IETF Network Slice for 5G and its characteristics
draft-rokui-5g-ietf-network-slice-00

Abstract

   5G Network slicing is an approach to provide separate independent
   end-to-end logical network from User Equipment (UE) to various mobile
   applications where each network slice has its own Service Level
   Agreement (SLA) and Objectives (SLO) requirements. Each end-to-end
   network slice consists of a multitude of contexts across RAN, Core
   and transport domains each with its own controller. To provide
   automation, assurance and optimization of the 5G the network slices,
   a 5G E2E network slice orchestrator is needed which interacts with
   controllers in RAN, Core and Transport network domains. The
   interfaces between the 5G E2E network slice orchestrator and RAN and
   Core controllers are defined in various 3GPP technical
   specifications. However, 3GPP has not defined a similar interface
   for transport network.

   The aim of this document is to describe E2E network slicing and its
   relation to "IETF network slice" for 5G use-case. It also provides
   an information model for control and mangement of IETF network slices
   for 5G.

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1. Introduction

Network slicing offers network operators a mechanism to allocate
dedicated infrastructure, resources and services from a shared
operator's network to a customer for specific use-case. As discussed
in draft [I-D.nsdt-teas-ietf-network-slice-definition], there are a
number of use-cases benefiting from network slicing including:

o 5G network slicing (See [TS.23.501-3GPP])

o Network wholesale services

o Network sharing among operators

o NFV connectivity and Data Center Interconnect

It is important to note that the concept of network slicing is not
only limited to 5G but other use-cases can also benefit from it as
shown above. However, the 5G use case is one of the important use
cases for network slicing. This memo will discuss the 5G use-case in
more details. In specific, 5G network slicing is a mechanism which a
mobile network operator can use to allocate dedicated
infrastructures, resources and services from a shared mobile and
transport network to a 5G customer for specific 5G use-case.

A 5G network slice is inherently an E2E concept and is composed of
multiple logical independent networks in a common operator's network
from a user equipment to various 5G applications. In particular, 5G
network slicing receives attention due to factors such as diversity
of services and devices in 5G each with its own SLA requirements.
Each 5G E2E network slice consists of multiple 5G RAN, 5G Core and
transport network domains each with its own controller (See
[TS.28.531-3GPP].

To enable automation, assurance and optimization of 5G network
slices, an E2E network slice orchestrator is needed which interacts
with 5G RAN, 5G Core and Transport network controllers. The
interfaces between the E2E network slice orchestrator and RAN and
Core slice controllers are defined in various 3GPP technical
specifications. However, 3GPP has not defined the same interface
towards the transport network. Draft
[I-D.wd-teas-transport-slice-yang] addresses the object model of such
interface for all network slice use-cases. However, for 5G network

slicing, the current model shall be augmented to address the specific
characteristics of the 5G network slices. The aim of this document
is to provide characteristics of 5G network slices and how it relares
to "IETF network slice". It also provides the IETF network slice
interface specifications and its information model to be used for
automation, monitoring and optimization of IETF network slices for
5G. See [I-D.contreras-teas-slice-nbi].

1.1. Definition of Terms

Please refer to [I-D.nsdt-teas-ietf-network-slice-definition] and
[I-D.homma-slice-provision-models] as well.

Tenant: Also known as Customer. A network slice tenant is a person
   or group that rents and occupies an instance of the network slice
   from network provider.

5G End-to-end Network Slice: A logical end-to-end network provided
   by a 5G network slice provider that has the functionality and
   performance to support a specific 5G service. It spans multiple
   network domains (e.g. radio, transport and core) and in some cases
   more than one administrative domain. It may well support dynamic
   modification or it might be long-lasting i.e. only change on
   commercial timescales.

5G IETF Network Slice: We will use the term "5G IETF network slice"
   throughout this draft. It simply refers to IETF network slice
   define in [I-D.nsdt-teas-ietf-network-slice-definition] applicable
   to 5G.

RAN Slice: Also known in 3GPP as RAN Sub-Slice or RAN Slice-Subnet.
   The context and personality created on RAN network functions to
   address the 5G radio portion of a 5G E2E network slice.

Core Slice: Also known in 3GPP as Core Sub-Slice or Core Slice-
   Subnet. The context and personality created on Core network
   functions to address the 5G Core portion of a 5G E2E network
   slice.

S-NSSAI: Single-Network Slice Selection Assistance Information,
   defined by 3GPP which is the identification of a 5G E2E Network
   Slice

gNB: The radio portion of a 5G E2E network slice and in a
   distributed radio deployment (called Cloud-RAN), it incorporates
   two major modules; Central Unit (CU) and Distribute Unit (DU)

   DU: Distributed Unit: This logical unit includes a subset of gNB
      real-time functions. Its operation is controlled by the CU.

   CU: Central Unit: It is a logical unit that includes the gNB non-
      realtime functions.

   UE: User Equipment such as vehicle infotainment unit, cell phone,
      IoT sensor and etc.

   RAN: Radio Access Network is the part of a mobile system that
      connects individual devices to other parts of a network through
      radio connections. It provides connection between user equipment
      (UE) and mobile core network.

   Transport Domain: Transport domain is a network domain implemented
      by the deployment of IETF network technologies.

[2]. Architecture of a 5G end-to-end network slice

   To demonstrate the concept of 5G E2E network slice and the role of
   various controllers, consider a typical 5G network shown in Figure 1
   where a mobile network operator Y has two customers C1 and C2. The
   boundaries of administrative domain of the operator includes RAN,
   transport, Core and mobile application domains. Customer C1 and C2
   request to have one or more logical independent E2E networks from UEs
   (e.g. vehicle infotainment, mobile phone, IoT meters etc.) to the 5G
   application servers, each with its own distinct SLO.

   Each of these independent networks is called a 5G E2E network slice.
   Each E2E network slice comprised of three componets RAN slice, IETF
   network slice, and Core slice, respectively representing RAN,
   transport and core domain portions of the slice.

```
      <--------------- 5G End to End Network Slice ---------------->

      <-- RAN --> <-- IETF Network --> <- Core -> <-- IETF Network -->
         Slice           Slice 1            Slice         Slice 2


        ......... .................. ............ ................
        :       : :                  : :         : :              :
        :       : :                  : :         : :              :
NS1  -----------------------------------------------------------------
NS2  ===============================================================
NS3  +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
        :       : :                  : :         : :              :
NS4  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
        :       : :                  : :         : :              :
        :       : :                  : :         : :              :
        :.......: :................: :.........: :..............:


           RAN          Transport          Core       Transport     App
         Network       Network 1          Network     Network 2    Servers
```
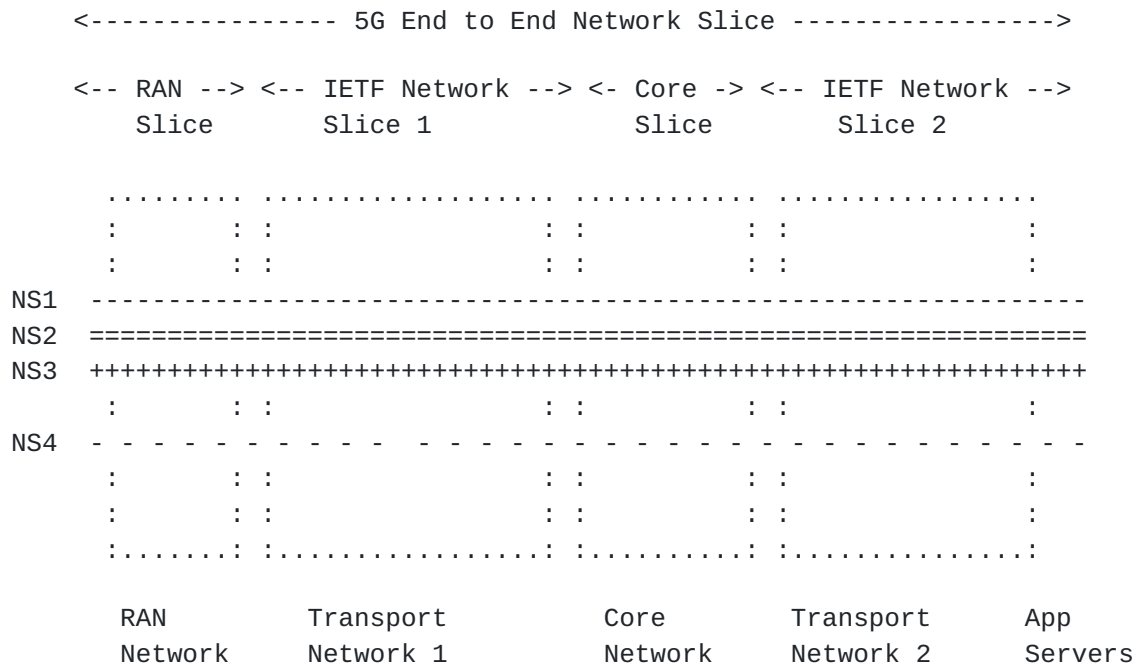
Legend:
```
 ----- NS1: 5G E2E NS 1 for customer C1, service type Infotainment
 ===== NS2: 5G E2E NS 2 for customer C1, service type Autonomous Driving
 +++++ NS3: 5G E2E NS 3 for customer C1, service type HD Map
 - - - NS4: 5G E2E NS 4 for customer C2, service type CCTV
```

   Figure 1: High level architecture of a 5G end-to-end network slice

   In Figure 1 mobile network operator Y has created four 5G E2E network
   slices, NS1, NS2, NS3 and NS4, each with its own RAN, Core and IETF
   network slices. To create a RAN slice, the RAN network function s
   such as eNB and gNB should be programmed to have a context for each
   5G E2E network slice. This context means that the RAN network
   functions should allocate certain resources for each 5G E2E network
   slice they belong to such as air interface, various schedulers,
   policies and profiles to guarantee the SLO requirement for that
   specific network slice. By the same token, the Core slices will be
   created which means that the mobile network operator will create the
   context for each 5G E2E network slice on Core network functions.

   For each 5G E2E network slice NS1, NS2, NS3 and NS4, after creation
   of RAN and Core slices, they should be connected to each other and be
   connected to mobile application servers to form the 5G E2E network
   slice. As defined in [I-D.nsdt-teas-ietf-network-slice-definition],
   the set of connections are referred to "IETF Network Slices" and
   specifically for 5G they are referred to "5G IETF Network Slices".

Referring to Figure 1, for each 5G E2E network slice, the following
5G IETF network Slices are needed:

o 5G IETF Network Slice 1: To connect RAN slice to Core slice in
   Transport Network 1

o 5G IETF Network Slice 2: To connect Core slice to Mobile
   Application Servers in Transport Network 2. This might be needed
   if the mobile application servers are connected to core network
   functions through a transport network. For example, if the Core
   slice, which is realized on VNFs, and mobile application servers
   are in the same data center, the 5G IETF Network Slice 2 is not
   needed. In this case the transport network 2 does not exist.

Note that as we will see later in Section 4.1, Section 4.2 and
Section 4.3, the number of "5G IETF network slices" might be more
than two which depends on some factors such as RAN deployment:

After creation of RAN, Core and 5G IETF network slices, they will be
associated together to form a working 5G E2E network slice identified
by an ID referred as to S-NSSAI. Please refer to [TS.23.501-3GPP]
for more info on S-NSSAI.

To support fully automated enablement and assurance of 5G E2E network
slices, multiple controllers are needed to perform the life cycle of
5G E2E network slices in RAN, Core and Transport domains. As shown
in Figure 2 each RAN, Core and Transport domain needs its own
controller called RAN Slice Controller, Core Slice Controller and
IETF Network Slice Controller. In addition, an E2E network slice
orchestrator is needed to provide coordination and control of network
slices from an E2E perspective.

In summary, a 5G E2E network slice will involve several domains, each
with its own controller; 5G RAN, 5G Core and transport domains need
to be coordinated in order to deliver an E2E mobile service. Note
that in this context a service is not an IP/MPLS service but rather
customer facing services such as CCTV service, eMBB service,
Infotainment service and so on.

```
|-----------------------------------------------------------|
|                E2E Network Slice Orchestrator             |
|-----------------------------------------------------------|


|---------------|  |------------------|  |---------------|
|   RAN Slice   |  |   IETF Network   |  |  Core Slice   |
|   Controller  |  |  Slice Controller|  |   Controller  |
|---------------|  |------------------|  |---------------|


........  ................  ...........  .................
:       : :              : :         : :                 :
:       : :              : :         : :                 :
: RAN   : :   Transport  : : Core  : :   Transport  :  Mobile
: Network: :  Network 1  : : Network : :  Network 2  :  App
:       : :              : :         : :               :  Servers
:       : :              : :         : :                 :
:.......: :..............: :.........: :...............:
```
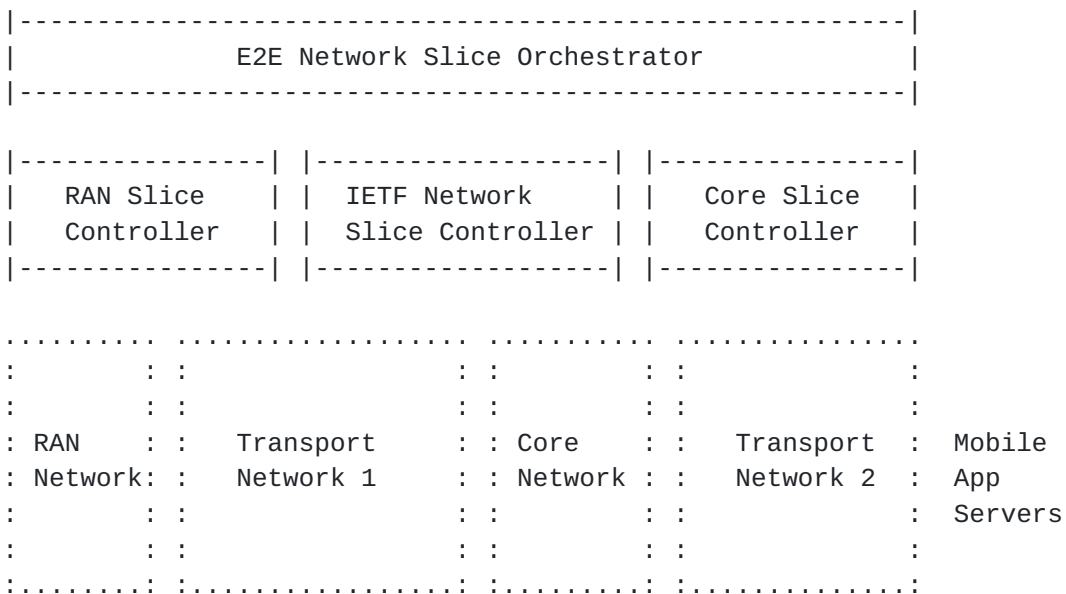
Figure 2: Various controllers for 5G end-to-end network slice

3. Typical flow for fulfillment of a 5G E2E network slice

Figure 3 provides a typical flow across various controllers,
orchestrator, NFVO and RAN/Transport/Core networks to achieve the
automatic creation of a 5G E2E network slices such as NS1, NS2, NS3
or NS4 shown in Figure 1. Below are typical steps from the time a
customer sends its request for a 5G E2E network slice creation to the
operators network until the network slice is created and ready to be
used by the customer. It is important to note that in practice some
of these steps can be combined or re-ordered.

1.   The customer C1 requests, from operator Y, the creation of a 5G
     E2E network slice NS1 for Infotainment service type and SLO of
     10 [Mbps]

2.   The 5G E2E network slice orchestrator receives this request and
     using its pre-defined network slice blueprints (a.k.a. network
     slice templates), creates a network slice profile (a.k.a.
     network slice instance) containing all the network functions in
     RAN and core which should be part of this E2E network slice. It
     then goes through decomposition of this profile and triggers
     various actions towards RAN, Core and transport domains.

3.   A request for creation of 5G RAN slice will be sent to RAN Slice
     Controller.

4.   If new instances of virtual RAN network functions are needed,
     the RAN Slice Controller triggers the creation of new VNFs in
     RAN (using for example ETSI interface Os-Ma-nfvo)

5.   NFVO manages the life cycle of virtual RAN network functions

6.   Since both physical and virtual RAN network functions which are
     part of 5G E2E network functions are known to the RAN slice
     controller, it triggers the creation of a RAN slice by
     programming 5G RAN network functions

7.   Similary to previous step (3), a request for creation of a Core
     slice will be sent to the Core Slice Controller.

8.   If new instances of virtual Core network functions are needed,
     the Core Slice controller triggers the creation of new 5G core
     VNFs (using for example ETSI interface Os-Ma-nfvo) and NFVO
     manages the life cycle of virtual Core network functions

9.   Since both physical and virtual 5G Core network functions as
     components of 5G E2E network functions are known to the Core
     slice controller, it triggers the creation of Core slice by
     programming 5G Core network functions

10. In this step, the creation of various 5G IETF network slices
     will be triggered. Each 5G IETF network slice contains one or
     more connections between RAN network functions, Core network
     functions and 5G mobile applications. For example, connectivity
     between 5G RAN and 5G Core slices, connectivity between 5G RAN
     network functions (such as DU to CU) or connectivity between 5G
     core slice and mobile applications. Note that this step can be
     triggered by E2E network slice orchestrator, RAN slice
     controller, Core slice controller, or a combination of them.

11. [Optional] If the realization of a 5G IETF network slice
     involves creation of new VNFs (e.g. Firewall, security gateway
     etc.), 5G IETF network slice controller triggers the creation of
     those VNFs (using for example ETSI interface Os-Ma-nfvo)

12. Various 5G IETF network slices will be realized in transport
     network. Note that interface (10) is technology-agnostic
     whereas interface (12) is technology-specific

13. The E2E network slice orchestrator associates RAN slice, Core
     slice and 5G IETF network slices together to form a single 5G
     E2E network slice NS1

14. At the end, when the E2E network slice is created, the E2E
     network slice orchestrator will allocate a unique network slice
     id (called S-NSSAI) and eventually, during the UE network
     attach, UEs will be informed about the existence of this newly
     created E2E network slice. UEs can request it using the 3GPP 5G
     signaling procedures.

Note that the interfaces 3 and 7 between 5G E2E network slice
orchestrator and RAN and Core slice controllers along with their
information models are defined in various 3GPP technical
specifications. However, 3GPP has not defined the same interface for
transport network (i.e. interface 10).

The aim of this document is to define specific attributes related to
5G network slices which will be used later to augment
[I-D.wd-teas-transport-slice-yang].

```
    |----------------------------------------------------------|
    |                    Customer portal                       |
    |----------------------------------------------------------|
                         |(1)
                         V
    |----------------------------------------------------------|
    | Generate NS Profile (aka NSI) using NS Blueprints | 5G E2E
    |                      |(2)                          | Network Slice
    |                      V                             | Orchestrator
    |   Decompose NS Profile and trigger various actions |
    |----------------------------------------------------------|
        |(3)                      |(10)                |(7)
        |            |--------| | |------|             |
        V            |        V V V      |             V
    ---------------  | ----------------  | ----------------
    | RAN         |  | | IETF         |  | |  Core        | Domain
    | Slice       |-|  | Network Slice |  |-|  Slice      | Controllers
    | Controller  |  | | Controller   |  | |  Controller | 
    ---------------    ----------------    ----------------
     (6)|  |(4)          (12)|  |(11)            (8)|  |(9)
        |  |                 |   |--------|         |  |
        |  |--------------   |  --------| | |------|  |
        |                    |          V V V         |
        |                    |      |----------|      |
        |                    |      |   NFVO   |      |
        |                    |      |----------|      |
        |                    |          |             |
        |                    |          |             |
    .............  ................   |  ................
    :   RAN    :  : IETF Network  :   |  :     Core    :
    :  Slice   :  : Slice         :   |  :     Slice   :
```

```
    :............:  :.............:   |  :..............:
    .... | .............. | ........ | .......... | ..... 5G E2E
    :    |                |          |            |      : Network Slice
    :... | .............. | ........ | .......... | ....: (13)
         |                |          |            |
     (6)|            (12)|       (5)|            |(9)
        V                V          V            V
    |-------------------------------------------------------|
    |    ,--------.     ,-------------.    ,--------.        | Network of
    |   /   RAN    \   /   Transport   \  /   Core   \       | Mobile
    |   \  Network /   \    Network    /  \  Network /       | Operator "Y"
    |    `--------'     `-------------'    `--------'        |
    |-------------------------------------------------------|
```

```
    Legend:
      NS: 5G E2E Network Slice
      NSI: Network Slice Instance
      NFVO: NFV Orchestrator
```

    Figure 3: Typical flow for fulfillment of a 5G E2E network slice

4. Definition of 5G IETF Network Slice

Referring to [I-D.nsdt-teas-ietf-network-slice-definition], the IETF
network slice is define as follows:

An IETF network slice is a logical network topology connecting a
number of endpoints with a set of shared or dedicated network
resources. These resources are used to satisfy specific Service
Level Objectives (SLOs).

The 5G IETF Network slice specification is technology-agnostic.
Using the above-mentioned definition, the 5G IETF network slice is
define as follows:

5G IETF network slices are sets of connections among the following
network functions and mobile applications:

o   5G RAN slice and 5G Core slice

o   5G Core slice and mobile application server

o   Among 5G RAN network functions DU to CU

o   Among 5G RAN network functions RU to DU

In Section 4.1, Section 4.2 and Section 4.3, the details of various
5G IETF network slices for following RAN deployment will be provided:

o Distributed RAN

o Centralized RAN

o Cloud RAN (C-RAN)

4.1. 5G IETF Network Slices in Distributed RAN deployment

Distributed RAN is the most common deployment of 4G and 5G RAN
networks whereas shown in Figure 4, the RAN network is connected to
Core network using the transport network 1. Optionally the mobile
applications can be also connected to the Core network using another
transport network 2.

In this case, a single 5G E2E network slice contains not only 5G RAN
and 5G Core slices but two 5G IETF network slices INS_1 and INS_2.
INS_1 connects the RAN slice to Core slice and INS_2 connects Core
slice to mobile application servers (if needed).

```
          <------------- 5G E2E Network Slice  ------------->
          <--- RS -->                <-- CS -->
                     <--- INS_1 -->          <--- INS_2 --->
 .................
 : RAN          :
 :              : .............          ............
 : |----| |-----| : :            : |------|  :           : |-----|
 : | RU | | BBU | : : Transport : | Core |  : Transport : | App |
 : |----| |-----| : : Network 1 : |------|  : Network 2 : |-----|
 :              : :............:          :...........:
 :..............:
```
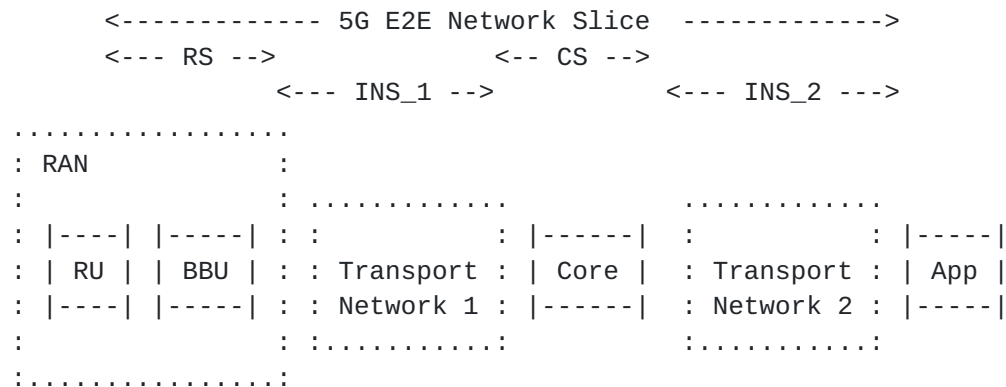
Legend
  INS: 5G IETF Network Slice
  RS: RAN Slice
  CS: Core Slice
  RU: Radio Unit
  BBU: BaseBand Unit
  App: Mobile Application Servers

  Figure 4: 5G IETF network slices in distributed RAN deployment

4.2. 5G IETF Network Slices in Centralized RAN deployment

   The RAN consists of two functional units: the baseband unit (BBU) and
   the radio unit (RU). The BBU processes the signal and is connected
   to the transport network. The RU transmits and receives the carrier
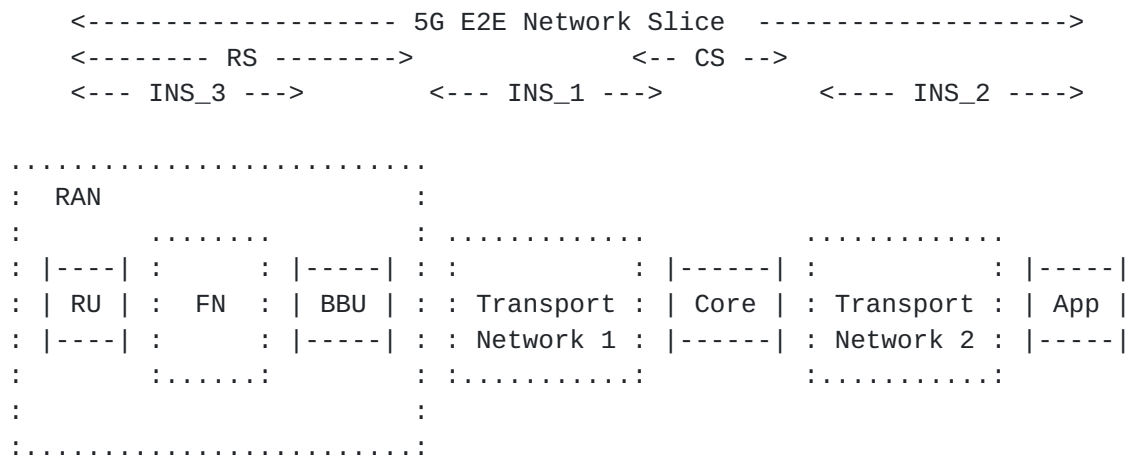   signal that is transmitted over the air to the end user equipment
   (UE). In Centralized RAN as depicted in Figure 5, the RU and BBU are
   separated by a network called fronthaul network.

   In this deployment a single 5G E2E network slice contains not only 5G
   RAN and 5G Core slices but three 5G IETF network slices INS_1, INS_2
   and INS_3 where INS_1 and INS_2 are identical to their counterparts
   in distributed RAN deployment case (see Figure 4) and a new INS_3
   connects the Radio Units (RU) to the BBUs.

```
   <-------------------- 5G E2E Network Slice  -------------------->
    <-------- RS -------->              <-- CS -->
     <--- INS_3 --->         <--- INS_1 --->        <---- INS_2 ---->


...........................
:  RAN                    :
:       ........          : .............       ............
: |----| :       : |-----| : :             : |------| :            : |-----|
: | RU | :   FN  : | BBU | : : Transport : | Core | : Transport : | App |
: |----| :       : |-----| : : Network 1 : |------| : Network 2 : |-----|
:       :......:          : :...........:         :..........:
:                         :
:.........................:

Legend
  INS: 5G IETF Network Slice
  RS: RAN Slice
  CS: Core Slice
  FN: Fronthaul network
  RU: Radio Unit
  BBU: BaseBand Unit
  App: Mobile Application Servers
```
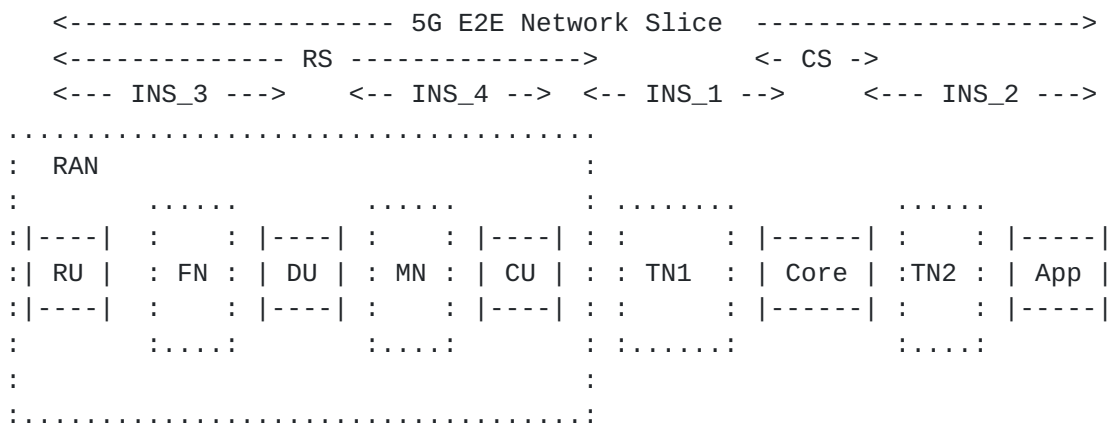
        Figure 5: 5G IETF network slices in Centralized RAN deployment

4.3. 5G IETF Network Slices in Cloud RAN (C-RAN)

   In Cloud-RAN deployment, the baseband unit (BBU) is further
   disaggregated into real-time and non-real-time components. The
   former is deployed close to antenna to manages the real-time air
   interface resources while the non-real-time control functions are

hosted centrally in the cloud. In 5G, BBU is split into two parts
called CU (Central Unit) and DU (Distributed Unit) as shown in
Figure 6 where these entities are connected by a new network called
Midhaul network.

In this deployment a single 5G E2E network slice contains not only 5G
RAN and 5G Core slices but four 5G IETF network slices INS_1, INS_2,
INS_3 and INS_4 where INS_1, INS_2 and INS_3 are identical to their
counterparts in centralized RAN deployment case (see Figure 5) and a
new 5G IETF network slice INS_4 connects the DUs to CUs.

```
  <-------------------- 5G E2E Network Slice  -------------------->
  <------------- RS --------------->          <- CS ->
   <--- INS_3 --->    <-- INS_4 --> <-- INS_1 -->     <--- INS_2 --->
 ......................................
 :  RAN                                :
 :       ......      ......      : ........       ......
 :|----| :    : |----| :    : |----| : :       : |------| :    : |-----|
 :| RU |  : FN : | DU | : MN : | CU | : : TN1  : | Core | :TN2 : | App |
 :|----| :    : |----| :    : |----| : :       : |------| :    : |-----|
 :       :....:       :....:       : :......:        :....:
 :                                    :
 :....................................:
```

Legend
  INS: 5G IETF Network Slice
  RS: RAN Slice
  CS: Core Slice
  FN: Fronthaul network
  MN: Midhaul network
  TN: Transport network
  DU: Distributed Unit
  CU: Central Unit
  RU: Radio Unit
  App: Mobile Application Servers

         Figure 6: 5G IETF network slices in Cloud RAN deployment

4.4. 5G IETF Network Slice as a set of Connection Groups
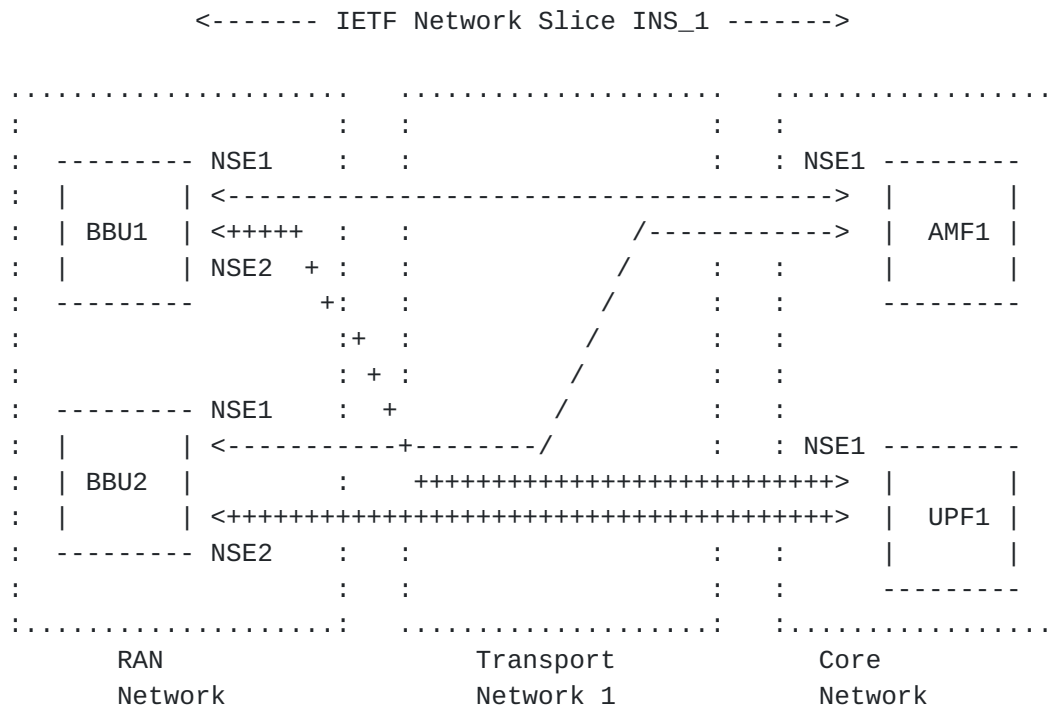
As discussed in [I-D.nsdt-teas-ietf-network-slice-definition], an
IETF network slice contains one or more connections between various
network functions, application and devices. These connections can be
grouped into various Connection Groups where each group has its own
SLA/SLO.

To further explore this concept in 5G E2E network slicing, consider
Figure 7, where the details of 5G IETF network slice INS_1 introduced
in Figure 4 is illustrated. The 5G IETF network slice INS_1 is
between 5G RAN and Core slices and has multiple connections between
5G RAN network functions BBU1 and BBU2 and 5G Core network functions
AMF1 and UPF1. In particular, it contains the following connection
groups, each with its own SLO where SLO-C and SLO-U might be
different (e.g. they might be control and user plans SLOs):

o "Connection group C" connects BBU1 and BBU2 to AMF1 with SLO-C

o "Connection group U" connects BBU1 and BBU2 to UPF1 with SLO-U

The combination of two connection groups will form the 5G IETF
network slice INS_1. Note that the definition of 5G IETF network
slice INS_1 does not specify how these connections should be realized
in transport network 1. Although it is optionally possible, it is
not necessarily mandatory for the definition of a 5G IETF network
slice to state which technology (e.g. IP, MPLS, Optics, PON etc.) or
tunnel type (e.g. RSVP-TE, SR-TE etc.) should be employed for
realization. As discussed in
[[I-D.nsdt-teas-ietf-network-slice-definition], any of these
technologies may be used by the IETF Network Slice Controller (NSC)
to realize an IETF network slice.

In summary, a 5G IETF network slice is a distinct set of technology-
agnostic connection groups between various 5G network functions, 5G
devices or 5G applications each with its own deterministic SLO which
can be realized by any suitable technology, tunnel type and service
type.

```
              <------- IETF Network Slice INS_1 ------->


   ......................   ......................   ...................
   :                    :   :                    :   :                 :
   :  --------- NSE1    :   :                    :   : NSE1 ---------   :
   :  |       | <------------------------------------------>  |     |  :
   :  | BBU1  | <+++++  :   :                /------------>  |  AMF1 |  :
   :  |       | NSE2  + :   :              /        :   :      |     |  :
   :  ---------      +:  :              /         :   :    ---------  :
   :               :+  :             /          :   :                 :
   :               : + :           /            :   :                 :
   :  --------- NSE1    :   +        /             :   :                 :
   :  |       | <-----------+--------/             :   : NSE1 ---------   :
   :  | BBU2  |       :    +++++++++++++++++++++++++>  |     |  :
   :  |       | <++++++++++++++++++++++++++++++++++++>  |  UPF1 |  :
   :  --------- NSE2    :   :                    :   :      |     |  :
   :                    :   :                    :   :    ---------  :
   :....................:   :....................:   :.................:
        RAN                      Transport               Core
        Network                  Network 1               Network
```

   5G IETF Network Slice INS_1:
       {"Connection group C" + "Connection group U"}
   Connection Group C {from BBU1.NSE1, BBU2.NSE1 to AMF1.NSE1 with SLO-C}
   Connection Group U {from BBU1.NSE2, BBU2.NSE2 to UPF1.NSE1 with SLO-U}

   Legend
     BBU: BaseBand Unit
     AMF: Access and Mobility Management Function
     UPF: User Plane Function
     NSE: 5G IETF Network Slice Endpoint
     ---- Connection group C
     ++++ Connection group U

      Figure 7: Details of 5G IETF Network Slice as a set of Connection
                                   Groups

5. IETF Network Slice Controller NBI for 5G

   As discussed in [I-D.nsdt-teas-ietf-network-slice-definition] and
   [I-D.nsdt-teas-ns-framework], to fulfill (i.e. create, modify,
   delete) any IETF network slice and perform monitoring on it, an
   entity called IETF Network Slice Controller (NSC) is required to take
   abstract requests for 5G 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 transport

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.wd-teas-transport-slice-yang] addresses the base data model of
the NSC NBI interface for all network slicing use-cases. However,
for 5G network slicing, the current model shall be augmented to
include the specific characteristics of the 5G network slices for
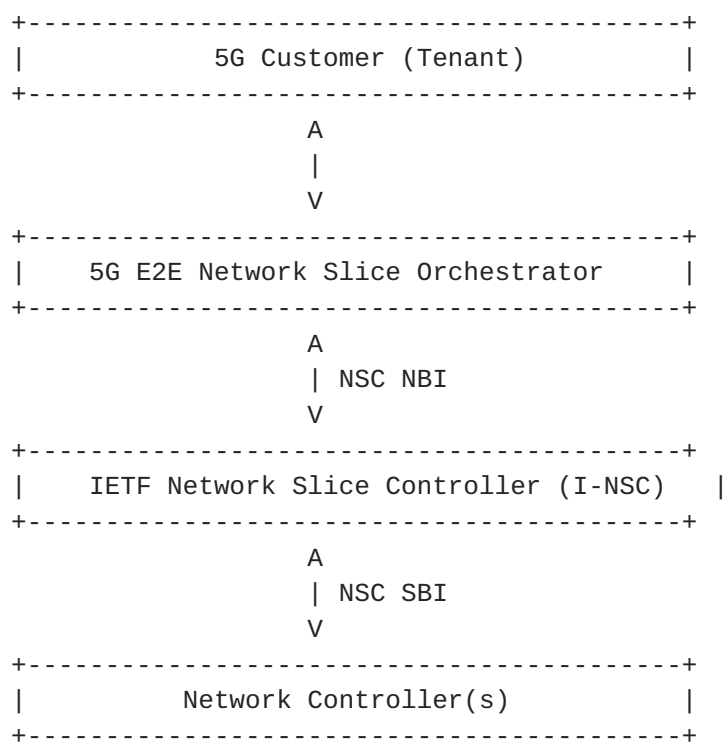this interface. The details of NSC NBI interface for 5G provided in
Section 6.

```
        +-------------------------------------------+
        |            5G Customer (Tenant)           |
        +-------------------------------------------+
                            A
                            |
                            V
        +-------------------------------------------+
        |      5G E2E Network Slice Orchestrator    |
        +-------------------------------------------+
                            A
                            | NSC NBI
                            V
        +-------------------------------------------+
        |      IETF Network Slice Controller (I-NSC)  |
        +-------------------------------------------+
                            A
                            | NSC SBI
                            V
        +-------------------------------------------+
        |             Network Controller(s)         |
        +-------------------------------------------+
```

             Figure 8: IETF Network Slice Controller NBI for 5G

5.1. Relationship between 5G IETF Network Slice NBI and various IETF data models

As discussed in [I-D.nsdt-teas-ns-framework], 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
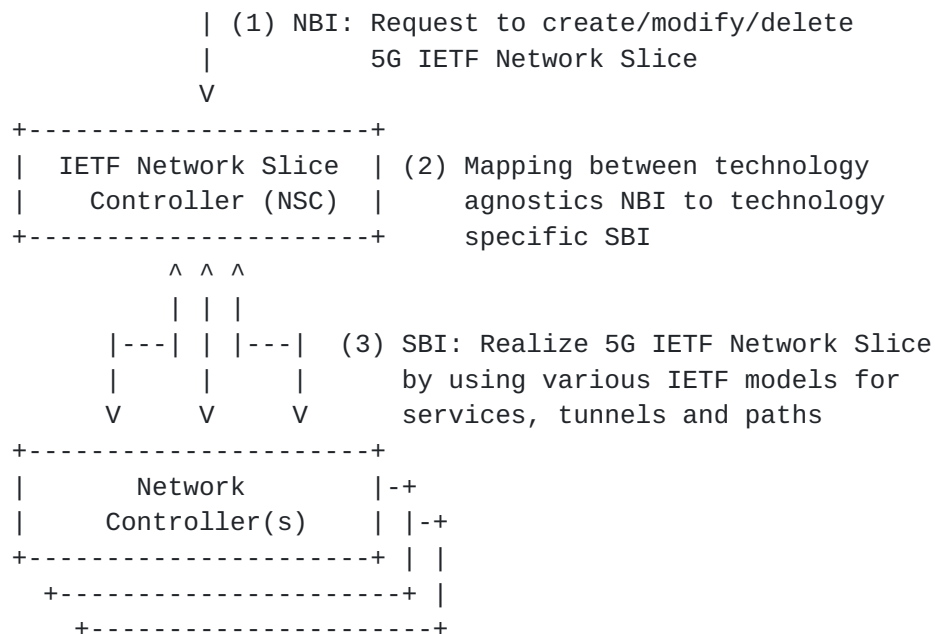SBI for 5G IETF network slices.

```
                          | (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

6. 5G IETF Network Slice NBI Information Model

Based on the definition of 5G IETF Network slices (see Section 4),
the high-level information model of northbound interface of IETF
Network Slice Controller (NSC) for 5G IETF network slices should
conform with Figure 10:

```
module: 5g-ietf-network-slices
 +--rw 5g-ietf-network-slice
    +--rw 5g-ietf-network-slice-info
```

```
      +--rw ins-id
      +--rw ins-name
      +--rw ins-plmn
      +--rw ins-hierarchical-tenant-id
   +--rw 5g-network-slice-info [s-nssai]
      +--rw s-nssai (i.e. 5G E2E network slice id)
      +--rw 5g-customer (i.e. 5G tenant)
      +--rw 5g-mobile-service-type (e.g. CCTV, infotainment etc)
   +--rw 5g-connection-group* [connection-group-id ]
      +--rw connection-group-id
      +--rw connection-group-name
      +--rw connection-group-type  (e.g., P2P, MP2MP, etc.)
      +--rw connection-group-status
         +-- admin-status
         +-- operational-status
      +--rw connection-group-member* [member-id]
         +--rw member-id
         +--rw member-name
         +--rw member //Ref. to 5G-ietf-connection-group-member
         +--ro member-slo-monitoring
           +--ro latency?
           +--ro jitter?
           +--ro loss?
      +--rw connection-group-slo-policy
         +--rw policy-id
         +--rw slo attributes
      +--rw connection-group-realization-policy //Optional
         +--rw policy-id
         +--rw realization-attributes //Optional
                                      //Technology-specific attributes
      +--rw connection-group-monitoring-policy //Optional
         +--rw policy-id
         +--rw monitoring-attributes //Optional. Such as if monitoring
                                     //is needed, frequency of
                                     //monitoring and how often send
                                     //them to NBI etc.
 +--rw 5g-ietf-network-slice-endpoint* [ep-id]
    +--rw ep-id
    +--rw ep-name
    +--rw domain-id
    +--rw node-id
    +--rw transport-port-id
    +--rw transport-vlan-id
    +--rw transport-id (e.g. IP address of the transport)
    +--rw transport-label (For future use)
    +--rw transport-bsid (For future use)
  +--rw 5G-ietf-connection-group-member* [member-id]
    +--rw member-id
```

```
   +--rw member-endpoint-a  //Ref. to 5g-ietf-network-slice-endpoint
   +--rw member-endpoint-b  //Ref. to 5g-ietf-network-slice-endpoint
```
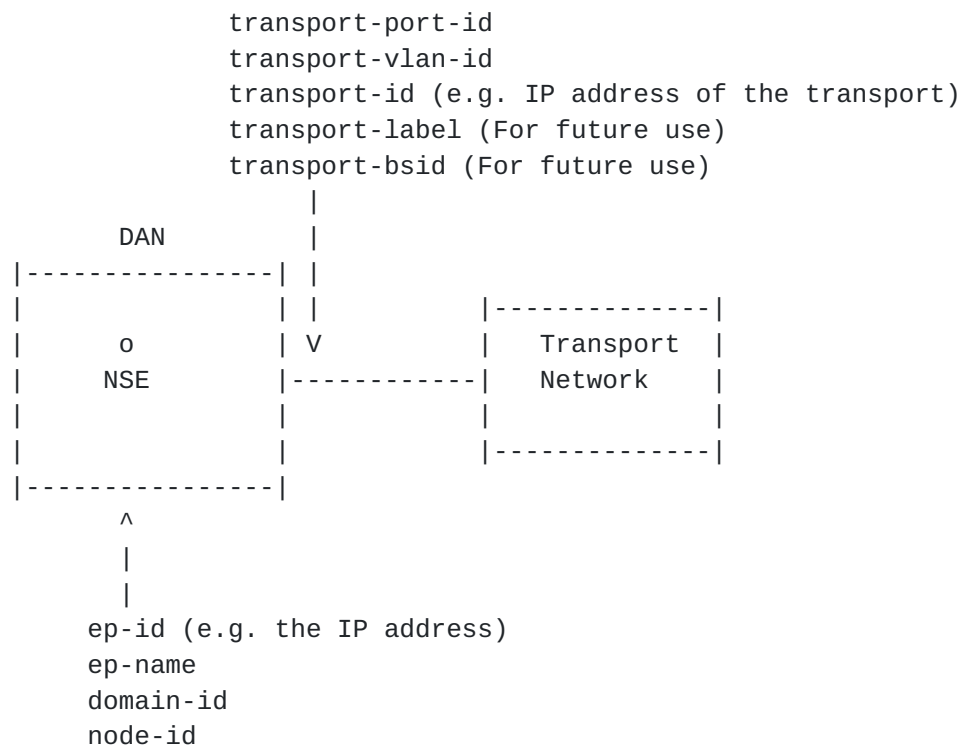
        Figure 10: Information model of NSC NBI interface for 5G IETF Network
                                      Slices

   The proposed information model should include the following building
   blocks:

   o 5g-ietf-network-slice-info: All attributes related to 5G IETF
      Network Slice. It contains information such as 5G IETF network
      slice name, 5G IETF network slice ID, PLMN and hierarchical tenant
      ID etc.

   o 5g-network-slice-info: A list of all E2E network slices mapped to
      this 5G IETF network slice. As discussed in Section 3, a request
      for creation of a 5G IETF network slice is sent from 5G E2E
      network slice orchestrator to IETF Network Slice Controller (NSC)
      for a customer and certain service type (e.g. CCTV, Infotainment,
      URLLC, etc.). It is NSC's decision to either create a new
      transport slice or use one of the existing ones. As a result, the
      mapping between 5G E2E network slice and IETF network slice is
      many to one, i.e. one 5G IETF network slice can be used with
      multiple 5G E2E network slices. The attributes of each 5G E2E
      network slices are included here. The 5g-network-slice-info
      contains the list of E2E network slices which are mapped to a 5G
      IETF network slice with all relevant attributes such as S-NSSAI,
      customer name and service type.

   o 5g-connection-group: A 5G IETF network slice contains one or more
      connection groups each with its own SLA/SLO. Each connection
      group contains:

      * connection-group-attributes: A list of attributes for each 5g-
         connection-group such as connection-group-id, connection-group-
         name and connection-group-status

      * connection-group-member: A list of members. Each member is a
         connection between two endpoints. A connection group can
         contain one or more members. For example, the connections
         BBU1-UPF1 and BBU2-UPF1 are 2 members of "connection group U"
         in Figure 7.

      * connection-group-slo-policy: This is a mandatory policy. The
         connection-group-slo-policy represents in a generic and
         technology-agnostics fashion the SLO requirement needed to
         realize members of a connection group. It contains SLOs such

as bounded latency, bandwidth, reliability, security etc. Note
that all members of a connection group must have the same SLO.

*   connection-group-realization-policy: This is an optional
    policy. In some scenarios, the 5G E2E network slice
    orchestrator might be able to influence the IETF Network Slice
    Controller on how to realize a 5G IETF network slice by
    providing some technology-specific information.

*   connection-group-monitoring-policy: This is an optional policy.
    The 5G E2E network slice orchestrator can influence the IETF
    Network Slice Controller on how to perform monitoring,
    analytics and optimization on 5G IETF Network Slices. It
    contains, the type of assurance needed, time interval,
    frequency of how often to inform the 5G E2E Network Slice
    Orchestrator etc.

o 5g-ietf-network-slice-endpoint: It contains the list of all
   endpoints along with their attributes which belong to a 5G IETF
   network slice. See Figure 11

o 5G-ietf-connection-group-member: It contains the list of all
   members of connectin groups along with their attributes which
   belong to a 5G IETF network slice.

```
                        transport-port-id
                        transport-vlan-id
                        transport-id (e.g. IP address of the transport)
                        transport-label (For future use)
                        transport-bsid (For future use)
                             |
             DAN             |
        |---------------| |
        |               | |        |--------------|
        |       o       | V        |  Transport   |
        |      NSE       |------------|  Network    |
        |               |          |              |
        |               |          |--------------|
        |---------------|
              ^
              |
              |
          ep-id (e.g. the IP address)
          ep-name
          domain-id
          node-id

   Legend:
      DAN: Device, application and/or network function
      NSE: IETF Network Slice Endpoint
```

         Figure 11: Details of the 5G IETF network slice endpoints

7. IANA Considerations

   This memo includes no request to IANA.

8. Security Considerations

   TBD

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   o   Ryan Hoffman, Telus

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