**Source: Intel – Seau Sian (seau.s.lim@intel.com)**

**Title:****Details of Solution Direction Option 7**

**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 combinationb) Option 5): Maximize slice supportc) 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 reselectiond) 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 5b) 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 mobilityd) 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:

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.

# **Phase 1**

## How does Solution Direction (Option 7) work?

### 2.1.1 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.

### 2.1.2 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.

### 2.1.3 Detailed description with examples

#### 2.1.3.1 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 1Slice 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 3Slice 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.

#### 2.1.3.2 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.

#### 2.1.3.3 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).

#### 2.1.3.4 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.

#### 2.1.3.5 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)

### 2.1.4 Comments on the solution direction option#7

***Q1 Any comments on the example deployment scenario in Section 2.1.1?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm  | Agree that the illustrated scenario should be supported |  |
|  |  |  |
|  |  |  |

***Q2 Any comments on the high level description of the solution in Section 2.1.2?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm | Generally, we agree that the solution is the only feasible way if only per slice frequency priority is provided to UE. And we support this simple solution if only if only per slice frequency priority is provided to UE. |  |
| ZTE | Regarding QC’s comments, for the case when there is no specific slice priority available, we understand another alternative is to treat the first slice in the allowed S-NSSAI to be the highest priority and follow the corresponding slice specific priority provided.No additional NAS signaling is needed if we go this way and we can keep the intended slice definition as we had in TR38.832. | [Intel] The Solution DIrection#7 assumes that there is no need for explicit slice priority. Most of the objective of having a slice priority can be achieved by setting the slice priority in the frequency priority of the slice. With this solution, all configured (I.e., subscribed) slices (we don’t want to use the term intended slice as it is ambiguous in our view) can be considered by the UE for all frequencies available (with the intended/configured slices) and not just the frequencies associated with slice with highest slice priority or the need to loop through the frequency priority of the different slices. However, this can be discussed further in Phase 2. |
|  |  |  |

***Q3 Any comments on the slice info in the SIB/RRC Release in Section 2.1.3.1?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm | One minor comment, it seems RRC release signalling is not really necessary because RAN is aware of UE’s intended slices. Then, RAN can perform maximum operation among frequency priority of all slices supported by the UE, and then send it to UE via legacy UE dedicated frequency priority (i.e. per slice frequency priority in RRC release may not be required). | [Intel] We agree that RRC Release signalling is not needed when the slice availability is broadcast. It is just another mechanism of providing the information as with dedicated priorities. We also agree that current dedicated priority can be used to steer the UE to a frequency by the network without having to provide the slice availability to the UE as in Rel-15/16. However, RAN2 has already agreed that Slice info is provided also in the RRC Release and it can override the Slice info provided in the SIB. This is just following this principle/agreement. We were just pointing out that this signalling can then be used to provide a UE specific slice availability if needed. |
| ZTE  | Agree in General and we have the following structure in mind for the slice info provided via system information and RRCRelease message

|  |
| --- |
| Slice info |
| For the serving frequency (only in system information) |
|  | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) |
| Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) |
| .... |  |
| For inter-frequency |
| Frequency 1 | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) |
| Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) |
| ... | ... |
| Frequency 2 | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) |
| Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) |
| ... | ... |
| ... |

 | [Intel We are aligned.  |
|  |  |  |

***Q4 Any comments on the frequency priority selection for a frequency in Section 2.1.3.2?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm  | Agree |  |
| ZTE | We understand another alternative is to treat the first slice in the allowed S-NSSAI to be the highest priority and follow the corresponding slice specific priority provided. | See our response to Q2 |
|  |  |  |

***Q5 Any comments on the slice based cell reselection mechanism for solution direction option#7 in Sections 2.1.3.3?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm  | Agree. This is the only feasible way if only per slice frequency priority is provided to UE. |  |
| ZTE | We understand another alternative is to treat the first slice in the allowed S-NSSAI to be the highest priority and follow the corresponding slice specific priority provided.Fine with other operation after the frequency priority determination. | See our response to Q2 |
|  |  |  |

***Q6 Any comments on the UE specific frequency prioritization for solution direction option#7 in Sections 2.1.3.4?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm | Agree |  |
| ZTE | Agree |  |
|  |  |  |

***Q7 Any comments on the summary of specification changes for Option#7 in Sections 2.1.3.5?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm  | Agree |  |
|  |  |  |
|  |  |  |

***Q8 Any comments on the examples in Annex-1?***

|  |  |  |
| --- | --- | --- |
| **Companies** | **Comments** | **Response** |
| Qualcomm | Agree all comments |  |
|  |  |  |
|  |  |  |

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

See Section 2.1.3.1

## If used, 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 Direction?

With homogeneous deployments, we think the definition in the TR cannot be directly applied for cell reselection. See Section 2.1.3.2 for more details on what is used instead.

# **Annex-1 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.

# **Annex-2**

*Somewhat* in line with the TR 38.832 following geographies are depicted – only as a checkpoint to see how your solution works here. Only “slice” is mentioned but it can also mean “slice group”. A general term of “desired slice” is used to intentionally avoid using the term “intended slice”. A “desired slice” for one solution may mean higher priority slice (if a slice priority exists) or, for another solution may just point to the slice corresponding to the highest absolute priority for a supporting frequency.



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.

Answer to Q1: The best cell concept should be adhered to for intra-frequency cell reselection.



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.

Answer to Q2: 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 TA1 is in UE’s RA and 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 will camp on cell 4 based on best cell principle and perform registration update.



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

Answer to Q3: From the best cell concept, the UE should be in Cell 6 regardless of the desired slice



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)
2. Only TA1
3. Only TA2

Answer to Q4: From solution direction Option#7:

For a), we think it violates the homogeneous deployment principle that requires all the cells of an RA to support the same slices.

No difference for b) and c), cell 8 has no slice info and hence this feature does not apply.



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
2. Only TA2.

Answer to Q5: 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 solution direction Option#7, since the only desired slice is Slice 1, UE will stay in Cell 11 or move to Cell 11.

# **Annex-3**

List of companies contributing to this option

|  |  |  |
| --- | --- | --- |
| Company Name | Delegate Name | Email Address |
| Qualcomm  | Peng Cheng | chengp@qti.qualcomm.com |
| ZTE | Yuan Gao | gao.yuan66@zte.com.cn |
|  |  |  |