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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Study on Enhanced Access to and Support of Network Slice

(Release 18)

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document studies various use cases and scenarios using network slices, in order to identify potential service requirements for the 5G system, e.g.:

- when there is a restriction of network slice to e.g., certain frequency bands/sub bands, RATs, geographical areas, networks and applications,

- when a UE has a subscription to multiple network slices and these network slices are deployed for e.g., different frequency bands/sub bands, RATs, geographical area and applications,

- when there is a preference or prioritization for a network slice over other network slices e.g. when there are conflicting constraints on network slice availability.

The present document also includes a gap analysis of its derived potential requirements versus existing 3GPP requirements.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 22.261: "Service requirements for the 5G system; Stage 1"

[3] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System; Stage 2".

[4] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".

[5] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[6] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

# 3 Definitions and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

<ACRONYM> <Explanation>

# 4 Overview

The concept of network slice was discussed from the beginning of the study for 5G system. Network slicing supports the flexible use of network resources so that multiple networks customized to the needs of each set of applications can be provided simultaneously over the network resources while ensuring resource isolation and meeting different SLAs. As more diverse industries start to use the capabilities provided by 5G system and various new services are implemented over the 5G system, the expected service requirements on the 5G system vary. To meet these diverse requirements on the network, the use of network slices will increase further as 5G system deployments are expanded.

When configuring network slices within its network, each network operator may consider various factors, such as required QoS of the applications supported over the network slices, the amount of required network resources to support the applications, the expected geographical and time boundary where the network slice services need to be provided, the usable and deployed network resources at the location where the applications are used, the number of users, the type of devices (e.g., IIoT), etc. After considering these factors, a network operator may provide a network slice for different services to users. Similarly, 3rd parties may be authorized by the network operator to configure their own network slices based on these various criteria, within the bounds of an SLA with the network operator.

However, the provisioning of network slices can be complicated, such as when a UE requests the simultaneous use of multiple network slices where the configurations for those network slices may not be compatible, when network slices are deployed over different network resources due to isolation requirements, when location based applications have specific requirements based on time of the day, or when the available networks support different sets of network slices.

# 5 Use cases

## 5.1. Initial access scenario for a network slice service

### 5.1.1 Description

Typically, users want for their devices to camp on a cell and be online as soon as possible after power-on. Especially, for 5G System which can provide ultra-low-latency data transport service, it is also important to reduce the time that takes for a device to send a packet after power on, to satisfy overall 5G experience.

### 5.1.2 Pre-conditions

Figure 5.1.2-1 shows the use case scenario where different network slices are configured on different frequency bands at a certain geographical location. In this scenario, all network slices and radio frequency bands belong to the same operator.



Figure 5.1.2-1 Initial Setup before-power on

In this use case and figure 5.1.2-1, following is assumed as pre-condition:

- Initially, UE A1, A2 and A3 are located at location GA and UE B1, B2 and B3 are located at location GB.

- UE A1 and B1 have a subscription only to slice M, and UE A2 and B2 have a subscription only to slice N.

- UE A3, B3 and B4 have a subscription to both slice M and slice N. A3 and B3 have preference to slice M while UE B4 has preference to slice N.

- At location GA, cells are deployed over only frequency F1.

- At location GB, cells are deployed on both frequency F1 and F2.

Furthermore, in this use case and in figure 5.1.2-1, due to requirement such as slice-isolation, following is further assumed:

- Slice M is configured to be provided only if it is accessed over F1.

- Slice N is configured to be provided only if it is accessed over F2.

- Slice N and Slice M are not simultaneously provided to UEs.

### 5.1.3 Service Flows

After power-up, following occurs for UE A1, A2 and A3:

- UE A1, A2 and A3 start searching of available cells.

- UE A1, A2 and A3 detect cells on Frequency F1.

- UE A1, A2 and A3 start registration via cells on F1.

- Based on subscription information, A1 and A3 are served with Slice M.

- Because the UE A2 does not have subscription for slice M, A2 stays in limited service state on F1 and does not perform further activity toward the cells on F1.

After power-up, following occurs for UE B1, B2, B3 and B4 when the UEs first try F1:

- UE B1, B2, B3 and B4 start searching of available cells.

- UE B1 and B3 select cells on Frequency F1 and start registration via the selected cell. Based on subscription information, the network provides services to UE B1 and B3 with Slice M over F1.

- UE B2 and B4 switches to Frequency F2 as soon as possible and selects cells on Frequency F2 and start registration. Because the network does not provide service of F1, UE B2 needs to minimize unnecessary attempt on F1. Similarly, the preferred slice is provided over F1 than F2, the UE B4 needs to move to F2 as soon as possible.

In this use case, it is desirable for the UEs to quickly camp on desired frequency where they can get required network slice services, to minimize time period of service unavailability. E.g. in above service flow, if UE B2 is stuck at F1, the UE B2 is out of service until it moves to F2.

### 5.1.4 Post-conditions

Figure 5.1.4-1 shows on which frequency each UE camps on finally to get desirable network slice service.



Figure 5.1.4-1 UE status after-power on

### 5.1.5 Existing features partly or fully covering the use case functionality

When a UE is located in an area where there is an authorized network slice for the UE, the 5G system shall be able to efficiently enable the UE to camp on radio resources where the network slice is provided.

### 5.1.6 Potential New Requirements needed to support the use case

[PR.5.1.6-2] When a UE is located in an area where there is at least one authorized network slice for the UE, the 5G system shall be able to minimize the time for the UE to access the network slices which is most suitable based on e.g., location of the UE, active applications, UE capability, frequency used by the network slice.

[PR.5.1.6-1] When a UE is located in an area where there is no authorized network slice for the UE, the 5G system shall support a mechanism to efficiently enable the UE to minimize power consumption (e.g., cell search, cell measurement).

## 5.2. Mobility Handling scenario for a network slice service Use case

### 5.2.1 Description

Due to various reasons, the availability of cell on a certain frequency is not homogeneous. For example, in an area where lots of people gather e.g. like office district, operator may deploy cells on all available frequencies. On the other hand, in an area whether population density is low, only part of owned frequency bands will be used to provide connectivity service.

In this use case, the above situation is investigated with movement of terminals. I.e., as mobile devices move from an area where some frequency band is used to deploy cells to an area where other frequency band is used to deploy cells. Even in this case, it is important to reduce the time that the UE is not provided with network slice service which it deserves.

### 5.2.2 Pre-conditions

Figure 5.2.2-1 shows the use case scenario where different network slices are configured on different frequency bands at a certain geographical location. In this scenario, all network slices and radio frequency bands belong to the same operator.



Figure 5.2.2-1 Initial Setup before-power on

In this use case and figure 5.2.2-1, following is assumed as pre-condition:

- Location:

- Initially, UE A1, A2, A3 and A4 are located at location GA.

- Initially, UE B1, B2, B3 and B4 are located at location GB.

- Subscription:

- UE A1 and B1 have a subscription only to slice M.

- UE A2 and B2 have a subscription only to slice N.

- UE A3, A4, B3 and B4 have a subscription to both slice M and slice N. A3 and B3 have preference to slice M while A4 and B4 have preference to slice N.

- Deployment:

- At location GA, cells are available over frequency F1, but not over frequency F2.

- At location GB, cells are available over both F1 and F2.

- Slice M is configured to be available over only F1 and Slice N is configured to be available over only F2. Slice N is available only within a certain location, e.g. within a factory. Slice M is available in wide area

- Due to isolation policy, slice N and slice M are strictly isolated. I.e., hardware is not shared between the slices.

- Based on application policy, some applications are allowed to be served over either slice N and slice M, while some applications are restricted to use only specific slice.

* Initial condition:

- A1, A2, A3, A4, B1 and B3 are on F1. B2 and B4 are on F2.

### 5.2.3 Service Flows

Following is potential service flow for UE A1, A2, A3 and A4:

- UE A1, A2, A3 and A4 are on Frequency F1. UE A1, A3 and A4 are served with Slice M, but UE A2 is in limited service state, due to lack of subscription for slice M. Accordingly, the UE A2 needs to minimize power consumption, e.g., that may be caused due to unnecessary monitoring of other cells.

- UE A1, A2, A3 and A4 move toward GB via GC.

- UE A1 and A3 continues to be serviced with Slice M via Frequency F1 at location GC and GB.

- At location GC, the UE A2 starts searching cells on Frequency F2. After moving to F2, the UE A2 starts to be served with Slice N. This should occur as soon as possible, because the UE A2 was out of service from location GA to location GC.

- Somewhere between location GC and location GB, the UE A4 moves to Frequency F2 and starts to be served with Slice N, because the UE A4 prefers Slice N to Slice M. To minimize impact on the ongoing services over Slice M, when the UE A4 moves to Frequency F2 can be dependent on many other factors such as active applications on each slice.

Following is potential service flow for UE B1, B2, B3 and B4:

- UE B2 and B4 are on Frequency F2 and served with Slice N. UE B1 and B3 are on Frequency F1 and served with Slice M.

- Due to lack of subscription of network slices provided over F1, the UE B2 may be allowed to minimize power consumption that may be caused, e.g., due to monitoring cells of other frequency F1.

- UE B1, B2, B3 and B4 move toward GA via GC.

- UE B1 and B3 are still serviced with Slice M via Frequency F1 from location GC to location GA.

- As the UE B2 moves across location GC and moves toward GA, the UE B2 will eventually lose connectivity service because there is no available cell on Frequency F2 and there is no allowed network slice on F1 for the UE B2. In this case, it is desirable for the UE B2 to prepare for the sudden loss of connectivity service. Especially, if the service over slice N is kind of URLLC service that is available only within some specific places such as within a smart factory, the sudden loss of connectivity should be avoided as much as possible. Thus, before the UE crosses the location GC, the UE B2 needs to be given with grace time to prepare for the loss of connectivity, e.g. termination of ongoing applications.

- As the UE B4 approaches location GC, the UE B4 needs to move to Frequency F1. As the UE B4 moved to Frequency F1, the UE starts to be served with Slice M. Because the UE B4 prefers Slice N to Slice M, the transition from F2 to F1 should not occur unnecessarily too early. On the other hand, if the transition from F2 to F1 occurs after the UE B4 crosses the location GC, there is potential loss of connectivity. Thus, the transition from F2 to F1 should occur before crossing location GC. To minimize impact on the ongoing services over Slice N, it may also be better for the UE to be notified in advance of the transition from F2 to F1. This may enable for the UE to do smooth adjustment of services, such as termination of application or relocation of application to one slice to another.



Figure 5.2.3-1 Transition

Figure 5.2.3-1 shows the UE movement.

### 5.2.4 Post-conditions

After passing through location GC, following are desired results after mobility:

- UE A1, B1, A3 and B3 keep on staying on F1 and are provided with slice M.

- UE A2 moves to F2 and is now provided with slice N.

- UE A4 moves to F2 and is now provided with slice N and is not provided anymore with slice M.

- UE B2 camps on F1, is disconnected from slice N and is in limited state.

- UE B4 moves to F1, is provided with slice M and not any more with slice N.

Figure 5.2.4-1 shows on which frequency each UE camps on after movement.



Figure 5.2.4-1 UE status after movement

### 5.2.5 Existing features partly or fully covering the use case functionality

When a UE moves from an area where there is no authorized network slice for the UE to an area where there is at least one authorized network slice for the UE, the 3GPP system shall be able to efficiently enable the UE to access the authorized network slices as soon as possible.

### 5.2.6 Potential New Requirements needed to support the use case

[PR.5.2.6-1] When a UE moves out of the service area of a network slice for an active application, the 5G system shall be able to minimize impact on the applications (e.g., providing early notification).NOTE: Various methods can be used to detect whether the UE moves toward the border area and to notify the UE.

## 5.3. Service scenario for disjoint network slices

### 5.3.1 Description

As more network slices are deployed, it is likely that each UE can access to multiple network slices. While some network slice services can be simultaneously provided to the UE, there can be network slices which cannot simultaneously provide services to the UE. This is because there are multiple related factors for a network slice, e.g., enterprise use vs personal use, isolation requirement, general public use vs public safety use, frequency limitation, location restriction, etc.

### 5.3.2 Pre-conditions

Network slices are deployed by same geographical location but they are incompatible by configuration. Figure 5.3.2-1 shows the use case scenario where a RAN node connects to two network slices simultaneously. Slice M and Slice N have no shared/common core network nodes supporting these network slices due to network resources incompatibility in 5GC. For example, Slice M is used for public security and Slice N is used for Internet access. In the 5GC, dedicated network resources and network functionalities are separately customised for public security emergency service and video service to meet the isolation requirements, which ensures the independence of core network resources between different network slices. Accordingly, the two network slices are isolated and cannot be simultaneously provided to the UE.

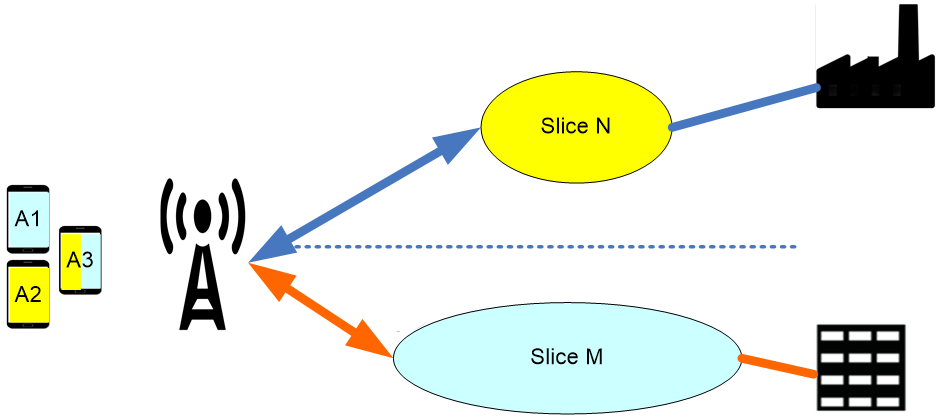


Figure 5.3.2-1 Initial condition

In this figure, it is assumed that

- Subscription and configuration:

- UE A1 and A3 are authorized to access Slice M.

- UE A2 and A3 are authorized to access Slice N.

- For UE A3, it is configured which applications use which network slices.

- Deployment:

- Slice N and Slice M are deployed at the same geographical location. Slice N and Slice M are isolated. Due to the network resources incompatibility in 5G core network, there are no shared/common core network nodes supporting the Slice N and Slice M.

- NG-RAN is able to connect to both Slice M and Slice N.

- Slice M and Slice N are provided by the same PLMN.

### 5.3.3 Service Flows

Following is the service flow for UE A1, A2 and A3 when the signaling from these UEs is initially routed toward nodes managing Slice N:

- UE A1, A2 and A3 select the NG-RAN and start registration.

- Network slices provide connectivity services to UE A1, A2 and A3.

- While the UE A3 is connected to Slice N, Slice M cannot provide the connectivity service to UE A3. The user traffic applicable to Slice N is transported.

- Later, user traffic configured to use slice M is generated in UE A3. While the same NG-RAN is used, the traffic is switched to Slice M.

- If the user prioritizes applications configured to use Slice N, as soon as applications configured to use Slice M finish, the UE A3 needs to move back to Slice N, to minimize the latency.

### 5.3.4 Post-conditions

UE A1 is connected to Slice M.

UE A2 is connected to Slice N.

UE A3 switches between Slice N and Slice M, depending on e.g. ongoing applications.

### 5.3.5 Existing features partly or fully covering the use case functionality

There are related requirements on change of network slices based on services, as defined in clause 6.1.2.2 in TS 22.261 [2]:

*The 5G system shall allow the operator to assign a UE to a network slice, to move a UE from one network slice to another, and to remove a UE from a network slice based on subscription, UE capabilities, the access technology being used by the UE, operator's policies and services provided by the network slice.*

There are related requirements on impacts on other network slices caused by traffic and services from one network slice, as defined in clause 6.1.2.2 in TS 22.261 [2]:

*Traffic and services in one network slice shall have no impact on traffic and services in other network slices in the same network.*

Based on TS 22.261 [2] clause 6.1 network slicing, the following service requirement is supported:

*The 5G system shall enable a UE to be simultaneously assigned to and access services from more than one network slice of one operator.*

### 5.3.6 Potential New Requirements needed to support the use case

The following new requirements can be derived from this use case:

[PR.5.3.6-1] For a UE authorized to access multiple network slices of one operator which cannot be simultaneously used by the UE (e.g. due to radio frequency restrictions), the 5G system shall be able to allow the UE to access the most suitable network slice (e.g. based on the ongoing applications).

[PR.5.3.6-2] For a UE authorized to access to multiple network slices of one operator which cannot be simultaneously used by the UE (e.g. due to radio frequency restrictions), the 5G system shall support the minimized interruption when the UE changes the access from one network slice to another network slice. (e.g. based on changes of active applications).

## 5.4. Use of Multi-RATs for network slices

### 5.4.1 Description

5GC is connected to NG-RAN and the NG-RAN supports both E-UTRA and NR. However, for a third party who wants to utilize a network slice, the different potential and flexibility of E-UTRA and NR is not something that can easily be disregarded.

Also, the unequal possibility of radio resource slicing for NR and E-UTRA leads to a unique use case scenario.

### 5.4.2 Pre-conditions

Figure 5.4.2-1 shows the use case scenario where an NG-RAN is supporting both NR and E-UTRA radio resources.



Figure 5.4.2-1 Initial condition

In this figure, it is assumed that

- Subscription:

- UE A1 and A4 are subscribed to a service using Slice M.

- UE A2 and A4 are subscribed to a service using Slice N.

- UE A3 is subscribed to a service using Slice O.

- Deployment:

- E-UTRA is configured to serve Slice M, e.g. for general eMBB services, including a slice for IMS service.

- NR is configured to serve Slice N and O, e.g. for URLLC or V2X. Due to demanding requirements of V2X application, V2X application providers (e.g. OEM) requests to use only NR for Slice O.

The frequencies used for E-UTRA and NR can be the same or different. For example, when DSS (Dynamic Spectrum Sharing) is used, the same frequency is used for both E-UTRA and NR, but in different time slots.

### 5.4.3 Service Flows

The following is an example service flow based on the setting in the previous section:

- After power-on, UE A1, A2, A3 and A4 start searching for cells.

- UE A1, A2, A3 and A4 start registration in the found cells.

- Depending on factors such as e.g., use of Dual Connectivity, priorities of network slices, different UEs may camp on different RATs. For example, the UE A1 may camp on E-UTRA.

- Based on the various inputs, for the transport of user traffic for a network slice, the RAT and radio resources can be configured. For example, when user traffic for slice M is generated for UE A4, the network may configure E-UTRAs resource for the UE to deliver the traffic. For this UE A4, when user traffic for slice N is generated, the network may configure NR resources for the UE. When both NR and E-UTRA resource are configured, the user traffic for the network slice only flows over the allowed RATs.

- When service policy changes, e.g. when slice M is now set to use NR instead of E-UTRA, UEs camp NR cells instead of E-UTRA cells. For a UE with ongoing active communication, handover occurs to move the UE from E-UTRA to NR.

### 5.4.4 Post-conditions

The following figure 5.4.4-1 shows the status at the end of the service flow. For the transport of user traffic, UE A1 is served by E-UTRA, UE A2 and A3 are served by NR. UE A4 may camp on either E-UTRA or NR during Idle mode and be configured with E-UTRA, NR or both depending on the active application during Connected mode.



Figure 5.4.4-1 End result

### 5.4.5 Existing features partly or fully covering the use case functionality

TS 22.261 [2] contains many requirements related to user traffic management and network slices.

*- The 5G system shall allow the operator to define and update the set of services and capabilities supported in a network slice.*

*- Based on operator policy, a 5G network shall provide suitable APIs to allow a trusted third-party to create, modify, and delete network slices used for the third-party.*

*- Based on operator policy, the 5G network shall provide suitable APIs to allow a trusted third-party to define and update the set of services and capabilities supported in a network slice used for the third-party*

### 5.4.6 Potential New Requirements needed to support the use case

The following new requirements can be derived from this use case:

[PR.5.4.6-1] 5G system shall minimize signaling exchange and service interruption when there is a change in the allowed radio resources (e.g. RATs) for a network slice.

## 5.5 Use case on access to slices when roaming

### 5.5.1 Description

A UE subscribes to multiple network slices from its home operator. The home operator has agreements with various other operators to support the same slices for roaming UEs. In this case, the most preferred VPLMN in a specific area does not support all the needed slice; however, a second VPLMN does support the slice not available in the most preferred VPLMN. In this case, the home operator can provide the necessary information to allow the UE to use the second VPLMN to obtain the service available on that network slice, while otherwise being served by the most preferred VPLMN. Figure 5.5.1-1 illustrates the scenario.

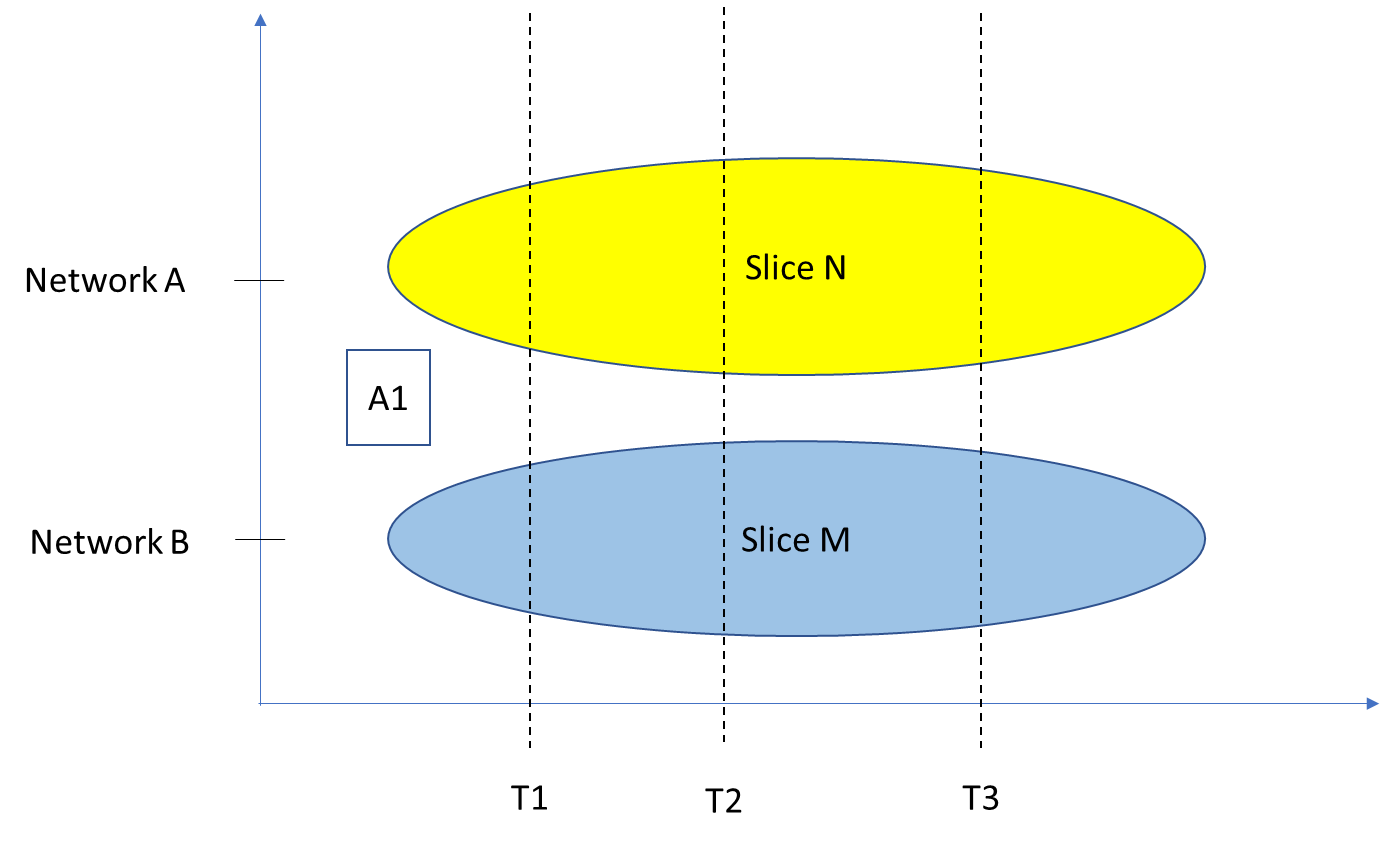


Figure 5.5.1-1: Roaming UE with subscriptions to services on network slices available on different networks

### 5.5.2 Pre-conditions

In this scenario, the UE A1 is roaming in an area covered by 2 VPLMNs, Network A and Network B. UE A1 subscribes to services that require use of slices M and N in its home network. The corresponding slices and services are available in the visited area, even though these slices are not offered by the same network in the visited area. Network A is the most preferred VPLMN in this area.

### 5.5.3 Service Flows

When UE A1 first enters the visited area, it registers with Network A and can uses services from slice N.

At a later time (T2), the user decides to activate a service that needs slice M. The UE, detecting that slice M is not available on Network A, looks for the network that provides the slice. The UE registers on Network B and the user is able to use the service of slice M.

When the service concludes and slice M is no longer needed (T3), the UE returns to Network A.

### 5.5.4 Post-conditions

The user is able to access all their subscribed services while roaming, even though the needed slices are not available on a single VPLMN.

### 5.5.5 Existing features partly or fully covering the use case functionality

Roaming and slice access work as usual, with the addition of being able to change VPLMNs to gain access to a slice not available on the most preferred VPLMN.

### 5.5.6 Potential New Requirements needed to support the use case

[PR.5.5.6-1] For a roaming UE activating a service/application requiring a network slice not offered by the serving network but available in the area from other network(s), the HPLMN shall be able to provide the UE with prioritization information of the VPLMNs with which the UE may register for the network slice.

## 5.6 Use case on simultaneous access to multiple slices on different VPLMNs

### 5.6.1 Description

A UE has access to multiple network slices when on the HPLMN. When the UE is roaming and the VPLMN where the UE is currently registered only provides a subset of the network slices that the UE needs to use, the UE can connect to other VPLMNs at the same time to access the other subscribed network slices.

### 5.6.2 Pre-conditions

- UE is subscriber of Operator Toffee

- When on its home network, Operator Toffee, UE has access to three network slices: (A)pricot, (B)anana and (C)herry

- UE runs different applications that require the UE to simultaneously access Apricot, Banana and Cherry slices

- Operator Toffee has agreements with:

- Operator Chocolate to support Apricot and Banana slices

- Operator Fudge to support Cherry slice

- Operator Chocolate is the preferred roaming network

- UE moves out of Operator Toffee’s coverage area, into an area where the coverage is provided by Operator Chocolate and Operator Fudge

### 5.6.3 Service Flows

1. UE connects with Operator Chocolate, and has access to Apricot and Banana slices

2. UE requires simultaneous access to all three slices, Apricot, Banana and Cherry, due to the different applications running on the UE. However, the VPLMN the UE is registered to, Operator Chocolate, does not provide support for Cherry slice

3. UE is authorised by the HPLMN to additionally access the Cherry slice in the Operator Fudge network.

4. UE connects to Operator Fudge's network, while retaining the connection to Operator Chocolate

### 5.6.4 Post-conditions

Roaming UE is able to access all three network slices simultaneously from Operator Chocolate and Operator Fudge.

### 5.6.5 Existing features partly or fully covering the use case functionality

There are related requirements in TS 22.261 [2], clause 6.18 on "Multi-network connectivity and service delivery across operators ":

*The 5G system shall enable users to obtain services from more than one network simultaneously on an on-demand basis.*

*For a user with a single operator subscription, the use of multiple serving networks operated by different operators shall be under the control of the home operator.*

TS 23.501 clause 5.3.2.4 on "Support of a UE registered over both 3GPP and Non-3GPP access" indicates:

*A UE supporting registration over both 3GPP and Non-3GPP access to two PLMNs shall be able to handle two separate registrations, including two 5G-GUTIs, one per PLMN, and two associated equivalent PLMN lists.*

Also, TS 33.501 has a clause 6.3.2 on "Multiple registrations in same or different serving networks"

### 5.6.6 Potential New Requirements needed to support the use case

[PR.5.6.6-1] For UEs that have the ability to obtain service from more than one VPLMN simultaneously, the following requirements apply:

- When a roaming UE with a single PLMN subscription requires simultaneous access to multiple network slices and the network slices are not available in a single VPLMN, the 5G system shall enable the UE to:

- be registered to more than one VPLMN simultaneously; and

- use network slices from more than one VPLMN simultaneously

- The HPLMN shall be able to authorise a roaming UE with a single PLMN subscription to be registered to more than one VPLMN simultaneously in order to access network slices of those VPLMNs.

- The HPLMN shall be able to provide a UE with permission and prioritisation information of the VPLMNs the UE is authorised to register to in order to use specific network slices.

NOTE: The above requirements assume certain UE capabilities, e.g. the ability to be connected to more than one PLMN simultaneously.

## 5.7 Slice Access with Application Preference

### 5.7.1 Description

This use case intends to bring a use case for network slice to support important applications like gaming and online video in a more flexible and efficient way. For gaming or online video applications, the end users, who have subscription with MNOs who may provide multiple network slices to different users or services, may still have different priority or membership e.g. VIP maintained by 3rd party Service Provider (SP). And depending on the priority or membership information from 3rd party SP perspective, based on the agreement between SP and MNO, the UE have different priority for the available network slices.

Figure 5.7.1-1 shows an example scenario for this use case.



Figure 5.7.1-1 Example scenario for this use case

### 5.7.2 Pre-conditions

1. MNO provisioned network slices Slice#1, Slice#2, Slice#3. As an example, Slice#1 is dedicated for online video services for SP#1. Slice#2 is dedicated for gaming for SP#2. Slice#3 is a network slice for eMBB service i.e. text or voice chat, file downloading or web surfing.

2. UE 1 and UE 2 are registered to MNO’s 5G network and they have subscription to slice#1, #2 and #3. The owner of UE 1, i.e., User A, have installed Game App x and Video App y. The owner of UE 2, i.e., User B, have installed Game App z and Video App y.

3. User A and User B are high priority users for SP#1 and SP#2 which means when these users start to use game or video app, they can use the corresponding network slice to guarantee their QoS compared with other users with lower priority and the MNO network resource can accommodate high priority users.

4. Due to the fact that the 3rd party SP may roll out new services/applications and the users may change their VIP membership dynamically, the 3rd party needs to negotiate the priority of a network slice for UE per application.

### 5.7.3 Service Flows

1. MNO and SP have agreements e.g. SLA and Slice#1, Slice#2 and Slice#3 are provisioned.

a) The MNO provisioned the slices and maintains the user subscription to access these slices. The SP maintains the application related user membership information.

b) UE 1 and UE 2 may or may not be accessing three slices simultaneously.

2. User A’s smart phone UE 1, and User B’s smart phone UE 2 turns on and registered to MNO network. After registration, UE 1 and UE 2 are able to access corresponding network slices.

c) User A can access Slice#1 for online video app x and Slice#2 for gaming, also Slice#3 for other services.

d) User B can access Slice#1 for online video y and gaming app z, and also Slice#3 for other services.

3. User A and User B started chat and web surfing service, it accesses network Slice#3

4. User A started online video, UE A access to Slice#3 which can only provide a basic SLA for the online video e.g. with lower resolution1.

5. User A’s priority for slices is dynamically changed due to the SP side updates e.g. User A changes his/her VIP. membership, thus different SLA is provided to User A’s online video via Slice#1..

6. User B started game app, UE B access to Slice #3 which can only provide a basic SLA for the game service e.g. with lower resolution and low latency is not ensured.

7. User B’s priority for slices is dynamically changed due to the SP side updates e.g. User B changes his/her VIP membership, thus different SLA is provided to User A’s game app via Slice#2.

8. User A’s priority for slices are changed back to original value due the SP side update e.g. VIP membership. expired, thus the online video is provided via Slice#3.

9. User B’s priority for slices are changed back to original value due to SP side update e.g. VIP membership expired, thus the game app is provided via Slice#3.

In the above service flows, the different slices may be provided by same or different frequency and the coverage may be different. If different slices are deployed in different frequency bands, access of different network slices due to application should not cause degradation of user experiences.

### 5.7.4 Post-conditions

SP and MNO may monitor the QoS of online video and game applications and also support flexible charging for these users which change their priority accessed slices per application.

### 5.7.5 Existing features partly or fully covering the use case functionality

In Clause 6.1.2 of TS 22.261 [2], network slicing requirements are specified including general, management, network slice constraints and cross-network slice coordination.

In 6.1.2.2 of TS 22.261 [2], there is a requirement as follows:

*The 5G system shall enable the network operator to define a priority order between different network slices in case multiple network slices compete for resources on the same network.*

This requirement enables priority mechanism from network resource configuration perspective.

In 6.1.2.2 of TS 22.261 [2], there is another requirement as follows:

*The 5G system shall allow the operator to assign a UE to a network slice, to move a UE from one network slice to another, and to remove a UE from a network slice based on subscription, UE capabilities, the access technology being used by the UE, operator's policies and services provided by the network slice.*

This requirement is from operator perspective and doesn’t cover the aspect whether 3rd party application can influent the priority of network slices.

The existing requirements for network slicing, e.g. which is cited in this section, is from network resource configuration perspective.

However, when UE can access multiple network slices which may be tailored for different applications, there is no support of changing the priority or the preferred network slicing for the UE based on application. And this process cannot be carried out efficiently without standard-based means for MNO and third party to communicate/negotiate the preferred network slices according to application.

For this use case, additional two requirements below are considered already supported:

* The 5G system shall support means to dynamically change the UE priority of network slices per application with minimized interruption, according to third party’s policy.
* The 5G system shall support mechanisms to allow a 3rd party and the 5G network to negotiate the UE priority of a network slice per application.

### 5.7.6 Potential New Requirements needed to support the use case

No new requirement is derived from this use case.

## 5.8 Use case for application-based preference

### 5.8.1 Description

Applications using Network Slice(s) offered on different radio resources may be used differently in location and time. This brings motivation for the 5G System to support a mechanism to establish and manage a preference ordering among subscribed applications/services for use in cell (re)selection.

Application preference could be set by the user or derived based on the user’s application usage pattern. Application preference information in the network can be overridden by application activation, such that activating an application with a lower preference order may trigger a change in serving network slice (assuming no other application is also active on that slice) and cell (re)selection if the newly activated application requires a different radio resource.

### 5.8.2 Pre-conditions

Slice M & Slice N are two slices provided by the same Operator. Services from Slice M are provided over frequency band FR1 and services from slice N are provided over frequency band FR2.

Slice M provides VPN and streaming services while slice N provides VPN and AR/VR-Gaming services. The UE’s shown in the illustration have subscriptions to applications provided by both the slices M and N. The key difference in network slice selection lies in the application preference order used by each UE.

Rama and Krishna work in different companies at the same location (e.g., an office building). Rama has a WFH (Work from Home) option which he can use frequently while Krishna does not have a WFH option from his company but may be allowed WFH in rare situations. Both their homes are located in the same service area. Rama likes to use his AR/VR-Game application during office-breaks while at the office. Krishna mostly uses his streaming service during office-breaks while at the office. Both use their streaming service application most after office hours when at home.

- Rama (UE1) and Krishna (UE2) have subscriptions to applications VPN, AR/VR-Game and a streaming service.

- Rama has his preference profiles set in the following order:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Rama’s UE Application Preference Profile Setting | | | | | | |
| Profile | Time of Day, Day | Location | Preference-1 | Preference-2 | Preference-3 |
| Work Profile | 9-5 Work Day Setting | Office | VPN | AR/VR-Game | Streaming service |
| Rest of the Time/Days | Any | Streaming Service | AR/VR-Game | VPN |
| WFH Profile | 9-5 WFH Day Setting | Home | VPN | Streaming Service | AR/VR-Game |
| Rest of the Time/Days | Any | Streaming Service | AR/VR-Game | VPN |
| Default Profile | Any | Any | Streaming Service | AR/VR-Game | VPN |

- Krishna does not have his preference pre-set, however it is established by the 5G System based on his usage pattern in below order:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Krishna’s Application Preference Setting derived by 5G System | | | | |
| Time of Day | Location | Preference-1 | Preference-2 | Preference-3 |
| 9-5 Work Days | Office | VPN | Streaming Service | AR/VR-Game |
| Rest of the Time/Days | Any | Streaming Service | VPN | AR/VR-Game |

### 5.8.3 Service Flows

For a normal working day at the office, Rama’s UE selects slice M and Krishna’s UE selects slice N based on their preferences.

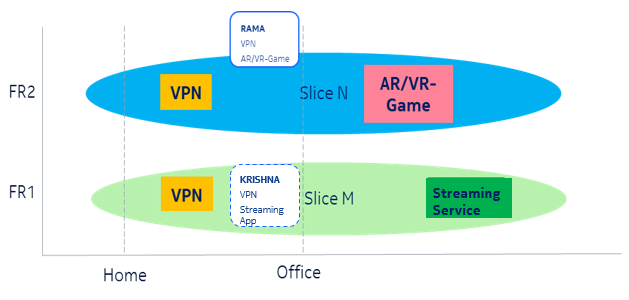


Figure 5.8.3-1: Applications preferred network slices for Rama and Krishna during Workdays (Working Hours)

Both return to their homes after office hours. Both Rama’s UE and Krishna’s UE select slice M based on their preferences.

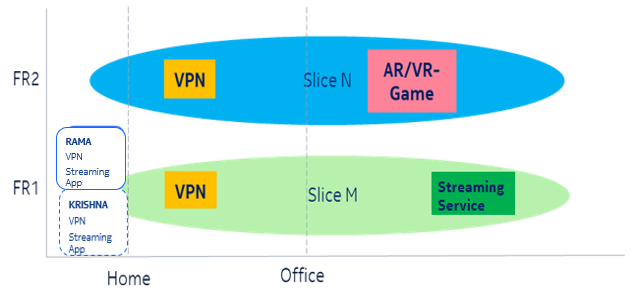
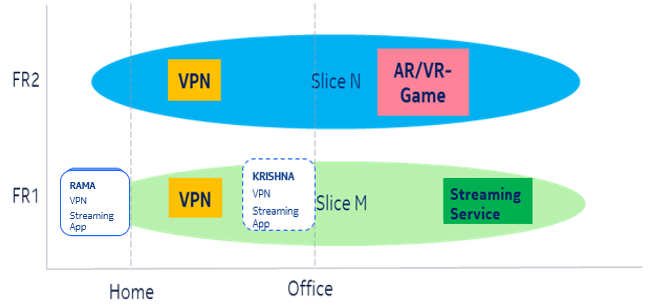


Figure 5.8.3-2: Applications preferred network slices for Rama and Krishna during Evenings (off-Working Hours)

During a WFH Day for Rama, he changes his profile setting to use ‘WFH Profile’. While Krishna goes to office as usual. Rama’s UE stays on slice M instead of switching to Slice N while Krishna’s UE selects slice M as usual at the office.



**Figure 5.8.3-3: WFH Scenario for Rama and normal work day for Krishna.**

Once, both Rama and Krishna meet at a conference and become friends. Rama invites Krishna to join him to play an AR/VR game during office-breaks. Krishna accepts the invitation and subsequently starts playing the AR/VR game during office-breaks instead of watching his streaming service. Initiating the AR/VR-Gaming application triggers Krishna’s UE to use the least preferred application during his office breaks and causes it to (re)select a cell offering Slice N

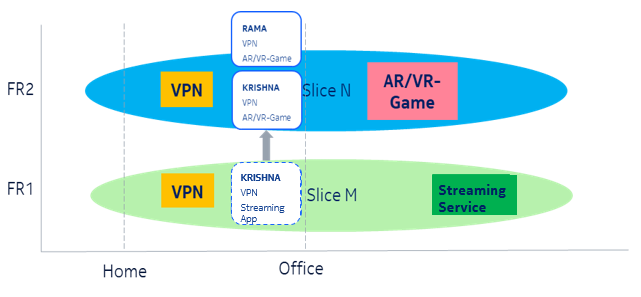


Figure 5.8.3-4: Slice Switch Triggered for Krishna due to AR/VR-Game usage

The 5G System now derives/updates the new preference for Krishna based on AR/VR-Game Usage during office breaks.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Krishna’s Preference Setting derived by 5G System | | | | |
| Time of Day | Location | Preference-1 | Preference-2 | Preference-3 |
| 9-5 Work Days | Office | VPN | AR/VR-Game | Streaming Service |
| Rest of the Time/Days | Any | Streaming Service | VPN | AR/VR-Game |

### 5.8.4 Post-conditions

Both Rama and Krishna are able to access their preferred application(s) in a timely and efficient manner.

### 5.8.5 Existing features partly or fully covering the use case functionality

The 5G system shall allow the operator to assign a UE to a network slice, to move a UE from one network slice to another, and to remove a UE from a network slice based on subscription, UE capabilities, the access technology being used by the UE, operator's policies and services provided by the network slice.

Establishing UE usage patterns based on time/date/location is supported by TS 23.503 [3].

### 5.8.6 Potential New Requirements needed to support the use case

[PR.5.8.6-1] The 5G system shall support a mechanism for a UE to select and access network slice(s) based on UE capability, ongoing application, radio resources assigned to the slice, and policy (e.g., application preference).

[PR.5.8.6-2] The 5G system shall support a mechanism to optimize resources of network slices (e.g., due to operator deploying different frequency to offer different network slices) based on network slice usage patterns and policy (e.g., application preference) of a UE or group of UEs.

## 5.9. Regionally different resources for network slices

### 5.9.1 Description

Installation of radio equipment needs a lot of work to be done. Thus, typically, even if an operator owns a certain radio frequency nationally, the operator may gradually deploy radio equipment one region by one region, expanding coverage gradually. As a result, even if some network slice, for example, such as a slice for IMS service is provided nationally, the used frequency band for that network slice may be different per different areas.

### 5.9.2 Pre-conditions

Figure 5.9.2-1 shows the use case scenario where network slices use different radio resources for different areas.



Figure 5.9.2-1 Initial condition

In this figure, it is assumed that

- Subscription and configuration:

- UE A1 has a subscription to slice M.

- UE A2, A3 and A4 have subscription to slice N.

- Deployment:

- F1 is used at all areas. F2 is available only at area around GB, e.g. in a highly populated area.

- Due to high demand of applications related to Slice N, at area around GB, frequency F2 is dedicated to serve the network slice N, and F1 is dedicated to serve other network slices such as network slice M.

### 5.9.3 Service Flows

Following is service flow for UE A1 and A2 which move from area GA to area GC:

- UE A1 and A2 are serviced with network slices over F1 at area GA.

- UE A1 continues to be serviced with network slice M over F1 toward area GB. Because F1 at area GB does not support slice N, the network moves the UE A2 to F2 to provide service continuity for network slice N from area near GD. While the frequency used for Slice N changes, the service interruption to applications over Slice N is minimized.

- UE A1 continues to be serviced with network slice M over F1 toward area GC. UE A2 moves back to F1 to get network slice N from as the UE moves along from GB to GC. While the frequency used for Slice N changes, the interruption to application over Slice N is minimized.

Following is service flow for UE A3 which is stationary at area GD:

- UE A3 is located at the boundary area where the used frequencies for a network slice N differ. To prevent unnecessary power consumption, service interruption and increased signaling, frequency change between F1 and F2 needs to be minimized, when the UE A3 is serviced with network slice N.

Following is a service flow for UE A4 which moves from area GA to area GB:

- UE A4 is serviced with network slice N over F1 at area GA. When application ends, the user of UE A4 switches off the UE A4.

- While the UE A4 is switched off, the user moves from the area GA to the area GB.

- When the user arrives at the area GB, the user turns on the UE A4 and starts finds cells, beginning with F1 which is the last used frequency.

- The UE A4 finds out that F1 does not support Slice N. In the end, the UE access cells on F2 and gets service for network slice N over F2 at area GB.

### 5.9.4 Post-conditions

Following figure 5.9.4-1 shows the status at the end of service flow.



Figure 5.9.4-1 End result

### 5.9.5 Existing features partly or fully covering the use case functionality

Following are service requirements that can be drawn out of service description in previous sections and that can be supported with existing specifications:

- 3GPP shall support the same network slice to be configured over different frequencies at different areas.

- 3GPP shall support service continuity for a network slice at the boundary where radio resources configured for the network slice change, for a UE in Connected mode.

However, the existing specification does not yet provide specific means when the UE moves between different regions in Idle mode.

- 3GPP shall support to minimize the time that takes for a UE to be able to access radio resource configured for a network slice when the used radio resources for the network slice change e.g. during mobility, power cycle.

Following service requirements may be supported with existing specifications:

- 5G system shall support a mechanism to minimize service interruption for a UE when different radio resources are configured for a network slice in different geographical areas and when the UE crosses the geographic area boundaries.

### 5.9.6 Potential New Requirements needed to support the use case

No new requirement is derived from this use case.

## 5.10. Isolation of resource for network slice

### 5.10.1 Description

Due to various sources and ways to gain right to use specific frequency resources, even within a continuous frequency range, different blocks of frequency within the range can be restricted to different purposes.

Also, based on the requirements on the levels of isolation and security, access by a network slice beyond the authorized blocks should not occur, even if the frequency blocks are adjacent.

### 5.10.2 Pre-conditions

Figure 5.10.2-1 shows the use case scenario where frequency band are partitioned into multiple subbands.



Figure 5.10.2-1 Initial condition

In this figure, it is assumed that

- Subscription:

- UE A1 and A4 have subscription to slice M, and this slice M is optimized e.g. for IoT type of application.

- UE A2 and A4 have subscription to slice N, and this slice N is optimized e.g. for eMBB type of application.

- UE A3 has subscription to slice O, and this slice O is optimized e.g. for URLLC. The users or application providers request isolation of radio resources used for this network slice.

- Deployment:

- The cell is configured to use frequency band which is from F1 to F2.

- The frequency band is sub-divided into three subbands. The allocated frequency for the first subband spans from F1 to Fa. The allocated frequency for the second subband spans from Fa to Fb. The allocated frequency for the third subband spans from Fb to F2.

- The first subband is used for slice O. The second subband is used for slice N. The third subband is used for slice M. in addition, third subband can be used for common procedure, e.g. SIB.

### 5.10.3 Service Flows

Following is service flow for UE A1, A2, A3 and A4:

- After power-on, UE A1, A2, A3 and A4 camp on a cell, where the subscribed slices can be provided. Because the UEs are accessing the same cell supporting at least one of the subscribed network slices, there is no need for the UEs to move to other cells.

- When applications start, UE A1 transmits and receives data over Slice M, which is restricted to subband 3.

- When applications start, UE A2 transmits and receives data over Slice N, which is restricted to subband 2.

- When applications start, UE A3 transmits and receives data over Slice O, which is restricted to subband 1.

- When applications start, UE A4 transmits and receives data. For traffic configured to use Slice M, the transmission and reception is performed using radio resources within subband 3. For traffic configured to use Slice N, the transmission and reception is performed within radio resources within subband 2. Due to isolation requirement or service agreement for the network slice, traffic for Slice M is not transported over subband 2. Similarly, traffic for Slice N is not transported over subband 3.

- As demands for the network slice changes according to the number of UEs for the network slice or time of the day, the network adjusts the allowed frequency range of each network slice. There is no recognized impact to the user experience.

### 5.10.4 Post-conditions

Following figure 5.10.4-1 shows the status at the end of service flow.

For the transport of user traffic, each UE may use different part of frequencies of the cells, which corresponds to the configured frequency range for each network slice.



Figure 5.10.4-1 End result

### 5.10.5 Existing features partly or fully covering the use case functionality

Following service requirements are already supported by current specifications:

*- 3GPP system shall provide means to support flexibility in configuring the allowed or restricted radio resources for a network slice.*

*- 3GPP system shall support for a network slice to use specific portion of the radio resources (e.g. frequency range) within a cell.*

*- 3GPP system shall be able to allow or disallow user traffic for a network slice to be multiplex with the user traffic for other network slice, based on the security and isolation requirement of the network slice.*

BWP (Bandwidth Part) operation defined in TS38.300 [4] does not provide a UE with the support for providing different network slices on different frequency bands, when the UE is authorized to use multiple network slices.

### 5.10.6 Potential New Requirements needed to support the use case

Following new requirements can be derived from this use case:

[PR.5.10.6-1] 5G system shall be able to minimize service interruption when configured radio resource (e.g. frequency range) for a network slice changes.

## 5.11. Interaction with Third party for network slice

### 5.11.1 Description

A network slice can be provided and customized based on the request of customers. For example, an application provider may want a dedicated network slice for its application and may expand or decrease the capacity of the network slices based on the dynamic demand for the application.

In other scenario, the third party itself may get and have right to use a specific frequency band. For example, by applying for local spectrum license, third party itself may own the right to use some frequency band and this frequency band can be used for a network slice and UEs dedicated to this third party.

### 5.11.2 Pre-conditions

Application provider AP1 has a service agreement with operator OP1. With this service agreement, OP1 creates and runs a network slice NSz, which is dedicated for AP1. AP1 provides application App1 to its customers and this application requires very demanding QoS. Traffic generated for the application App1 are transported via NSz. Initially, frequency band FB1 with size of 50 MHz are allocated for NSz.

There is another application provider AP2, which also has a service agreement with operator OP1. With this service agreement, OP1 creates and runs a network slice NSy, which is dedicated for AP2. AP2 provides application App2 to its customers and the QoS requirement for this application is not stringent. Thus, instead of using a licensed spectrum, application provider AP2 requests the OP1 to provide network slice NSy over unlicensed spectrum, which is frequency band UFB1.

### 5.11.3 Service Flows

Following is service flow for application provider AP1:

- UEs using App1 transmit data over frequency band FB1.

- As the App1 gets popular, the application provider decides to increase capacity for the network slice NSz. The application provider requests the operator OP1 to increase the dedicated frequency bandwidth.

- The OP1 adjusts its 3GPP system so that additional frequency band is dedicated to support the network slice NSz.

- Later, the application provider identifies that there is a periodicity in the usage pattern for its application. I.e., some specific time period during the day, there is a small demand for its application. So, the application provider requests to reduce the allocated frequency bandwidth for network slice NSz for a specific time period.

- The OP1 takes into account the information from the application provider, and reduce the size of dedicated frequency during the time period.

- Later, the application provider itself gets a right to use some specific frequency band FB2 at a certain location from authorities.

- The application provider requests the OP1 to additionally use FB2 for network slice NSz. OP1 updates configuration for network slice NSz. From this point, OP1 keeps record usage of network slices per used frequency bands.

Following is service flow for application provider AP2:

- Application provider requests OP1 to create network slice NSy using unlicensed frequency band UFB1.

- When there is a user traffic for App2, the traffic is delivered over frequency band UFB1.

- For a UE subscribes to both App1 and App2, traffic for app2 is delivered through NSy over UFB1 while traffic for app1 is delivered over other frequency bands.

### 5.11.4 Post-conditions

The UEs using App1 are served with NSz over FB2.

The UEs using App2 are served with NSy over UFB1.

### 5.11.5 Existing features partly or fully covering the use case functionality

Following are existing requirements specified in TS 22.261 [2]:

*- Based on operator policy, a 5G network shall provide suitable APIs to allow a trusted third-party to manage this trusted third-party owned application(s) in the operator's Service Hosting Environment.*

*- Based on operator policy, the 5G network shall provide suitable APIs to allow a trusted third-party to scale a network slice used for the third-party, i.e. to adapt its capacity.*

*- The 5G network shall provide suitable APIs to allow a trusted third-party to get the network status information of a private slice dedicated for the ' party, e.g. the network communication status between the slice and a specific UE.*

*- Based on operator policy, the 5G network shall provide suitable APIs to allow a trusted third-party to define and update the set of services and capabilities supported in a network slice used for the third-party.*

*- Based on operator policy, the 5G network shall expose a suitable API to allow an authorized third-party to define and reconfigure the properties of the communication services offered to the third-party.*

*- Based on operator policy, a 5G network shall provide suitable APIs to allow a trusted third-party to create, modify, and delete network slices used for the third-party.*

*- Based on operator policy, the 5G network shall provide suitable APIs to allow a trusted third-party to define and update the set of services and capabilities supported in a network slice used for the third-party.*

*Based on operator policy, the 5G network shall provide suitable APIs to allow a trusted third-party to configure the information which associates a UE to a network slice used for the third-party.*

*- Based on operator policy, the 5G network shall expose a suitable API to an authorized third-party to provide the information regarding the availability status of a geographic location that is associated with that third-party.*

*- Based on operator policy, the 5G network shall provide suitable APIs to allow a trusted third-party to configure the information which associates a service to a network slice used for the third-party.*

These existing requirements allow interaction between the third party and the 5G system. However, these requirements do not fully address the service flow in previous section:

*-* Existing requirements focused on the capability of the network slice, and not on the details of configuration, e.g. using specific resources owned by third party.

- Existing requirements do not address restriction that can be set by third party, in using network slice.

### 5.11.6 Potential New Requirements needed to support the use case

Following new potential requirements can be derived from this use case:

[PR.5.11.6-1] In case a third party has requested provision of a network slice using specific radio resources for the network slice, 5G system shall be able to generate charging information regarding the used radio resources e.g. used frequency bands.

## 5.12. Broadcast for network slice

### 5.12.1 Description

For a flexible and dynamic management, a network slice used for broadcast services can be provided over a dedicated frequency band. For example, in a specific frequency band or in a specific region, only sessions for broadcast can be allowed while all other unicast sessions are not allowed. This may trigger various deployment scenarios where third parties such as broadcasters may create their own network slices and the mobile operator packs these network slices into a specific dedicated frequency band.

Typically, for broadcast service, all or most traffic flows in downlink direction only. This characteristic may fit well to some frequency spectrum allocation and can increase utilization ratio of frequency spectrum.

### 5.12.2 Pre-conditions

An operator OPM owns a bunch of spectrum. One of the spectrum is FB1, and this is an unpaired spectrum, e.g. downlink only spectrum. The other spectrum is FB2 and this spectrum supports both downlink and uplink.

OPM decides to dedicate spectrum FB1 for broadcast service slices. Because, services over broadcast service slices are broadcast/multicast service which does not generates UL traffic. For example, TV service is best suited for this broadcast service slice.

The operator OPM also provides network slices for unicast traffic services, and this network slices are configured to use frequency band FB2, because FB2 is a paired spectrum which supports both UL traffic and DL traffic.

With OPM, a UEa has a subscription for the broadcast service slice, and also for a unicast traffic service slice. This UEa does not support simultaneous operation over FB1 and FB2 due to capability limitation. Thus, while the UE engaged in the broadcast service slice, the QoS over a unicast service slice may degrade or may stop.

### 5.12.3 Service Flows

Following is service flow for this use case:

- User of UEa starts browsing internet contents. The internet traffic for the browsing is transported over unicast network slices, which is configured to use FB2.

- The user discovers that a famous TV show is ongoing and he/she has a subscription for that. The user launches a TV application, which uses broadcast service slice. Now, the user does not use browsing application anymore because the user now watches TV service.

- Because the broadcast service slice is provided over FB1, the UEa tunes to that frequency band.

- The UEa starts to receive traffic for TV show via the broadcast service slice.

- While the user is watching the TV show delivered over broadcast service slice, an incoming call is notified. From the phone number information, the user identifies it as a Robocall and decides not to take the call. In this step, i.e., while the UEa is engaged in the notification procedure of incoming call, the quality of experience of broadcast service slice is not degraded. I.e., there is no noticeable interruption of TV show.

- Later, a friend of the user makes a phone call to the user. An incoming call is notified to the user who is in the middle of watching a TV program.

- Once the user decides to take the phone call, the UEa may suspend TV application. I.e, the use of broadcast slice is suspended.

### 5.12.4 Post-conditions

The user ends TV reception and starts voice call with his/her friend.

### 5.12.5 Existing features partly or fully covering the use case functionality

Following are existing requirements specified in TS 22.261 [2]:

*- The 5G system shall enable a UE to be simultaneously assigned to and access services from more than one network slice of one operator.*

*- Traffic and services in one network slice shall have no impact on traffic and services in other network slices in the same network.*

These existing requirements specify the case where the UE access simultaneous access multiple network slices. However, the assumption here is that the UE can support multiple frequency spectrum simultaneously. If the UE cannot support multiple frequency bands and if each frequency band supports different network slices, the UE cannot simultaneously use network slices on different frequencies. For this UE, the UE can use multiple network slices only when the network slices are on the same frequencies.

In the service flow in the previous section, the UE has limited capability so that the UE cannot support simultaneous reception/transmission on multiple frequency bands. And, this has not been addressed by existing service requirements.

The ability for a 3rd party to configure a network slice is already supported in TS 22.261 [2], including configuring the direction (e.g., uplink only, downlink only, both) of supported traffic.

Similarly, requirements to avoid interference between network slices are already included in TS 22.261 [2].

*- Traffic and services in one network slice shall have no impact on traffic and services in other network slices in the same network.*

### 5.12.6 Potential New Requirements needed to support the use case

N/A

## 5.13. Relaying and backhauling data for a network slice

### 5.13.1 Description

Relay nodes can be used to provide extended coverage for a UE located in area where radio signal from radio access network is weak. Also, relay nodes can be used to reduce power consumption of UEs. When a user traffic generated by a UE is relayed by relay nodes, the radio resources used between the relay nodes and gNB can be different from the radio resource used between the relay nodes and the UEs.

In most cases the relay node is more capable than the UE. E.g., it can support more different frequency ranges or support simultaneous use of different frequency bands.

### 5.13.2 Pre-conditions

Figure 5.13.2-1 shows the use case scenario where there are two possible frequency bands between the UEs, the intermediate nodes and gNBs.



Figure 5.13.2-1 Initial condition

In this figure, it is assumed that

- UEs and intermediate nodes:

- UE A1 and A2 have subscription to slice N.

- R1 and R2 are intermediate nodes. These intermediate nodes can be IAB-nodes. Both are authorized to relay traffic for any network slice.

- Intermediate node R1 is configured to use F2 toward UEs, while intermediate node R2 is configured to use F1 toward UEs. The link between the intermediate node R1/R2 and NG-RAN can use either F1 or F2 or both.

- UE A1 is within coverage of R1 and UE A2 is within coverage of R2.

- Deployment:

- Slice N is configured to use Frequency F2.

- Slice M is configured to use Frequency F1.

### 5.13.3 Service Flows

Following is service flow for this use case:

- The UE A1 and A2 are out of coverage. After power-on, these UEs start search for potential intermediate nodes.

- Intermediate nodes R1 and R2 are operational. R1 provides connectivity service to UEs via F2 and R2 provides connectivity service to UEs on F1. Both are connected to gNB.

- The UE A1 detects intermediate node R1 on frequency F2, and establishes connection toward R1. Because the network slice N is configured to use F2, the UE A1 transmits and receives user traffic of network slice N to/from the intermediate node R1 over frequency band F2. Because the link between R1 and NG-RAN is backhauling link, the user traffic for the UE A1 for the network slice N can be transported either F1 or F2 over the link between intermediate node R1 and gNB.

- The UE A2 detects intermediate node R2 on frequency F1, and establishes connection toward R2. Because the network slice N is configured to use F2, the UE A2 does not transmit and receive user traffic of network slice N to/from the intermediate node R2.

### 5.13.4 Post-conditions

UE A1 is provided with network service for the network slice N.

UE A2 is not provided with network service for the network slice N.

### 5.13.5 Existing features partly or fully covering the use case functionality

Following are existing requirements specified in TS 22.261 [2]:

*- The 3GPP system shall support selection and reselection of relay UEs based on a combination of different criteria e.g.*

- *the capabilities/capacity/coverage when using the relay UE,*

*- the QoS that is achievable by selecting the relay UE,*

*- the power consumption required by relay UE and remote UE,*

*- the pre-paired relay UE,*

*- the 3GPP or non-3GPP access the relay UE uses to connect to the network,*

*- the 3GPP network the relay UE connects to (either directly or indirectly),*

*- the overall optimization of the power consumption/performance of the 3GPP system, or*

*- battery capabilities and battery lifetime of the relay UE and the remote UE.*

The existing requirement talks about the criterion that is used by a remote UE for relay selection. However, it does not describe the radio resource usage restriction or configuration. Thought the service flow in the previous section discusses some aspect of relay selection, the focus is the radio resource restriction that can be put in place when relay functionality is used. The existing requirements do not clarify whether restriction on frequency resource for a network slice also applies in case the relay is used.

### 5.13.6 Potential New Requirements needed to support the use case

Following new requirements can be derived from this use case:

[PR.5.13.6-1] For traffic pertaining to a network slice offered via a relay node, 5G system shall use only radio resources (e.g. frequency band) allowed for the network slice.

NOTE: Allowed radio resources (e.g., frequency band) may be different for direct network connections (between UE and NG-RAN) than for backhaul connections (between the relay node and the NG-RAN).

# 6 Consolidated Potential Requirements

Following are consolidated potential requirements.

n of the VPLMNs the UE is authorised to register to in order to use specific network slices.

Table 6-1. Consolidated Potential Requirements

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR-001 | For a UE authorized to access multiple network slices of one operator which cannot be simultaneously used by the UE (e.g. due to radio frequency restrictions), the 5G system shall be able to support the UE to access the most suitable network slice in minimum time (e.g. based on the location of the UE, ongoing applications, UE capability, frequency configured for the network slice). | [PR.5.3.6-1] |  |
| CPR-002 | For a UE authorized to access to multiple network slices of one operator which cannot be simultaneously used by the UE (e.g. due to radio frequency restrictions), the 5G system shall minimize service interruption time when the UE changes the access from one network slice to another network slice. (e.g. based on changes of active applications). | [PR.5.3.6-2] |  |
| CPR-003 | 5G system shall minimize signaling exchange and service interruption time for a network slice, e.g. when restrictions related to radio resources change (e.g., frequencies, RATs). | [PR.5.4.6-1] |  |
| CPR-004 | For a roaming UE activating a service/application requiring a network slice not offered by the serving network but available in the area from other network(s), the HPLMN shall be able to provide the UE with prioritization information of the VPLMNs with which the UE may register for the network slice. | [PR.5.5.6-1] |  |
| CPR-005 | The 5G system shall be able to generate charging information regarding the used radio resources e.g. used frequency bands. | [PR.5.11.6-1] |  |
| CPR-006 | The 5G system shall be able to minimize power consumption of a UE (e.g. reduce unnecessary cell measurements), in an area where no authorized network slice is available. | [PR.5.1.6-1] |  |
| CPR-007 | When a UE moves out of the service area of a network slice for an active application, the 5G system shall be able to minimize impact on the active applications (e.g., providing early notification).  NOTE 1: Various methods can be used to detect whether the UE moves toward the border area and to notify the UE. | [PR.5.2.6-1] |  |
| CPR-008 | The 5G system shall support a mechanism for a UE to select and access network slice(s) based on UE capability, ongoing application, radio resources assigned to the slice, and policy (e.g., application preference). | [PR.5.8.6-1] |  |
| CPR-009 | The 5G system shall support a mechanism to optimize resources of network slices (e.g., due to operator deploying different frequency to offer different network slices) based on network slice usage patterns and policy (e.g., application preference) of a UE or group of UEs. | [PR.5.8.6-2] |  |
| CPR-010 | For traffic pertaining to a network slice offered via a relay node, 5G system shall use only radio resources (e.g. frequency band) allowed for the network slice.  NOTE 2: Allowed radio resources (e.g., frequency band) may be different for direct network connections (between UE and NG-RAN) than for backhaul connections (between the relay node and the NG-RAN). | [PR.5.13.6-1] |  |
| CPR-011 | For UEs that have the ability to obtain service from more than one VPLMN simultaneously, the following requirements apply:  - When a roaming UE with a single PLMN subscription requires simultaneous access to multiple network slices and the network slices are not available in a single VPLMN, the 5G system shall enable the UE to:  - be registered to more than one VPLMN simultaneously; and  - use network slices from more than one VPLMN simultaneously  - The HPLMN shall be able to authorise a roaming UE with a single PLMN subscription to be registered to more than one VPLMN simultaneously in order to access network slices of those VPLMNs.  - The HPLMN shall be able to provide a UE with permission and prioritisation information of the VPLMNs the UE is authorised to register to in order to use specific network slices.  NOTE 3: The above requirements assume certain UE capabilities, e.g. the ability to be connected to more than one PLMN simultaneously. | [PR.5.6.6-1] |  |

# 7 Conclusions and Recommendations

This document analyses a number of use cases to enhance the support of network slice. The resulting potential requirements have been consolidated in clause 6.

It is recommended that the consolidated potential requirements identified in this TR are considered as the basis of normative requirements in order to better serve the communication services.

Annex A:  
Consideration for different type of frequency

Frequency band defined in 3GPP can be classified into FDD frequency and TDD frequency as shown in Table 5.2-1 of TS 38.101-1 [5] and TS38.101-2 [6]. In case of TDD system, the same frequency is used for both UL and DL. However, in case of FDD system, UL frequency is different from DL frequency. Thus, when radio resource restriction scenario is discussed, care should be taken by considering these variations e.g. frequency used for both DL/ UL, UL only or DL only.

In addition, 5G system introduces further flexibility in using frequency band. For example, SUL (Supplementary UL) and SDL (Supplementary DL) are frequency band either defined only in DL or only in UL, as described in annex B of TS 38.300 [4]. This spectrum is used to assist other frequency band, e.g. when base frequency band lacks coverage in either DL or UL, then SUL or SDL can be used to replace the base frequency band. If the SUL and/or SDL band is restricted for a certain network slice, some UEs may experience reduced coverage for the network slice.

Aspects related to carrier aggregation also needs to be considered similarly, because it is used to support QoS requirement by using different combination of DL bands and UL bands, e.g. using three DL bands together with one UL bands to boost downlink data rate. If allowed network slices differs for different frequency bands, then operation of CA also needs to take this into account for a network slice.

DSS (Dynamic Spectrum Sharing) allows use of same frequency band for both NR and E-UTRA, to cater for various deployment scenario of operators. Thus, same frequency band is split in time to support both E-UTRA and NR. Thus, when there is active restriction for a RAT in using a frequency, consideration should be given in which case it is restricted and any potential impact on quality of service.

Annex B:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2020-08 | SA1#91e | S1-203025 |  |  |  | TR Skeleton | 0.0.0 |
| 2020-09 | SA1#91e | S1-203280  S1-203408  S1-203321  S1-203322  S1-203323  S1-203410  S1-203326  S1-203409 |  |  |  | Incorporating agreed use cases and scope | 0.1.0 |
| 2020-11 | SA1#92e | S1-204409  S1-204410  S1-204310  S1-204311  S1-204312  S1-204411  S1-204088  S1-204313  S1-204314  S1-204412  S1-204018  S1-204316  S1-204317  S1-204318  S1-204315 |  |  |  | Incorporating agreed use cases | 0.2.0 |
| 2021-02 | SA1#93e | S1-210417  S1-210416  S1-210418  S1-210027  S1-210419  S1-210420  S1-210421  S1-210422  S1-210423  S1-210424  S1-210425  S1-210053 |  |  |  | Incorporating agreements of SA1#93e | 0.3.0 |
| 2021-03 | SA#91e | SP-210203 |  |  |  | Presented for one-step approval to SA.  MCC clean-up | 1.0.0 |
| 2021-03 | SA#91e | SP-210203 |  |  |  | Raised to v.18.0.0 following SA one-step approval | 18.0.0 |
| 2021-06 | SA#92e | SP-210508 | 0002 |  | F | Clarification on charging requirement | 18.1.0 |
| 2021-06 | SA#92e | SP-210508 | 0001 | 1 | B | on Resolution of Editor’s NOTE and consolidation of remaining requirements | 18.1.0 |
| 2021-06 | SA#92e | SP-210508 | 0003 | 1 | C | Clarification for simultaneous access to multiple slices on different PLMNs | 18.1.0 |
| 2021-06 | SA#92e | SP-210508 | 0004 | 1 | B | Update to the requirements of application-based preference | 18.1.0 |
| 2021-12 | SP-94 | SP-211496 | 0005 |  | D | EASNS CPR mapping to PR(s) | 18.2.0 |