3GPP TSG-RAN WG2 #116-bis R2-21xxxxx

E-meeting, 17th – 25th Jan 2022

Agenda Item: x.x.x

Source: Ericsson

Title: [Post116-e][242][Slicing] Slice-based cell re-selection algorithm (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

This contribution summarizes the following discussion:

* [Post116-e][242][Slicing] Slice-based cell re-selection algorithm (Ericsson)

 Scope: Continue running CR for the 38.304 CR details. Should consider issues raised in discussion [AT116-e][241]. Also update CR based on meeting agreements. Should consider both previous running CR and Ericsson updates.

 Intended outcome: Running CR to 38.304

 Deadline: Long (December 17th, 0900 UTC)

Contact person(s) for each participating company:

|  |  |
| --- | --- |
| **Company** | **Email** |
| Ericsson | hakan.l.palm@ericsson.com |
| Nokia | gyorgy.wolfner@nokia.com |
| Qualcomm | chengp@qti.qualcomm.com |
| Huawei, HiSilicon | jun.chen@huawei.com |
| Intel Corporation | seau.s.lim@intel.com |

**Endorsed running CR**

[R2-2110239](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110239.zip) Running 38.304 CR for RAN slicing CMCC draftCR Rel-17 38.304 16.6.0 B NR\_slice-Core

* Endorsed as running CR (to be updated after the meeting, see discussion under 8.8.2 on CR structure)

**RAN2#115-e agreements**

Slice based cell reselection

**RAN2 needs to check with SA2/ CT1 if it is alright for AS to expect to receive slice list as well as slice priority information from NAS for cell (re)selection. Ask about both slices and slice groups.**

**2 Following is taken as the baseline for Solution Option 4:**

**The “slice info” (for a single slice or slice group) agreed to be provided to the UE in the last RAN2 meeting using both broadcast and dedicated signaling are provided for the serving as well as neighboring frequencies. The following steps are used for slice based cell (re)selection in AS:**

**Step 0: NAS layer at UE provides slice information to AS layer at UE, including slice priorities.**

**Step 1: AS sorts slices in priority order starting with highest priority slice.**

**Step 2: Select slices in priority order starting with the highest priority slice.**

**Step 3: For the selected slice assign priority to frequencies received from network.**

**Step 4: Starting with the highest priority frequency, perform measurements (same as legacy).**

**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 frequencies then go back to step 4.**

**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.**

**1: Solution Option 4 is selected for further work i.e., resolve the FFSs, send any required LSs and consequently start to draft specification CRs.**

**Other solutions can be discussed based on company contributions (with technical analysis) next time.**

**After online session, it was noted that the solution 4 FFSs were not resolved. Email discussion is assigned to try to tackle those (as they may involve LS to RAN4).**

**RAN2#116-e discussions and agreements**

[R2-2109725](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2109725.zip) [Post115-e][244][Slicing] Resolving FFSs for solution 4 (Lenovo) Lenovo, Motorola Mobility (Rapporteur) discussion Rel-17 NR\_slice-Core

Slice support of neighbour cells

*Proposal 1: A serving cell provides slice support of neighbour cells.*

- Ericsson thinks this relates to P3 and intra-frequency should not be needed.

- Xiaomi agrees but thinks some other information is also needed.

- QC is fine but thinks the wording makes it mandatory for network. Should make it optional.

- ZTE agrees with the principle and slice info should be per frequency. Can discuss details later. LGE and CMCC agree. Samsung agrees with the updated version with "can".

* 1: A serving cell can provide slice support of neighbour cells.

*Proposal 3: Use SIB3 for broadcasting slice info of intra-frequency neighbor cells.*

- Lenovo thinks that two cells can have different slice information in the same frequency if they belong to different TAs. That's why P3 is still needed. LGE agrees.

- QC has concern to use legacy SIBs. Should use new SIB e.g. to avoid SIB segmentation. LGE agrees.

- Apple is fine with P3/4 and thinks frequency ranking process considers intra-frequency and UE needs the slice info there. Best cell principle is still upheld.

- Huawei thinks the same discussion was done in the running CR discussion. Could consider alternatives first and then decide.

- Ericsson asks if UE should prioritize intra-frequency reselection based on slice info? Or should UE just use the best cell principle? Lenovo indicates this was discussed earlier and we didn't want to change the trigger conditions for reselection. So intra-/inter-frequency reselections would be triggered as in legacy. No new measurements are needed. Ericsson thinks why do we need it then if it's not used? Lenovo explains we need to take the different slice support into account.

- QC, Intel support best cell concept (as in legacy).

* Best cell principle for intra-frequency cell reselection should be maintained i.e. UE camps on the strongest cell according to existing cell reselection rules.
* Network broadcasts slice info for the purpose of inter-frequency reselection. This will also need slicing priority for the serving frequency. FFS in which SIB.

*Proposal 3: Use SIB3 for broadcasting slice info of intra-frequency neighbor cells.*

*Proposal 4: Use SIB4 for broadcasting slice info of inter-frequency neighbor cells.*

*Proposal 2: RAN2 further discuss how the slice support of neighbour cells can be optimally provided.*

LS to RAN4?

*Proposal 5: RAN2 send LS to RAN4 explaining the scenario and checking if measurements can be reused between different iterations (due to Step 7).*

* RAN4 is not in the scope of the WI

[R2-2110699](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110699.zip) Slice-based cell re-selection algorithm Ericsson discussion Rel-17 NR\_slice-Core

*Observation 1 The cell re-selection procedure as currently described in draft running CR to TS38.304 does not correctly cover the fallback from slice-based cell re-selection to legacy cell re-selection.*

*Observation 2 RAN2 should select the algorithm for deriving the SliceBasedReselectionPriority based on the wanted cell re-selection behaviour. There is no need to take algorithm complexity into account, since re-selection performance is not impacted.*

*Proposal 1 We ask RAN2 to agree that Slice Based Cell re-selection, just as in legacy, shall be based on reselection priorities for all frequencies that the UE may use. The priorities used may be called ‘SliceBasedReselectionPriorities’.*

*Proposal 2 We ask RAN2 to accept the TP in Appendix A.*

*Proposal 3 We ask RAN2 to discuss what behaviour is preferred for Slice Based Cell re-selection and agree on the algorithm for calculating the SliceBasedReselectionPriorities.*

*Proposal 4 We ask RAN2 to accept the TP in Appendix C.*

*Proposal 5 A new section is used to describe the calculation of a temporary reselection priority. The content of that section depends on what algorithm is selected for calculating the frequency SliceBasedReselectionPriorities.*

- Ericsson explains this tries to align with existing procedure and doesn't introduce new measurements.

- Nokia supports the proposal in principle: The outcome will be the same as in the procedure in current running CR, and this way the UE procedures are clearer. Some small clarifications can be discussed.

- Intel also promoted similar concept earlier and supports this. Thinks the current running CR is not exactly the same, determining frequency priorities is different.

- CMCC also supports the intention of the approach. Shuld also consider other slices than highest priority slice.

- QC thinks this is technically better than existing running CR but thinks this is late change and it looks complex. Don't need multiple algorithms.

* There is suppport to go with this approach.
* Offline discussion [241] (Ericsson) to sort out the details of this solution. If no problems are found, we adopt this approach in the running CR. We try to decide in 2nd week CB session.

[R2-2111566](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2111566.zip) Summary of [AT116-e][241][Slicing] Slice-based cell re-selection algorithm (Ericsson) Ericsson discussion Rel-17 NR\_Slice-Core Late

*Proposal 1 Continue with (short?) email discussion to conclude whether to adopt the TP provided in Annex B in the 38304 running CR.*

- Lenovo thinks we have many open issues so should rather progress running CR. Intel thinks this is not alternative but work on the details of solution 4. The approach allows those details to be captured well. Nokia agrees.

- Lenovo wonders what is the baseline CR? Thinsk we could consider both alternatives to ensure we have a working CR in the end. Xiaomi agrees.

* Post-meeting email discussion to conclude the questions raised in [AT116-e][241] via the running CR.

# 2 Discussion

## 2.1 Introduction

In section 2.2.1 “UE Cell re-selection behaviour in Solution 4 variants”, we ask companies to discuss which slice-based cell reselection variant based on Solution 4 to use. This is a general topic, independent of TP discussions.

In section 2.2.2 and 2.2.3, we ask companies to discuss the existing TP in running 38.304 CR (Annex A), and the Alternative TP (Annex B), and finally we ask companies to provide their preference on TP alternative to use.

In section 2.3 we ask companies to discuss the UE behaviour when UE discovers that the best cell on the target frequency does not support the preferred slice.

In section 2.4, we ask companies to provide other comments on the 38.304 running CR.

## 2.2 Selecting frequencies for slice-based cell reselection

### 2.2.1 UE Cell re-selection behaviour in Solution 4 variants

Before discussing TP for cell re-selection, we need to agree on the wanted UE behaviour. Some alternatives/simplifications on the Solution 4 have been raised

In order to describe the UE’s behaviour with different Solution 4 alternatives, we will use a simple NW scenario with three frequency bands, where F1 and F2 provide full/continuous coverage, and F3 have partial coverage. There are three slices: slice A, slice B and slice C, which is the default slice. This is illustrated in figure 1

We will investigate 3 example UE’s:

1. UE 1 is in coverage of all cells. The prioritized slices are in priority order: {A, B}
2. UE 2 camped on cell 2, loses cell 2 coverage, and is in coverage of cells 1 and 3. The prioritized slices are in priority order: {A, B}
3. UE 3 is in coverage of all cells. The prioritized slices are in priority order: {B, A}

All UE’s have ongoing services on slice A and B, so the wanted behaviour is that the UE should when possible camp in cell 2, where both slice A and B are served. When out of coverage of cell 2, the UE’s should camp in cell 3, so that at least slice B can be served.

Frequency band F1

**Broadcasted Frequency Priorities**

There are slice-specific frequency priorities for slice A and B, but not for slice C.
Legacy reselection priorities are used for the (default) slice, C

|  |  |  |  |
| --- | --- | --- | --- |
|  | F1 | F2 | F3 |
| Slice A | - | 1 | - |
| Slice B | - | 1 | 2 |
| Slice C | (3) | (2) | (1) |

Frequency band F2

Frequency band F3

#### Solution Alternatives

With the **original solution 4**, the UE first uses the frequency priorities of the highest priority slice, and if no cell is found, it will use the priorities of other slices in priority order, and at last it will use legacy priorities.

With this solution, UE1 would select F2, since that is the only frequency supporting slice A, which is of highest priority. UE2 would select F3, since slice B is considered when slice A is not accessible.

UE 3 would select F3, since that frequency have highest priority for slice A. F3 does not support slice B, so UE would only be able to access slice A.

There are also two simplified alternatives of solution 4 discussed. One alternative is that if slice A is not available, the lower priority slices are not considered, but legacy priorities are used directly. The other alternative is that neither other slices or legacy priorities are considered. For these solutions, the behaviour will be similar as the original solution 4 for UE1 and UE3.

For UE 2, in the first alternative, when slice A is not accessible, legacy priorities will be used, and UE 2 will select F1, which only supports the default slice C. With the second alternative, when cell 2 (and slice A) is not accessible, the UE will after losing cell 2 coverage trigger cell selection, and may end up on either cell 1 or cell 3. There is no means to steer the UE camping.

In the table below, the UE’s camping frequency is shown for the different algorithms. It is marked with orange when the wanted slices are not available, and red when there is means to steer the UE.camping by re-selection priorities.

Table 1 Final Camping frequency of UE

|  |  |  |  |
| --- | --- | --- | --- |
|  | **UE 1** | **UE 2** | **UE 3** |
| 1. Ideal behaviour
 | F2 (Slice A&B) | F3 (Slice B) | F2 (Slice A&B) |
| 1. Solution 4, Original
 | F2 (Slice A&B) | F3 (Slice B) | F3 (Slice B) |
| 1. Solution 4, Only highest prio slice considered.
 | F2 (Slice A&B) | F1 (Slice C) | F3 (Slice B) |
| 1. Solution 4, Only first prio slice considered, legacy priorities not considered.
 | F2 (Slice A&B) | Short loss of coverage, unspecified cell camping. . | F3 (Slice B) |

It can be noted that with solution 4, the wanted behaviour will not be achieved for UE 3, since the support for slice B is not considered if frequencies supporting slice A are found

**Q1: Do you agree with the analysis (Yes/No), and which of behaviours A-D do you think is preferred/acceptable, e.g. when taking algorithm complexity into account?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes/No** | **Preferred behaviour** | **Comments** |
| Nokia | Yes | A, but B and C are also acceptable | Note that the purpose of slice aware cell reselection is to specify a solution that works well in most of the cases. |
| Qualcomm | Yes | A and C | Option B is not acceptable to us because we don’t see much performance difference between Option B and C (they both can’t work for UE3) but Option B introduced extra /complex slice looping.We also don’t prefer Option D because it will cause unspecified UE behavior for UE2 and it can be simply improved by considering legacy priority (i.e. Option C). By the way, we don’t understand what below text means:“where F1 and F2 provide full/continuous coverage, and F3 have partial coverage.“And it seems to be misaligned with the figure. Thus, we suggest company to ignore this text. |
| Huawei, HiSilicon | Yes | C | We wonder how option A is considered as ideal behaviours. For UE3, we think it should camp on F3 as indicated by network configuration. So Option C should also be the ideal behaviour.In addition, we also have the following comments regarding the text above:**Firstly**, we think the above text “F1 and F2 provide full/continuous coverage, and F3 have partial coverage” seems to contract with the figure above, i.e. F3 have partial coverage, but Cell 2 is actually smaller than other cells in the figure.**Secondly**, the following text is strange, and it seems more about option 5 (in previous RAN2 discussion). In addition, here it is saying the UE should move from Cell 2 (full coverage) to Cell 3 (partial coverage), what is the motivation of doing this?All UE’s have ongoing services on slice A and B, so the wanted behaviour is that the UE should when possible camp in cell 2, where both slice A and B are served. When out of coverage of cell 2, the UE’s should camp in cell 3, so that at least slice B can be served.In the example, the email rapp does not provide the type of slices, and we think it is very important, otherwise, any companies can list any scenarios for slicing, which will cost a lot of time for RAN2.In our opinion: Slice C is obviously eMBB slice Slice A should be eMBB sliceFor Slice B and C, if they are URLLC slices, it depends on network policies, e.g. if there is no F3 coverage, the network should prioritize F2 for such URLLC slices; if there is F3 coverage, maybe F3 is higher priority than F2 |
| Intel | Yes (apart from some typos as pointed out above) | A or B | In our view, this analysis just shows that the slice based frequency priorities need to be considered for the frequencies that they are assigned. Without that, the UE may end up without coverage or end up not using the slice based frequency priority assigned (i.e. end up using legacy priorities). This can be observed with behaviours C and D where the frequency priority of only the highest priority slice is considered. This can be resolved by assigning the frequency priority for a frequency/cell corresponding to that of the highest priority slice supported on that frequency/cell - the alternative TP as in Section 2.2.3 or perform the iteration as in Step 7 in the existing TP for solution aims to achieve that in different ways. However, performing the iteration as in the original solution 4 will have other issues as highlighted by the rapporteur.We are actually not sure where solution D was taken from. |

### 2.2.2 TP from running CR (See Annex A)

In Annex A, the relevant parts of the TP in the 38.304 running CR [2] are presented.

In the TP, the cell re-selection process is performed in **two iterations**.

* In the first iteration, the frequency priorities of the highest prioritized slice are used
* In the second iteration the legacy priorities are used.

This corresponds to the “simplified solution 4”, with only first prio slice considered (C), not taking lower priority slices into account.

There are issues with the TP, as expressed by companies in Tdocs and previous email discussions:

1. Cell re-selection is an ongoing process of evaluating the cell re-selection criteria. The second iteration with “fallback to legacy re-selection”, will not be performed, unless an exit condition is added to the first iteration. And after having fall-backed, there is no return to again toke slice priorities into account.
2. The TP is not aligned with how existing cell re-selection is described in 38.304. It is not clear how current TP interacts/relates to existing specification text, e.g.
	1. 5.2.4.2 Measurement rules for cell re-selection current cell re-selection
	2. 5.2.4.5 NR Inter-frequency and inter-RAT Cell Reselection criteria
3. The TP describes a simplified version of solution 4, as mentioned above.
4. Since only a subset of the frequencies are considered in the first iteration, a UE in bad coverage may experience additional delay before it re-selects to a frequency with better radio conditions.
5. Some frequencies will have both slice specific frequency and legacy priorities. This may need additional measurements, unless measurements can be re-used between iterations (RAN4 impact?)

**Q2: Do you agree with these issues (Yes/No)? Are there more issues with this solution?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes |  |
| Qualcomm  | Yes | Besides the issues list above, we also see below other issues:1. It is not clear how frequency priority is assigned to inter-RAT frequencies. For example, we may have below alternatives
	* Alt-1: legacy LTE frequency priority is assigned
	* Alt-2: no frequency priority is assigned (i.e., LTE frequency can’t be reselected always
	* Alt-3: lowest frequency priority is assigned to LTE frequencies.

 Not sure whether companies have same understanding. 1. It is not clear what “the highest ranked cell is suitable (as defined in 38.304)” means. We think there are two different understandings on it among companies:
	* Understanding 1: It means that highest ranked cell only needs to satisfy the definition of “suitable” specified in clause 4.5 of TS 38.304.
	* Understanding 2: It means that highest ranked cell needs to satisfy both the definition of “suitable” specified in clause 4.5 of TS 38.304 and inter-frequency reselection criteria specified in clause 5.2.4.5 of TS 38.304.
2. It is not clear what is the Validity time of slice specific frequency priority (i.e., if the UE performs legacy cell reselection due to failures with slice specific frequency priority, it is not clear when the UE can use the slice specific frequency priority again).
 |
| Huawei, HiSilicon | Yes |  |
| Intel | Yes | The approach taken in the draft CR and Annex A is that the slice based cell reselection replaces the existing cell reselection mechanism. This approach requires us to develop a new complete solution for slice based cell reselection that also includes the behaviours and interactions defined in Clauses 5.2.4.2 [Measurement rules], 5.2.4.3 [Mobility States], 5.2.4.4 [Cell restriction], 5.2.5.5 [priority cell reselection criteria], 5.2.4.6 [cell ranking], 5.2.4.8 [Inter-RAT cell reselection in RRC\_Inactive state] and 5.2.4.9 [Relax measurement]). Clause 5.2.4.2 [Measurement rules]. Simply referring to these sections does not capture the interactions between them and slice based cell reselection and this is the primary cause of the issues listed above.For example, in the draft CR, it is unclear of how and when the slice based cell reselection is initiated after the first cell reselection; cell reselection is a continuous process and when in that process does this happen? Even during the slice based cell reselection, when the UE is going through one loop related to a selected slice, the legacy cell reselection mechanism has to apply together with inter-RAT handling. This means that the frequency priorities for the selected slice is also handled together with inter-RAT cell reselection priorities when the UE triggered by Clauses 5.2.4.2 [Measurement rules] is searching for a suitable cell based on the cell reselection criteria in Clauses 5.2.4.5 [priority based cell reselection criteria involving inter-frequency and inter-RAT cells) and 5.2.4.6 (cell ranking for intra-frequency cell). If inter-RAT cells are not considered when the UE is applying slice based cell reselection, it will not perform inter-RAT cell reselection at all which does not seem to be logical. For inter-RAT handling, with Annex A, the network will never be able to provide a higher priority to an inter-RAT as long as slice based cell reselection is applicable. For example, it should be possible for an operator to make LTE higher priority than NR for eMBB. With looping in solution 4, UE will continue to apply slice based cell reselection as long as any of the slices (eMBB) is available and UE will never have a priority for an inter-RAT carrier and will not be able to prioritise an inter-RAT carrier. As seen in behaviour C and D, if frequency priorities are not assigned for the frequencies that are available, the UE may lose coverage as there no reselectable frequency or end up using legacy priorities without considering the frequency priorities of other slices. Our understanding of the original solution 4 is that the looping through the slice list is just a form of modelling to determine the frequency priorities for NR. The TP in Annex B ensures that the available frequencies are assigned with frequency priorities as provided by the sliced based frequency priorities.One other issue without looping through the slice list is that UE may always end up using the legacy cell reselection. As mentioned in our contribution R2-2109616, in our understanding, the NAS provided list should include not only the Allowed NSSAI but also Requested NSSAI which the UE may have requested during registration that are not supported in the current registration area. We think this is essential for UE to be able to reselect to a cell in a different TA that is offering an additional slice. If we strictly follow step 2 as stated, then in our understanding, if the highest priority slice in the UE slice list provided by NAS (i.e., URLCC) is not available in any of the frequencies in the coverage region of the UE and Step 7 is removed (and not replaced by some other mechanism), the UE will fall back to legacy reselection mechanism. That is, a consequence of not supporting step 7 in the current solution 4 seems to be that UE will fall back to legacy frequency prioritisation if the highest priority slice is not found. For example, if a UE has URLLC and eMBB in its slice list from NAS, and URLLC is not available in any of the inter-frequency cells in that geographical region, UE will fall back to legacy reselection and will not follow the slice based frequency priority for eMBB. |

**Q3: Do you have proposals to solve these issues? (Can also propose new/draft text proposal inline in Word comments in Annex A)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Nokia | No |  |
| Qualcomm  | Yes | For the 3 issues we list in Q2, our proposals to fix them:1. We prefer Alt-3: i.e., lowest frequency priority is assigned to LTE frequencies
2. We prefer Understanding 2. So, clarify that condition “If the highest ranked cell is suitable (as defined in 38.304)” in Step 5 means that highest ranked cell needs to satisfy both the definition of “suitable” specified in clause 4.5 of TS 38.304 and inter-frequency cell reselection criteria specified in clause 5.2.4.5 of TS 38.304.
3. Clarify that after slice specific frequency priority is changed (e.g., the UE camps in a new cell, slice specific frequency priority in SIB is changed, or gNB sends a new slice specific frequency priority via RRC release), the UE performs slice specific cell reselection from highest priority slice when inter-frequency cell reselection is triggered.
 |
| Huawei, HiSilicon | Yes | Our responses are as below (for listed 5 issues):1. Cell re-selection is an ongoing process of evaluating the cell re-selection criteria. The second iteration with “fallback to legacy re-selection”, will not be performed, unless an exit condition is added to the first iteration. And after having fall-backed, there is no return to again toke slice priorities into account.

[Huawei] For the 2nd sentence, one alternative is to add a timer for UE doing slice based cell reselection.For the 3rd setence, please refer to our responses to 3) below (related to the issues provided by Qualcomm).1. The TP is not aligned with how existing cell re-selection is described in 38.304. It is not clear how current TP interacts/relates to existing specification text, e.g.
	1. 5.2.4.2 Measurement rules for cell re-selection current cell re-selection
	2. 5.2.4.5 NR Inter-frequency and inter-RAT Cell Reselection criteria

[Huawei] the existing sections should be reused as much as possible.1. The TP describes a simplified version of solution 4, as mentioned above.

[Huawei] more time to check.1. Since only a subset of the frequencies are considered in the first iteration, a UE in bad coverage may experience additional delay before it re-selects to a frequency with better radio conditions.

[Huawei] it is related to network deployments and configurations.1. Some frequencies will have both slice specific frequency and legacy priorities. This may need additional measurements, unless measurements can be re-used between iterations (RAN4 impact?)

[Huawei] it can be up to UE imlementation.For listed issues provided by Qualcomm, our responses are as below:For 1), we think that the UE will not consider inter-RAT measurements, and when the UE fallback to legacy cell reselection, the legacy inter-RAT measurements will be applied (legacy behaviours).For 2), we prefer understanding#2.For 3), we think that after the fallback, the UE will perform legacy cell reselection and select a suitable cell, so this cell reselection is over. From the network cell reselection procedure, the UE will start slice based cell reselection. |
| Intel |  | We think Annex B approach can solve these issues. |

### 2.2.3 Alternative TP (See Annex B)

In [1], Ericsson presented TP that aims to avoid the issues raised with the existing TP.

By calculating (new) reselection priorities for frequencies that have slice-specific priorities, all frequencies (with and without slice-specific priorities) are considered with the existing cell reselection principles. Existing specification text are retained without impact

This method ensures the original/complete solution 4 is used, i.e. also taking also lower priority slices into account.

**Q4: Do you agree that alternative TP in Annex B covers original/complete solution 4 (B)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes, but | Additional specification is needed in 5.2.4.5 to specify the case when the "best" cell on a band does not support the slice (group) used to select the band |
| Qualcomm | See comments | In high level, we agree that the method ensures the original/complete solution 4 is used, i.e. also taking also lower priority slices into account. However, the current TP is not acceptable to us (see our comments in Q5).  |
| Huawei, HiSilicon | No | In table 1, it is listed all possible UE camping behaviours, and we wonder whether both solutions will lead to the same UE behaviours. More justifications are needed.In addition, as we stated in the email report R2-2111566, lots of issues would be introduced and it will take RAN2 more time to check the new issues, e.g. the new formular and relevant UE/NW behaviours. |
| Intel | Yes, in principle | We agree with the general approach of Annex B as it integrates the slice based cell reselection into the existing cell reselection mechanism. That is all of the existing cell reselection procedures and interactions with regard to Clauses 5.2.4.2 [Measurement rules], 5.2.4.3 [Mobility States], 5.2.4.4 [Cell restriction], 5.2.5.5 [priority cell reselection criteria], 5.2.4.6 [cell ranking], 5.2.4.8 [Inter-RAT cell reselection in RRC\_Inactive state] and 5.2.4.9 [Relax measurement] are all applied also for slice based cell reselection and the only difference is the assignment of the frequency priority for a carrier.The formula captured in Annex B is one mechanism of assigning the priorities for the frequencies corresponding to that of the highest priority slice available on that frequency. We are open to other ways of achieving this as well.We also note that both Annex A and Annex B solutions require the UE to be explicitly provided with slice priorities by NAS. If slice priority is not provided by NAS and is left to UE implementation, both TPs (Annex A or B) only provides part of a solution and will not result in a known and specified or network controlled outcome in terms of which frequency will be prioritised by the UE. For Annex B, if slice priority is left to UE implementation, one way is that we can consider that the slice priority is set to 0 and the frequency priority of a frequency is then based on the slice based frequency priority broadcast or via dedicated signalling, i.e.SliceBasedReselectionPriority = SliceReselectionPriority,Hence if slice priority is not provided by NAS, RAN2 will need to consider other AS procedure or some implicit mechanism for assigning frequency priority for slice based cell reselection that also considers slice priority.  |

**Q5: Do you see any issues with this TP?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes | Additional specification is needed in 5.2.4.5 to specify the case when the "best" cell on a band does not support the slice (group) used to select the band, see Q6 |
| Qualcomm | Yes | We do not agree to use the below formular in Section 5.4.2.x of Annex B to calculate slice specific frequency priority: *SliceBasedReselectionPriority = SlicePriority \* MaxReselectionPriorityValue + SliceReselectionPriority** First, we do not prefer to use a formular in TS 38.304. If necessary, one description is sufficient. Note that there is not any formular captured in TS 38.304 up to now, and we don’t think RAN2 should open the door for it due to a small feature.
* Secondly, it is possible that SA2 will agree *SlicePriority* (i.e. priority among intended slice) is left to UE implementation. Then, it doesn’t make sense to use it to calculate slice specific frequency priority.
* Thirdly, the main intention of the formular is to ensure frequency priority of a high priority slice is larger than frequency priority of a low priority slice. However, we believe Network implementation can ensure it (i.e., NW assigns a higher frequency priority for a slice with higher priority). Thus, we believe this formular is not necessary.

Thus, we suggest to remove the formular and not explicitly couple slice specific frequency priority with *SlicePriority.* |
| Huawei, HiSilicon | Yes | Share similar views as Qualcomm. |
| Intel | No | The only issue is if it is found that the neighbour cell support slices that are different to the frequency level. Our understanding is that this is to be discussed in Section 2.3 |

**Q6: Do you have any change proposals for the TP? (Can also propose new/draft text proposal inline in Word comments in Annex A)**

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  | Text proposal for clause 5.2.4.5 can be based on text proposal of [R2-2111566](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs/R2-2111566.zip):Otherwise, cell reselection to a cell on a lower priority NR frequency or inter-RAT frequency than the serving frequency shall be performed if:- The serving cell fulfils Srxlev < ThreshServing, LowP and a cell of a lower priority RAT/ frequency fulfils Srxlev > ThreshX, LowP during a time interval TreselectionRAT; and- More than 1 second has elapsed since the UE camped on the current serving cell.If one or more cells fulfil the above criteria for cell reselection with reselection priority values larger than [10] calculated as defined in 5.2.4.x, the UE shall validate whether sliceFrequencyPriority applies for the cell(s). If sliceFrequencyPriority does not apply for a validated cell, the UE shall use the c*ellReselectionPriority* for that frequency if any, and the UE shall not use sliceFrequencyPriority for this frequency for 300 seconds or until new slice priorities is received from NAS.NOTE: If there is no cellReselectionPriority for the frequency, or a cell with the cellReselectionPriority of the frequency does not fulfil the above criteria for cell reselection, the UE will not consider this cell as a candidate for cell reselection.Cell reselection to a higher priority RAT/frequency shall take precedence over a lower priority RAT/frequency if multiple cells of different priorities fulfil the cell reselection criteria. |
| Qualcomm | We have strong concern on the formular in Section 5.4.2.x. Thus, we propose to change it to below text:“For frequencies with a slice specific frequency priority for at least one slice in the slice list, the SliceBasedReselectionPriority is the slice priority frequency of the highest prioritized slice supported by the UE on the frequency ~~calculated by the formula:~~ ~~SliceBasedReselectionPriority = SlicePriority \* MaxReselectionPriorityValue + SliceReselectionPriority,~~~~where SlicePriority is the priority of the highest prioritized slice for which the UE have received~~ *~~SliceSpecificFrequencyPriority~~* ~~on the frequency. MaxReselectionPriorityValue is a constant which is higher than the maximum reselection priority, and SliceReselectionPriority is the~~ *~~SliceSpecificReselectionPriority~~* ~~of the highest prioritized slice on the frequency.”~~ In addition, we suggested below changes on some detailed issues:1. On ”the UE shall not use sliceFrequencyPriority for this frequency until the highest ranked cell changes on the frequency or until new slice priorities is received from NAS.”

We think the current CR just list two conditions to apply sliceFrequencyPriority: 1) the highest ranked cell changes on the frequency; 2) new slice priorities is received from NAS. However, we think one more condition is missing: 3) sliceFrequencyPriority is changed (e.g. the UE camps in a new cell, or sliceFrequencyPriority is changed in SIB, or gNB send new sliceFrequencyPriority via RRC release)1. One related issue is that if the UE uses c*ellReselectionPriority* because sliceFrequencyPriority does not apply, the UE may need to re-evaluate criteria of inter-frequency reselection criteria (below) because it depends on priority value of serving frequency and target frequency. Since the UE changed priority value of target frequency, one cell satisfying criteria (under high priority value) may not satisfy the criteria any more (under the legacy priority).

If *threshServingLowQ* is broadcast in system information and more than 1 second has elapsed since the UE camped on the current serving cell, cell reselection to a cell on a lower priority NR frequency or inter-RAT frequency than the serving frequency shall be performed if:-    The serving cell fulfils Squal < ThreshServing, LowQ and a cell of a lower priority NR or E-UTRAN RAT/ frequency fulfils Squal > ThreshX, LowQ during a time interval TreselectionRAT.Otherwise, cell reselection to a cell on a lower priority NR frequency or inter-RAT frequency than the serving frequency shall be performed if:-    The serving cell fulfils Srxlev < ThreshServing, LowP and a cell of a lower priority RAT/ frequency fulfils Srxlev > ThreshX, LowP during a time interval TreselectionRAT; and |
| Huawei, HiSilicon | Prefer to use Annex A for more discussions. |

In summary, we ask companies to indicate their preference whether to use/evolve the existing TP (Appendix A) or use the Alternative TP (Appendix B)

**Q7. Which specification approach to you prefer**

1. **Use TP according to Appendix A**
2. **Use TP according to Appendix B**

|  |  |  |
| --- | --- | --- |
| **Company** | **A/B** | **Comments** |
| Nokia | B |  |
| Qualcomm | A removing FFS or B removing formular  | Our preference is: A removing FFS on slice looping > B removing formula in Section 5.4.2.x (as we suggested in Q5). |
| Huawei, HiSilicon | A |  |
| Intel | B |  |

## 2.3 Actions if wanted/prioritised slice is not supported in highest ranked cell on target frequency

### 2.3.1 Introduction

In [1], we (Ericsson) provided a TP for section 5.2.4.5 in 38.304, as well as a new section describing the UE’s actions when UE detects that the wanted/prioritised slice is not supported on the cell of the target frequency. Several companies had comments and other proposals on how to solve the issue.

Before discussing details in the TP’s, we think the wanted behaviour should be discussed. In short, this is the Ericsson proposal:

1. Recalculate the frequency priority based on slices supported in current cell.
2. Re-evaluate if the cell fulfills the cell re-selection criteria.
	1. Yes - > Reselect Cell
	2. No - > Continue cell re-selection procedure, using the recalculated frequency priority for this frequency until the highest ranked cell changes on the frequency.

**Q7: Do you agree with the main outline of the solution (Y/N)? (If not, provide alternative.)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Nokia | No | 1) We prefer the use of legacy (non-slice aware) frequency priorities (option B of Q8) for this case.2) As the UE may never need to make any measurements on the frequency after not selecting the cell due to unsupported slices (e.g., the frequency has no other priority) a timer-based solution looks simpler (Option B of Q9) |
| Qualcomm  | Yes |  |
| Intel | Yes (with comments) | In principle we agree with this approach. Step 1 is needed if we are to consider the slice availability at a cell level as was agreed by RAN2. However, in our understanding, this “recalculation” of priority is for the neighbouring cell (note that by “cell” here, the calculation is done for the highest ranked cell but we will work with priorities per frequency) rather than current cell (we don’t think this is really a “recalculation” as such as the priority of that particular cell was not directly calculated before). For example, while the UE is in cell A, and cell B is the highest rank cell, then “recalculate” the priority of frequency of cell B based on the slices available in cell B (that is, this recalculation is done while the UE is still in Cell A). The step 2 in our understanding is part of the normal reselection procedure after the re-assignment of the priority for the cell B.  |

### 2.3.2 Frequency priority when wanted/prioritised slice is not supported in highest ranked cell on target frequency

In Ericsson proposal in [1], the frequency priority is re-calculated the frequency priority for solution 4. It has also been proposed that the UE should use legacy priorities (to simplify).

In the following example, we show the difference between the two methods. In Figure 2, a network configuration is shown.

**Broadcasted Frequency Priorities**

Legacy priorities are used for the slice C (default), while there are specific priorities for slice A & B.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Cell 1 | Cell 21 | Cell 21 |
|  | F1 | F2 | F1 | F2 | F1 | F2 |
| Slice A | - | 1 | - | 1 | - | - |
| Slice B | - | 1 | - | 1 | - | 1 |
| Legacy | 2 | 1 | 2 | 1 | 2 | 1 |

Figure 2 Example NW configuration

Frequency band F2

Frequency band F1

Example:

The prioritized slices of a UE are A and B, in priority order. The UE is in IDLE mode with ongoing services in slice A and B, and is camping in Cell 21. UE moves into the coverage area of cell 22.

This is the UE’s actions for cell re-selection if the frequency priorities are re-calculated:

1. Based on slice specific broadcast from cell 21, the frequency priority of F2 is highest. Cell 22 is highest ranked cell on the frequency.
2. Evaluate slice support on cell 22 -> Slice A is not supported.
3. Re-calculate slice priority for the frequency, (still using parameters broadcasted in cell 21, but assuming slice A is not supported): F2 have still highest priority, since slice B is supported in cell 22.
4. UE camps in cell 22
5. Register in cell 22, since new RA. -> PDU session on slice A closed, but continue using slice B.

If legacy priorities are used instead of re-calculated priorities, the UE’s cell re-selection will follow the steps:

1. Based on slice specific broadcast from cell 21, the frequency priority of F2 is highest. Cell 22 is highest ranked cell on the frequency.
2. Evaluate slice support on cell 22 -> Slice A is not supported.
3. Use legacy frequency priorities -> F1 is highest prio.
4. UE camps in cell 1
5. Register in cell 1, since new RA. -> PDU sessions on slice A and B closed.
6. AMF signals a Target NSSAI with slice A and B, and a RFSP with frequency F2 prioritized.
7. Cell 1 signals dedicated frequency priorities to UE with F2 prioritized.
8. UE camps in cell 22
9. Register in cell 22, since new RA. ->UE may start new PDU session on slice B.

It can be noted that this example is just a special case, and in many other scenarios, the legacy priorities will work just as good as re-calculated priorities. However, the re-calculated priorities will ensure that the UE directly camps on the frequency prioritized by solution 4.

**Q8: What frequency priorities should UE use to re-evaluate cell reselection?**

1. **Re-calculated frequency priorities**
2. **Legacy frequency priorities**

|  |  |  |
| --- | --- | --- |
| **Company** | **A/B** | **Comments** |
| Nokia | B | Re-calculating frequency priorities may have some advantages in some cases, but makes the procedure much more complex, as e.g., the priority for a frequency may need to recalculate several times. |
| Qualcomm | A | We agree A can take low priority slice into consideration without introducing extra slice looping. Thus, we prefer to use Option A. But Option B is acceptable to us if majority prefer. |
| Intel | A | Please also see our response to Q7 for more details.However, we are also open to other solutions on how to capture the recalculation of frequency priorities  |

### 2.2.3 UE trigger to return to slice-based frequency priority

In Ericsson proposal [1], the UE is using the modified frequency priority until the highest ranked cell changes. A similar method is also used in the beginning of TS38.304 section 5.2.4.4:

*For the highest ranked cell (including serving cell) according to cell reselection criteria specified in clause 5.2.4.6, for the best cell according to absolute priority reselection criteria specified in clause 5.2.4.5, the UE shall check if the access is restricted according to the rules in clause 5.3.1.*

*If that cell and other cells have to be excluded from the candidate list, as stated in clause 5.3.1, the UE shall not consider these as candidates for cell reselection. This limitation shall be removed when the highest ranked cell changes.*

Other UE actions used in TS38.304 section 5.2.4.4 of the spec are:

*the UE may consider this frequency to be the lowest priority for a maximum of 300 seconds*

the UE shall not consider this cell and other cells on the same frequency as candidates for reselection for a maximum of 300 seconds.

We note that the rule of 300 ms is used in order to ensure that UE is not required to read SIB1 repeatedly when not able to find a suitable cell on a frequency. Since it will not be required that the UE shall read the SIB in order to evaluate slice support, we think the rule of “until highest cell changes” is more suitable.

**Q9: For how long should the re-calculated priorities be used?**

1. **Until highest ranked cell on the target frequency changes.**
2. **300 s.**
3. **Other.**

|  |  |  |
| --- | --- | --- |
| **Company** | **A/B/C** | **Comments** |
| Nokia | B, but | We do not support the proposal of priority recalculation, as we think that the use of legacy priority of the band (option B of Q8) is much simpler. Even in that case the UE may start using again the sliced-based priority for that frequency after a time (option B).  |
| Qualcomm | A | We agree with Rapporteur’s analysis. Slice specific cell reselection is one best-efforts enhancement. It is not necessary to bar the frequency for 300s just because of slice availability on best ranked cell. It is an overkill. |
| Intel | A | In general, barring or not considering the serving frequency for 300s does not seem the right approach when considering cell level priority based on slices supported in that particular cell. In the particular example above, just because when cell 22 is the highest ranked cell, entire frequency F2 should not be barred/not considered for cell reselection for 300s. After cell reselection, when cell 22 is no longer the highest ranked cell, frequency F2 should be considered again.  |

## 2.4 Other comments on Running 38.304 CR for RAN slicing

A draft revision (copy of the endorsed Running 38.304 CR for RAN slicing [1]) have been provided in the email discussion folder.

**Q10. Companies are invited to provide comments and modifications on the running CR that are not related to topics discussed in 2.2 and 2.3 (comments may also be inserted directly in the draft CR).**

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

# 3 Conclusion

TBA.

# 4 References

[1] [R2-2110699](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_116-e/Docs/R2-2110699.zip) Slice-based cell re-selection algorithm (Ericsson)

[2] [R2-2110239](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_116-e/Docs/R2-2110239.zip) Running 38.304 CR for RAN slicing (CMCC)

# Annex A

*Start of changes*

5.2.4.1 Reselection priorities handling

Absolute priorities of different NR frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an NR frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information, including slice or slice group specific frequency priorities. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling and *deprioritisationReq* received in *RRCRelease* unless specified otherwise. When the UE in camped normally state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than any of the network configured values). If the UE is configured to perform both NR sidelink communication and V2X sidelink communication, the UE may consider the frequency providing both NR sidelink communication configuration and V2X sidelink communication configuration to be the highest priority. If the UE is configured to perform NR sidelink communication and not perform V2X communication, the UE may consider the frequency providing NR sidelink communication configuration to be the highest priority. If the UE is configured to perform V2X sidelink communication and not perform NR sidelink communication, the UE may consider the frequency providing V2X sidelink communication configuration to be the highest priority.

For a UE supporting slice-based cell reselection, if the UE is provided with slice priorities from NAS, and if slice or slice group specific frequency priorities are included in the cell reselection information used by the UE, UE performs slice-based cell reselection as described in clause 5.2.4.x.

…

(Irrelevant text omitted)

…

*New Clause*

5.2.4.X Slice-based cell reselection

The slice-based cell reselection procedure is the following:

- The UE selects the slice group with highest priority slice.

- The UE assigns the slice frequency priority corresponding to the selected slice group for NR frequencies received in *RRCRelease* or in the system information messages.

- The UE performs measurements and selects the highest ranked and suitable cell as candidate for camping according to clauses 5.2.4.2, 5.2.4.3, 5.2.4.4, 5.2.4.5, 5.2.4.6 using the slice group specific NR frequency priorities. - If the highest ranked and suitable cell supports the selected slice, then the UE camps on the cell.

Editor's Note: FFS: How the UE determines whether the highest ranked cell supports the selected slice.

Editor' Note: It is FFS whether the UE should select another slice group and perform cell reselection with the priorities of that slice group if no suitable cell supporting the selected slice group is found.

- If no suitable cell is found using slice group specific frequency priorities, then the UE continues to perform cell reselection according to clause 5.2.4 without considering slice group specific frequency priorities.

*End of changes*

# Annex B

*Start of changes*

5.2.4.1 Reselection priorities handling

Absolute priorities of different NR frequencies or inter-RAT frequencies may be provided to the UE in the system information, in the *RRCRelease* message, or by inheriting from another RAT at inter-RAT cell (re)selection. In the case of system information, an NR frequency or inter-RAT frequency may be listed without providing a priority (i.e. the field *cellReselectionPriority* is absent for that frequency). If priorities are provided in dedicated signalling, the UE shall ignore all the priorities provided in system information, including slice or slice group specific frequency priorities. If UE is in *camped on any cell* state, UE shall only apply the priorities provided by system information from current cell, and the UE preserves priorities provided by dedicated signalling and *deprioritisationReq* received in *RRCRelease* unless specified otherwise. When the UE in camped normally state, has only dedicated priorities other than for the current frequency, the UE shall consider the current frequency to be the lowest priority frequency (i.e. lower than any of the network configured values). If the UE is configured to perform both NR sidelink communication and V2X sidelink communication, the UE may consider the frequency providing both NR sidelink communication configuration and V2X sidelink communication configuration to be the highest priority. If the UE is configured to perform NR sidelink communication and not perform V2X communication, the UE may consider the frequency providing NR sidelink communication configuration to be the highest priority. If the UE is configured to perform V2X sidelink communication and not perform NR sidelink communication, the UE may consider the frequency providing V2X sidelink communication configuration to be the highest priority.

For a UE supporting slice-based cell reselection, if the UE is provided with slice priorities from NAS, and if slice or slice group specific frequency priorities are included in the cell reselection information used by the UE, UE calculates a Slice-Based Reselection Priority for each frequency, as defined in 5.2.4.x, and use these priorities for cell re-selection instead of the priorities in the field *cellReselectionPriority*.

…

(Irrelevant text omitted)

…

*New Clause*

#### 5.2.4.X Calculation of SliceBasedReselectionPriority

For each slice in the slice list received from NAS, the *SliceSpecificFrequencyPriority* is the *sliceSpecificFrequencyPriority* signalled for the slice group of the slice.

For frequencies with a slice specific frequency priority for at least one slice in the slice list, the SliceBasedReselectionPriority is calculated by the formula:

SliceBasedReselectionPriority = SlicePriority \* MaxReselectionPriorityValue + SliceReselectionPriority,

where SlicePriority is the priority of the highest prioritized slice for which the UE have received *SliceSpecificFrequencyPriority* on the frequency. MaxReselectionPriorityValue is a constant which is higher than the maximum reselection priority, and SliceReselectionPriority is the *SliceSpecificReselectionPriority* of the highest prioritized slice on the frequency.

For frequencies with no slice specific frequency priority for any slice included in the slice list received from NAS, the Slice Based Reselection Priority is set to the *CellReselectionPriority* of the frequency.

*End of changes*