**3GPP TSG-RAN WG2 Meeting #117-e R2-220XXXX**

**Electronic Meeting, 21 February – 3 March, 2022**

**Source: Lenovo, Motorola Mobility**

**Title: Report for [AT117-e][244][Slicing] Frequency sorting and equal frequency priorities (Lenovo)**

**WID/SID: FS\_NR\_slice**

**Document for: Discussion and Decision**

# Introduction

The following email discussion has been triggered on Friday, February 25, 2022:

* **[AT117-e][244][Slicing] Frequency sorting and equal frequency priorities (Lenovo)**

       Scope: Discuss how the frequency sorting and equal priority is handled and provide TPs for each alternative. Should discuss how each option works and provides consistent UE behaviour

       Intended outcome: Discussion report in [R2-2203782](https://apc01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.3gpp.org%2Fftp%2FTSG_RAN%2FWG2_RL2%2FTSGR2_117-e%2FDocs%2FR2-220XXXX.zip&data=04%7C01%7Cpmallick%40lenovo.com%7C2432aa88fb674aa0ec9608d9f83d30fe%7C5c7d0b28bdf8410caa934df372b16203%7C0%7C0%7C637813763969189669%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C2000&sdata=gbxL2KBlJzVpy3YAJlaFpb8%2FXG5quClg3fOjVfoUNUU%3D&reserved=0).

**Deadline: Deadline 4:**

**Deadline 4 (discussions for 2nd week Wed online): Prateek**

* **Comment deadline:** MondayW2, 1200 UTC (for collecting views)
* **Rapporteur proposals:** Tuesday W2, 1200 UTC (proposed resolution of issues)
* **Document deadline:** Tuesday W2, 1600 UTC (report or agreed CRs)

No extensions to this deadline for regular discussions. Discussions handling CRs may continue to short post-meeting email (based on chair decision).

# Discussion

### Agreements

RAN2 has reached following agreements:

|  |
| --- |
| * *1: RAN2 confirm the working assumption on option A without formula.*   ***(prateek)***   * *2: The UE should determine the frequency priority order according to the following rules:*   *a) Considering the slice/slice group priority provided by NAS, the frequencies that support higher priority slice/slice group have higher slice based frequency priority than the frequencies that support lower priority slice/slice group;*  *b) Among the frequencies supporting a slice/slice group with the same priority, the UE should follow the slice specific frequency priority received in SIB or RRCRelease (if configured);*  *c) Among the frequencies supporting the same slice/slice group, the frequency not configured with slice specific reselection priority should be considered as lower priority than other frequencies configured with slice specific reselection priority;*  *d) The frequencies that support any slice/slice group have higher slice based frequency priority than the frequencies that support none of slice/slice group;*  *e) For the frequencies that do not support any slice/slice group, the UE should follow the legacy cell reselection priority received in SIB, FFS when only legacy priority received in RRCRelease;*   * *5: RAN2 confirm that if the UE is configured with slice specific frequency priority via RRCRelease message, the UE shall ignore all the slice specific priorities provided in system information. FFS if we still apply the legacy cell reselection frequency priorities in SIB.* * *6: The legacy procedure (i.e., UE first enters any cell selection state and performs cell selection) should be reused when the UE cannot find a suitable cell using any cell reselection priorities (including slice-based and legacy (non-slice based) priorities) if the UE is configured with slice based dedicated priority.* * *7: Inter-RAT frequencies are not configured with slice specific frequency priority, but inter-RAT frequencies can be considered using legacy cell reselection frequency priority after all NR frequencies that support any slice/slice group.* * *8: The slice specific cell reselection information provided by the network in SIB is slice group specific.* * *10: Reuse the legacy T320 timer for slice specific frequency priority in RRCRelease.* * *11: RAN sharing can be supported for slice based cell reselection and RACH by network implementation (e.g. dedicated priorities in RRCRelease). We don't define PLMN-specific reselection priorities or RACH configuration. FFS if we need something extra in RACH (may not be critical to WI completion).* |

Every solution would sort the list of frequencies at least once according to its methodology. The main question here is about a need for “re-sorting” at some point in time. If the need for re-sorting is left to UE implementation, some UEs may do the “re-sorting” and others may not. In certain scenarios this may differently influence the outcome of slice based reselection procedure.

**Q1: Does your company consider this as a central feature of current work (i.e., not just an optimization) and prefer a consistent and testable slice based reselection outcome/ performance?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/ No** | **Comments** |
| Nokia | Yes |  |
| Qualcomm | No (it is not essential to finalize RAN slicing WI) | We don’t think specifying “re-sorting” procedure is essential to complete this WI:   * We are not sure what “re-sorting” means (and whether each company can have the aligned understanding by end of this meeting). * In some candidate CR, there is no need for “re-sorting” (e.g. [R2-2202514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2202514.zip) from Apple and BT, or [R2-2203071](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203071.zip) from Nokia) * In current TS 38.304, it is a continuous cell reselection procedure without any similar concept to mandate UE to “stop” and “re-sorting” frequency priority.   So, we suggest RAN2 can try to make progress in this meeting. But if no consensus is made by end of this meeting, we can conclude no need to specify it. |
| OPPO | Yes | Otherwise, there will be different cell reselection outcomes for a certain case. |
| CMCC | Prefer each frequency can appear multiple times in the sort pool, and no re-calculate is needed.  Acceptable for each frequency only appears once in the sort pool, and re-calculate is needed. | We understand the **re-sorting means a frequency can appear multiple times in the sort pool**. And this issue is related to whether re-calculate is needed if the highest ranked cell doesn’t support the selected slice. RAN2 need to make a decision on this issue. The following options are proposed in previous discussion:   * **Option 1: each frequency can appear multiple times in the sort pool, and no re-calculate is needed**. * **Option 2: each frequency only appears once in the sort pool, and re-calculate is needed if the highest ranked cell doesn’t support the selected slice.** * **Option 3: left to UE implementation**   We think that the candidate TP from Apple and BT (R2-2202514) *“A final single frequency ranked list to be considered by the UE is created from the concatenation of each individual slice or slice group frequency ranked list”* also means that a frequency can be sorted multiple times, same as option 1.  In addition, we agree with rapporteur that if this is left to UE implementation, this may differently influence the outcome of slice based reselection procedure and has negative impacts on network control. In order to avoid UE camping behaviour on the frequency unpredictable, we should avoid option 3 (left to UE implementation).  From our view, option 1 is simpler and straight forward. But if majority prefer option 2, we are also acceptable. |
| Spreadtrum | No for re-sorting | Share similar view with CMCC.  In our understanding, the “re-sorting” may not the exact focus we discussed in last week. If a frequency can be sorted multiple times, it will be assigned different frequency priorities in first sort, rather than in the midway of reselection.  In order to reduce UE complexity and guarantee predictable UE behaviour, we prefer to align with the legacy cell reselection procedure that the list of frequencies is sorted once. |

Further, a UE would receive **Slice reselection information** (Slice Info) from the serving cell, listing slice group support in neighboring cells and frequencies. Based on this a UE would have an accurate/ reasonable idea of which of its slice group (among slice groups with priorities received from NAS) is available i.e., supported by at least one neighbouring cell. So, the UE can measure and evaluate only those frequencies considered available based on the Slice reselection information.

**Q2: Do you agree that a UE can/ should limit its measurement and evaluation to only those frequencies considered available based on the Slice reselection information?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/ No** | **Comments** |
| Nokia | No | There can be frequencies that have no slice-based reselection information but have normal reselection information. The UE shall also perform measurements on those frequencies (as defined in Rel-16) before falling back to any cell selection state. |
| Qualcomm | No | Same view as Nokia.  In addition, we have agreed RAN4 work is out of scoping. So, there is not spec impact on measurement due to slicing, which means UE follows legacy way of measurement without optimization on slicing info. |
| OPPO | No | We also understand that all frequencies(including the ones without slice-based reselection information) should be measured before UE turns to any cell selection state. If we go with the proposed way as Q2, the measurement behaviour is different from what the UE does currently. |
| CMCC | No | Share similar views with Nokia and QC. We can focus on frequency priority handling and no impact on measurement. |
| Spreadtrum | Neutral | From our side, the above description benefits for shortening the process of reselection. However, the frequency that do not support slice will be added to end of the frequency priority list according to last week agreements.  To make it work, some modification to the rules is needed, like slice frequency and legacy frequency are considered separately (i.e., if no suitable cell is found on slice specific frequency, legacy frequency will be considered). |

### Understanding what is with and without re-sorting

Building on the previous question and based on the following agreed rule:

|  |
| --- |
| *a) Considering the slice/slice group priority provided by NAS, the frequencies that support higher priority slice/slice group have higher slice based frequency priority than the frequencies that support lower priority slice/slice group;*  *b) Among the frequencies supporting a slice/slice group with the same priority, the UE should follow the slice specific frequency priority received in SIB or RRCRelease (if configured);* |

Any solution works fine if the highest ranked cell of the first frequency (according to the above rules) supports the highest priority available slice group. Therefore, the question really is what happens when the best ranked cell on a frequency does not support a UE’s selected slice.

Based on the two rules above and companies’ response to the previous question, measurement/ evaluation of frequencies for Slice based reselection procedure starts with frequencies supporting its highest priority available slice group. As rule b) clarifies, the frequencies for a UE’s certain available slice group are listed in the slice specific frequency priority order. Now let’s take a very simple example where a UE has been signalled 2 slices (S1 and S2) from NAS with PriorityS1 > PriorityS2.

For S1 (available on f1 and f2): Priorityf1 > Priorityf2

For S2 (available on f1 and f3): Priorityf1 > Priorityf3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **without re-sorting** | |  | **with re-sorting** | |
| time instance | frequency | selected slice group | frequency | selected slice group |
| T1 | f1 | S1 | f1 | S1 |
| T2 | f2 | S1 | f2 | S1 |
| T3 | f3 | S2 | f1 | S2 |
| T4 | non-slice based frequencies | | f3 | S2 |
| T5 | non-slice based frequencies | |

The results for both methodologies (without/ with re-sorting) are consistent until time instance T2. At time instance T3, UE will measure/ evaluate f3 for S2 when no re-sorting is used, and f1 for S2 when re-sorting is used. In the latter case, as soon as the highest priority available slice does not yield (i.e., no successful reselections made for S1), UE prepares a frequency order list according to the next available slice. Of course, there can be other flavors e.g., when f1-S1 does not work at time T1end, UE selects the highest ranked cell on f1 if that supports any of the UE’s slice group. But such additional flavors are ruled-out due to the agreed rules a) and b).

**Q3: Do you agree that re-sorting only/ mainly applies when the slice based reselection procedure for the highest/ higher priority available slice group is exhausted without any yield (i.e., no successful reselections made) and there are still one or more slice group remaining?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/ No** | **Comments** |
| Nokia | Yes |  |
| Qualcomm | Yes, but | We are confused by Rapporteur’s wording in the question. We suggest to use below wording which are from [R2-2203271](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203271.zip) and R2-2203412 (we understand they are same. Let us know if any misunderstanding):  “Re-sorting is applied if the UE performs slice-based cell reselection and if the highest ranked cell, according to neighbouring cell information, does not support the highest priority slice supported by its frequency” |
| OPPO | Yes | While, Re-sorting is also applied for the frequencies which support other slices if the best ranked cell of that frequency does not support the highest priority slice on that frequency. Thus, the words proposed by Qualcomm seems more generic. |
| CMCC | See comments | We understand that this case may happen only when a frequency is sorted only once in the frequency order and the highest ranked cell doesn’t support the highest priority slice. If we agree that a frequency can be sorted multiple times, this case will not exist. |
| Spreadtrum | See comments | The issue that whether a frequency can be sorted multiple times should be discussed firstly.  If a frequency can be sorted multiple times for different slices, it will be assigned different frequency priority for different slices in the first sort, thus the case reporter listed will not happen. |

### Comparison:

Please find below a comparison table. **Companies kindly keep adding more benefits, shortcoming and even arguments in favor/ against argument made previously**:

Table 1

|  |  |
| --- | --- |
| Without re-sorting | |
| Benefits/ advantages | Shortcoming/ dis-advantages |
| 1) Easy UE implementation and specification | 1) Not optimal cell reselection from slice support perspective in some cases: E.g., it would fail to reselect to a higher priority frequency/ cell not supporting the highest priority slice, but supporting the 2nd highest priority available slice |
| 2) No re-measurements/ re-evaluation of the same frequency | 2) Triggers measurement/ evaluation of non-slice based frequencies too early |
| 3) Lower latency in cell reselection as no need either reevaluate measurements on a frequency or perform measurements multiple times on a frequency | 3) Please add |

And another table for with re-sorting case:

Table 2

|  |  |
| --- | --- |
| With re-sorting | |
| Benefits/ advantages | Shortcoming/ dis-advantages |
| 1) Optimal cell reselection from slice support perspective | 1) Re-measurements or at least re-evaluation will consume time and power *un-necessarily* if the reselections fail again for a freshly selected slice. |
| 2) There may be no need to measure a new frequency (f3 in the above example), if the reselection for a higher priority slice on an already measured frequency works out (S2 on f1) | 2) Optimization for measurements/ evaluation may need to be left for UE implementation. |
| 3) Please add | 3) It may result in longer cell reselection time and higher UE power consumption during cell reselection as it may require repeated measurements on some frequencies |

**Q4: Based on the above arguments, do you think slice based reselection procedure should be designed with or without re-sorting functionality?**

|  |  |  |
| --- | --- | --- |
| **Company Name** | **With or Without (re-sorting)** | **Comments** |
| Nokia | without re-sorting | 1) We think that there is no time to properly define a solution with resorting.  2) Resorting may have negative impact to the performance (cell reselection time and UE power consumption during cell reselection), as it may require repeated measurements on a frequency |
| Qualcomm | With re-sorting | We suggest to follow the way proposed in [R2-2203271](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203271.zip) and R2-2203412 (We understand they are same. Let us know if any misunderstand). They are simple: when the condition is met (i.e., best ranked cell doesn’t support highest priority slice), the UE re-calculates the frequency priority order by considering all slices except the highest priority slice.    The accurate wording can be:  “If the UE performs slice-based cell reselection and if the highest ranked cell, according to neighbouring cell information, does not support the highest priority slice supported by its frequency, the UE only considers the slices supported by the highest ranked cell among the NAS provided slice or slice group for slice specific prioritisation as in section 5.2.4.X for this frequency, until the highest ranked cell changes or NAS provides a new set of slices or slice groups.“ |
| OPPO | See comments | For measurement, we understand there should be no re-sorting and we understand that the UE only needs to measure each frequency once. The frequency priority of each frequency is associated with the highest priority available slice on that frequency.  For cell reselection criteria check, we need at most one re-sorting if the best ranked cell of one frequency does not support the highest priority available slice on that frequency. For this case, we use the frequency priority associated with the highest priority available slice on that cell (in the case that cell supports any UE intended slice) or use the legacy frequency priority of that frequency (in the case that cell does not support any UE intended slice). |
| CMCC | Prefer each frequency can appear multiple times in the sort pool, and no re-calculate is needed.  Acceptable for each frequency only appears once in the sort pool, and re-calculate is needed. | Same as our comments in Q1.  In addition, if there is no consensus on this issue, we try to provide **a compromise principle**:  If the best ranked cell does not support the highest priority slice supported by its frequency, the UE considers other NAS prioritized slices, but the exact method (e.g. a frequency sorted once + re-calculate, a frequency sorted multiple times + no re-calculate) can be up to UE implementation. |
| Spreadtrum | Without re-sorting | There is no need to introduce re-sorting. |

## Equal Priority case

Following is the situation from the Friday morning situation (RAN2#117)

*Proposal 4: FFS how to handle the frequency priority among the frequencies supporting the same slice/slice group with same frequency priority.*

*(7/19) Option 1: the frequency supporting maximum intended slices may be prioritized;*

*(13/19) Option 2: they are considered as equal priority;*

*(10/19) Option 3: up to UE implementation;*

From option 3, leaving this case to UE implementation will lead to different outcomes. Further, Option 2 is no different since a UE would need to prioritize “somehow” between the frequencies considered as equal priority. Is it then reasonable to say that there are really only two possibilities.

*Option 1: the frequency supporting maximum intended slices may be prioritized (an example TP is in R2-2202514)*

*Option 3: up to UE implementation*

***Q5: Do you agree that there are really only two options (1 and 3 above)?***

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/ No** | **Comments** |
| Nokia | No | There is a clear specification on handling equal priority NR frequencies in 5.2.4.6 ("Intra-frequency and equal priority inter-frequency Cell Reselection criteria") in 38.304. We do not understand why this cannot be applied in this case.  (Note also that option 2 was the most popular in the previous email discussion.) |
| Qualcomm | See comments | Same understanding as Nokia that we only need to follow legacy principle to handling equal priority frequency in 5.2.4.6. |
| OPPO | See comments | Similar understanding as Nokia and Qualcomm. If Option 2 is chosen, we can reuse the legacy principle. |
| CMCC | No |  |
| Spreadtrum | No | Option 2 should be preserved.  In our understanding, when using the option 2, all the frequencies that have the same equal priority will be measured. And the highest ranked cell among the cells on those frequencies will be selected as in legacy way. |

**Q6: Do you think this decision is one fundamental to the SI/ WI intention or can be considered an optimization?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes (=fundamental) / No (=optimization)** | **Comments** |
| Nokia | Yes | We think that there is a good reason that equal priority NR frequency reselection has been specified. |
| Qualcomm | Yes | Same view as Nokia |
| OPPO | Yes |  |
| CMCC | Yes |  |
| Spreadtrum | Yes |  |

**Q7: Finally, which Option do you prefer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option (1 or 3)** | **Comments (in case of Option 3, please indicate if you like to use a “Note” for this purpose)** |
| Nokia | Option 2 | Neither option 1 nor option 3 are acceptable. |
| Qualcomm | Option 2 with edit on wording | We only need to follow legacy principle to handling equal priority frequency in 5.2.4.6.  Thus, we suggest to modify option 2 as below (to avoid misunderstanding):  *Option 2: they are considered as equal priority, as the legacy way in section* *5.2.4.6 of TS 38.304* |
| OPPO | Option 2 |  |
| CMCC | Option 1 | If the frequency supporting maximum intended slices is prioritized, more slices are available for the UE.  Option 2 and 3 are also acceptable. |
| Spreadtrum | Option 2 | We are OK with option 2. |

## Text Proposals

For with re-sorting based solution, following TPs are available:

1. [R2-2203271](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203271.zip) Text Proposal for 38.304 on cell reselection for RAN slicing Samsung R&D Institute UK, Qualcomm Incorporated, OPPO discussion
2. [R2-2202514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2202514.zip) Text Proposal for slice based cell re-selection Apple, BT plc discussion Rel-17 NR\_slice-Core
3. [R2-2203183](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203183.zip) Way forward and TP for RAN Slicing solution Lenovo, Motorola Mobility discussion NR\_slice-Core

For without re-sorting based solution, following TPs are available:

1. [R2-2203071](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203071.zip) Slice-based cell reselection proposal Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_slice-Core
2. [R2-2203234](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_117-e/Docs/R2-2203234.zip) Cell reselection relevant open issues (38.304) NEC Telecom MODUS Ltd. discussion

**Q8: Based on your answer to Q4, kindly indicate which TP do you prefer and why.**

|  |  |  |
| --- | --- | --- |
| **Company** | **TP (1, 2, 3, 4 or 5)** | **Comments** |
| Nokia | 4 | As it is targeting a solution without resorting |
| Qualcomm | 1 | One of the proponents.  We think 1 most follows the following basic principle of current 38.304:   * Only rules are specified * The procedure how the UE realizes frequency prioritisations are not specified (e.g., it allows UE to a Matrix if it is capable of simultaneously evaluating more than 1 frequencies).   Because 5 basic rules have been agreed in last Friday, we think agreeing 1 will mean the CR work is finalized. |
| OPPO | 1 | It is aligned with what we already agreed and reflects our main intention. |
| CMCC | Prefer 2  Acceptable for 1 | As we comment in Q4, if there is no consensus, we try to provide **a compromise principle**:  If the best ranked cell does not support the highest priority slice supported by its frequency, the UE considers other NAS prioritized slices, but the exact method (e.g. a frequency sorted once + re-calculate, a frequency sorted multiple times + no re-calculate) can be up to UE implementation. |
| Spreadtrum | 1 | We prefer 1 as the starting point as it basically captures the rules achieved in last week. |