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**Title:****Details of Solution Direction Option 5**

**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:

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 5) work?

### 2.1.1 Overview of Option 5

In Option 5, UE tends to camp on a frequency that supports more slices than any other frequency. Therefore, the working assumption of Option 5 is that the *UE knows the slice availability per frequency or the supported slice list per frequency.*

The Idle mode UE shall apply the following rules for slice based cell reselection.

(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.

(2) If more than one frequency supports the same number of slices among UE’s intended slices, the UE can simply treat them with equal priority, or further consider the existing absolute cell reselection frequency priority or sliced based frequency priority (if provided, per slice per frequency), or slice priorities of UE’s intended slices, etc. The detail depends on what kind of “slice info” is provided to UE in system message or dedicated RRC singnalling, which would be analyzed case by case.

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

**Q1: Any comments on Overview of Option 5 in Section 2.1.1?**

|  |  |
| --- | --- |
| Company Name | Comment |
| Qualcomm | For Step (1), we think using “maximum number of slices” will delay UE’s cell reselection procedure. According to Section 5.2.4.5 of TS 38.304, the UE will check inter-frequency cell reselection criteria from frequency with highest priority to frequency lowest priority, and it will camp in a cell as long as the criteria is met, i.e. the UE is NOT required to check criteria for all frequencies. However, in Step (1), it will mandate UE to check all frequencies how many slices supported in one frequency. Otherwise, the UE will not know what is “maximum number of slices among all frequencies”.  To resolve this issue, we suggest to use “the frequency that supports **all slices among UE’s intended slices** has the highest priority in cell reselection”. This variant is similar to existing LTE eMBMS and LTE/NR V2X, i.e. if one frequency supports all the UE’s intended slices, the UE may regard this frequency as highest priority. The UE camps in one cell of this frequency if cell reselection criteria is met, without need to check other frequencies. For frequency which support part of UE’s intended slice, it is up to UE implementation whether to regard it as highest priority.  In addition, before Step (1), we think it should have one more step (step 0) that the UE applies the legacy frequency priority. It is intended to be aligned with existing LTE eMBMS and LTE/NR V2X, i.e. the UE applies the legacy frequency priority, but the UE may regard the frequency which supports its service (eMBMS or V2X) as highest priority. |
| OPPO | It depends on what extent the slice info indicates to the UE. In some cases, if there is the most desired slice but the UE follows Solution 5, the UE may select one cell supporting the maximum number of slices other than the one supporting the most desired slice, which may not be a desired UE intention.  We prefer a variant of Solution 5, which is similar to the legacy NR V2X. Specifically, the frequency that supports all slices among UE’s intended slices or supports the maximum number of UE’s intended slices has the highest frequency priority. |
| Nokia | Option 5 in general works on the assumption that prioritizing a frequency because the number of slices supported by the frequency is high. Only when there is a tie in frequencies (frequencies that support same number of slice) than the important parameters for slice specific RAN offloading comes in to play such as slice specific frequency priority. This gives very little control to RAN to steer a slice to a certain frequency.  Option 5 also assumes that slice availability is advertised for all neighboring cells. This may create huge SIB overhead and it is inefficient (waste of SIB resources); e.g.  a) if all bands support the same slices in an area then it is not useful to advertise slice availability;  b) if a slice is supported by all bands then it is not useful to advertise the availability of that slice;  c) if a slice is rarely used (e.g., a slice that is only used by a small amount of UEs), then dedicated signaling or general frequency priorities for the slice are good enough, advertising them in SIBs is a waste of resources. |
| Huawei, HiSilicon | For QC’s suggested option “the frequency that supports **all slices among UE’s intended slices** has the highest priority in cell reselection”, we think it can also be considered and seems simpler than original design. |
| Intel | 1. If it is just based on the allowed slices/NSSAI (as mentioned in bullet 1) above, the UE may not be able to find better frequency(ies) across UE RA boundary that supports UE’s configured slice.  How does it cover the scenario where a configured slice that is not in the allowed list is available on a different frequency in the same region? 2. What information is broadcast as slice availability in SIB?  We think that slice availability needs to be provided per frequency in order for the UE to find a frequency with the best match (i.e. the frequency that supports the most UE’s intended slices). |
| ZTE | * We understand this option works for the case when the supported slice info include the supported slice for each frequency but not include the slice specific reselection priority. For example, we have the following structure table for the slice info and the slice specific reselection priority is absent. * Since we have the principle that UE should use the slice info first if provided , the number of available slices which are overlapped with UE’s allowed S-NSSAI(s) or requested S-NSSAI(s) of each frequency can be used to decide the reselection priority.  |  |  |  | | --- | --- | --- | | Slice info | | | | For the serving frequency | | | |  | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) => absent | | Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) => absent | | .... |  | | For inter-frequency | | | | Frequency 1 | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) => absent | | Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) => absent | | ... | ... | | Frequency 2 | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) => absent | | Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) => absent | | ... | ... | | ... | | |  * To simplify the whole procedure, only the frequency supporting the maximum number will be treated to be the highest priority and if UE cannot find a suitable cell in this frequency, UE will then use the legacy reselection information. And the whole solution in our mind would be:   -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.  -Step 2: If there are more than one such frequency (i.e. supporting the maximum number of slices among UE’s intended slices), they will all be treated to be the highest priority or consider the legacy cell reselection frequency priority for further prioritization among these frequencies but they are still prioritized over other frequencies.  -Step 3: The UE performs the cell reselection following the priority assigned based on the above rules. |
| NEC | For bullets (2), We think it is not good that the UE simply treat frequencies with equal priority if these frequencies support the same number of UE’s intended slices. One simply example, assuming eMBB slice is supported on every frequency, and for UEs only support eMBB slice, it should not treat all frequencies with equal priority, but follow slice specific frequency priority or legacy frequency priority for traffic steering purpose. we propose following wording:  (1) frequencies supporting a greater number of slices among UE’s intended slices has the higher priority than frequencies supporting a smaller number of slices among UE’s intended slices.  (2) for these frequencies supporting the same number of slices among UE’s intended slices, UE can further consider the existing absolute cell reselection frequency priority or sliced based frequency priority (if provided, per slice per frequency), and or slice priorities of UE’s intended slices. See the detail in section 2.1.2.  (3) The UE performs the legacy cell reselection (specified in TS 38.304) following the priority assigned based on the above rules. |
| CATT | We have the same concern that when UE selects one frequency which supports the maximum number of slice, but does not support the UE most desired slice. The maximum number slice may not include the most desired slice. So we agree to add one restriction that UE selects the frequency which supports the maximum number of slices **and include the most desired slice of UE .** we should consider the highest priority intended slice firstly and then select the frequency support the maximum number slice include the most desired slice |
| CMCC | We think the scenario where there is no cell to support all slices among UE’s intended slices in TA boundaries is a valid and common use case, so the description “the frequency that supports the maximum number of slices among UE’s intended slices has the highest priority in cell reselection” in bullet (1) is fine for us. |

### 2.1.2 Details of the frequency priorities determination for frequencies supporting the same number of slices among UE’s intended slices

When determining the frequency priority of frequencies supporting the same number of slices among UE’s intended slices, there are two candidate sub-options.

**Sub-option 5a:** Frequencies supporting the same number of slices among UE’s intended slices are always treated as having the same frequency priority, regardless whether existing absolute cell reselection frequency priority or “slice info” is provided or not.

**Sub-option 5b:** Frequencies supporting the same number of slices among UE’s intended slices maybe treated as having different frequency priorities based on existing absolute cell reselection frequency priority or the “slice info” provided to UE.

In Sub-option 5b, for the frequencies that supports same number of slices among UE’s intended slices, the UE can further consider the existing absolute cell reselection frequency priority or “slice info” to determine the frequency priorities.

Since the content of “slice info” is still unclear in this phase, we can analyze the details to determine the frequency priorities case by case.

**Case 5b-1:** Based on existing absolute cell reselection frequency priority

In case 5b-1, the “slice info” provided to UE only includes the supported slices per frequency.

(1) Take Table1 for example, F2 and F3 both support 2 slices of UE’s intended slice. UE can treat F2 and F3 as having higher frequency priorities than F1.

(2) Then UE can further determine the frequency priorities based on the existing cell reselection frequency priority, i.e. F3 has a higher priority than F2.

(3) The final cell reselection frequency priority order: F3 >F2 >F1 (The priority value might be 7 for F3, 6 for F2, and 5 for F1.)

Table1. Example for case 5b-1

|  |  |  |
| --- | --- | --- |
| UE’s intended slices | slice 1, slice 2, slice 3 | |
| F1 | Supported slice | slice 1 |
| Existing cell reselection frequency priority | 5 |
| F2 | Supported slice | slice 1, slice2 |
| Existing cell reselection frequency priority | 4 |
| F3 | Supported slice | slice 2, slice3 |
| Existing cell reselection frequency priority | 5 |

**Case 5b-2:** Based on slice specific cell reselection frequency priority (per slice per frequency)

In case 5b-2, the “slice info” provided to UE includes the supported slices per frequency and also slice specific cell reselection frequency priority (per slice per frequency).

(1) Take Table2 for example, F2 and F3 both support 2 slices of UE’s intended slice. UE can treat F2 and F3 as having higher frequency priority than F1.

(2) UE can further determine the frequency priorities based on slice specific cell reselection frequency priority. The existing absolute cell reselection frequency priority will be ignored if provided. In this case, UE can treat the frequency that has the highest slice specific frequency priority as the highest priority, i.e. F2 has a higher priority than F3.

(3) The final cell reselection frequency priority order: F2 >F3 >F1 (The priority value might be 7 for F2, 6 for F2, and 5 for F1.)

Table2. Example for case 5b-2

|  |  |  |  |
| --- | --- | --- | --- |
| UE’s intended slices | slice 1, slice 2, slice 3 | | |
| F1 | Supported slice | slice 1 | |
| Slice specific cell reselection frequency priority | 5 | |
| F2 | Supported slice | slice 1 | slice2 |
| Slice specific cell reselection frequency priority | 4 | 6 |
| F3 | Supported slice | slice 2 | slice3 |
| Slice specific cell reselection frequency priority | 5 | 4 |

**Case 5b-3:** Based on slice priority

In case 5b-2, the “slice info” for UE includes the supported slices per frequency and slice priority that might be provided by network or determined by UE itself.

(1) Take Table3 for example, F2 and F3 both support 2 slices of UE’s intended slice. UE can treat F2 and F3 as having higher frequency priority than F1.

(2) Then UE can further determine the frequency priorities based on slice priority. The slice priority for UE is slice 1> slice 2> slice 3. In this case, UE can treat the frequency that support the highest priority as the highest priority, i.e. F2 has a higher priority than F3.

(3) The final cell reselection frequency priority order: F2 >F3 >F1 (The priority value might be 7 for F2, 6 for F2, and 5 for F1.)

Table3. Example for case 5b-3

|  |  |  |
| --- | --- | --- |
| UE’s intended slices with priority | slice 1> slice 2> slice 3 | |
| F1 | Supported slice | slice 1 |
| F2 | Supported slice | slice 1, slice2 |
| F3 | Supported slice | slice 2, slice3 |

The above cases for Option 5b are just potential examples to help better understand Option5b.

**Q2: Which sub-option is more preferred for Option 5?**

|  |  |  |
| --- | --- | --- |
| Company Name | 5a or 5b? | Comment |
| Qualcomm | 5a | The assumption behind Option 5 is that all slices are with same priority (Otherwise, why you can regard number of slices as criteria?). Then, we think Option 5b is not aligned with logic of Option 5. Specifically, if slice priority / slice specific frequency priority is available, we can further design algorithm with slice priority being considered in Case 5b-2/5-3.  Thus, we think 5a makes more sense (i.e. Frequencies supporting the same number of slices among UE’s intended slices are always treated as having the same frequency priority). According to Note 3 of Section 5.2.4.1 of TS 38.304, it is up to UE implementation how to handle these frequencies with same priority:  *NOTE 3: The prioritization among the frequencies which UE considers to be the highest priority frequency is left to UE implementation.*  As summary, our understanding on steps of Option 5 is:   1. The UE applies legacy frequency priority 2. For frequencies which support the UE’s all the intended slices, the UE may regard this frequency as highest priority. If there are more than one such frequencies, they are regarded as same priority, and up to UE implementation on prioritization among them 3. After frequency priority adjusted in Step 2), the UE applies the legacy cell reselection procedure in TS 38.304 |
| OPPO | 5a | Our assumption for Option 5 is all slices to be treated as the same. Thus, 5a makes sense and is simple. |
| Nokia | 5b | We think that Option 5a can easily lead to the situation that most of the UEs select the band that supports most of the slices and gives very little control to the network to move UEs away from congested band(s). 5b at least gives some control to the operator to avoid overloading some bands. |
| Huawei, HiSilicon | 5a | We share the same view as Qualcomm that it is up to UE implementation if more than one frequency supports all the intended slices in the UE. |
| ZTE | 5a  5b following the legacy priority | Agree with QC that this option 5 applies for the case when no slice specific priority is configured. Then we need a criteria to decide the highest priority frequency, that is the number of the supported slices overlapped with the allowed S-NSSAIs.  If we have two frequencies supporting the same number of slices overlapped with the allowed S-NSSAIs, they both can be treated to be the highest priority with the further prioritization handled via UE implementation as quoted by QC. Or UE follow the legacy priority and decide the further prioritization. |
| NEC | 5b | |  |  | | --- | --- | | 5a should be excluded, see our comment for Q1 for our reason.  For 5b, we think UE should consider both slice priority and slice-specific priority if provided. Suggested 5b:   |  | | --- | | For these frequencies supporting the same number of slices among UE’s intended slices:  If slice-specific priority is not provided   * Set these frequencies’ relative priority based on existing absolute frequency priority (Case 5b-1)   If slice-specific priority is provided:   * Set these frequencies’ relative priority based on slice-specific frequency priority corresponding to the UE’s highest priority slice (mix of case 5b-2 and 5b-3) | | |
| CATT | 5a/5b-3 | We think it is too restrictive to keep the slice priority on different frequencies are the same. We agree with Nokia that leaving some freedom to network.  If the priority of intended slice is available, the 5b-3 is fine |
| CMCC | 5b-1 or 5b-3 | We share the same view with Nokia that most of the UEs may select the same band that supports most of the slices and lead to some bands overloading.  Option 5b at least gives some control to the operator to avoid overloading some bands. And in our understanding, it may be not necessary to provide slice specific frequency priority to the UE if option 5 is used. However, slice priority may be provided to the UE by the order of allowed slices or other ways. From our point of view, option 5b-1 or 5b-3 are simple and make sense. |

**Q3: What are the essential content of “Slice Info” for Option 5? Or what is the use case for Option 5?**

|  |  |
| --- | --- |
| Company Name | Comment |
| Qualcomm | The assumption behind Option 5 is that all slices are with same priority (Otherwise, why you can regard number of slices as criteria?). Thus, we think the “Slice info” of Option 5 is just *the slice availability per frequency or the supported slice list per frequency.* |
| OPPO | The “Slice info” here is just the supported slice list per frequency. |
| Nokia | Slice specific frequency priority (optional) gives some control to the network operator. Note also that advertising a priority is an implicit indication of slice availability. |
| Huawei, HiSilicon | The slice info should at least include the supported slices per frequency. |
| Intel | In our understanding, Option 5 requires the slice availability per frequency to be provided.   Option 5 use case is where the slices are equal priority as it prioritisation is based on maximising the number of slices.  For example, if a frequency offers a higher priority slice but one less slice than other frequency, it will not be possible to prioritise that frequency. |
| ZTE | * We understand this option works for the case when the supported slice info include the supported slice for each frequency but not include the slice specific reselection priority. For example, we have the following structure table for the slice info and the slice specific reselection priority is absent. * Since we have the principle that UE should use the slice info first if provided , the number of available slices which are overlapped with UE’s allowed S-NSSAI(s) or requested S-NSSAI(s) of each frequency can be used to decide the reselection priority. * To simplify the whole procedure, only the frequency supporting the maximum number will be treated to be the highest priority and if UE cannot find a suitable cell in this frequency, UE will then use the legacy reselection information.  |  |  |  | | --- | --- | --- | | Slice info | | | | For the serving frequency | | | |  | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) => absent | | Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) => absent | | .... |  | | For inter-frequency | | | | Frequency 1 | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) => absent | | Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) => absent | | ... | ... | | Frequency 2 | Slice id-1/Slice Group Id-1 | Slice specific Freq-x-priority (Optional) => absent | | Slice id-2/Slice Group Id-2 | Slice specific Freq-x-priority (Optional) => absent | | ... | ... | | ... | | | |
| NEC | Agree with ZTE, “slice info” could be provided per frequency, and slice info of each frequency should indicate one or multiple slice groups the frequency supports and optionally the slice-specific frequency priority |
| CATT | We think slice specific frequency priority can be included for flexibility. |
| CMCC | The “slice info” here should at least include the supported slices per frequency. |

**Q4: Any other comments on Section 2.1.2?**

|  |  |
| --- | --- |
| Company Name | Comment |
|  |  |
|  |  |
|  |  |

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

For Option 5, the content of “Slice Info” shall at least include the slice availability per frequency or the supported slice list per frequency.

Other “Slice Info”, such as slice specific frequency priority (per slice per frequency), or slice priorities of UE’s intended slices may need further discussion.

## If used, 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 Direction?

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

# **Annex**

*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.



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.



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



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



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.

# **Annex-2**

List of companies contributing to this option

|  |  |  |
| --- | --- | --- |
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| Qualcomm | Peng Cheng | chengp@qti.qualcomm.com |
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