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5G End-to-end Network Slice Mapping from the view of Transport Network

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 5G end-to-end network slice to transport network slice defined in IETF. This draft also intends to expose some gaps in the existing network management plane and data plane technologies to support inter-domain network slice mapping. Further work may require collaboration between IETF and 3GPP (or other standard organizations). Data model specification, signaling protocol extension and new encapsulation definition 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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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, with specific performance commitment. For each end-to-end network slice, the topology and performance requirement for transport network can be very different,

which requests transport network to have the capability of supporting multiple different transport network slices.

The concept of IETF network slice is discussed in [[I-D.ietf-teas-ietf-network-slices](#)]. In summary, an IETF Network Slice is a logical network topology connecting a number of endpoints using a set of shared or dedicated network resources that are used to satisfy specific Service Level Objectives (SLOs) and Service Level Expectations (SLEs).

The realization of an IETF network slices in Transport network (TN) could span multiple technology (e.g., IP/MPLS, Optical) and multiple administrative domains. Depending on the consumer's requirement, an IETF network slice could be isolated from other concurrent IETF network slices, in terms of data plane, control plane and management plane. The procedure for lifecycle of an end-to-end network slice instance (i.e., creation, deletion, modification, termination etc.) is defined in [[TS28531](#)]. End-to-end network slicing provisioning is specified in ETSI [[ZSM003](#)]. But there is no specifications about how to map end-to-end network slice to IETF network slices in Transport Network (TN). This draft describes the procedure of mapping the 5G end-to-end network slice to IETF network slices in management plane, control plane and data 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:

NSC: IETF Network Slice Controller

NSI: Network Slice Instance

NSSI: Network Slice Subnet Instance

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

3. 5G End-to-End Network Slice Identification

The following figure illustrates a typical mobile network with three 5G e2e network slices. Each e2e network slice contains AN slice, CN slice and one or more IETF network Slices. 3GPP identifies each e2e network slice using an integer called S-NSSAI. In Figure-1 there are three instances of e2e network slices which are identified by S-NSSAI 01111111, 02222222 and 03333333, 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.

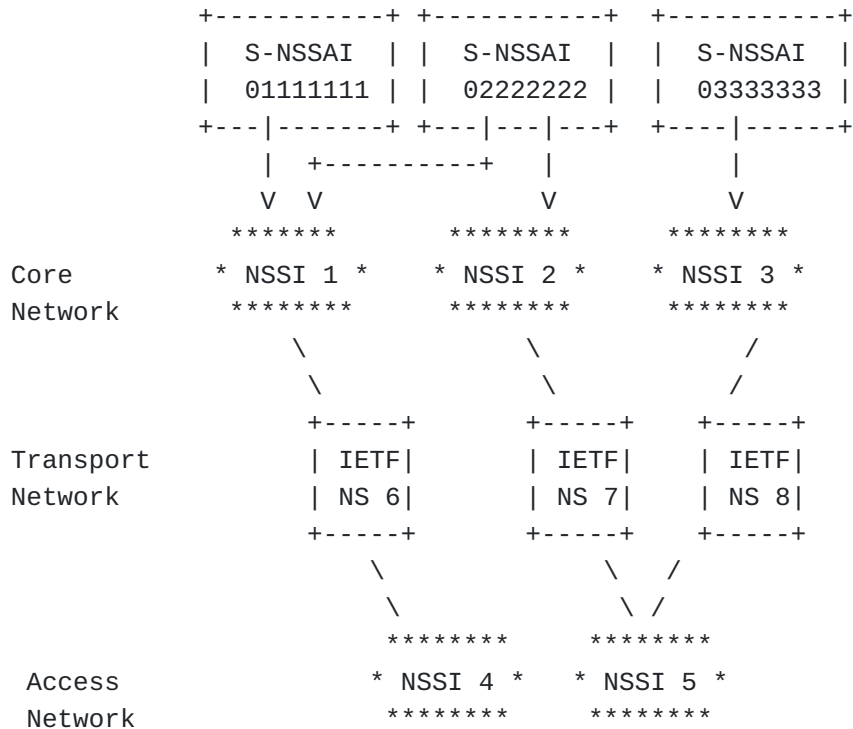
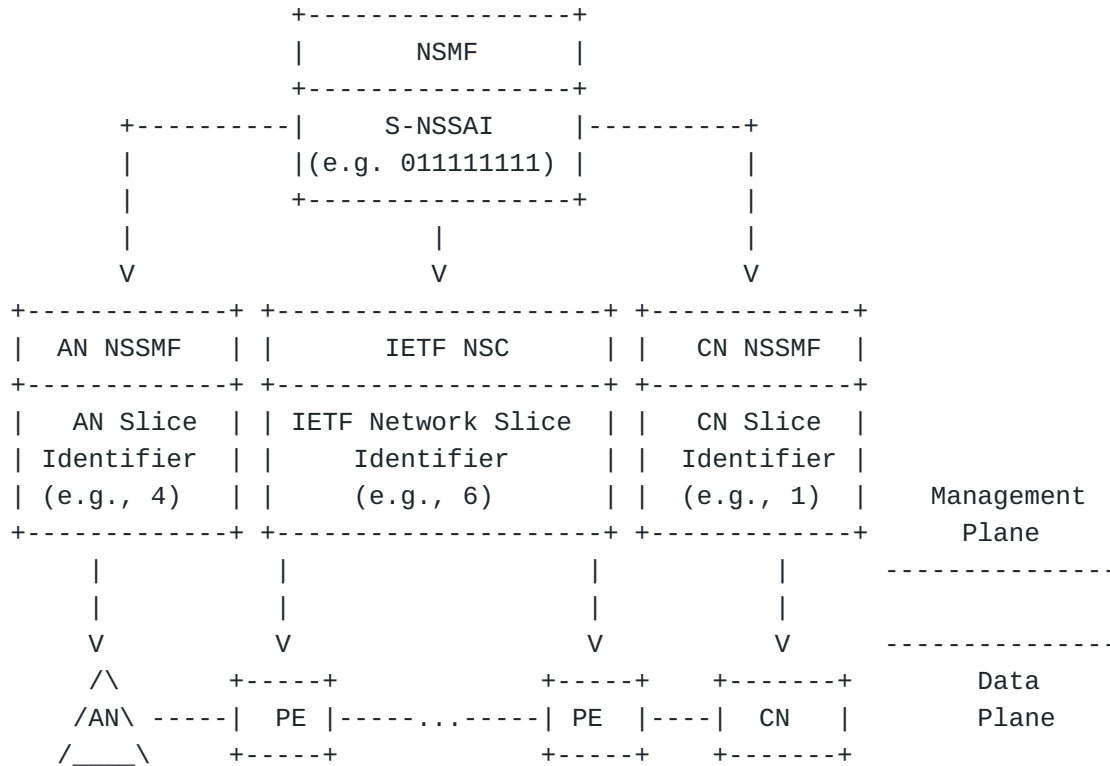


Figure 1 5G End-to-End Network Slice and its components

4. Network Slice Mapping Structure

Referring to 3GPP TR 28.801, the management of 5G e2e network slices from 3GPP view is shown in Figure-2(A). Figure-2(B) illustrates the view of IETF and how it maps to 3GPP network slice management. In particular, the IETF network slice controller (NSC) is equivalent to 3GPP TN NSSMF and functional block "Consumer" at IETF is equivalent to 3GPP NSMF.



Note: Refer to Figure-1 for S-NSSAI 011111111, AN, CN and IETF networks s

Figure-2 Relation between IETF and 3GPP Network Slice management

The following figure shows the necessary elements for mapping end-to-end network slice into IETF network slices.

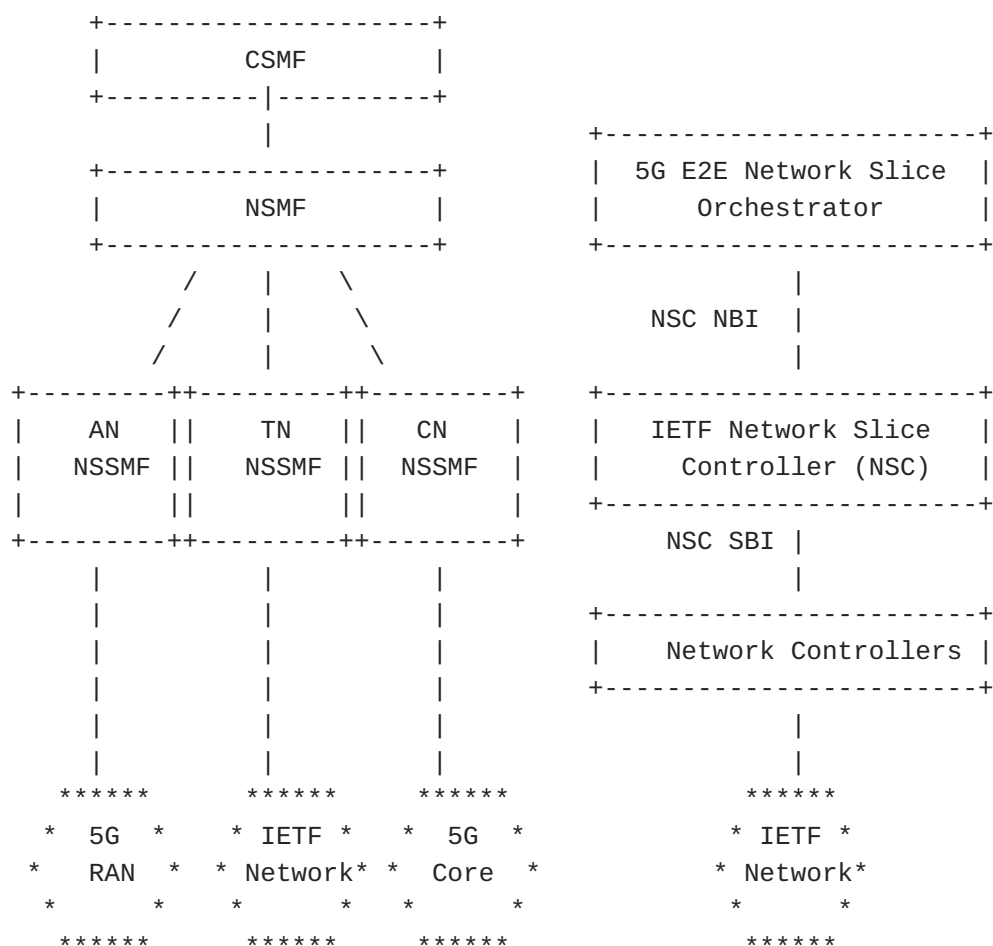


Figure-3 5G E2E Network Slice Mapping Structure

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 [TS23501]; 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.

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

5. 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. Based on Service Profile, NSMF identifies the network function and the required resources in AN, CN and TN networks. It also assigns the unique ID S-NSSAI.
4. NSMF sends a request to AN NSSMF for creation of AN Slice.
5. NSMF sends a request to CN NSSMF for creation of CN Slice.
6. NSMF sends a request to IETF Network Slice Controller (NSC) for creation of IETF Network Slice. The request contains such attributes such as endpoints, required SLA/SLO along with other IETF network slice attributes. It also contains mapping information for IETF Network Slice Interworking Identifier.
7. NSC realizes the IETF network slice which satisfies the requirement of IETF network slice between the specified endpoints (AN/ CN edge nodes). It assigns sliceID and sends it to NSMF.
8. NSMF has the mapping relationship between S-NSSAI and IETF Network Slice ID;
9. When the User Equipment (UE) appears, and during the 5G signalling, it requests to be connected to specific e2e network slice identified by S-NSSAI. Then a GTP tunnel (which is UDP/IP) will be created.
10. UE starts sending traffic in context of e2e network slice for specific S-NSSAI.
11. In context of GTP tunnel, the AN edge nodes encapsulate the packet with sliceID according to the selected S-NSSAI and send it to the transport network.

12. The transport network edge node receives the IP packet and parses the sliceIID from the packet and maps the packet to the corresponding IETF network slice. It may encapsulate packet with sliceID if needed (for example for enforcing QoS in transport network).

5.1. Network Slice Mapping in Management Plane

The transport network management Plane maintains the interface between NSMF and TN NSSMF, which 1) guarantees that IETF 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 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.

Inside the TN NSSMF, it is supposed to maintain the attributes of the IETF 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.

YANG data model for the Transport Slice NBI, which could be used by a higher level system which is the Transport slice consumer of a

Transport Slice Controller (TSC) to request, configure, and manage the components of a transport slices, is defined in [[I-D.wd-teas-transport-slice-yang](#)]. The northbound Interface of IETF network slice refers to [[I-D.wd-teas-ietf-network-slice-nbi-yang](#)].

5.2. 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 IETF network slice .

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

5.3. Network Slice Mapping in Data Plane

If multiple network slices are carried through one physical interface between AN/CN and TN, IETF Network Slice Interworking ID 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 IETF Network Slice Interworking ID is not the only option for network slice mapping, while it may help in introducing new network slices.

5.3.1. Data Plane Mapping Considerations

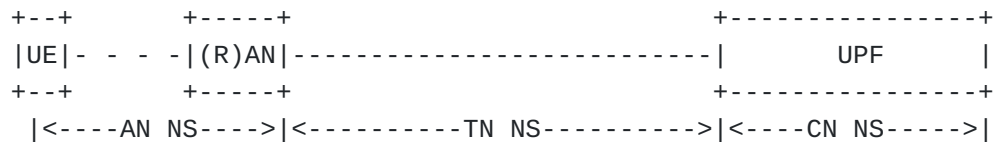
The mapping relationship between AN or CN network slice identifier (either S-NSSAI in control plane or NSI/NSSI in management plane) and IETF Network Slice Interworking ID needs to be maintained in AN/CN network nodes, and the mapping relationship between IETF Network Slice Interworking ID and IETF Network Slice 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 IETF Network Slice Interworking ID; then the encapsulation of IETF Network Slice Interworking ID is read by the edge node of transport network, which maps the packet to the corresponding IETF 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, IETF Network Slice

Interworking ID is not a competitive concept with network instance. IETF Network Slice Interworking ID 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 IETF Network Slice Interworking ID

5.3.2. Data Plane Mapping Options

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



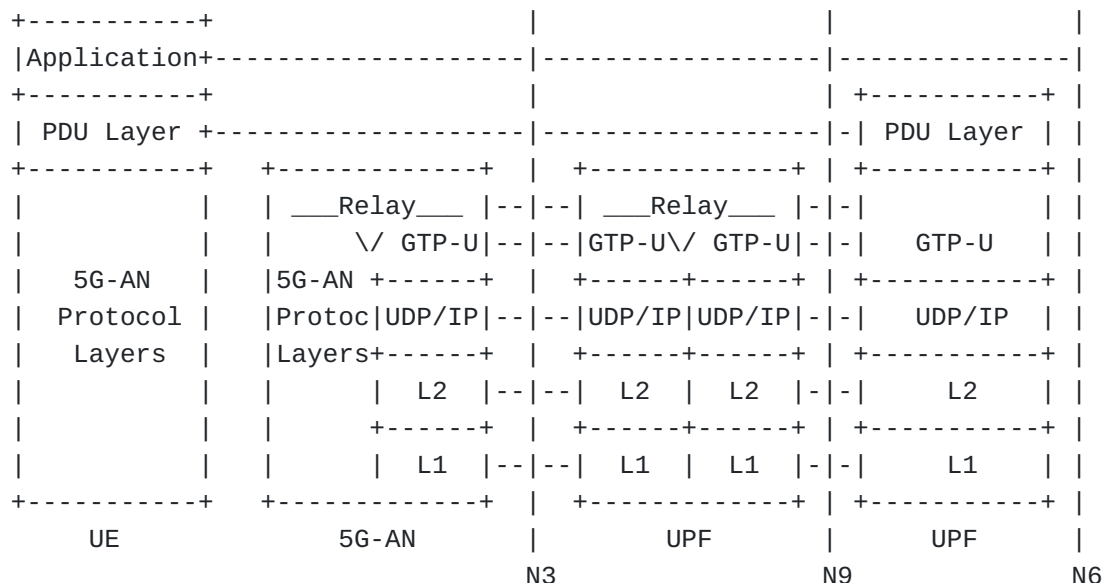
The mapping between 3GPP slice and transport slice in user plane could happens in:

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

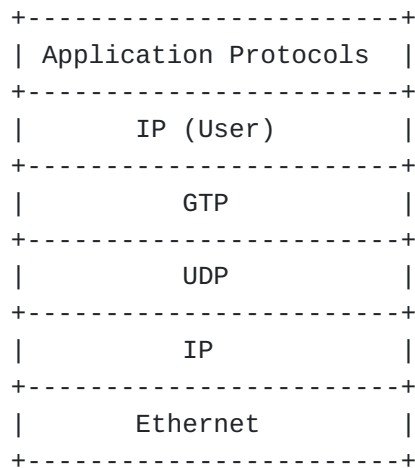
UPF: User data goes from core network functions to transport network

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. 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.

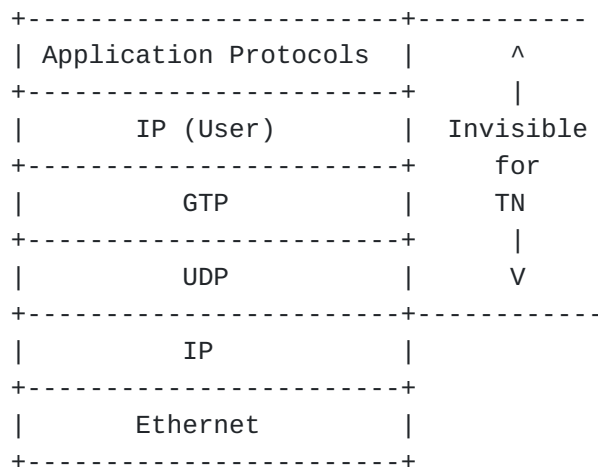


The following figure shows the typical encapsulation in N3 interface which could be used to carry the IETF Network Slice Interworking ID between AN/CN and TN.



5.3.2.1. 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.



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.

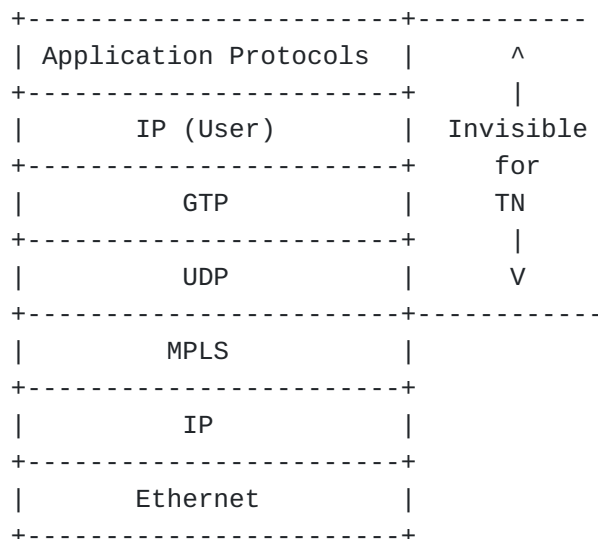
Ethernet header

*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.

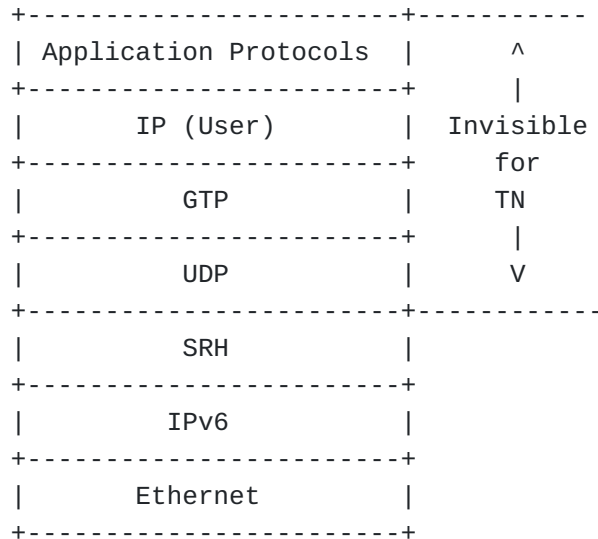
In some other case, when AN or CN could support more layer 3 encapsulations, more options are available as follows:

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



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:



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.

5.3.2.2. 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.

Application Protocols	Invisible
IP (User)	for
GTP	TN
UDP	
IP	
Ethernet	

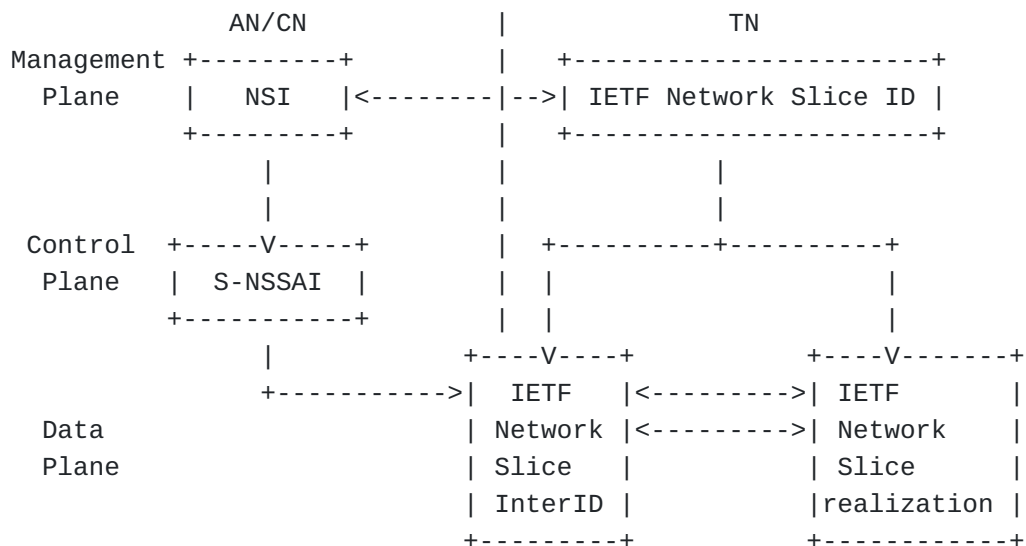
The following field in UDP header could be considered:

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.

6. Network Slice Mapping Summary

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



7. IANA Considerations

TBD

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

8. Security Considerations

TBD

9. Acknowledgements

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