Enhanced enterprise deployments with 5G-Advanced network slicing

An overview of 3GPP Release 18 enhancements

White paper

Contents

Executive summary

Differentiated services support, low latency and reliable communications are some of the critical elements of the 5G value proposition. Network slicing is foreseen as a key enabler of these diverse 5G services, ensuring that each has its own service guarantee and traffic isolation requirements on a shared underlying network infrastructure. These capabilities of network slicing are expected to support the enterprise digitalization drive as well as introduce new business-to-business (B2B) revenue streams for network operators. This is confirmed in a recent Global System for Mobile Communications Association (GSMA) Network Transformation survey, where operators highlight network slicing as the second topmost feature for the support of their enterprise use cases [1].

The identified enterprise use cases lie within the domain of industrial process automation, utility networks, public safety organizations, and media and entertainment to name a few. To support this digitization of enterprises, 5G-Advanced 3GPP Release 18 has introduced enhancements to the network slicing feature that will help simplify enterprise network slice operations and signaling. Nokia has been a key driver and contributor to network slicing standardization since its start in Rel-15. With 5G-Advanced Release 18, Nokia continues this effort to improve the support of network slicing for advanced enterprise use cases where the focus is on the specialization of individual services as well as the dynamic nature of their deployments.

A first example of the Release 18 enhancements is the support of extremely localized services. A key challenge for such deployments in pre Release 18 networks is the requirement for homogenous support of a network slice in the whole tracking area (TA). With Release 18 enhancements, a network slice can also be deployed in sub-TA granularity, for instance, in a small number of cells only. This is especially important for enterprise use cases where the majority of deployments will be localized campus scenarios. The feature helps operators to avoid the complex network planning involved in TA re-organization due to deployment and later decommissioning after the use of small service area network slices.

A second key example of Release 18 enhancements is the optimization of the concept of registration area (RA). The enhancement allows network slices to be part of the RA that are not homogenously supported in a full RA. It optimizes the RA configuration while minimizing the signaling for location and registration updates. This enables widespread adoption of specialized enterprise network slices and their co-existence within wide-area network slices.

Another key feature brought by Release 18 enhancements is support for dynamic and temporary communication networks, for example, for commercial events and emergency support. For dynamic network slices, the signaling procedures are optimized to minimize registration and session management signaling overhead with every activation and deactivation of a temporary slice. This dynamicity is something that was hardly achievable in pre-Release 18 networks when using private networks.

Other Release 18 enhancements enable improved network operator control over network slice resource use, as well as the number of UE(s) associated with it, to align more closely with the operator's service level agreement (SLA) with the enterprise customer. For instance, in one new feature, network operators can control which UEs can connect to a particular network slice as well as when and for how long. Further, the network operator's control over the number of UE(s) associated with a network slice can be extended to roaming use cases. This feature enables home operators to control and enforce quotas for network slices when the slice associated UEs are roaming abroad. All in all, the above features improve tiered services operation and provide better network slice quota enforcement and congestion management.

In yet another new feature, the traffic of one network slice can also be transferred to another network slice without interruption in case the first network slice experiences congestion or a planned maintenance.

For network operators simplified network slice management is crucial to minimize the additional complexity of multiservice and multi-slice operations. Release 18 also introduces the modeling of parameters like data network and resource isolation to the network slice management system. This helps to better model the technical requirements of network slice SLAs and, ultimately, service assurance for enhanced quality of experience.

Overall, the 5G-Advanced Release 18 network slicing enhancements take network slicing to a more advanced stage where highly customized network slices can be deployed for localized and temporary coverage. The new features also help overcome challenges associated with pre-Release 18 network slicing by simplifying the operations of those network slices as well as associated network signaling.

Introduction

Network slicing is a key 5G feature that provides flexible deployment and operation of diverse communication services. A network slice is a combination of network functions, network resources and their interconnections that provides a logical network over shared network infrastructure. Logical networks can be used to provide customized services with very diverse requirements, for example, in terms of quality of service (QoS) or traffic isolation. This makes network slicing a key element of the 5G value proposition to enterprise customers and will help to grow operators' B2B revenues. Potential enterprise use cases that can benefit from differentiated services and traffic isolation provided by network slicing include:

- Industrial process optimization, such as autonomous guided vehicles (AGV)
- Factory digital twins
- AR/VR based operations and maintenance
- Media/entertainment remote broadcast and production
- Enhanced live event experiences
- V2X support for connected vehicles
- Smart grid and metering solutions for utilities
- Communication support for public safety organizations and disaster recovery

These are only a subset of a growing range of enterprise digitalization use cases that network slicing can support, representing both Industry 4.0 digital transformation and metaverse applications [2].

The potential of network slicing for enterprise services was reaffirmed in a recent GSMA network transformation survey of mobile network operators, where network slicing was ranked as the second priority for enterprise use case enablement, only behind edge computing [1]. Based on these promises and potential, the survey also highlights that network slicing has experienced steady growth over the last few years with 18 percent of network operators already offering commercial network slice solutions and 66 percent of network operators in either the testing or planning phase of network slicing deployment.

To further support the enterprise digitalization drive, 5G-Advanced has introduced enhancements to the network slicing feature that can help simplify enterprise network slice operations and signaling. In particular, the enhancements focus on advanced deployment scenarios that require support of network slices in very small coverage areas and/or on a temporary basis.

Nokia continues to actively support 5G-Advanced enhancements to network slicing and is committed to realizing the full potential of network slicing for enterprise digitalization. In the next section, we explain the main feature improvements being introduced for network slicing in Release 18.

5G-Advanced network slicing for enterprise and industrial communications

5G-Advanced Release 18 introduces further optimizations to the baseline network slicing features in 5G. It simplifies network slice deployments for specialized and localized services such as enterprise and industrial settings where there is a need for communication services for a localized environment and/or on a temporary basis. For network operators offering these services, Release 18 ensures that network slices can be deployed and decommissioned with minimal effort and without impacting the traffic on other network slices.

3GPP specified the baseline network slicing feature in Rel-15 as a mandatory feature for both the network and UEs. Some of the key enablers for the support of network slicing were:

- Identification of network slices with single network slice selection assistance information (S-NSSAI)
- UE subscription and configuration support for individual network slices
- Slice-aware UE network registration for proper network slice access
- Session management enhancements to support establishment of traffic sessions for particular network slices
- Initial 4G interworking and roaming support

To help reduce the operational complexity of deploying network slicing in a multiservice network, the operations and management (OAM) specifications were also enhanced to support lifecycle management of the network slices.

Building on that, 3GPP Rel-16 enhanced the 4G interworking for network slices for optimal V-SMF selection instead of a default SMF. It also introduced the network slice-specific authentication and authorization (NSSAA) feature to enable user ID authentication and authorization using authentication, authorization and accounting (AAA) servers, which could even be deployed in the network slice tenant's domain. This helps simplify network slice access management for enterprise and industrial deployments by outsourcing the slice subscription management service to the corresponding slice tenants.

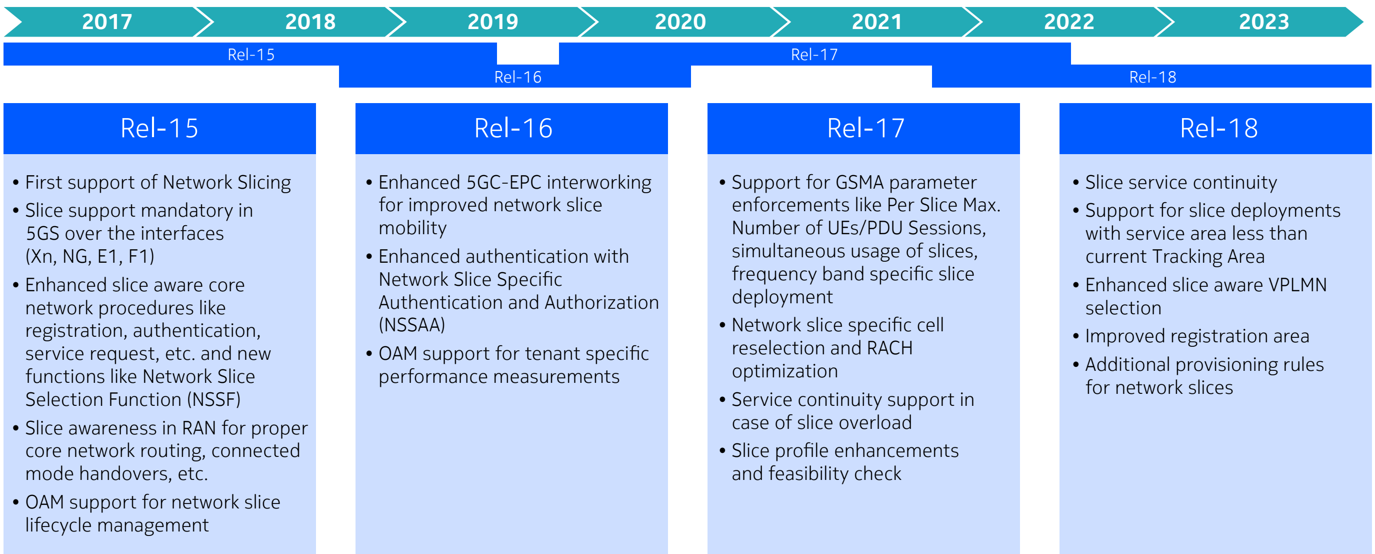
While Rel-15 and Rel-16 focused on the introduction of basic network slice functionality, Rel-17 introduced optimization enhancements to cater to specific deployment constraints. Based on GSMA requirements, it introduced features to support quotas and enforce restrictions per network slice related to:

- The number of simultaneously connected UEs
- The number of allowed PDU sessions
- UE data rate limitations
- Overall data rate limitations.

Rel-17 additionally optimized radio access network (RAN) performance in network slice deployments, introducing frequency-band-specific network slices, which enable the network to steer a UE to a specific frequency band where the UE-requested slice is supported. The configuration and execution of RAN procedures like cell re-selection and random access were also made slice-aware to meet their slice-specific performance requirements. Additionally, for performance analysis and service assurance, the network data analytics functions (NWDAF) and management data analytics (MDA) were also enhanced with network slice-specific analytics capabilities.

5G-Advanced Release 18 has introduced further optimizations to simplify network slice deployments for extremely specialized and localized services. The goal is to eliminate the earlier constraint, which required homogeneous support of network slices in a whole TA as well as to provide network operators better control of which UEs can connect to a particular slice and for how long.

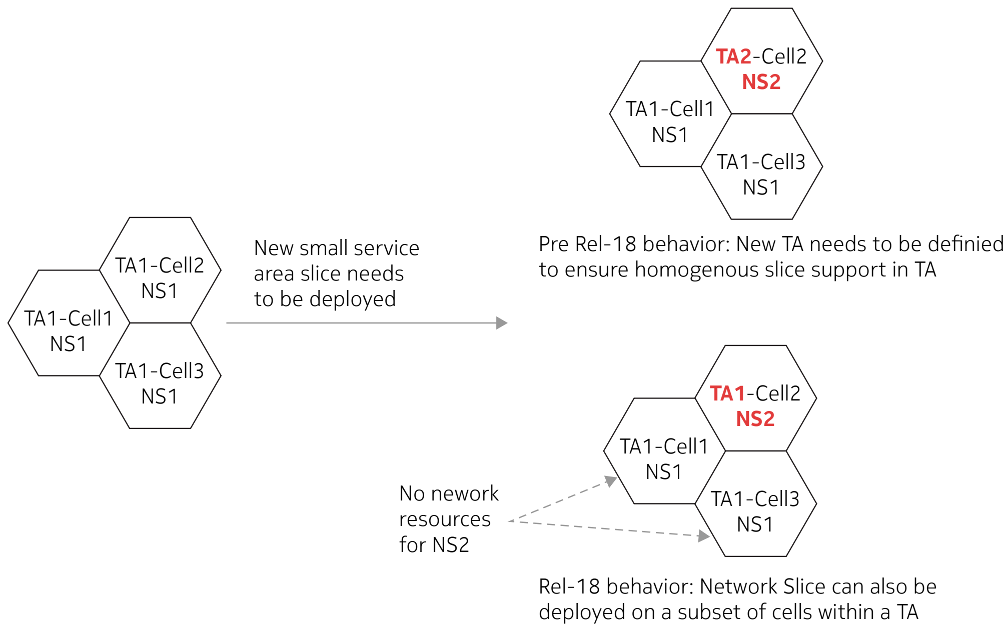
Figure 1. Network slicing in 3GPP standardization releases



Support for highly customized and localized services

5G-Advanced Release 18 brings new features that help simplify the deployment and operation of network slices within a very small service area, typical of enterprise campuses and industrial settings, which require highly customized and localized services. In pre-Release 18 networks, network slices have to be supported homogeneously across the whole TA. To deploy network slices in an area served only by a few cells, means that the TAs need to be re-defined with every deployment and decommissioning. Release 18 simplifies this process for network operators and allows network slices to be deployed in a subset of cells within a TA. This subset of cells is then included in the network slice area of service (NS-AoS) and only the cells in this NS-AoS are configured with resources for this network slice. Alternatively, no resources for this network slice are configured in cells outside of the NS-AoS even if those cells are within the same TA.

Figure 2. Network slice deployment and associated tracking area configuration before and after Release 18



3GPP still assumes, however, that even if the network slice is configured with resources in only a subset of cells of the TA(s) that are part of the NS-AoS, the slice is still indicated as supported in the TA(s), because slice support is indicated on the TA level, whereas slice availability is on the cell level. Further, the TA or TAs are also part of the registration area (RA) where the allowed network slice is supported. If a UE indicates support for this Release 18 feature, the network then signals to it the list of cells in the TA(s) where the slice is available in addition to the list of TAs that form the RA.

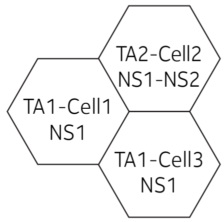
A requirement for pre-Release 18 network slicing deployments is that the network slice needs to be supported homogenously throughout the RA of a UE. The RA is a set of TAs and is used by the network to keep track of UE location within the network. With small coverage area network slices, this requirement puts constraints on how the network can assign an RA to individual UEs, which would lead to smaller RA assignments, resulting in increased registration/location update signaling in the network. Release 18 provides flexibility to the operators by removing this constraint and allowing the possibility that, in some of the TAs of the RA of a UE, the network slice might not be supported. To enable this new flexibility, the concepts of “partially allowed NSSAI” and “S-NSSAIs rejected partially” in RA were introduced.

For the former, when the UE registers on the network and indicates “partial support of a network slice in the RA”, the AMF accepts the registration. It then provides the UE with a list of network slices not uniformly supported on all TAs of the RA associated with a list of TAs where the network slice is supported.

For the latter, the AMF rejects the UE partially, as the requested S-NSSAI is not supported in all TAs of the RA. The S-NSSAI rejected partially in the RA is associated with a list of TAs where the network slice is not supported. Both solutions allow the network to be able to configure larger RAs for the UEs and diminish frequent signaling between the UE and the network entities for registration area updates. The AMF can indicate to a UE in the Registration Accept message, the Allowed network slices, Partially Allowed network slices and network slices rejected partially in the RA.

While introducing these methods, 3GPP allows efficient coexistence of customized network slices such as enterprise slices together with more common network slices (e.g., eMBB and URLLC) even though the latter ones may be deployed widely in the RA of the UE.

Figure 3. More flexible assignment of RAs to UEs in Release 18



UE in Cell2 and request Network Slice NS1 and NS2

Pre Rel-18 behavior
• Allowed NSSAI: NS1, NS2
• RA: TA2

Rel-18 behavior:
• Allowed NSSAI: NS1
• Partially allowed NSSAI: NS2
• RA: TA1, TA2

Dynamic network slices for temporary deployments

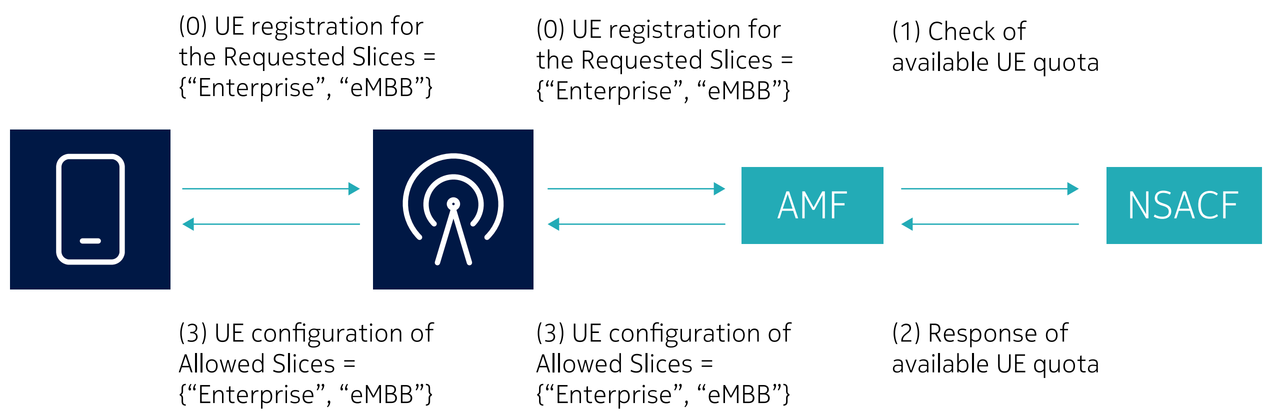
In enterprise and commercial environments, there are requirements to deploy network slices for only certain periods of time, for example, to support the communication requirements of special events or emergency services. To optimize signaling load and network resources related to such deployments, 3GPP has introduced the concept of a validity timer associated with a certain network slice. Based on subscription, a network slice may be available for all UEs all the time, or it may be available only for a certain period of time. The main benefit of a validity timer for a network slice that is available to both the UE and network is that it optimizes the allocated network resources utilized for the network slice based on the SLA and reduces signaling between the UE and the network. Indeed, the network functions are configured with the timing information associated to individual network slices, where applicable, and the network provides this information to the UE at the time of UE registration for a particular network slice. Once the validity timer of a network slice expires then the UE is not allowed to utilize or establish any PDU session(s) with that network slice. Additionally, any existing PDU sessions are also automatically terminated by the UE and the network implicitly, without the need for additional signaling between them.

Enhanced operator control for slice quota enforcement

In Rel-17, 3GPP introduced network slice admission control (NSAC) to enable network operators to set quotas on the maximum number of UEs that can connect to a network slice and the maximum number of PDU sessions that can be simultaneously associated to a network slice. This gives the operator full control over the use of a network slice and can limit the network resources used by a particular network slice. This is extremely important for operators when it comes to network resource utilization and monetization of their networks. It allows them to have full control over their resources and ensures they are distributed among customers in the most profitable manner.

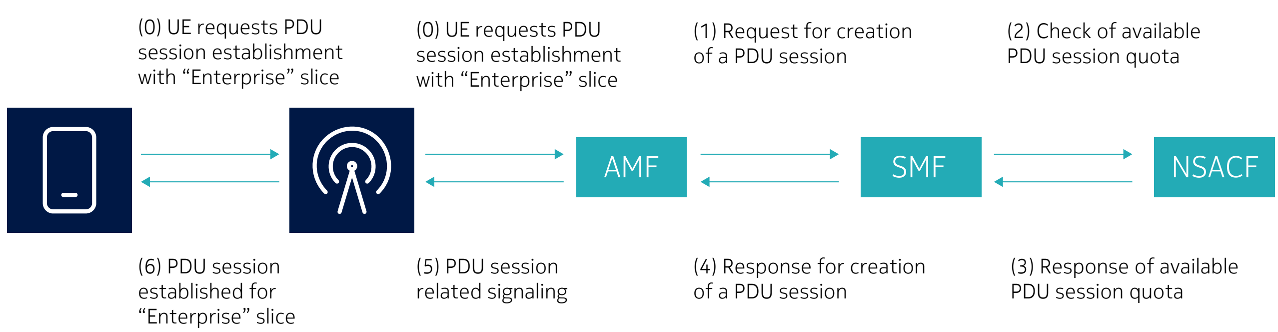
Release 18 offers improved network slice usage control for network operators. The NSAC feature introduces a new network function known as Network Slice Admission Control Function (NSACF). NSACF interfaces with other network functions controlling access and mobility (AMF), PDU sessions (SMF), or other NSACFs, for example, in roaming scenarios. Once the AMF determines that a UE is registering for a network slice (e.g., "Enterprise" slice) that is subject to NSAC, the AMF contacts the NSACF requesting to increase the count for the amount of registered UEs for the particular network slice, as shown in Figure 4. In the reply, NSACF indicates whether the maximum quota is reached or not. Accordingly, AMF decides whether the registration request can be accepted and whether to include the network slice in the list of allowed slices for the UE.

Figure 4. Application of NSAC for "Enterprise" slice at NSACF for number of Registered UEs



A similar approach is taken for establishing PDU sessions. The SMF contacts the NSACF to ensure that the PDU session quota for a network slice is not exceeded. In both cases, if there is no more available quota at NSACF, the PDU session or the UE registration is rejected for that network slice. This ensures enforcement of the operator's policy and the SLA. Figure 5 illustrates the interaction of SMF and NSACF during PDU session establishment for an example "Enterprise" slice that is subject to NSAC. Once the SMF is notified by the AMF to establish a PDU session for the slice, the SMF contacts the NSACF requesting the increase of count for PDU sessions for the particular network slice. In the reply the NSACF indicates whether the maximum quota is reached or not. Accordingly, the SMF either accepts or rejects the PDU session establishment.

Figure 5. Application of NSAC for "Enterprise" slice at NSACF for number of PDU sessions



Given that certain operators manage larger services areas, Release 18 includes a hierarchical and a centralized mode for NSAC operation. In the hierarchical mode, when a group of local NSACFs are responsible for a certain service area, a primary NSACF manages all local NSACFs (considered as secondary NSACFs) and updates the available quota for UEs and PDU sessions for the local NSACFs. In the centralized mode, all requests, irrespective of service area, are handled by the central NSACF.

Release 18 also offers enhanced control for roaming use cases with respect to the number of UEs and PDU sessions that a network slice can maintain. With it, home operators can enforce network slice quotas when users are roaming on a partner operator's network. To enhance NSAC in roaming scenarios, Release 18 introduces three options: Visited Public Land Mobile Network (VPLMN) NSAC admission; VPLMN with Home Public Land Mobile Network (HPLMN) assistance NSAC admission; and HPLMN NSAC admission.

When VPLMN NSAC admission mode is enabled, the VPLMN NSACF is configured with a maximum number of roaming UEs and/or PDU sessions quotas for the mapped network slice of the HPLMN. Admission control occurs as explained in Figure 4 and Figure 5 accordingly.

In VPLMN NSAC admission with HPLMN assistance mode, the VPLMN NSACF can coordinate with the HPLMN NSACF to acquire the quota for the number of roaming UEs and/or PDU sessions that are allowed by the home operator for a particular network slice. This mode gives more control to the home operator when its slice users roam on partner networks.

In HPLMN NSAC admission mode, the HPLMN NSACF is responsible for managing and enforcing the quota of roaming UEs and/or PDU sessions. This mode gives more control to the home operator when its slice users roam on partner networks.

Additionally, Release 18 enables network operators to enforce rules and quota management with respect to UEs with at least one PDN connection with a 4G/LTE core network (EPC) that is mapped to a PDU session in the 5G core (when interworking with EPC is enabled and the UE moves from 4G to 5G). This gives the network operator more flexibility and options with respect to resource management and quota enforcement.

Controlling when UEs can connect and use a network slice

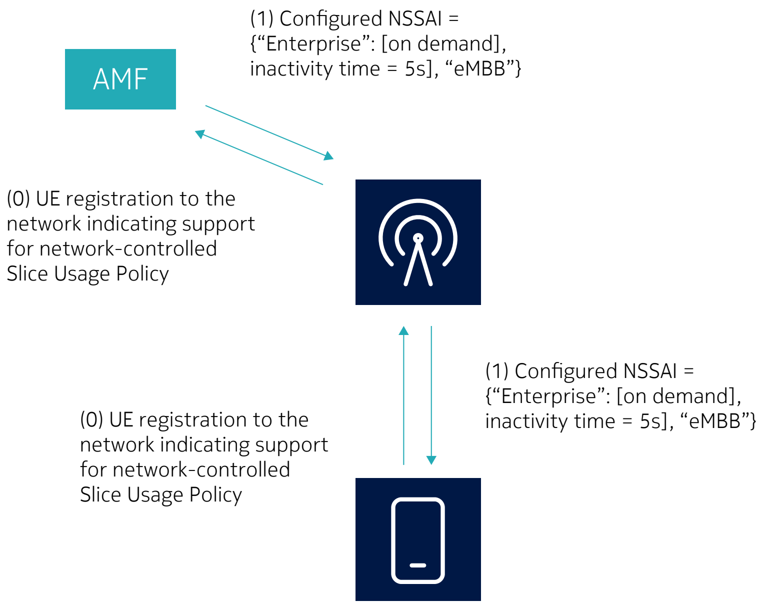
To provide network operators with enhanced control of when UEs can connect to and use a particular network slice, 3GPP has defined the following two capabilities:

1. Configuring network-controlled slice usage policy
2. Configuring PDU session inactivity timers and network slice deregistration inactivity timers.

During the registration procedure or the UE Configuration Update procedure, UEs that support these capabilities (which they communicate to the AMF during the UE registration procedure) are provided with a policy (1) that indicates if the requested network slice is an on-demand slice. The AMF delivers the appropriate policy based on its interaction with the policy control function (PCF) or unified data management (UDM). The policy includes the configured network slice selection assistance information (NSSAI), indicating whether one or more network slices in the configured NSSAI are on-demand. This directs the UE to register with those network slices only when applications running on the UE require active use of the slice (i.e., have data to transmit).

The policy may also include a deregistration inactivity timer (2) tied to the on-demand slice. The timer causes the UE to trigger a registration procedure that removes the on-demand network slice from the requested slices if a set time has elapsed from the last PDU session associated to the network slice is terminated (see Figure 6). This feature ensures that the UE does not occupy additional network resources that it no longer needs.

Figure 6. Example steps for UE registration and indication of network-controlled slice usage policy



To guarantee that on-demand slice resources are correctly released by the network once the UE no longer requires them, AMF and SMF are provisioned with network slice deregistration and PDU session inactivity timers respectively. Both network functions monitor their respective timers for each network slice. For instance, when an inactivity timer has elapsed for a particular slice because there has been no data traffic transmitted associated with the PDU session, the SMF will contact the user plane function (UPF) to release the PDU session for the indicated slice. And if there are no further PDU sessions active for that slice, then the SMF can also inform the AMF, which may locally remove the slice from the list of allowed slices the UE can operate and it may also trigger a UE Configuration Update procedure on the UE to remove the network slice from the list of allowed slices with which the UE can operate.

Slice continuity during congestion and network maintenance

When service continuity is disrupted for a network slice as a result of network problems such as slice congestion or planned maintenance the user experience can be adversely affected. Release 18 introduces the “slice replacement” feature to ensure that the performance requirements for active applications on the UE are met. It allows the tenant/operator to serve the applications of an affected UE by temporarily using an alternative slice or slice instance. A network slice instance is defined as a set of core network function instances and the required resources (e.g., compute, storage and networking resources), which form a deployed core network part of the network slice.

The AMF leads/coordinates the network functions that provision the slice replacement. The triggering of the replacement/remapping of an original slice by an alternative slice can be done based on a local configuration at the AMF, for example, a trigger from OAM, or based on a notification from the other network functions such as the policy control function (PCF) or network slice selection function (NSSF). OAM may prompt a network slice replacement based on scheduled maintenance or by utilizing system-level key performance indicators (KPIs). Similarly, the PCF or the NSSF may initiate slice replacement based on received information, for example, from the network data analytics function (NWDAF) or analytics output notifications from other network functions.

A UE that supports the slice replacement functionality indicates this capability during the registration procedure. When the AMF initiates slice replacement, it communicates the mapping between the original and alternative slices using a UE Configuration Update procedure. The alternative slice is assumed to be supported in the UE's current registration area and will be included in the UE's allowed and configured slice lists.

During the replacement sequence, the AMF informs the SMF about the slice replacement to initiate the transfer of the current PDU sessions from the original to the alternative slice. The SMF communicates the change to the UE, which either reconfigures the existing PDU sessions (SSC mode 3) or releases the existing PDU sessions and establishes new PDU sessions with the alternative slice (SSC mode 2 and 1). For the UEs in IDLE state, slice replacement is communicated when the UE establishes a new connection using the UE Configuration Update or Registration Accept messages.

When new PDU session(s) need to be established, they are requested by the UE, which indicates both the original and alternative slices, unless the UE has not yet received an update about the slice replacement (i.e., the UE was in IDLE state when the slice replacement occurred, so does not know about the alternate slice). In this case, instead of the PDU sessions being established directly with the alternative slice, the UE will request the establishment of a PDU session with the original slice and then the AMF will update the UE accordingly with the slice replacement information. The slice replacement procedure is summarized in Figures 7 and 8.

Figure 7. Example steps for UE registration and indication of slice replacement capability

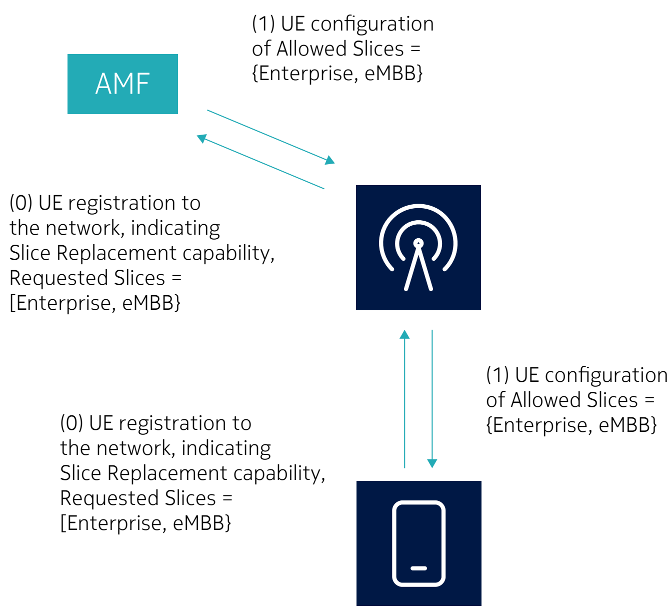
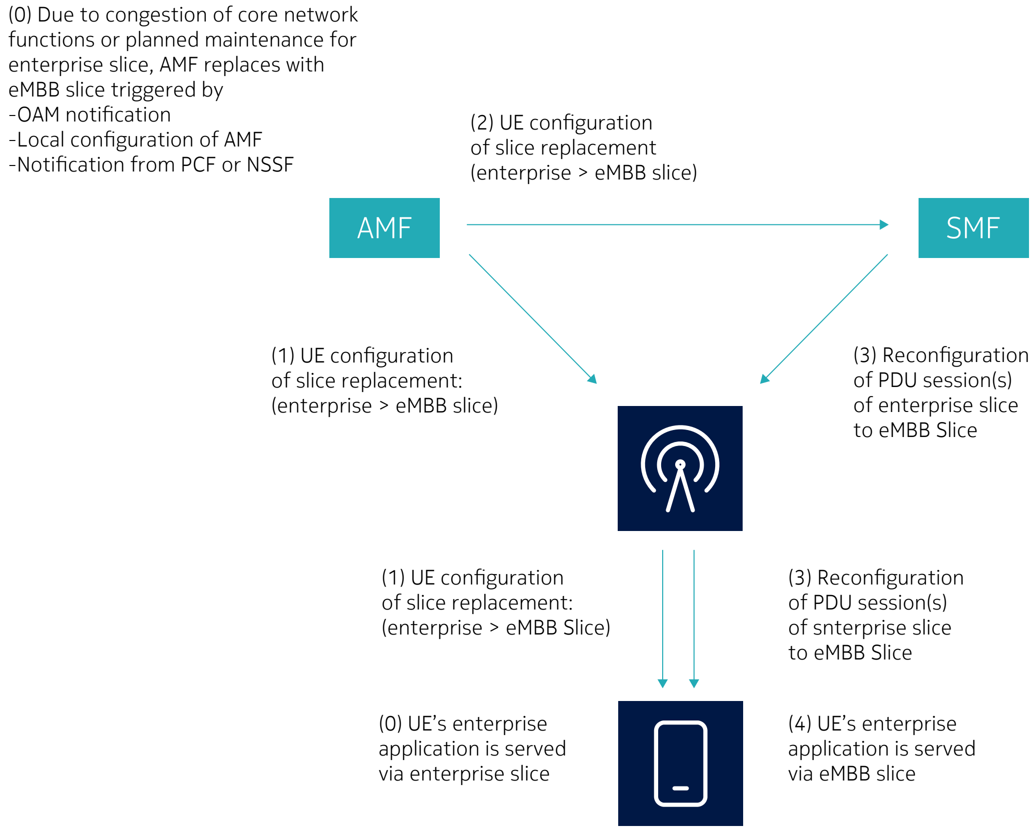


Figure 8. Example steps for enterprise slice replacement with eMBB slice



Network slice instance replacement is also possible. It can only be used when a PDU session for a network slice is established using a selected network slice instance and the network slice corresponding to this network slice instance is associated with multiple network slice instances. The network may change the network slice instance for a network slice in case the instance is not available due to issues such as congestion. Similar to network slice replacement, network slice instance replacement is coordinated by the AMF.

As long as the AMF has subscribed to the network slice instance replacement feature, the NSSF can trigger it by signaling to the AMF when a network slice instance it serves is unavailable. Upon initiation, the AMF can replace the original/replaced network slice instance and the SMF is informed by the AMF to release the corresponding PDU sessions. Subsequently, the SMF triggers the impacted UEs to establish new PDU sessions associated with the same network slice, and the AMF selects a new network slice instance for the newly established PDU sessions. The new network slice instance is chosen by the AMF with a possible communication to the NSSF to receive the new slice instance IDs.

Network slice replacement and network slice instance replacement are supported in roaming scenarios, where the network slice (or slice instance) in Home (i.e., for Home-Routed PDU sessions) or Visited-PLMN (i.e. for Local Break Out sessions in the VPLMN) needs to be replaced.

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Enhanced network slice management support

Network slicing provides the flexibility to offer diverse services using a common underlying 5G network infrastructure. However, this increases the complexity of network operations and maintenance. Network slice management has been a key focus area since its standardization in 3GPP Rel-15. The key standardization topics have been, for example, network slice life cycle management, network slice aware performance measurements, analytics support for network slice performance and service assurance.

To help formalize the network slice requirements between the slice tenant and network operator, GSMA introduced the concept of a generic network slice template (GST) [3]. 3GPP leveraged the parameters defined in GST to model the network slice technical requirements for the network operations and maintenance systems. In Release 18, parameters related to the data network are also added to the 3GPP network slice management system. These parameters define the data network the network slice can access, whether it be, for example, direct access to Internet, termination in a private network, or all data staying locally in the operator network. For enterprise deployments, this helps to better capture the requirements of different use cases.

Attributes related to network slice isolation have also been added to the network resource model to better capture the isolation requirements of different network slices. With these, network operators can define different isolation profiles to indicate, for example, which resources can and cannot be shared between different network slices. For example, for a highly sensitive public safety network there could be a requirement to have dedicated/ isolated resources that can be modeled into the management system using these newly introduced parameters. Both of these enhancements help to better model the specific technical requirements of the network slice SLA and help operators with performance management and service assurance.

Conclusion

Network slicing is a crucial element of the 5G value proposition because it enables support of differentiated and isolated services on a shared underlying communication infrastructure. Nokia has been a key driver of and contributor to network slicing standardization since its conceptualization and introduction in 3GPP Rel-15. With 5G-Advanced Release 18, Nokia continues to support enhancements for network slicing that will optimize its operation in diverse and dynamic deployments.

The newly introduced features include support for network slices in small service area(s) for extremely localized services. This helps operators to deploy these specialized network slices without the need to re-organize their TAs, which was required in pre-Release 18 networks. The definition of RAs is also enhanced to include network slices that are not supported homogenously throughout the RA. This helps optimizing the RA size as well as related signaling, especially for widespread deployment of localized enterprise slices given their co-existence with wide area network slices. Further, signaling optimization is also introduced for temporary network slices to allow automation of some of the session management and registration procedures without explicit signaling between the network and the UE.

Release 18 also features enhanced operator control over which UEs can connect to a particular network slice and when. This helps with managing network slice quotas, congestion management, and offers better support of tiered services. Release 18 also enables the network operator to enforce network slice quotas in the case of roaming, where the home operator can enforce its preferred quota for roaming UEs, including the ability to coordinate control with the roaming network partner. Finally, Release 18 enables support of NSAC and interworking with EPC, which allows network operators to count and enforce quota management rules for the number of UEs with at least one PDU session/PDN connection, for more flexibility and options for quota management.

To further help network slice congestion management, network slice and slice instance replacement enable operators to shift the traffic of one network slice or slice instance to an alternative network slice or slice instance in case there is congestion or planned maintenance on the original network slice. The network slice management features have also been updated with enhanced modeling of which data networks the network slice can access and to which resources the network slice has access.

These features are important for optimal deployment and operation of advanced network slice deployments, especially in enterprise customer environments, where a rapidly growing set of use cases require more specialized capabilities for network slices.

Abbreviations

3GPP	Third-generation partnership project
AAA	Authentication, authorization and accounting
AGV	Autonomous guided vehicles
AMF	Access and mobility management function
B2B	Business to business
eMBB	Enhanced mobile broadband
EPC	Evolved packet core
GST	Generic network slice template
GSMA	Global System for Mobile Communications Association
HPLMN	Home public land mobile network
KPI	Key performance indicator
MDA	Management data analytics
NS-AoS	Network slice area of service
NSSAA	Network slice specific authentication and authorization
NSSAI	Network slice selection assistance information
NSAC	Network slice admission control
NSACF	Network slice admission control function
NSSF	Network slice selection function
NWDAF	Network data analytics function
OAM	Operations and management
PCF	Policy control function
PDU	Packet data unit
PLMN	Public land mobile network
QoS	Quality of service
RA	Registration area
RAN	Radio access network
SLA	Service level agreement
SMF	Session management function
S-NSSAI	Single network slice selection assistance information
SSC mode	Session and service continuity mode
TA	Tracking area
UDM	Unified data management
UE	User equipment
URLLC	Ultra-reliable and low-latency communication
VPLMN	Visited public land mobile network
V-SMF	Visited session management function

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