**3GPP TSG-RAN WG2 Meeting #113 electronic R2-20xxxxx**

**Online, Jan 25th – Feb 5th, 2021**

**Agenda Item:**  **XX.XX.XX**

**Source: CMCC**

**Title:** **Report of [Post112-e][253][RAN slicing] Prioritized solutions for RAN slicing**

**Document for: Discussion and Decision**

## 1 Introduction

After RAN2#112-e meeting, based on the chair notes [1][2], the following email discussion was agreed:

* **[Post112-e][253][RAN slicing] Prioritized solutions for RAN slicing (CMCC)**

Scope: Discuss the potential solutions for slice-based cell reselection and slice-based RACH configuration based on agreements on candidate solutions. Collect company views on schemes that should be prioritized with analysis on benefits and complexity for each solution.

 Intended outcome: Discussion report including TP to the TR 38.832

 Deadline: Dec 16

This email discussion is to progress on solutions for RAN slicing.

Since upload announcement is not mandatory required, indicating contact person is helpful in case companies would like to offline.

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| --- | --- | --- |
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## 2 Slice based cell reselection under network control

### 2.1 RAN2#112-e agreements

Here are the relevant agreements made at RAN2#112-e meeting [2]:

Agreements

* 5.1: These issues will be studied in this SI:
Issue 1: The UE is unaware of the slices supported on different cells or frequencies, which prevents UE from (re)select to the cell or frequency supporting the intended slice.
Issue 2: Dedicated priorities would not be available to the UE prior to first RRC connection establishment and only remain valid before T320 expires upon entering IDLE mode. In addition, dedicated priorities are discarded each time when UE entering CONNECTED mode and need to be configured again before UE leaving CONNECTED mode.
Issue 3: Operator may require different frequency priority configurations for the specific slice in different areas, however the dedicated priority always overwrites the broadcast priorities if configured.
Issue 4: If the serving cell is unable to support the requested slices for the subsequent access of the UE, the serving cell may bring on handover or rejection of access request. That may increase control plane signalling overhead as well as long control plane latency for the UE to access the network.
* 7: The following solution approaches are captured in the TR and will be studied in this SI:
Solution 1: Legacy dedicated priority via RRCRelease message.
Solution 2: Rel-15 mechanisms such as HO, CA, DC and redirection can be used to access the intended slice in different cell
Solution 3: Slice related cell selection info, the slice info of serving cell and neighboring cells is provided in the system information or RRCRelease message. FFS: what information is broadcast.
Solution 4: Slice related cell reselection info (e.g. Cell reselection priority per slice), the slice info of neighboring cells is provided in the system information or RRCRelease message. FFS: what information is broadcast.

Please note that the solution number is changed to align with the solution number in draft TR 38.832.

### 2.2 Discussions on solutions

Based on the scope of this email discussion, the following tables are provided for collecting companies’ comments. The suggestions are as below:

* For benefit, it is suggested to focus on the agreed issues that each solution can solve. For complexity, it is suggested to focus on general impacts on specifications
* Companies can refer to submitted Tdocs for analysis, e.g. submitted at RAN2#112-e meeting, and it may save the size of this email discussion
* For solution details, if needed, it is suggested to only figure out key aspects of a solution but not all details

The above suggestions are also applied to section 3.2.

**Solution 1: Legacy dedicated priority via *RRCRelease* message.**

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| **Company** | **Preferred (Yes/No)** | **Benefits** **(Please list the issue(s) that this solution can address)** | **Complexity** |
| **Qualcomm** | **N/A** | **No need for benefit analysis.** **In our understanding, this legacy solution is captured in RAN2 TR as a reference (e.g. show the intention why enhancement is needed in Rel-17 RAN slicing SI)** | **No need for complexity analysis** |
| **Huawei, HiSilicon** | **N/A** | **Solution 1 is available, but it cannot solve Issue 1, 2, 3, and 4.****For initial access, and subsequent access where its Intended Slice has changed, the UE may still select the wrong cell. In this way, the legacy dedicated priority is only a passive solution to guide UE to the correct cell.** | **No RAN2 impact observed.** |
| **OPPO** | **N/A** | **We share the same view as Qualcomm.** | **No need** |
| **Vodafone** | **yes** | **Works with R15 UEs with existing R15 system design for slicing (i.e. based on a common set of slices being available in all cells in a TA).****The correct use of “TA not allowed” style cause values avoids the UE camping on cells in the incorrect slice.****Note that for URLLC service the UE needs to be in connected state – so idle mode reselection is not really an issue for URLLC slices.**  | **Existing functionality, copied from, and debugged in,4G.** |
| **Intel** | **Yes** | **Since this solution is already supported by UEs, it has to be considered. This solution will be part of the overall solution space by default, to solve the issue to steer the UE to the preferred frequency of a slice in a TA.** **If the 2 areas in the TR (Area 1 and 2 in Figure 5.1.1-1) are in different TAs, this solution will provide the up-to-date dedicated priority to move the UE to the right frequency layer and provide fast access.** | **No additional UE complexity as it is an existing mechanism.** |
| **Nokia** | **Yes** | **Issue 1, 4 for cell reselection** **Note that this solution does not solve the case when the cells on the same band support different slices (e.g. at the border of different geographical areas). Assigning CAG IDs to slices or group of slices could solve this issue as well [see details on CAG ID assignment in R2-2009067]** | **No impact, as it is legacy mechanism** |
| CMCC | No | Agree with Qualcomm and Huawei.Solution 1 cannot address issue 1~4. That’s why we need to study solutions in Rel-17. | Not needed. |
| **Xiaomi** | **N/A** | **It should be analyzed based on the different answers of SA2 LS.****A)different cells support same set of slices in the same RA/TA (i.e. if answer is “Yes” for SA2 LS R2-2008759) and different slices have no different preferred frequency(s) in the RA/TA****For A), the issue 1/4 is no exist as solution1 has considered allowed NSSAI and allowed NSSAI is supported within RA. If UE requests slices outside of allowed slices or moves out of RA, registration procedure is performed to update allowed NSSAI and dedicated priority can be updated accordingly.****B)different cells support same set of slices in the same RA/TA (i.e. if answer is “Yes” for SA2 LS R2-2008759) but different slices have different preferred frequency(s) in the RA/TA****C)different cells support different slices in the same RA/TA (i.e. if answer is “No” for SA2 LS R2-2008759)** **For B) and C), legacy dedicated priority can not solve all 4 issues because UE can not be aware of the relationship of (preferred) frequencies/cells and slices.** | **No impact on current spec as legacy mechanism.** |

**Solution 2: Rel-15 mechanisms such as HO, CA, DC and redirection can be used to access the intended slice in different cell.**

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| **Company** | **Preferred (Yes/No)** | **Benefits** **(Please list the issue(s) that this solution can address)** | **Complexity** |
| **Qualcomm** | **See comments** | **Similar to solution 1, it is legacy solution. However, there may be one new issue for HO/redirection if different cells support different slices in the same RA/TA (i.e. if answer is “No” for SA2 LS** [R2-2008759](file:///C%3A%5CUsers%5Cterhentt%5CDocuments%5CTdocs%5CRAN2%5CRAN2_112-e%5CR2-2008759.zip))**:** * **Issue scenario: the UE with active PDU session of slice 2 is HO/redirected to another cell not supporting slice 2 in the same RA/TA. In this case, it is not clear how the UE can handle the active PDU session of Slice 2**.
* **One possible solution is to release PDU session of Slice 2 while another alternative is to suspend the PDU session of Slice 2 so that it is still available when Slice 2 is available later, e.g. UE returning to original cell. But all these solutions need SA2 impacts**
 | **From RAN2 perspective, there is no further RAN2 impact even if the new issues need to be studied.** |
| **Huawei, HiSilicon** | **N/A** | **Solution 2 is available, however, solutions as HO, CA, and DC are only for connected mode UEs. The whole Section 2 here is about cell (re)selection, so Solution 2 can not address it. And legacy redirection solution has the same problem as the dedicated priority of Solution 1.****In the pre-meeting discussions (see summary in R2-2010366), there were lots of discussions regarding Solution 2, and generally the solution will lead to extra delay and signaling overhead if applied in cell (re)selection scenarios.** | **No RAN2 impact observed.** |
| **OPPO** | **N/A** | **It is legacy solution, and can only applied in limited cases. For CA/DC solution, the related UE capability is required. For HO/redirection, the network may redirect/handover UE to the cell not supporting the most intended slice, since the gNB does not know whether the subsequent required slice is the most intended one or not.** | **No need unless some RAN2 impact is foreseen.** |
| **Vodafone** | **yes** | **This is the existing Rel 15 solution that has been debugged and shown to work in 4G.****We believe that RAN 3 have answered “yes” to the question in SA2 LS** [R2-2008759](file:///C%3A%5C%5CUsers%5C%5Cterhentt%5C%5CDocuments%5C%5CTdocs%5C%5CRAN2%5C%5CRAN2_112-e%5C%5CR2-2008759.zip), and hence the (good) Qualcomm comments are not needed. |  |
| **Intel** | **Yes** | **This solution solves the issues for some scenarios where different slices are supported in different frequency layer within a TA as in the scenario below in the TR:****With CA/DC, the UE may still be able to access the intended slice even if it is not in the same freq depending on UE capability and network deployment.****Using redirection/handover to another frequency without CA/DC may not be a viable solution for some scenarios. As mentioned by Qualcomm, if UE is in F2 and has active slice 2, handover or redirection to F1 for Slice 1, may result Slice 2 becoming not available depending on UE capability and Issue 5 as in the previous email discussion may occur. Issue 5 also occurs for the case UE moves from Area 1 to Area 2 in the TR (Figure 5.1.1-1) with active Slice 2 and this also need to be resolved.** | **No additional UE complexity as it is an existing mechanism.** |
| **Nokia** | **Yes** | **Issue 1** | **No impact, as it is legacy mechanism** |
| CMCC | No | HO, CA, DC and redirection are the legacy mechanisms to make UE accessible to the intended slices on the non-serving cell. But as stated in issue 4, these mechanisms increase the control plane signalling overhead and latency.  | No impact |
| **Xiaomi** | **N/A** | **For IDLE/inactive UE, this solution requires UE to enter connected state first, which can consume additional signaling and access delay, and depends on network deployment and UE capability, e.g. DC/CA.****For connected UE, there is no problem with this solution.** | **No impact on current spec as legacy mechanism.** |

**Solution 3: Slice related cell selection info, the slice info of serving cell and neighboring cells is provided in the system information or *RRCRelease* message. FFS: what information is broadcast.**

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| **Company** | **Preferred (Yes/No)** | **Benefits** **(Please list the issue(s) that this solution can address)** | **Complexity** |
| **Qualcomm** | **Yes for SIB****No for RRC release** | **Providing supported slices info in SIB can resolve all the 4 identified issues:** * **For issue 1/2/4, the UE can avoid selecting a cell not supporting its intended slice from beginning (and thereby avoid signaling/latency caused by PDU session rejection);**
* **For issue 3, the UE will see different slice availability in Area 1 and Area 2, and thereby the UE can take area-different frequency priority, which is similar to existing Rel-13 LTE SC-PTM and Rel-16 NR V2X cell (re)selection.**

**We think the existing frequency priority mechanism in *RRCRelease* based RFSP is sufficient and can’t address any 4 identified issues. So, we see no need to enhance.**  | **The main 2 issues to provide supported slice info in SIB:*** **Payload size: we think it can be resolved (e.g. providing only SST, or on-demand SIB, or SIB segmentation)**
* **Security: we don’t see any security issue to broadcast supported slice info in SIB, but open to send LS to SA3**
 |
| **Huawei, HiSilicon** | **Yes** | **SIB solution should be the priority. It can resolve issue 1 and 4 efficiently.****SIB solution can enable UE fast access as the UE will know the suitable cell by identifying the supported slices.** **Slice related info in *RRCRelease* is not suitable for the initial access scenario.** | **The impacts are moderate because solution 3 is similar to priority-based cell reselection.****For signaling overhead due to slice related information, we have the following suggestions:*** **Slice info depends on slice deployment, for example, the number of slices deployed in an area**
* **Some solutions can be considered, such as slice group and on-demand SI**
 |
| **OPPO** | **Yes** | **If slice related information is provided in system information, issue 1/2/4 can be resolved.****If slice related information is provided in RRCRelease, issue 1/4 can be resolved in the scenarios expect initial access/RLF.** **But, the solution of RRCRelease can provide a UE-specific information and can be a supplementary to the solution of system information.**  | **Regarding the concern on provision of supported slice info in SIB, we share similar view as Qualcomm. In details:****Payload size: Simplified identity for slice id, e.g. SST, slice group, or on-demand SIB can be used.****Security: Slice info is already carried in msg5 which is unprotected. But, no serious issue on security is raised. If security issue does exist in some cases, gNB can control it and stop broadcasting slice related information.** |
| **Vodafone** | **Slice type OK to add to broadcast SIB** | **Benefits seem limited as R15/16 UEs are likely to need to be supported.****Existing RRC release messages seem able to address all 4 scenarios (so no updates needed) – although the RAN needs to know how to convert UE context information into the priority information sent in the RRC Release.****Dedicated priorities timer T320 can be set up to 3 hours – and most devices are likely to contact the network more frequently (e.g. for smartphone heartbeat traffic, or, periodic registration updates), so R15 techniques can work in most cases.****Broadcasting “slice type” to make cells preferred may be OK, but, using Slice Information to indicate prohibited cells (within the registered TAI list) will lead to wasted paging messages.**  |  |
| **Intel** | **Yes or No, depends on whether the 2 Areas need to be in the same TA** | **See our contribution R2-2009198 for detailed explanation. In brief:****If Area 1 and Area 2 are in different registration areas, current Rel-15 mechanisms addresses the dedicated frequency priority update issue and also update of the allowed NSSAI to provide fast access. Additional benefit of Slice related cell selection info in the SIB or in the RRC Release needs more discussion.** **On the other hand, if Area 1 and Area 2 in TR Figure 5.1.1-1 are in the same UE registration area, there are many issues (1, 3, 4, 5) on the system aspects. For example, how data of the active slice are handled etc. and how fast access can be achieved as mentioned in R2-2009198 needs further discussion as there is no common understanding on this during the discussion on SA2 LS response.**  | **If separate TA is used for both Area 1 and 2 as in the Figure 5.1.1-1, there is no further complexity as the existing mechanism may address all the issues.** **If same TA is used for both Area 1 and 2 as in the Figure 5.1.1-1, further discussion is needed on how it works end to end considering overall system aspects. And further discussion is also needed on the details of reduction in access delay that can be achieved with such broadcast to understand the solution and associated complexity.** |
| **Nokia** | **Yes for RRCRelease****No for broadcasting** | **Issue 1, 4 for cell selection** | **RRCRelease: Low**, as the details on cell selection could remain implementation specific.**Broadcasting: High:** SIB sizes are very limited, especially SIB1 case, and thus very high level of optimization is required. Note also that SIBs using a significant amount of radio resources |
| CMCC | Yes for SIBNo for RRCRelease | Solution 3 can address issue 1,2,3,4.The broadcasting slice info for serving cell and neighbour cell enable the UE to select to the cell supported the intended slices, which address all the issues in 1~4.Using RRCRelease message is not preferred, since it causes the same problem as issue 2. | Agree with Qualcomm. |
| **Xiaomi** | **Yes, both for SIB and RRCRelease, and can also be provided by NAS.** | **Providing supported slices in SIB can solve all issues but it is configured per cell rather than per UE.** **Providing supported slices in RRCRelease can solve issue1/4 but it has benefits that can be configured per UE considering network conditions and UE requests.** **For issue 2, we think it is not a big issue for UE without dedicated priorities prior to first RRC connection establishment. And the maximum value of T320 is min180 which is long enough to avoid frequent reconfiguration of dedicated priorities.****For issue 3, we think it can be solved by configuring valid area in RRCRelease message.****Besides, SA2 is considering to configure slice-specific frequency info to assist cell (re)selection, e.g. TR23.700-40 solution#29/30, thus, the slice related cell (re)selection info can also be provided by NAS.****For slice related cell （re）selection info, we think it should include available slices info and whether it includes slice priority depends on slice priority is decided by UE or by network which should be further discussed. If slice priority is decided by UE, slice related cell （re）selection info need not include slice priority. Otherwise, slice priority need to be included in slice related cell (re) selection info and indicated by network to UE.** | **same views as Qualcomm.** |

**Solution 4: Slice related cell reselection info (e.g. Cell reselection priority per slice), the slice info of neighboring cells is provided in the system information or *RRCRelease* message. FFS: what information is broadcast.**

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| **Company** | **Preferred (Yes/No)** | **Benefits** **(Please list the issue(s) that this solution can address)** | **Complexity** |
| **Qualcomm** | **Yes for SIB****No for RRC release** | **Same comments to Solution 3.** **We assume supported slices info can be included in one SIB type for both cell selection and reselection.** | **Same comments to Solution 3** |
| **Huawei, HiSilicon** | **Yes** | **SIB solution should be the priority. It can solve issue 3 and 4 efficiently.****Slice specific cell reselection priority in SIB could help UE to camp on suitable frequency/cell according to the Intended Slice and the network policy.** | **Same comments to Solution 3.** |
| **OPPO** | **Yes** | **Similar as the comments to Solution 3.** **In addition, for issue 3, if other information, e.g. area-specific frequency priority per specific slice, is provided in RRCRelease, it can be avoided that the dedicated priority wrongly overwrites the broadcast priorities.** | **See comments to Solution 3.** |
| Vodafone | No | Benefits seem limited. Co-frequency adjacent cells are likely to need to support the same services, so limited gain from adding this information is expected. | Complexity outweighs gains. |
| **Intel** | **Yes or No as per Solution 3** | **Same comments as Solution 3** | **Same comments as Solution 3** |
| **Nokia** | **Yes** | **RRC Release:** Issue 1, 4 and may provide partial solution for issue 2, 3 **Broadcasting:** Issue 1, 2, 3, 4 | **RRC Release: Medium****Broadcasting: High,** as SIB sizes are very limited, and thus optimization is required |
| CMCC | Yes for SIB,No for RRCRelease | Solution 4 can address issue 1,2,3,4.The broadcasting slice info for serving cell and neighbour cell enable the UE to reselect to the cell supported the intended slices, which address all the issues in 1~4.RRCRelease message is not preferred, since it causes the similar problem as issue 2&3. | Same comments to Solution 3. |
| **Xiaomi** | **Yes, both for SIB and RRCRelease, and can also be provided by NAS.** | **Same comments as solution 3** | **Same comments as solution 3** |

## 3 Slice based RACH configuration

### 3.1 RAN2#112-e agreements

Here are the relevant agreements made at RAN2#112-e meeting [2]:

Agreements

* 10: The intentions and use cases for slice-based RACH configuration are as follows:
Intention 1: RA resource isolation. From marketing point of view, some of the industrial customers have the requirement for access resource isolation, in order to provide guaranteed RA resources for their sensitive slices.
Intention 2: Slice access prioritization. In R15/16, all slices are sharing the same RA resources and cannot be differentiated by network side. But some slices may need to be prioritized during the RA procedure.
* 11: The following solutions will be studied and captured in the TR 38.832:
Solution 1: Slice-specific separate RACH resources pool can be configured per slice or per slice group, in addition to the existing common RACH resources.
Solution 2: Slice-specific RACH parameters prioritization can be configured per slice or per slice group.
Neither solution may not be applicable to all possible slices.

### 3.2 Discussions on solutions

Same suggestions as section 2.2. Please companies provide the comments into the following tables if any.

**Solution 1: Slice-specific separate RACH resources pool can be configured per slice or per slice group, in addition to the existing common RACH resources.**

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| **Company** | **Preferred (Yes/No)** | **Benefits** | **Complexity** |
| **Qualcomm** | **Lower priority than Solution 2** | **It can provide benefit to reduce RACH collision/delay for some slices with urgent requirement** | * **It may cause RACH resource fragment**
* **It may require spec change on basic RACH procedure, which should be avoided.**

**In all, we think it can be considered for the target of urgent slices, but its study priority should be lower than solution 2.**  |
| **Huawei, HiSilicon** | **Yes** | **Solution 1 can meet Intention 1 and 2.**  | **The impacts are moderate.****The UE gets Intended Slice info at its AS layer, and the UE also gets slice-specific RACH configurations, and then the UE will select suitable resources for the RACH procedure.** |
| **OPPO** | **Yes** | **It is suitable to the case of some slices with urgent requirement.** | * **To solve the collision of RA-RNTI if slice-based RACH resources are added in addition to the existing common RACH resources.**
 |
| **Vodafone**  |  | **Separating RACH resources into smaller groups reduces statistical multiplexing gains and may lead to increased congestion.****However, it is a tool that can be used to provide enhanced access to a subset of users.**  | **Configuring this in the UE may be complex unless related to simple broadcast (e.g. Slice Type) information.** |
| **Intel** | **Yes** | **Same comment as QC** | **Agree with QC. But could be used for urgent slices and hence beneficial to specify it.****Some mechanism will be needed to avoid broadcasting the slice info itself to reduce the size of SIB.** |
| **Nokia** | **Yes** | It makes total slice isolation is feasible at RAN level, but only very limited number of slice or slice group specific resources is feasible to minimize overhead and RACH resource fragmentation. | **Medium** in general**Low,** if existing Access Stratum knowledge on slices (Access Categories) is reused |
| CMCC | Yes | It addresses both intention 1 and 2, which are quite essential for operators to explore the vertical markets. | The complexity is low.We don’t think fragmentation is a problem, network can balance the trade-off between RACH resource fragmentation and the requirement of slice resource isolation which come from vertical customers. |
| **Xiaomi** | **Yes** | **Pros：** * **meet intention1 and 2**
* **provide totally resource isolation between slices, especially is beneficial for critical service while solution2 can not.**

**Cons: may lead to RACH resource fragmentation but we think it can be managed via network.** | **It may requires neccessary spec changes to provide guaranteed RACH resources for slices.** |

**Solution 2: Slice-specific RACH parameters prioritization can be configured per slice or per slice group.**

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| **Company** | **Preferred (Yes/No)** | **Benefits** | **Complexity** |
| **Qualcomm** | **Yes** | **It can provide benefit to reduce RACH collision/delay for some slices with higher latency requirement** | * **It is simple and has minor impact on UE behavior and spec,**
* **RAN2 has specified RACH prioritization for MPS and MCS in NR Rel-16 TEI, which can be easily extended to slice (group) based RACH parameter prioritization**
 |
| **Huawei, HiSilicon** | **Yes** | **Solution 2 can meet Intention 2.**  | **The impacts are minor.****The UE gets Intended Slice info at its AS layer, and the UE also gets slice-specific RACH parameters prioritization, and then the UE will select relevant parameters for the RACH procedure.** |
| **OPPO** | **Yes** | **It is suitable to the case of different slices with different priority/latency requirements.** | **To solve the collision between RA parameters prioritization for access identity and RA parameters prioritization for specific slice(s).** |
| Vodafone |  | This does not seem to relate to user plane latency, but to Idle/inactive mode to connected mode transition time. | Configuring this in the UE may be complex unless related to simple broadcast (e.g. Slice Type) information. |
| **Intel** | **Yes** | **Agree with QC comments** | **Complexity is minimal as such mechanism is already possible for HO and beam recovery in Rel-15 and is extended to MPS and MCS in Rel-16.** **Some mechanism will be needed to avoid broadcasting the slice info itself to reduce the size of SIB.** |
| **Nokia** | **Yes** | It enables prioritization of access to slices, but only very limited number of slice or slice group specific parameters is feasible to limit the overhead | Medium (general)Low, if existing Access Stratum knowledge on slices (Access Categories) is reused |
| CMCC | Yes | It addresses the intention 2. | The complexity is low. |
| **Xiaomi** | **Yes** | **This solution only meets the intention 2 and can not provide resource isolation because all slices still share the common RACH resource. Once congestion happened, all slices can be affected and UE can not access network.** **Considering limited RACH resource, slice-specific RACH resource may be assigned to a group of slices. In this case, solution2 can be applied for different slices sharing the same resource per UE to prioritize the slice.** | **It can be easier extended based on current spec to prioritize slices and has minor impacts on spec.** |

## 4 Conclusion

[Note: the conclusion will be made by the email rapporteur, and then draft TP to the TR 38.832 will be provided for further review]

[To be added]

## 5 Reference

1. RAN2 112-e Chairman Notes 2020-11-15 EOM
2. RAN2-112e LTE DCCA Mobility RAN slicing and Multi-SIM (Tero)\_2020-11-13-eom UTC