaction between transport network and AN/CN in the control plane, but the S-NSSAI defined in [TS23501] 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, we assume that there is mapping relationship between S-NSSAI and NSI in the management plane, thus it could be mapped to a transport network slice .

Editor's note: The mapping relationship between NSI defined in [TS23501] and S-NSSAI defined in [TS23501] is still in discussion.

#### **4.3. Network Slice Mapping in data plane**

If multiple network slices are carried through one physical interface between AN/CN and TN, transport network slice interworking identifier(TNSII) in the data plane needs to be introduced. If different network slices are transported through different physical interfaces, Network Slices could be distinguished by the interface





directly. Thus TNSII is not the only option for network slice mapping, while it may help in introducing new network slices.

#### **4.3.1. Data Plane Mapping Considerations**

The mapping relationship between AN or CN network slice identifier (either S-NSSAI in control plane or NSI/NSSI in management plane) and TNSII needs to be maintained in AN/CN network nodes, and the mapping relationship between TNSII and TNSI is maintained in the edge node of transport network. When the packet of a uplink flow goes from AN to TN, the packet is encapsulated based on the TNSII; then the encapsulation of TNSII is read by the edge node of transport network, which maps the packet to the corresponding transport network slice.

Editor's Note: We have considered to add "Network Instance" defined in [\[TS23501\]](#) in the draft. However, after the discussion with 3GPP people, we think the concept of "network instance" is a 'neither Necessary nor Sufficient Condition' for network slice. Network Instance could be determined by S-NSSAI, it could also depends on other information; Network slice could also be allocated without network instance (in my understanding) And, TNSII is not a competitive concept with network instance. TNSII is a concept for the data plane interconnection with transport network, network instance may be used by AN and CN nodes to associate a network slice with TNSII

#### **4.3.2. Data Plane Mapping Design**

The following picture shows the 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

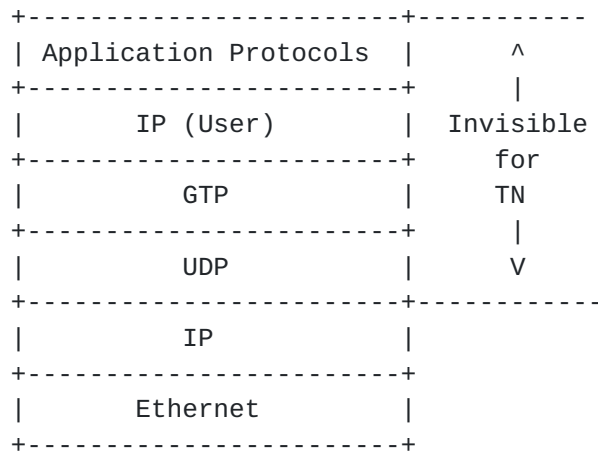
UPF: User data goes from core network functions to transport network

Editor's Note: As figure 4.7.1. in [\[TS28530\]](#) describes, TN NS will not only exist between AN and CN but may also within AN NS and CN NS.









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

#### IP Header:

- o 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.;
- o 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.
- o Option fields/headers: It requires that both AN and CN nodes can support the encapsulation and decapsulation of the options.

#### Ethernet header

- o 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 transport 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 TNSII, 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:

+-----+-----	
Application Protocols	^
+-----+-----	
IP (User)	Invisible
+-----+-----	for
GTP	TN
+-----+-----	
UDP	V
+-----+-----	
MPLS	
+-----+-----	
IP	
+-----+-----	
Ethernet	
+-----+-----	

A specified MPLS label could be used to as a TNSII.

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

+-----+-----	
Application Protocols	^
+-----+-----	
IP (User)	Invisible
+-----+-----	for
GTP	TN
+-----+-----	
UDP	V
+-----+-----	
SRH	
+-----+-----	
IPv6	
+-----+-----	
Ethernet	
+-----+-----	

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



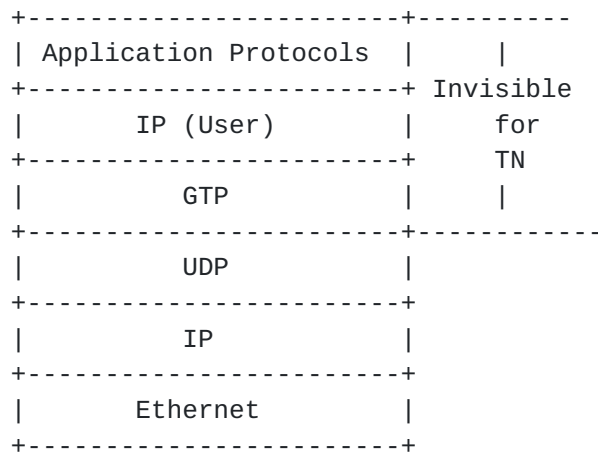


SRH:

- o SRv6 functions: AN/CN is supposed to support the new function extension of SRv6.
- o Optional TLV: AN/CN is supposed to support the extension of optional TLV of SRH.

#### **4.3.2.2. 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.



The following field in UDP header could be considered:

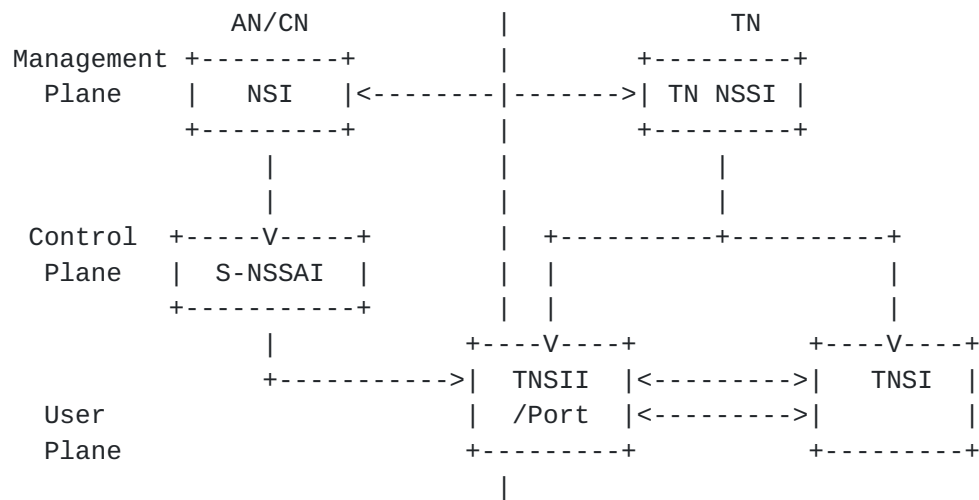
UDP Header:

- o 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.

## **5. Network Slice Mapping Summary**

The following picture shows the mapping relationship between the network slice identifier in management plane, control plane and user plane.





## 6. IANA Considerations

TBD

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

## 7. Security Considerations

TBD

## 8. Acknowledgements

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