5G Network Slicing Procedures

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Learning Objectives

Upon completion of this module, you should be able to:

- Describe 5G Network architecture for Network Slicing.
- Explain UE assisted Network Slice selection.
- Discuss the Establishment of PDU session establishment.

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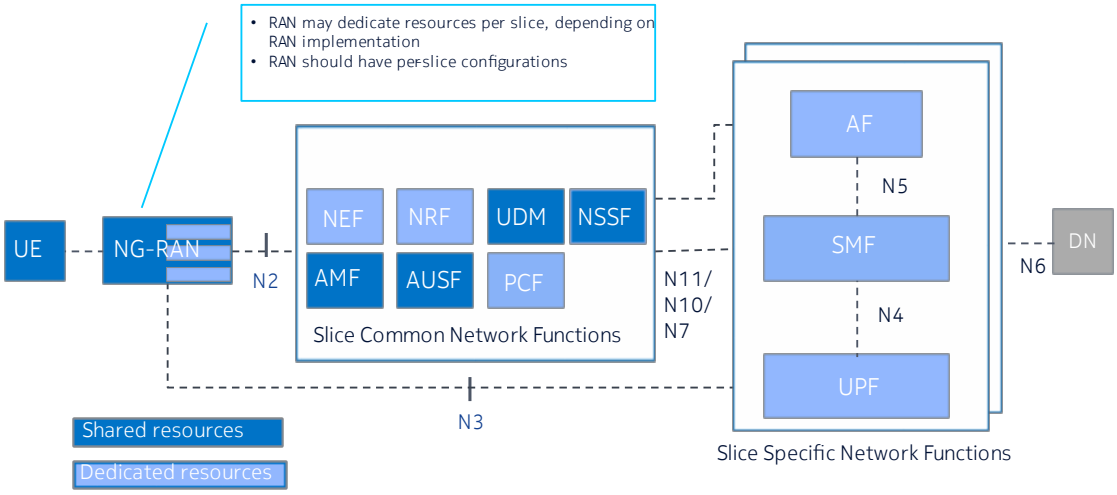
5G Network Architecture for Network Slicing



The end-to-end 5G Network architecture for Network Slicing is shown on the slide:

- Each network slice is made of subnets, example: RAN subnet, CN subnet, Transport subnet.
- Operator determines which subnets make a network slice. For instance, CN can have two subnets, CN-shared subnet and CN-dedicated subnet. Also, RAN may have dedicated resources, virtual transport links may be dedicated for a slice, etc.

NFV (cloud infra) and Software Defined Networks (SDN) enable 5G slicing. NFV and SDN make it possible to set up logically isolated computing and network instances from a shared infrastructure.

Unlike 4G/LTE slicing, 5G solution offers two slicing types:

- Hard slicing: network slices must be completely isolated from each other.
- Soft slicing: network slices may share certain network resources.

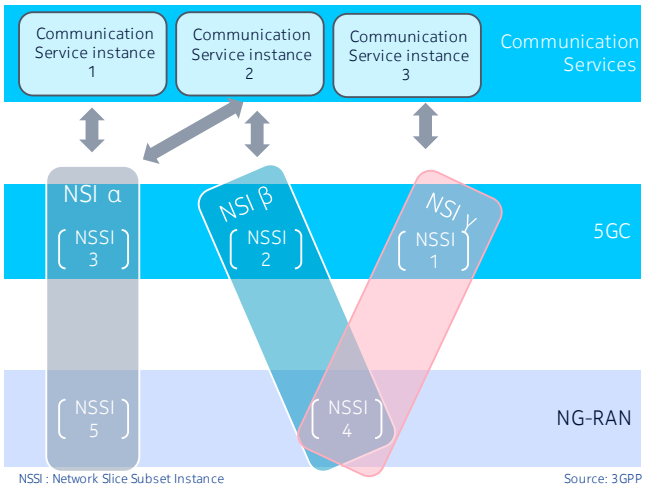
Complete slice isolation requires that the given VNF, e.g., AMF can be used only by a specific slice identified by S-NSSAI, or a set of specific slices identified by NSSAI. Slice sharing would permit the given VNF, e.g., AMF to be used by any network slice.

Network Slicing Procedures
Network Slice Instance

Network Function:
A 3GPP adopted or 3GPP defined processing function in a network, which has defined functional behavior and 3GPP defined interface

Network Slice:
A logical network that provides specific network capabilities and network characteristics to serve a defined business purpose of a customer.

Network Slice Instance (NSI):
A set of Network Function instances and the required resources (e.g., compute, storage and networking resources) which form a deployed Network Slice.



NSSI : Network Slice Subset Instance

Source: 3GPP

The Initial release for NR (3GPP Release 15) defines Network Function, Slice, and Slice Instance as follows:

Network Function: A 3GPP adopted or 3GPP defined processing function in a network, which has defined functional behavior and 3GPP defined interfaces. Note that: A network function can be implemented either as a network element on a dedicated hardware, as a software instance running on a dedicated hardware, or as a virtualized function instantiated on an appropriate platform, e.g., on a cloud infrastructure.

Network Slice: A logical network that provides specific network capabilities and network characteristics to serve a defined business purpose of a customer. Network Slicing allows multiple virtual networks to be created on top of a common shared physical infrastructure. Network slice is end-to-end logical network entity which consists following subnets; Radio Access network, 5G core network and transport network

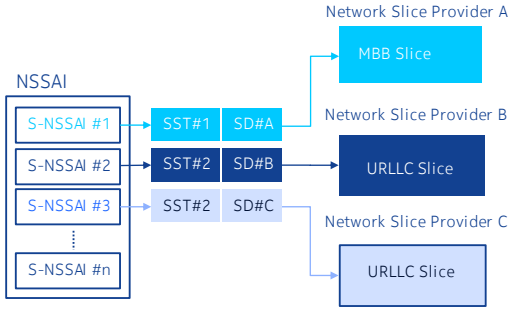
3 Network Slice instance: A set of Network Function instances and the required resources (e.g., compute, storage and networking resources) which form a deployed Network Slice.

4 The different parts of an NSI are grouped as Network Slice Subnets (e.g., RAN, 5GC and Transport) allowing the lifecycle of a Network Slice Subnet Instance (NSSI) to be managed independently from the lifecycle of an NSI.

Network Slicing Procedures
Identification and Selection of a Network Slice

NSSAI:	• Network Slice Selection Assistance Information • The NSSAI is a collection of up to 8 S-NSSAIs
S-NSSAI: Single NSSAI	• S-NSSAI : Single Network Slice Selection Assistance information • It identifies a Network Slice.
S-NSSAI is comprised of:	• A Slice/Service type (SST), which refers to the expected Network Slice behavior in terms of features and services • A Slice Differentiator (SD). which is optional information that complements the Slice/Service type(s) to allow further differentiation for selecting a Network Slice from the potentially multiple Network Slices that all comply with the indicated Slice/Service type

S-NSSAI = Slice/Service type (SST) + Slice Differentiator (SD)



SST	SST value	Characteristics.
eMBB	1	Slice suitable for the handling of 5G enhanced Mobile Broadband.
URLLC	2	Slice suitable for the handling of ultra reliable low latency communications.
MIoT	3	Slice suitable for the handling of massive IoT.

TS 23.501 Standardized SST table

Major identifier for enabling end to end network slice is Single Network Slice Selection Assistance Information (S-NSSAI). UE may be entitled to use a set of slices, which means a set of S-NSSAIs that is referred to as NSSAI. Currently 3GPP allows up to eight S-NSSAIs in the NSSAI sent in signaling messages between the UE and the Network. This means a single UE may be served by at most eight Network Slices at a time. The S-NSSAI signaled by the UE to the network, assists the network in selecting a particular Network Slice instance.

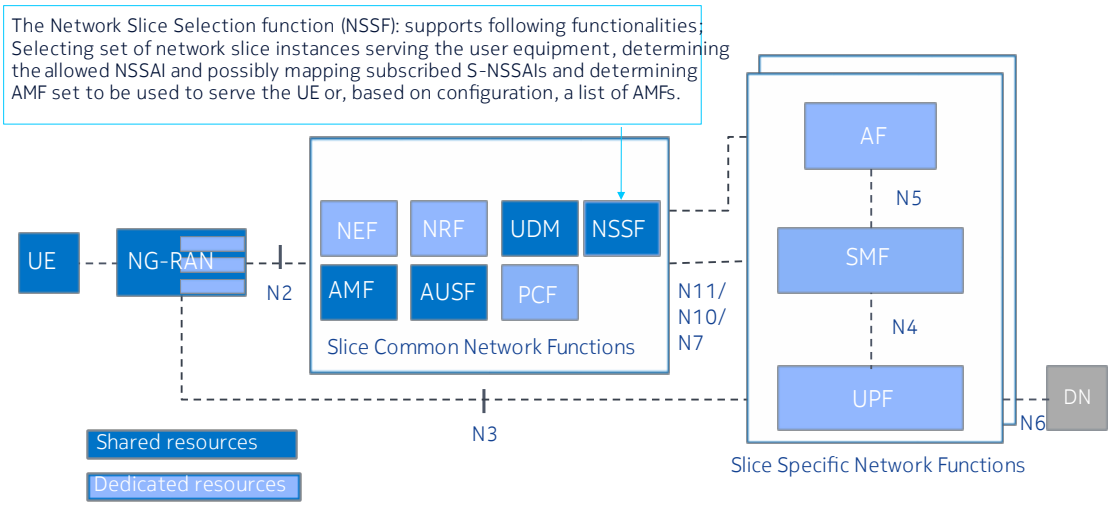
An S-NSSAI is comprised of:

- A Slice/Service type (SST), which refers to the expected Network Slice behavior in terms of features and services;
- A Slice Differentiator (SD), which is an optional information that complements the Slice/Service type(s) to differentiate amongst multiple Network Slices of the same Slice/Service type.

The S-NSSAI may be associated with a PLMN (e.g.,, PLMN ID) and have network-specific values or have standard values. An S-NSSAI is used by the UE in access network in the PLMN that the S-NSSAI is associated with.

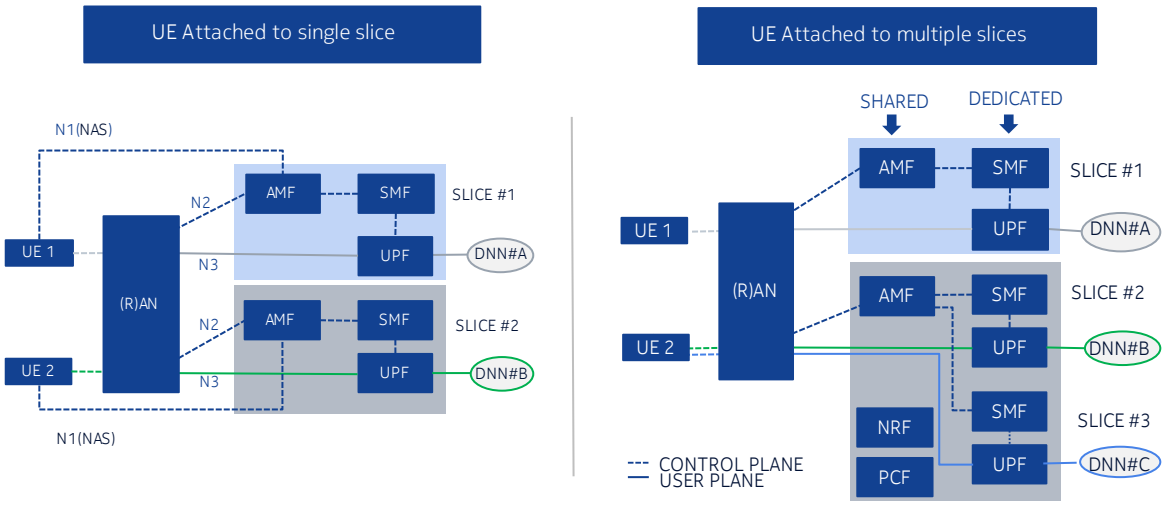
Standardized SST values provide a way for establishing global interoperability for slicing so that PLMNs can support the roaming use case more efficiently for the most commonly used Slice/Service Types.

Network Slicing Procedures
Network Slice Selection Function



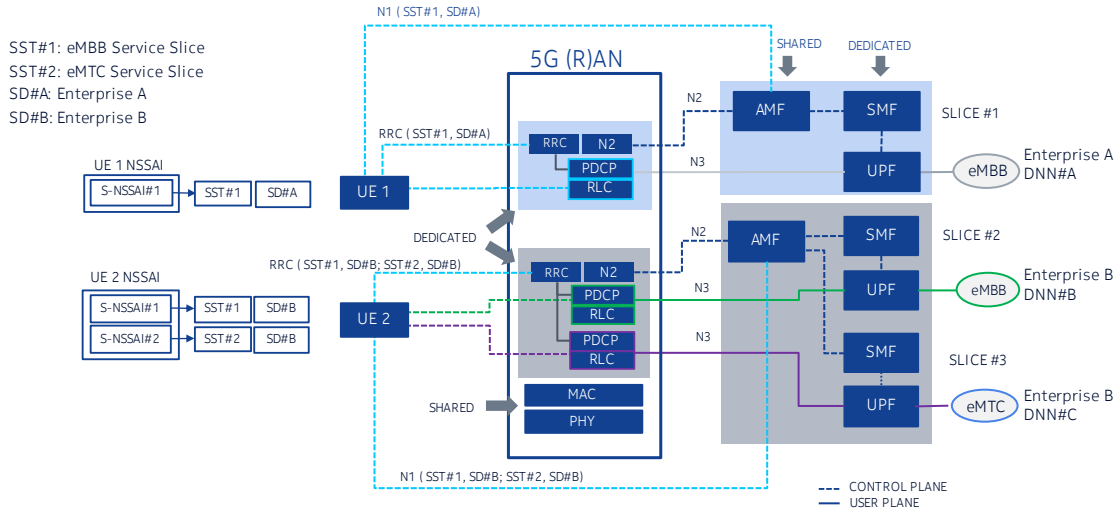
5G core network specific Network Slice Instance Selection Function (NSSF) is provisioned to keep mapping between an NSSAI and AMF FQDN (Fully Qualified Domain Name) or IP address. NSSF also may use Network Repository Function (NRF) identifier to help resolving an AMF or other functions for a given slice instance.

Network Slicing Procedures
Slice Examples in 5G Core



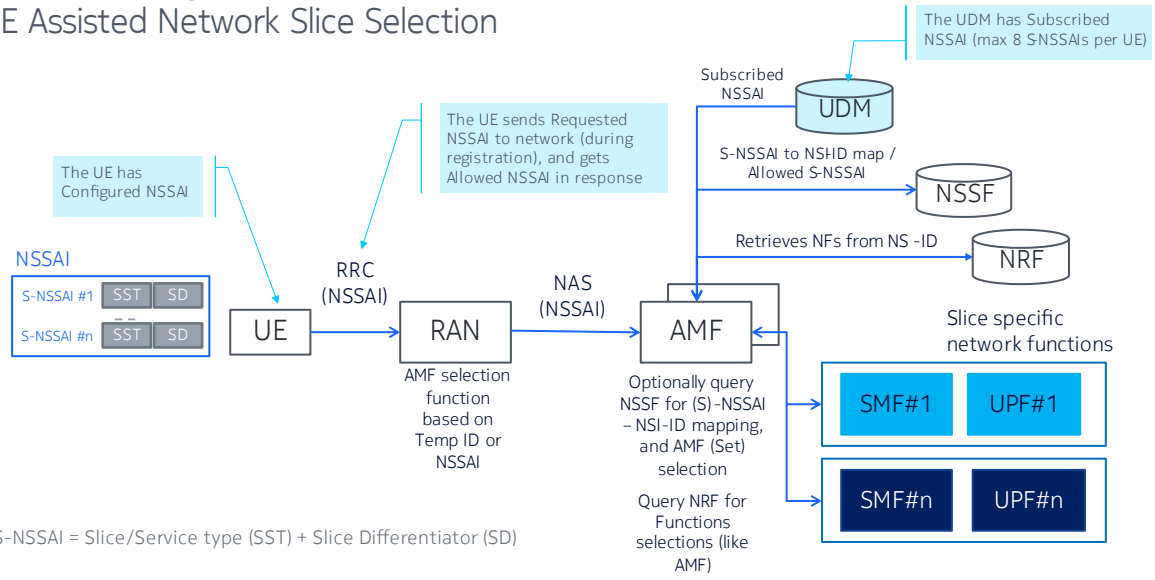
In this figure, network slice #1 is a straightforward deployment where all network functions serve a single network slice only . The figure also shows how a UE receives service from multiple network slices, #2 and #3 . In such deployments there are network functions in common for a set of slices, including the AMF and the related policy control (PCF) and network function services repository (NRF). This is because there is a single access control and mobility management instance per UE that is responsible for all services of a UE. The user plane services, specifically the data services, can be obtained via multiple, separate network slices. In the figure, slice #2 provides the UE with data services for Data Network B, and slice #3 for Data Network C. Those slices and the data services are independent of each other apart from interaction with common access and mobility control that applies for all services of the user. This makes it possible to tailor each slice for e.g., different QoS data services or different application functions, all determined by means of the policy control framework.

Network Slicing Procedures
Slice Examples in 5G Core and 5G RAN



In this Figure, NG-RAN is pre-configured with a set of different configurations for different network slices. Each slice is assigned with either shared or dedicated radio resource. How NG-RAN supports the slice enabling in terms of NG-RAN functions (i.e. the set of network functions that comprise each slice) is implementation dependent.

Network Slicing Procedures
UE Assisted Network Slice Selection



Based on the Requested NSSAI (if any) and the Subscription Information, the 5GC is responsible for selecting a Network Slice instance(s) to serve a UE including the 5GC Control Plane and User Plane Network Functions corresponding to this Network Slice instance(s).

The Network Slice instance selection for a UE is normally triggered as part of the registration procedure by the first AMF that receives the registration request from the UE. The AMF retrieves the slices that are allowed by the user subscription and interacts with the Network Slice Selection Function (NSSF) to select the appropriate Network Slice instance (for example, based on Allowed S-NSSAIs, PLMN ID, etc.). This could result in a change of AMF if needed.

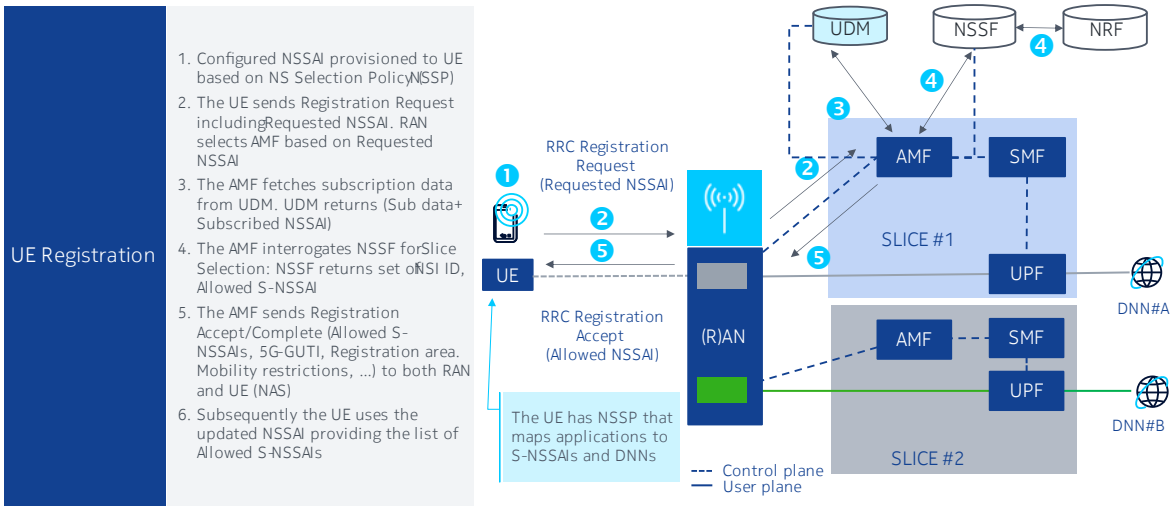
Network Slicing Procedures
UE Assisted Network Slice Selection

Configured NSSAI	• The Configured NSSAI is a NSSAI configured by default in a UE to be used in a PLMN before any interaction with the PLMN ever took place. • If the UE did not receive any Allowed NSSAI for the ID of the PLMN that the UE accesses, the UE provides the Configured NSSAI in RRC and NAS, if the UE has been provided with a Configured NSSAI for that PLMN.
Allowed NSSAI	• Allowed NSSAI may include one or more S-NSSAIs. These S-NSSAIs are valid for the current Registration Area provided by the serving AMF the UE has registered with and can be used simultaneously by the UE. • UE receives as part of the Initial Access procedure the Allowed NSSAI • For each PLMN, the UE shall store the Configured NSSAI and, if any, the Allowed NSSAI. When the UE receives an Allowed NSSAI for a PLMN, it shall store it and override any previously stored Allowed NSSAI for this PLMN.
Requested NSSAI	• Can be either Configured NSSAI (or subset of it), Allowed NSSAI (or subset of it) or a combination of those (or a subset of the combination.
Default S-NSSAI	• If an S-NSSAI is marked as default, then the network is expected to serve the UE with the related Network Slice even when the UE does not send any S-NSSAI to the network in a Registration request. • At most 8 S-NSSAI can be marked as Default S-NSSAI. • A single UE may be served by at most 8 Network Slices at a time.

The definitions of Configured, Requested and Allowed NSSAI are given in this table.

The Subscription Information shall contain one or more S-NSSAIs, that is to say Subscribed S-NSSAIs. Based on operator's policy, one or more Subscribed S-NSSAIs can be marked as a default S-NSSAI. If an S-NSSAI is marked as default, then the network is expected to serve the UE with a related applicable Network Slice instance when the UE does not send any valid S-NSSAI to the network in a Registration Request message as part of the Requested NSSAI.

Network Slicing Procedures
UE Registration



The establishment of User Plane connectivity to a Data Network via a Network Slice instance(s) comprises two steps:

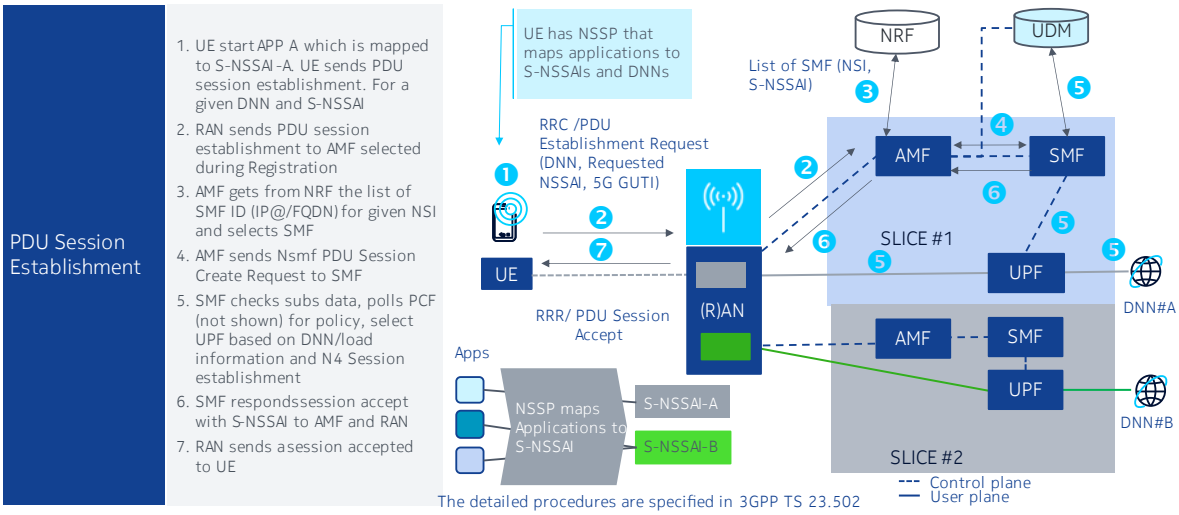
- Performing a Registration Management procedure to select an AMF that supports the required Network Slices.
- Establishing one or more PDU Session to the required Data network via the Network Slice Instance(s).

This diagram describes how network slicing works in the 5G standalone system:

Let's review the **functional steps.

1. **The configured NSSAI is provisioned to the UE based on the Network Slice Selection Policy (the NSSP defines the rules associating an Application with an S-NSSAI and the Data Network Name linked to the Application).
2. **The UE sends a Registration Request including the **Requested NSSAI**. The RAN selects the AMF based on the Requested NSSAI plus other criteria then the Security procedure is performed (this is not shown here).
3. **The AMF fetches the subscription data from the UDM. The UDM returns the subscription data including the **Subscribed NSSAI**.
4. **The AMF interrogates the NSSF for Slice Selection: the NSSF returns a set of NSI ID and Allowed S-NSSAI.
5. **The AMF sends Registration Accept (including Allowed S-NSSAIs, 5G-GUTI, Registration area, Mobility restrictions, etc.) to both the RAN and the UE (via NAS signaling).
6. **Subsequently, the UE uses the updated NSSAI providing the list of Allowed S-NSSAIs.

Network Slicing Procedures
PDU Session Establishment



A Protocol Data Unit (PDU) session is a 5G concept for an association between the device and a data network, which can be IP, Ethernet or Unstructured (that is to say, transparent to the 5G system). The device will associate an application with one out of multiple parallel PDU sessions. Each PDU session correspond to one core Network Slice and one RAN slice. Different PDU sessions may belong to different slices. More precisely, an application will be associated with an S-NSSAI (this includes a slice service type and may also include a slice differentiator). Data for this application will be routed to a PDU session associated to this S-NSSAI.

A PDU Session is associated to one S-NSSAI and one Data Network Name (DNN). The establishment of a PDU session within the selected instances-NSSAI is triggered**3** when the AMF receives a Session Management message from the UE. The AMF discovers candidate Session Management Functions (SMF) using multiple parameters including the S-NSSAI provided in the UE request and selects the appropriate SMF. The selection of the User Plane Function (UPF) is performed by the SMF and uses the S-NSSAI. The Network Repository Function (NRF) is used for the discovery of the required Network Functions using the selected Network Slice instance – the detailed procedures are specified in 3GPP TS 23.502. The data transmission can take place after a PDU session to a Data Network is established in a Network Slice. The S-NSSAI associated with a PDU Session is provided to the Access Network, and to the policy and charging entities, to apply slice specific. policies.

Network Slicing Procedures
Quiz 1

1. How many Network Slices can be assigned to one UE?
   a. A single UE may be served by at most 1 Network Slices at a time
   b. A single UE may be served by at most 2 Network Slices at a time
   c. A single UE may be served by at most 8 Network Slices at a time
   d. none of the above
2. Which of the following factors are considered in the 5G -AN to select the AMF Set?
   a. AMF Region ID and AMF Set ID derived from GUAMI
   b. Requested NSSAI
   c. Load balancing across candidate AMFs
   d. The Network Slice Selection Policy (NSSP)
3. Which message contains the RequestedNSSAI IE?
   a. RRC Connection Establishment procedure message
   b. NAS Registration procedure messages
   c. RRC Registration Accept
   d. PDU Session Establishment Request

Wrap-up

In this module we have covered the following items:

- Describe 5G Network architecture for Network Slicing.
- Explain UE assisted Network Slice selection.
- Discuss the Establishment of PDU session establishment.