**3GPP TSG-RAN WG2 Meeting #115 e R2-21xxxxx**

**E-Meeting, August 09th - 27th  2021**

**Source: Lenovo, Motorola Mobility**

**Title:****Comparison of Solution Options**

**Document for:** **Discussion and Decision**

# **Introduction**

RAN2 has initiated the following long email discussion.

* [Post114-e][251][Slicing] Solution direction details for slice priorities in cell reselection (Lenovo)

      Scope: Discuss technical details for solution directions identified as part of [AT114-e][250] and identify their pros and cons. Can ask questions on how the solutions work, can discuss combined solutions etc.

      Intended outcome: Discussion report (may include also draft CRs if there is enough convergence)

      Deadline:  Long

Following are the agreements from the RAN2#114e:

|  |
| --- |
| * 1: Frequency priority mapping for each slice (slice -> frequency(ies) -> absolute priority of each of the frequency) is provided to a UE.   Note: Signaling optimizations are not excluded.  Note: "slice may also mean "slice group"   * 1b: Frequency priority mapping for each of the slice (slice -> frequency(ies) -> absolute priority of each of the frequency) is part of the “slice info” agreed to be provided to the UE using both broadcast and dedicated signaling. * 2: RAN2 kindly allow one more meeting cycle for understanding the necessity of Slice priority along with the following shortlisted solution directions for Idle mode mobility:   a) Option 4): Slice priority first looping over slice-frequency combination  b) Option 5): Maximize slice support  c) Option 6): Frequency priority of highest priority slice with adjustment based on actually supported slice(s) in best ranked cell, without multiple iterations of cell reselection  d) Option 7): Perform legacy cell reselection mechanism based on slice specific frequency priority   * 3: RAN2 consider a scenario in its work for slice specific cell (re)selection where it is possible that (Suitable) cells on the same frequency belonging to different TAs support different Slice(s). * 4: Working assumption: The Best cell principle according to absolute priority reselection criteria specified in clause 5.2.4.5 of TS38.304 needs to be met also for slice specific cell (re)selection. * 6: In addition to proposal 2, following aspects are FFS:   a) Content of “Slice Info” – to what extent the information needs to be and should be provided to support the Principle in proposal 5  b) If used, who provides the “Slice priority” (NAS/ AS, UE/ Network)  c) Can RAN2 continue to use “intended” slice for initial registration and idle-mode mobility  d) How UE in each of the solutions from proposal 2 uses slice info for cell reselection if both slice info and existing cell reselection priority is signaled (in the SIB and/ or dedicated signaling) |

This email discussion will be carried in 3 phases; currently we are in the second phase:

Phase 1: Development of Solution directions to one well defined solution

Phase 2: Comparison among solutions out of Phase 1 and selecting the most reasonable one

Phase 3: Coming up with an acceptable draft CR for the selected solution if time and situation permits – depending on the outcome of Phase 2.

# **Solution Options**

# **Option 4**

## How does it work?

The UE Idle mode behavior for slice priorities can be described in following sequence of operation:

**Step 1**: List Slices in the priority order starting with highest priority slice.

**Step 2**: Select the first (or next if from Step 7) slice in the list

**Step 3**: Assign the priorities to frequencies according to the priorities provided to the selected slice

**Step 4**: Perform cell search according to the legacy procedure using the priorities assigned in step 3

**Step 5**: If the highest ranked cell is suitable (as defined in 38.304) and supports the selected slice in step 2 then camp on the cell and exit this sequence of operation; FFS: How the UE determines whether the highest ranked cell supports the selected slice.

**Step 6**: If there are remaining cell frequencies then go back to step 3

**Step 7**: **FFS:** If the end of the slice list has not been reached go back to step 2

**Step 8**: Perform legacy cell reselection (using non-slice-based priorities i.e. for frequencies not corresponding to any slice support)

## What is the content of “Slice Info” when provided using Broadcast and dedicated signaling?

In a tabular form the Slice Info looks like:

|  |  |  |
| --- | --- | --- |
| SliceInfo-List | | |
| Slice Id-1/ Slice-Group Id-1 | Supported-on-Freq-x | Freq-x-priority |
| Supported-on-Freq-y | Freq-y-priority |
| Slice Id-2/ Slice-Group Id-2 | Supported-on-Freq-x | Freq-x-priority |
|  | Supported-on-Freq-z | Freq-z-priority |
| … | … | … |

## Who provides the “Slice priority” (NAS/ AS, UE/ Network)

AS receives the Slice Priority from NAS and how NAS receives it is left for SA2/ CT1 to solve.

## Can “intended” slice as defined in TR38.832 be used “as is” for in this Solution?

Yes. The content of “intended slice” i.e. which slice is signalled by NAS as part of “intended slice” is left to NAS. For mobility related reselections, the AS uses the “intended slice(s)” last received from NAS.

# **Option 5**

## How does it work?

In general, Option 5 can work for the case when the supported slice info include the supported slice for frequencies but not include the slice specific reselection priority.

When only the supported slice list for frequencies is provided as “slice info” to the UE, the Idle mode UE shall apply the following rules for slice based cell reselection.

**Step (1):** The UE will consider the frequency priority in cell reselection based on the number of supported slices among UE’s intended slices (i.e. allowed S-NSSAIs). That is, the frequency that supports the maximum number of slices among UE’s intended slices has the highest priority in cell reselection. The frequency that supports the second most slices among UE’s intended slices has the second highest priority in cell reselection, and so on.

**Step (2):** If more than one frequency supports the same number of slices among UE’s intended slices, the UE can treat them with equal priority, or further consider the existing absolute cell reselection frequency priority if provided.

**Step (3):** The UE performs the legacy cell reselection (specified in TS 38.304) following the priority assigned based on the above rules.

When additional “slice info” such as slice specific frequency priority or slice priority is provided, how to use them to determine the slice based cell reselection frequency priority is FFS, e.g. use them before step (1), in step (1) or in step (2).

## What is the content of “Slice Info” when provided using Broadcast and dedicated signaling?

For Option 5, the content of “Slice Info” shall include the supported slice list for frequencies.

In a tabular form the Slice Info looks like:

|  |  |
| --- | --- |
| Slice info | |
| For the serving frequency | |
|  | Slice id-1/Slice Group Id-1 |
| Slice id-2/Slice Group Id-2 |
| .... |
| For inter-frequency | |
| Frequency 1 | Slice id-1/Slice Group Id-1 |
| Slice id-2/Slice Group Id-2 |
| ... |
| Frequency 2 | Slice id-1/Slice Group Id-1 |
| Slice id-2/Slice Group Id-2 |
| ... |
| ... | |

Other “Slice Info”, such as slice specific frequency priority (per slice per frequency), or slice priorities of UE’s intended slices are needed or not is FFS.

## Who provides the “Slice priority” (NAS/ AS, UE/ Network)

For Option5, whether Slice priority is used or not may need further discussion.

## Can “intended” slice as defined in TR38.832 be used “as is” for in this Solution?

Yes. For Option 5, UE’s intended slices equal to the allowed S-NSSAIs.

# **Option 6**

## How does it work?

Option 6 can be regarded as one enhanced solution on top of Option 4 if slice availability info on neighbor cells are provided to UE. Compared with Option 4, it has below 2 differences:

1. Adjust frequency priority based on actually supported slice(s) in best ranked cell, to avoid wrongly setting a too high frequency priority corresponding to unsupported slice.
   * In Option 4, if highest ranked cell is suitable but doesn’t support the UE’s intended highest priority slice, the frequency is excluded.
2. There is no need for UE to perform multiple iterations of cell reselection (i.e. remove Option 4’s Step 7 which is labelled as FFS)

Please note that when slice availability info on neighbour cells are absent, Option 6 fallbacks to Option 4 (removing slice iteration in Step 7). The detailed procedure is illustrated in Section 2.3.1.1 and an example can be found in Section 2.3.1.2.

In addition, Option 6 is not exclusive-mutual with other Options. It can work with Option 4 and Option 5 together. Its relationship with Option 4 and Option 5 is provided in Section 2.3.1.3.

*2.3.1.1 Procedure step*

Based on companies’ input, the “slice info” are:

* **From SIB/RRC release**: A list of {Slice group ID, list of [frequency, frequency priority value (Optional), slice availability (Optional)]}
  + “slice availability” is a list of neighbor cell PCI(s) which support the slice group.
  + An example is illustrated in Table 2.3.1

|  |  |  |  |
| --- | --- | --- | --- |
| SliceInfo-List | | | |
| Slice-Group Id-1 | Supported-on-Freq-x | Freq-x-priority (Optional) | PCI 1, PCI2, ... (Optional) |
| Supported-on-Freq-y | Freq-y-priority (Optional) | PCI 3, PCI4, ... (Optional) |
| Slice-Group Id-2 | Supported-on-Freq-x | Freq-x-priority (Optional) | PCI 5, PCI6, ... (Optional) |
|  | Supported-on-Freq-z | Freq-z-priority (Optional) | PCI 7, PCI8, ... (Optional) |
| … | … | … |  |

**Table.2.3.1: An example of “slice info” in SIB/RRC release**

* **From NAS**: Slice priority
  + Whether to introduce NAS signaling is left for SA2/ CT1 to solve. If SA2/CT1 don’t agree to introduce new NAS signaling, it is up to UE implementation.

Option 6 works when both per-slice frequency priority and slice availability are present in SIB/RRCRelease. The procedure step can be described in following sequence of operation **on top of option 4** with different steps highlighted (i.e. add Step 5-a/5-b, remove Step 7):

**Step 1**: List Slices in the priority order starting with highest priority slice.

**Step 2**: Select the first slice in the list

**Step 3**: Assign the priorities to frequencies according to the priorities provided to the selected slice

**Step 4**: Perform cell search according to the legacy procedure using the priorities assigned in step 3

**Step 5**: If the highest ranked cell is suitable (as defined in 38.304) and supports the selected slice in step 2 then camp on the cell and exit this sequence of operation.

**Step 5-a**: Else if the highest ranked cell is suitable (as defined in 38.304) but **doesn’t support** the selected slice in step 2, then the priority value of this frequency is changed to the priority value of the highest priority slice supported by both UE and the highest ranked cell (i.e. intersection slice set).

**Step 5-b**: With updated frequency priority, if legacy inter-frequency cell reselection criteria (as illustrated below) is met, camp on the cell and exit this sequence of operation.

* If priority of target frequency is **higher than** serving frequency, Srxlev > ThreshX, HighP during a time interval
* If priority of target frequency is **lower than** serving frequency, Srxlev < ThreshServing, LowP and Srxlev > ThreshX, LowP during a time interval

**Step 6**: If there are remaining cell frequencies then go back to step 3

**~~Step 7~~**~~:~~ **~~FFS:~~** ~~If the end of the slice list has not been reached go back to step 2~~

**Step 8**: Perform legacy cell reselection (using non-slice-based priorities i.e. for frequencies not corresponding to any slice support)

*2.3.1.2 Example*

One example is illustrated in Figure2.3.1.



**Figure.2.3.1 Example scenario**

Then, the UE performs below cell reselection procedure:

UE is provided below “slice info”:

* Cell 3’s SIB provides:
  + List 1: {eMBB, F1, priority 2, (Cell 1, Cell2}}
  + List 2: {eMBB, F2, priority 3, (Cell3)}
  + List 3: {URLLC, F1, priority 8, (Cell 1)}
  + List 4: {URLLC, F2, priority 7, (Cell 3)}
* UE’s slice priority: URLLC > eMBB (from NAS)
* Step 1: List slice in priority order: {URLLC, eMBB}
* Step 2: Select 1st slice (i.e. URLLC)
* Step 3: The UE derives frequency priority value of F1 is 8 and F2 is 7 (i.e. priority of F1 is taken from List 3 and priority of F2 is taken List 4)
* Step 4: Assuming priority of F1 is 8, the UE performs IDLE measurements for cell 1 and cell 2
* Step 5: Both Cell 1 and 2 are suitable. Cell 2 is best ranked cell due to it being close to UE (-82dBm>-92dBm).
* Step 5-a: Because only eMBB is supported in Cell 2, UE decreases priority value of F1 from 8 to 2 (value 2 is from List 1 for eMBB).
* Step 5-b: Because priority value of F1 (value 2) is lower than serving frequency F1 (value 7), the UE checks whether condition of reselection to Cell 2 is fulfilled, i.e. whether cell 3 fulfils Srxlev < ThreshServing, LowP and cell 2 fulfils Srxlev > ThreshX, LowP. The condition is not satisfied because RSRP of serving cell (cell 3) is larger than ThreshServing, LowP. Thus, the UE stay in Cell 3.
  + Please Note if without priority adjustment for F1 in Step 5-a, the UE will regard priority value of F1 is 8 (higher than serving frequency). Then, the UE just need to check whether Srxlev > ThreshX, HighP, the condition of reselection to Cell 2 is fulfilled. So, the UE will reselect to Cell 2 supporting only eMBB, which is not intended behavior.
* Step 6 and 8 are skipped because no remaining frequencies are left

*2.3.1.3 Relationship with Option4 and Option 5*

Option 6 is not exclusive-mutual with other Options:

* It can be regarded as one enhanced solution on top of Option 4 if slice availability info on neighbor cells are provided to UE (besides per-slice frequency priority required by Option 4).
* When slice availability info is absent but per-slice frequency priority is present, it fallbacks to Option 4 (removing slice iteration in Step 7).
* When per-slice frequency priority is absent, the UE performs Option 5 with the assumption that all slices are same priority.

It is illustrated in Table 2.3.2:

|  |  |  |
| --- | --- | --- |
| Slice availability of neighbor cell  Per-slice frequency priority | Absent | Present |
| Absent | Option 5 | Option 5 |
| Present | Option 4 removing slice iteration Step 7 | Option 6 (i.e. Option 4 + Step 5-a/5-b) |

**Table.2.3.2: Relationship of Option 6 with Option 4/5**

## What is the content of “Slice Info” when provided using Broadcast and dedicated signaling?

In a tabular form the Slice Info looks like:

|  |  |  |  |
| --- | --- | --- | --- |
| SliceInfo-List | | | |
| Slice-Group Id-1 | Supported-on-Freq-x | Freq-x-priority (Optional) | PCI 1, PCI2, ... (Optional) |
| Supported-on-Freq-y | Freq-y-priority (Optional) | PCI 3, PCI4, ... (Optional) |
| Slice-Group Id-2 | Supported-on-Freq-x | Freq-x-priority (Optional) | PCI 5, PCI6, ... (Optional) |
|  | Supported-on-Freq-z | Freq-z-priority (Optional) | PCI 7, PCI8, ... (Optional) |
| … | … | … |  |

* Option 6 is applied when both per-slice frequency priority and Slice availability on neighbor cell are present.
* When slice availability info is absent but per-slice frequency priority is present, it fallbacks to Option 4 (removing slice iteration in Step 7).
* When per-slice frequency priority is absent, the UE performs Option 5 with the assumption that all slices are same priority.

## Who provides the “Slice priority” (NAS/ AS, UE/ Network)

UE’s AS receives the Slice Priority from NAS. Whether to introduce NAS signaling is left for SA2/ CT1 to solve. If SA2/CT1 don’t agree to introduce new NAS signaling for slice priority, it is up to UE implementation.

## Can “intended” slice as defined in TR38.832 be used “as is” for in this Solution?

Yes, “intended slice” is signaled by NAS. The signaling details can be discussed further (e.g. left to SA2/CT1 to decide).

# **Option 7**

## How does it work?

### 2.4.1.1 Example deployment scenario for discussion

While homogeneous deployments provide all the allowed slices in all of the cells of a TA, there may be other carriers in another TA in the same geographical region that might offer a slice in the UEs configured list that is not in the allowed slices (i.e. Allowed NSSAI). Take for example, the following Figure 1. Cells 1 offer slice 2 while cells A, B, 2 in the same geographical region does not offer slice 2. Such a deployment can be supported by using different TAs for the cell 1 and cell 2.



Figure 1: Example homogeneous deployments with different slice availability in different carriers of a geographical region

In our view, this example scenario covers all the scenarios (i.e. Geo-1 to 5) described in the Annex. Further, we think this is a valid scenario that corresponds to geographical area 1 and 2 of Figure 5.1.1-1 in TR38.832 when mapped to homogeneous deployments within a TA and should be supported.

### 2.4.1.2 High level description of the solution

Here we provide a high-level summary description of the solution. Details are provided in subsequent sections.

In existing priority based inter-frequency cell reselection, the frequency priority for each frequency is either based on the dedicated priority configuration that the UE receives during RRC release or the cell reselection priority for each frequency in the SIB4.

The key aspect of solution direction option 7 is that the same legacy cell reselection priority mechanism is used. Instead of the broadcast absolute frequency priority, the priority for a frequency is derived from the broadcast slice information and UEs configured slices.

The actual algorithm used for frequency priority determination is dependent on the main objective of slice based cell reselection. For homogeneous deployments, all the cells of a RA support the same slices. Hence prioritisation based on slice availability within an RA is not applicable and operators will have to ensure that all carriers offer the appropriate slices to maximise the available slices to a UE.

We assume that the objective then could be to prioritise a frequency that offers the higher priority slice for a UE among its configured slices. With homogeneous deployments, this frequency is likely to be outside its registration area if the slice was not available previously. Based on this, the algorithm we propose is where the frequency priority for each frequency for cell reselection is the highest frequency priority of the available slices in the frequency among the UE configured slices (i.e. Configured NSSAI).

The reason for doing this is that operator may have some preference on the frequency to use for a particular slice/slice group and hence provides the frequency priority of a frequency for the slice/slice group based on this preference.

A flow chart of procedure steps for Option 7 is shown below (details are provided in subsequent sections):



This option will move the UE to the frequency layer that is the highest priority for slices available among the configured slices in that geographical area based on operator configuration of the highest priority slice. For example, if the operator wants UE to select a carrier where URLCC is available, URLCC will be given higher frequency priority. UE that has URLCC in its configured list will reselect to that carrier whenever it is available in a region. This may involve a change in registration area. If so, UE will perform a TA update and the URLCC slice will be included in the allowed list.

### 2.4.1.3 Detailed description with examples

#### 2.4.1.3.1 Slice info in the SIB/RRC Release

The slice info in the SIB/RRC Release used by Solution direction Option#7 is as follows (same as agreed last meeting):

* 1b: Frequency priority mapping for each of the slice (slice -> frequency(ies) -> absolute priority of each of the frequency) is part of the “slice info” agreed to be provided to the UE using both broadcast and dedicated signaling.

That is, for each frequency where a slice is available, a corresponding frequency priority associated with the available slice is provided. Taking the example above, the SIB/RRC Release can provide the following:

|  |  |
| --- | --- |
| **Cell 2 and Cell B** | **Cell 1 and Cell A** |
| Slice 1, F1, frequency priority 3  Slice 1, F2, frequency priority 1  Slice 3, F1, frequency priority 5  Slice 3, F2, frequency priority 2  Slice 4, F1, frequency priority 2  Slice 4, F2, frequency priority 1 | Slice 1, F1, frequency priority 1  Slice 1, F2, frequency priority 3  Slice 2, F1, frequency priority 8  Slice 3, F2, frequency priority 2  Slice 4, F2, frequency priority 1 |

In the above example in the region of Cell 2 and Cell B, operator has preference for UE supporting Slice 3 to be in F1. In the region of Cell 1 and Cell A, operator has preference for UE supporting Slice 2 to be in F1.

The signalling structure for signalling the above can be further discussed in Stage-3. For example, the slices available and the corresponding frequency priority could be provided in SIB4 per inter-frequency neighbour.

#### 2.4.1.3.2 Selecting Frequency priority selection for a carrier frequency based on slice info and UE configured slices

Other than knowing the slice availability and its frequency priority in a carrier frequency, the frequency priority selection also needs to know the slices that UE desires.

In Figure 1, consider a UE that is configured with slice 1 and 2, will request both slices 1 and 2 when registering in cell B in TA1. It is provided with an allowed list of just slice 1 when it registered in TA1 as slice 2 is not available in TA1.

Consider that the UE then moves into cell A, where there is an overlapping cell 1 on frequency F1 in TA2 that offers slice 2. If slice 2 is higher priority than slice 1 (which is reflected in the frequency priority of Slice 2 in F1), UE should then prioritise frequency F1, reselect cell 1 and then perform registration in TA2 to be able to access slice 2. To be able to perform this slice based frequency prioritisation, UE has to consider all the configured slices (slices 1 and 2 in this example) when it does the frequency prioritisation.

In summary, the frequency priority for a carrier is chosen as follows:

For each carrier frequency:

1. identify the available slices in UEs configured slice list (i.e., the slices that are the intersection of the available slices in the slice info and the configured slices)
2. assign a frequency priority equal to the highest frequency priority amongst those identified slices

The above proposal is intended to provide a description of the basic framework. Special cases such as not perfectly overlapping cells can result in non-optimal selection in the cell borders. Whether to introduce additional solutions (e.g. providing cell specific slice info) on top of this basic framework and the additional complexity/benefit can be discussed separately.

#### 2.4.1.3.3 Slice based Cell reselection with solution direction option#7

The slice based cell reselection mechanism for solution direction option#7 reuses the legacy cell reselection mechanism – the main difference is in the determination of the frequency priority for each NR carrier frequency. The frequency priority for a carrier frequency is as provided in bullet 2 in section 2.1.3.2, which is derived first using the configured slice and the slice info in the SIB/RRC Release.

As with the legacy frequency prioritisation, it applies for both RRC IDLE and RRC INACTIVE state and we do not see a difference between RRC IDLE and RRC INACTIVE states. This also works seamlessly with the existing priority based inter-RAT cell reselection (the frequency priority for inter-RAT cells are the same as the legacy broadcast absolute priority).

#### 2.4.1.3.4 UE specific frequency prioritization

As with legacy, UE specific slice info can be provided over dedicated signalling in RRC Release message and will override the broadcast slice info as agreed by RAN2 below:

In the case that slice info is also provided to the UE in the RRC Release message while SIB also provides the slice info, UE follows the dedicated slice info from RRC Release while T320-like timer is running and only if it expires that it follows the slice info in the SIB

This allows the network to provide a UE specific frequency priority for each frequency of an available slice.

For example, a UE can be provided with a slice info that makes slice 1 in F1 as higher frequency priority, while another UE can be provided with a slice info with slice 1 in F2 has the higher frequency priority.

#### 2.4.1.3.5 Summary of specification changes for option #7

1. TS38.331: introduction of the slice info in SIB and RRC Release
2. TS38.304:
   1. Add a new subsection in §5.2.4 the carrier frequency priority determination for each NR frequency based on the slice info and the UE’s desired slices.
   2. The frequency priority determined in a) overrides the legacy broadcast frequency priority (no other changes to the cell reselection procedure)

#### 2.4.1.3.6 Examples based on Figure 1

To understand the option better, we have provided the following examples as illustration with reference to Figure 1:

Example 2\_1:

UE is in Cell A and has configured slices {Slice 1, 2 and 4}. Cell A broadcast the following slice specific cell reselection priority for F1, F2:

Slice 1, F1, cell reselection priority 1

Slice 1, F2, cell reselection priority 3

Slice 2, F1, cell reselection priority 8

Slice 3, F2, cell reselection priority 2

Slice 4, F2, cell reselection priority 1

Based on the configured slices of the UE, F1 = 8 (slice 1 and 2 are part of configured slices and the highest priority for F1 is 8 related to configured slice 2), F2 = 2 (since slice 1 and 4 are in F2 and slice 4 sets higher priority for F2 of 2),

Cell reselection priority for the UE = {F1=8, F2=2}.  This will steer the UE to F1.

The above setting is assuming Slice 2 is of highest slice priority to the network and this is reflected in the use of 8 for F1 where Slice 2 is available, Slice 3 and 4 are preferred in F2, Slice 1 is preferred in F1. This also allows the UE to cross TA boundary to get slice that it previous can’t access in TA1.

Example 2\_2:

Instead of in Cell A, in this example, UE is in Cell 1. Cell 1 can also broadcast the same setting as Cell A. UE moves to Cell A based on the priority based cell reselection parameters (for going from high priority frequency to lower priority frequency).  Logically, the cell reselection parameters will keep UE to higher priority F1 before UE is allowed to go to lower priority frequency

Example 2\_3:

In this example, UE’s configured slice is only Slice 1 and is in Cell A with the same broadcast setting as Example 1

Cell reselection priority for the UE is {F1=3, F2=1}.  This cell reselection will steer the UE to higher priority F1

Example 2\_4:

In this example, UE’s configured slice is Slice 1 and is in Cell 1 with the same broadcast setting as Example 1, it will stay in Cell1 which has highest frequency priority for Slice 1.

## What is the content of “Slice Info” when provided using Broadcast and dedicated signaling?

See Section 2.4.1.3.1

## Who provides the “Slice priority” (NAS/ AS, UE/ Network)

For solution direction Option#7, “slice priority” is not used as such in the frequency priority selection. The slice priority is considered when the network provides a frequency priority for a slice in the slice info. For example, if a slice has higher priority, it will be provided with a higher frequency priority.

If there is a need to provide different slice priority to different UEs, the network can provide UE specific slice info in the RRC Release to in the form of UE specific frequency priority for a slice (See Section 2.1.3.4).

## Can “intended” slice as defined in TR38.832 be used “as is” for in this Solution?

With homogeneous deployments, we think the definition in the TR cannot be directly applied for cell reselection. See Section 2.4.1.3.2 for more details on what is used instead.

# **Behaviours in different scenarios**



Q1: Best Cell (Cell 1) on a high priority frequency (F1) does not support the-most-desired Slice (Slice 2). Where should the UE camp (or reselect)? Only one of TA1 or TA2 is part of UE’s RA.

Option 4: The UE camps on Cell 1, based on the best cell principle.

Option 5: The best cell concept should be adhered to for intra-frequency cell reselection. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.

Option 6: The UE camps on Cell 1, based on the best cell principle.

Option 7: The best cell concept should be adhered to for intra-frequency cell reselection. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.



Q2: Best Cell (Cell 4) on a high priority frequency (F1) does not support UE’s only desired Slice (Slice 1). Where should the UE camp (or reselect)? Only TA1 is part of UE’s RA.

Option 4: UE behavior from option 4: On Cell 5 to be able to use Slice 1.

Option 5: It is not clear where the UE is currently in. If it is in Cell 3, the best cell concept should be adhered to for intra-frequency cell reselection. If the best cell is cell 4, then it implies to us that the UE has moved from cell3/5 to cell 4. In this particular figure (which is not entirely clear to us what it is trying to say), UE behaviour depends on the slice info in Cell 4. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.

Option 6: Because best Cell in F1 (Cell 4) doesn’t support Slice 1, UE will decrease priority of F1 and thereby stay in Cell 5 to use Slice 1 (i.e. not reselection to F1 as inter-frequency cell reselection criteria is not met)

Option 7: It is not clear where the UE is currently in. If it is in Cell 3, the best cell concept should be adhered to for intra-frequency cell reselection. If the best cell is cell 4, then it implies to us that the UE has moved from cell3/5 to cell 4. In this particular figure (which is not entirely clear to us what it is trying to say), UE behaviour depends on the slice info in Cell 4. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.



Q3: Only TA1 is part of UEs Registration area. All Slices (1, 2, 3 and 4) are part of UEs Slice list. From radio quality Cell 6 is the best cell on F1. Where should the UE camp (or reselect) if

1. Slice 1 is most desired
2. Slice 4 is most desired

Option 4: UE behavior from option 4: In both cases the UE selects cell 6, the best radio cell.

Option 5: In both cases, it is intra-frequency cell reselection, so UE shall camp on Cell 6 if Cell 6 is best cell.

Option 6: In both cases the UE selects cell 6, the best radio cell.

Option 7: From the best cell concept, the UE should be in Cell 6 regardless of the desired slice. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.



Q4: F1 has the highest absolute frequency priority according to the *cellReselectionPriorities* provided to the UE but none of the UE desired slices prefer F1 (as configured in the Slice-Info) and cell 8 does not broadcast any Slice support indication. Slice 1 is the only desired slice for the UE and UE’s RA consist of:

1. Both TA1 and TA2 (assuming this is not violating “homogeneous principle in the UE’s RA since cell 11 - TA1 does not prohibit use of any particular slice)

Option 4: UE selects cell 9 on F2 since F1 does not explicitly support Slice 1.

Option 5: In all the 3 cases, UE shall camp on Cell 9, if cell 9 is a suitable cell on F2.

Option 6: As no slice availability info, Option 6 fallback to Option 4, i.e. UE selects cell 9 on F2 since F1 does not explicitly support Slice 1.

Option 7: We think it violates the homogeneous deployment principle that requires all the cells of an RA to support the same slices.

1. Only TA1

Option 4: Same behavior as above and UE needs to perform a RAU procedure.

Option 5: In all the 3 cases, UE shall camp on Cell 9, if cell 9 is a suitable cell on F2.

Option 6: As no slice availability info, Option 6 fallback to Option 4, i.e. same behavior as above and UE needs to perform a RAU procedure.

Option 7: No difference for b) and c), cell 8 has no slice info (it is not clear to us why this is so) and hence this feature does not apply. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.

1. Only TA2

Option 4: UE selects cell 9.

Option 5: In all the 3 cases, UE shall camp on Cell 9, if cell 9 is a suitable cell on F2.

Option 6: As no slice availability info, Option 6 fallback to Option 4, i.e. UE selects cell 9.

Option 7: No difference for b) and c), cell 8 has no slice info (it is not clear to us why this is so) and hence this feature does not apply. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.



Q5: F1 has the highest absolute frequency priority according to the *cellReselectionPriorities* provided to the UE but none of the UE desired slices prefer F1 (as configured in the Slice-Info). Cell 10 supports only Slice 2 but Slice 1 is the only desired slice for the UE. UE’s RA consist of:

1. Only TA1

Option 4: UE camps on Cell 11 since Slice 1 can be used – UE will need to perform a RAU/ TAU.

Option 5: In both cases, UE will camp on Cell 11, if Cell 11 is a suitable cell on F2.

Option 6: Because best Cell in F1 (Cell 10) doesn’t support Slice 1, UE will decrease priority of F1 and thereby this results in priority of F2 becoming higher than F1. The UE finally camps on Cell 11 to use Slice 1. The UE will also need to perform a RAU/TAU as Cell 11 is in different TA.

Option 7: The question is not very clear to us. Is the *cellReselectionPriorities* referring to the legacy field? If this feature is deployed, the legacy priority is not used by the UE (supporting this feature) anymore. From Option#7, since the only desired slice is Slice 1, UE will stay in Cell 11 or move to Cell 11. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.

1. Only TA2

Option 4: Same procedure as above but without a RAU/ TAU.

Option 5: In both cases, UE will camp on Cell 11, if Cell 11 is a suitable cell on F2.

Option 6: Because best Cell in F1 (Cell 10) doesn’t support Slice 1, UE will decrease priority of F1 and thereby it results in priority of F2 becoming higher than F1. The UE finally camps on Cell 11 to use Slice 1. But the UE will NOT need to perform a RAU/TAU as Cell 11 is in same TA.

Option 7: The question is not very clear to us. Is the *cellReselectionPriorities* referring to the legacy field? If this feature is deployed, the legacy priority is not used by the UE (supporting this feature) anymore. From Option#7, since the only desired slice is Slice 1, UE will stay in Cell 11 or move to Cell 11. What is in UE’s RA has no relevance to cell reselection. UE performs RA update if it crosses RA boundary.

# **Comparison of options**

**Q1: Is the solution proposed out of Phase 1 clear enough and covering relevant details?**

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| **Solution 4** | |
| Company Name | Comments |
| BT | The process can be simplified avoiding extra loops and unnecessary measurements. With current procedure, step 5 says “and supports the selected slice in step 2”. Therefore, with current description, the UE performs cells search (step 4) and after that, it checks if the slice is supported. If slice has priority over frequency, then slice needs to be checked first.  Once the UE is configured (FFS how it is configured) with the set “slice -> frequency(ies) -> absolute priority of each of the frequency”, the UE can create a list of frequencies in priority order where the slice priority is given by their order.  We propose the following sequence:   |  | | --- | | **Step 1**: List Slices in ~~the~~ priority order starting with highest priority slice. If none of the slices are supported by the UE, go to step 8.  **Step 2**: ~~Select~~ Order the UE supported slices based on their priority ~~the first (or next if from Step 7)~~ ~~slice in the list~~.  **Step 3**: Assign the priorities to all frequencies included in the slice set according to the priorities provided to the selected slices (step 2). Lowest duplicated priority slice – frequencies combo will be removed from the list.  **Step 4**: Perform cell search according to the legacy procedure using the priorities assigned in step 3 or step 6 if step 5 has been executed.  **Step 5**: If the highest ranked ~~cell~~ frequency is suitable (as defined in 38.304), ~~and supports the selected slice in step 2~~ then camp on the cell and exit this sequence of operation. FFS: How the UE determines whether the highest ranked cell supports the selected slice.  **Step 6**: If there are remaining ~~cell~~ frequencies, select the following highest ranked cell and ~~then~~ go back to step ~~3~~4. Other case, go to step 7.  **~~Step 7~~**~~:~~ **~~FFS:~~** ~~If the end of the slice list has not been reached go back to step 2~~  **Step ~~8~~**7: Perform legacy cell reselection (using non-slice-based priorities i.e. for frequencies not corresponding to any slice support) |   The following example shows how our proposal works:  Slice information:   * Slice\_URLLC ->[ freq\_A, freq\_B, freq\_C] -> [3, 2, 7] * Slice\_eMBB -> [freq\_A, freq\_B, freq\_C, freq\_D, freq\_E] -> [5, 5, 3, 7, 7]   In this example, it is assumed the order the slice info is transmitted defines the slice priority, thus no extra signalling is required. URLCC is sent before so it has priority over eMBB. The UE supports URLCC and eMBB.  In **step 1,** UE only considers its supported slices. The UE can fallback to legacy procedure if none of them is supported. In **step 2** the UE prioritize only the slices that it supports instead all the slices. **Step 3** creates the frequency list based on slice priority so it its input will be UE eMBB supported frequencies [freq\_A, freq\_B, freq\_C, freq\_D, freq\_E] and the output in the example will be [freq\_C, freq\_A, freq\_B, freq\_D, freq\_E].  In **step 5**, the UE will check first *freq\_C* as it has the highest frequency priority for the slice with highest priority. If it is not suitable, then it will check *freq\_A* and so on. The process will continue until the conditions are meet as defined in 38.304 or until there aren’t remaining frequencies to check in the list. The UE will fallback to legacy procedure if none of them meet the conditions.  If the UE only supports eMBB, after **step 3** it will have to check the frequencies in this specific order [freq\_D, freq\_E, freq\_A, freq\_B, freq\_C]. |
| Lenovo, MotM | Yes, the solution is clear and covers the relevant details. The proposed solution was arrived after the result of discussions in Phase 1 with all interested companies. |

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| **Solution 5** | |
| Company Name | Comments |
| BT | Yes but in the way step 2 is defined, the network may have an unpredicted behaviour. |
| Lenovo, MotM | The use of the main relevant aspect of *slice specific frequency priority* is kept FFS and not clear if this will be used. This is a deviation from an agreement that RAN2 made in the previous meeting:  *“1: Frequency priority mapping for each slice (slice -> frequency(ies) -> absolute priority of each of the frequency) is provided to a UE.”* |

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| **Solution 6** | |
| Company Name | Comments |
| BT | Proposal for solution 6 isn’t clear. Steps 5-a and 5-b are confusing.  Is step 5-b executed only if conditions in step 5 are validated?  In the example, why step 5-a is considered? In the way it is described, once the UE meets step 5 conditions, it won’t check step 5-a due to its condition is else if.  If (conditions step 5)  // check cell is suitable (as defined in 38.304)  } else if (conditions step 5-a)  //in the way it is, it looks a confusing behaviour;  }  Step 5-b;  “Step 5: If the highest ranked cell is suitable (as defined in 38.304) and supports the selected slice in step 2 …”  “Step 5-a: **Else if** the highest ranked cell is suitable (as defined in 38.304) but **doesn’t support** the selected slice in step 2, then the priority value of this frequency is changed to the priority value of the highest priority slice …”. |
| Lenovo, MotM | Agree with BT that this solution is not easy to understand, at least not in the first reading. However, it is possible to understand it and the example provided by the proponent helps. |

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| **Solution 7** | |
| Company Name | Comments |
| BT | It is clear but it doesn’t cover all the details (see Q2 option 7). |
| Lenovo, MotM | Yes, solution is clear and covers relevant details. |

**Q2: How well the given solution fulfils relevant Objective set out in the WID [RP:210912] and is in accordance with the intention of the study [TR 38.832]?**

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| **Solution 4** | |
| Company Name | Comments |
| BT | Initial proposal may not fulfil the relevant objectives if the UE cannot camp in a cell where the highest ranked slice is supported. |
| Lenovo, MotM | The following objective from the WID will be appropriately fulfilled:   1. *Support slice based cell reselection, specify mechanisms and signalling including [RAN2]* 2. *To assist cell reselection, broadcast the supported slice info of the current cell and neighbour cells, and cell reselection priority per slice in system information message.* 3. *To assist cell reselection, include slice info (with similar information as in SI message) in RRCRelease message.*   Now it seems the “*slice info of the current cell and neighbour cells*” can be provided on a per-frequency basis and a more detailed “per cell” information can be weighed further.  The solution is very much in line with the intention of slice priority based cell (re)selection as established during study i.e. Solution 4 ensures that if the highest priority slice (say URLLC) is available in any of the cell of any of the frequencies provided to the UE as part of Slice-Info, it will camp on that. Some optimizations have been proposed by other supporting companies to save UE battery, wherein the UE camps rather on the highest priority frequency (of the highest priority slice) on a cell supporting a non-highest priority slice. RAN2 should discuss on need for such an optimization once the group decides in favor of Option 4. |
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| **Solution 5** | |
| Company Name | Comments |
| BT | It is not our interpretation of the WI “Support slice based cell reselection, specify mechanisms and signalling including [RAN2]”. The UE will select the frequency based on the number of supported slices on that frequency. This solution precludes operators to reserve a frequency for a specific slice and give it the highest priority.  On the contrary to our understanding, in order to provide highest priority to one frequency, it will be required to deploy the highest number of slices on that frequency on that RA resulting in an undesirable congestion not only for data traffic but also for control traffic. |
| Lenovo, MotM | Since “Slice Info” is not essentially required in this solution, it is difficult to say that the objectives have been met. |

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| **Solution 6** | |
| Company Name | Comments |
| BT | Prioritizes the frequency over the slice. Can the same behaviour be achieved with legacy mechanisms? |
| Lenovo, MotM | The solution is in line with the WID objectives.  The solution however lacks the will to get to the highest priority slice and the solution gives up on finding any cell that supports any of the slices supported by the UE.  One can argue that in the end no one knows which application will trigger RRC establishment (i.e. have data available for transmission) but the entire efforts RAN2 is making is to ensure that the highest priority slice dictates cell camping – if data arrives for a non- highest priority slice, it will have more “tolerance” e.g. in terms of latency and so a slight delay here would be acceptable compared with the case if the highest priority slice would have to wait longer for attaining service. |

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| **Solution 7** | |
| Company Name | Comments |
| BT | Solution 7 partially supports point 1.  “1. Support slice based cell reselection, specify mechanisms and signalling including [RAN2]”  It is true that in homogenous deployments, a slice will be supported in the whole RA but it doesn’t mean it is mandated the 1-to-1 association slice – frequency or that every cell in the RA supports all slices.  In this solution, prioritization is given per frequency and then, per slice. In case the same slice is supported in more than one frequencies, frequencies will have the same priority level as captured in step 2b. When that happens, nothing precludes that the best cell (step 2a) doesn’t support the highest intended slice. Therefore, the intention to prioritize the slice cannot be fulfilled.  For example, cells with only lower FR1 bands that support slice\_A and Slice\_B. These cells may be used like umbrellas inside the RA. In the same RA, we may have cells with high FR1 bands only with Slice\_B. In this scenario, low and high FR1 bands will result having the same priority. |
|  | The solution is in line with the WID objectives.  From the intention of the RAN2 study, we think this solution deviates:   1. the solution centres around change of registration area (RAU) to ensure attaining configured slice which is not among allowed slice list – to us it seems that the solution tries to solve an issue which is not in RAN2 scope. We assume this is mainly a SA2/ CT1 subject; we think, RAN2 needs to trust/ respect the allowed slice list (or whatever is sent to it by the NAS for the given purpose). A change of Registration area should rather be guided mainly by the radio conditions. Not sure but perhaps this solution may lead to ping-pong between registration areas, leading to un-necessary RAUs – and thereby wasting battery. 2. The solution implicitly uses slice priority, which is realized inherently in the slice specific frequency priority – this is fine but since the total number of slice priority and frequency priority can’t exceed 8 (1..8) this can be too restrictive. One option would be to extend this range to 16 (or more) but then why would one rather not define and use the slice priority? |

**Q3: How easy/difficult is to implement/ specify the solution?**

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| **Solution 4** | |
| Company Name | Comments |
| BT | We consider the logic can be simplified as we propose in Q1. |
| Lenovo, MotM | The solution is proposed in clear steps and it would be easy to specify these in one small paragraph and implementation, testing should be straightforward since there are no complicated conditions. All cases/ scenarios can be handled with the same logic. |

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| **Solution 5** | |
| Company Name | Comments |
| BT | Considering our Q2 answer, this question is not relevant. |
| Lenovo, MotM | We do not expect much specification, implementation complexity if implemented exactly as shown by the proponents. |

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| **Solution 6** | |
| Company Name | Comments |
| BT | We consider our proposed text for option 4 captures the intention of option 6. |
| Lenovo, MotM | Lot of things e.g., Freq-x-priority, PCI-list are left optional which of course provides some flexibility to the operator but will be a lot of effort for specification, and especially in implementation and testing since there will be multiple permutation and combinations as a result. Also, the basic algorithm is not simple and would need re-assignment of priorities, re-evaluation etc. It might be one of the hardest option to implement. |

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| **Solution 7** | |
| Company Name | Comments |
| BT | Considering our Q2 answer, this question is not relevant. |
| Lenovo, MotM | We do not see major hurdles here. |

**Q4: Which Option does your company support?**

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| --- | --- | --- |
| Company Name | Supported Option | Comments |
| BT | Option 4 with changes | We consider our proposed logic simplifies option 4 and captures the intention of option 6. |
| Lenovo, MotM | Option 4 | This option is   * technically most aligned with the intention of the WID, * allows reasonable flexibility to the operator, * is relatively simple to specify and implement and * had maximum support in the previous email discussion [R2-2106501]. |

# **Conclusion**

# **Contact list**

|  |  |  |
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