**3GPP T****SG-RAN WG2 Meeting #117-e R2-220xxxx**

**E-Meeting, Feb 21th – Mar 3rd, 2022**

**Agenda item:**  **8.10.4.1**

**Source: Intel Corporation**

**Title: Report of email discussion [Pre117-e][NTN][104] UE caps open issues (Intel)**

**Document for: Discussion**

# Introduction

This is the report of the following email discussion:

**[Pre117-e][NTN][104] UE caps open issues (Intel)**

Initial scope: Continue the discussion on the open issues for UE capabilities listed in R2-2201962, also the issue on L2 buffer size (mentioned in R2-2201545)

Initial intended outcome: Summary of the offline discussion with e.g.:

* + - List of proposals for agreement (if any)
    - List of proposals that require online discussions
    - List of proposals that should not be pursued (if any)

Initial deadline (for companies' feedback): Feb 14

Initial deadline (for rapporteur's summary): Feb 17

# Discussion

According to R2-2201962, the following open issues are identified for pre-meeting offline discussion:

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| **List of open issues on NR NTN UE capabilities**  **Set 1 for pre-meeting offline discussion:**  **Regarding Essential features:**   1. Whether to specify that SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are only essential for NGSO; 2. Whether CHO enhancements (time based and Event A4 based CHO) are essential for both GSO and NGSO, or only for NGSO, or optional.   **Regarding Optional features:**   1. Whether to have separate RAN2-specific TA reporting UE capability, i.e., TA offset threshold based reporting, or incorporate this feature into TA reporting UE capability defined in RAN1 feature list; 2. Whether to have two UE capabilities for UL HARQ state B and the new LCP restriction respectively.   **Regarding New UE capability bits:**   1. Whether/how to indicate a UE only supports NGSO or a UE only supports GSO or both; 2. Whether/how to indicate one TN feature can be supported or not in NTN:   Option 1:            We discuss case by case, e.g., 2-step RACH in NTN may need a separate IoT bit as existing 2-step RACH UE capability bit is considered only for TN.  Option 2:            We enable signalling possibility for at least MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE to be separately indicated for NTN.  Option 3:            Whether optional TN feature can be supported or not in NTN is indicated based on the existing UE capability signalling, e.g., if UE indicates support of 2-step RACH using existing UE capability bit, 2-step RACH is supported in both TN and NTN. |

Companies are invited to provide views in the following questionnaire tables.

**Question 1: Whether to specify that SMTC enhancements (event-triggered assistance information reporting, 2 SMTC in parallel) are only essential for NGSO?**

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| **Company** | **Y or N** | **Additional comments** |
| Interdigital | Y | Can specify optional for GSO |
| MediaTek | Y | It is of no use for GSO. |
| Samsung | Y | Essential for NGSO, optional for GSO |
| Qualcomm | Y/N | If the assumption is that the UE in GEO cell does not need to perform measurement of NGSO satellites, then answer is yes.  So, we think this needs to be clarified first. |
| Apple | Y |  |
| Huawei, HiSilicon | Y |  |
| Lenovo, Motorola Mobility | Y with comments | Agree with Qualcomm. If a UE in GSO needs to perform measurement on an NGSO, the SMTC enhancements are needed. Only when the serving and all neighbour satellites are all GSO then the SMTC enhancements are not essential. |
| OPPO | No | Similar questions as Qualcomm. RRM measurement involves serving cell and neighbor cells. For the mixed cell scenarios, UE in GSO may need to perfrom measurement on NGSO. |
| Xiaomi | Y |  |
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**Question 2: Whether CHO enhancements (time based and Event A4 based CHO) are essential for both GSO and NGSO, or only for NGSO, or optional.?**

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| **Company** | **Essential for which case(s), or optional** | **Additional comments** |
| InterDigital | Essential for NGSO | Similar to Q1 can have a capability that is optional for GSO and mandatory for NGSO |
| MediaTek | Only for NGSO | Similar to Q1 |
| Samsung | Optional | As CHO is optional in Rel-16. |
| Qualcomm | Optional | How this can work correctly for NGSO moving cell as the network may not have accurate UE location information.  As Samsung indicated, it is already optional in Rel-16 and we will be using same Rel-16 per band UE capability indication in NTN. |
| Apple | Optional |  |
| Huawei, HiSilicon | Optional | We think time-based CHO is useful for NGSO (not for GSO). If neither time-based nor location-based CHO is supported by the UE, the overall performance will be degraded as the legacy RSRP-based mobility does not work well in NTN.  However, if companies have concerns, we are also ok with having it as an optional feature since the UE can implement optional features anyway. |
| Lenovo, Motorola Mobility | Optional | As legacy CHO in Rel-16. |
| OPPO | Optional |  |
| Xiaomi | Optional |  |
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**Question 3: Whether to have separate RAN2-specific TA reporting UE capability, i.e., TA offset threshold based reporting, or incorporate this feature into TA reporting UE capability defined in RAN1 feature list?**

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| **Company** | **Views** | **Additional comments** |
| InterDigital | Incorporate | We assume the TA reporting related features would come as a package, but no strong view if companies think separate IoT availability is likely/possible then fine to have separate capabilities. |
| MediaTek | Separate | We think separate capabilities will be easier to manage and implement. |
| Samsung | Incorporate | We understand TA reporting is specified from RAN1 and RAN2 perspectives, and will be finalized as a single TA reporting feature. |
| Qualcomm | Incorporate | We think a single UE capability for reporting TA in connected mode is sufficient. A trigger event is needed for the use of TA report in connected mode.  See agreement: Other than event-triggered TA reporting, no more triggers are introduced for TA reporting in connected mode. |
| Apple | Incorporate |  |
| Huawei, HiSilicon | See comments | The problem is whether RAN2 needs two capabilities for TA reporting, i.e., one for TA reporting during RACH, the other for event-triggered TA reporting in connected mode.  The RAN1 discussion is based on RAN2 agreements and does not differentiate the TA reporting during RACH or TA reporting in CONNECTED mode. In other words, the UE capability introduced by RAN1 cover both cases.  During initial access, the network does not know UE capability yet. Therefore for **TA reporting during RACH**, one **optional capability without signalling** is enough. As for **event-triggered TA reporting in connected mode**, an **optional capability with signalling** is needed.  Besides, we need to align the understanding with RAN1 (an LS is needed). |
| Lenovo, Motorola Mobility | Incorporate | A single feature is simple. |
| OPPO | Incorporate |  |
| Xiaomi | Incorporate | Agree with Samsung that TA reporting from RAN1 and RAN2 is actually one feature. |
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**Question 4: Whether to have two UE capabilities for UL HARQ state B and the new LCP restriction respectively?**

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| **Company** | **Y or N** | **Additional comments** |
| InterDigital | N | Based on agreement in RAN2#116e [6]: *“if uplinkHARQ-DRX-LCP-Mode-r17 is configured, a HARQ process may be mapped to either ‘HARQ mode A’ or ‘HARQ mode B’.” either all HARQ processes are configured as “no HARQ state” or as “HARQ mode A/B”.* Since configuration of a HARQ mode is necessary to support DRX RTT timer extension, which is an essential sub-feature, then we would consider the HARQ mode configuration as mandatory and no UE capability is needed for Mode B specifically.  For LCP restriction this is needed for proper prioritisation in the UE so we’d prefer if this is also a mandatory feature, but fine to go with majority and have this as optional UE feature if necessary. |
| MediaTek | N | This does not need to be mandatory. |
| Samsung | N | Only need one UE capability and it’s an optional feature. The new LCP mapping restriction is applicable only when UL HARQ state B is supported, i.e. if only UL HARQ state A is supported, there is no need of the new LCP rule. If the UL HARQ state B is supported, the new LCP rule should also be supported. If the UL HARQ state B is not supported, the new LCP rule is not needed to be supported. |
| Qualcomm | N | They are connected and should be used together. |
| Apple | N | Since they are related, it does not make much sense to separate these capabilities. Also this needs to be optional. |
| Huawei, HiSilicon | N | The new LCP restriction can be used to guarantee that services with reliability requirement can be transmitted on the grant associated with a HARQ process of state A and services with latency requirement can be transmitted on the grant associated with a HARQ process of state B. The new LCP restriction works well with HARQ state A/B, there is no need for separate UE capabilities for state B and the new LCP restriction. |
| Lenovo, Motorola Mobility | N | They are associated with each other. |
| OPPO | N |  |
| Xiaomi | N | They are connected |
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According to discussion in [Post116bis-e][110][NTN], one company pointed out that a single UE capability indication for essential features to support both GSO and GSO does not mean that interoperability testing between GSO and NGSO is also supported. UE needs to further indicate whether it is tested and supporting GSO, or NGSO, or both.

**Question 5: Whether/how to indicate a UE only supports NGSO or a UE only supports GSO or both?**

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| **Company** | **Views** | **Additional comments** |
| InterDigital |  | It’s only important for optimal handover between NGSO and. Otherwise the UE may report different capabilities depending on the network type. |
| MediaTek | Required | This should be supported, as it should not be assumed that every NTN capable UE has been tested to support both GSO and NGSO.  More discussion is needed on how to indicate it. |
| Samsung | Yes | The network has to know whether the UE supports only GSO or only NGSO or both so that the network will not configure GSO cells for UE only supporting NGSO for measurement or handover. The UE can indicate IoT bits for {GSO, NGSO, both}. |
| Qualcomm | Yes | We share same view with Samsung. IoT bit would still be needed for essential features since there may be only either of GSO or NGSO NW for IoT. |
| Apple | Yes |  |
| Huawei, HiSilicon | No | In our understanding, a UE will not access a GSO cell and an NGSO cell at the same time. The UE only needs to report its capabilities corresponding to GSO or NGSO to the cell it is accessing. |
| Lenovo, Motorola Mobility | Yes | NW needs to know. |
| OPPO | Yes | Agree with Samsung and Qualcomm. |
| Xiaomi | Yes |  |
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**Question 6: Whether/how to indicate one TN feature can be supported or not in NTN:**

**Option 1: We discuss case by case, e.g., 2-step RACH in NTN may need a separate IoT bit as existing 2-step RACH UE capability bit is considered only for TN.**

**Option 2: We enable signalling possibility for at least MAC parameters, measurement parameters, SON/MDT, RRC\_INACTIVE to be separately indicated for NTN.**

**Option 3: Whether optional TN feature can be supported or not in NTN is indicated based on the existing UE capability signalling, e.g., if UE indicates support of 2-step RACH using existing UE capability bit, 2-step RACH is supported in both TN and NTN.**

**Option 4: Existing capability signalling is used but only valid in the network type it is reported to (e.g. when UE reports to NTN network the capability refers to NTN and not TN)**

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| **Company** | **Option 1/2/3** | **Additional comments** |
| InterDigital | Option 2 or 4 | TN and NTN we would need separate sets of capabilities, there is no guarantee that support of a feature on TN means it works fine on NTN without IoT test.  It may however be possible to report the capabilities using the existing capability signalling, and the UE sets the values such that the correct capabilities are reported depending on the network type which the UE is currently connected to (option 4). This means that in R17 that a new UE capability enquiry is needed after any handover to update the capabilities. We may then need to revisit this in R18 to report 2 sets of capabilities in order to support handover more optimally.  Alternatively we can go with option 2 in R17 already and report 2 sets of capabilities. For example beam management differs in TN and NTN and may need separate values to be reported. |
| MediaTek | Option 2 or Option 4 |  |
| Samsung | Option 1 | Apart from the existing capability bit for TN, UE needs to indicate a separate bit whether an optional TN feature is supported for NTN or not, mandatory TN features should be supported without indication to enable normal operation in NTN. |
| Qualcomm | Option 2 + Option 3 | If the UE is able to implement/test, option 2 is equivalent to Option 3 as it does not need to signal those in Option 2 separately. See table below.   |  |  |  | | --- | --- | --- | | UE capability request from the network  *frequencyBandListFilter* | *UE-NR-CapabilityNTN-Mode-r17* | Remarks | | Does not include NTN bands | Not included | Existing per UE capabilities apply to TN (legacy behavior) | | Includes NTN band | Not Included  option # 3 | Existing per UE capabilities apply to both TN and NTN bands | | Included  Option # 2 | Existing UE capability indication applies to TN bands (if supported).  *UE-NR-CapabilityNTN-Mode-r17* applies to NTN bands. | |
| Apple | Option 1, 2 or 4 | TN and NTN UE capabilities should be kept distinct. |
| Huawei, HiSilicon | Option 1 |  |
| Lenovo, Motorola Mobility | Option 2 |  |
| OPPO | Option 1 |  |
| Xiaomi | Option 1 or 4 |  |
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According to arrangement, also the issue on L2 buffer size (mentioned in R2-2201545) will be handled in offline discussion [Pre117-e][NTN][104].

Note that there is already an agreement made for IoT NTN in this aspect as below:

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| Don’t change the L2 buffer requirement for IoT NTN (assume the network may need to limit the bit rate in order to not exceed L2 buffer). |

In LTE (36.306) the actual buffer size is specified per category (RTT and buffer size calculation are “hidden”), however in NR (38.306) the data rate and RTT is specified along with the formula to calculate buffer size. The currently specified RTT of 50ms is obviously wrong for the case of NTN.

Layer 2 buffer size is specified in 38.306 as follows;

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| The required total layer 2 buffer size in MR-DC and NR-DC is the maximum value of the calculated values based on the following equations:  -     *MaxULDataRate\_MN* \* *RLCRTT\_MN* + *MaxULDataRate\_SN* \* *RLCRTT\_SN* + *MaxDLDataRate\_SN* \* *RLCRTT\_SN* + *MaxDLDataRate\_MN* *\** (*RLCRTT\_SN* + *X2/Xn delay* + *Queuing in SN*)  -     *MaxULDataRate\_MN* \* *RLCRTT\_MN* + *MaxULDataRate\_SN* \* *RLCRTT\_SN* + *MaxDLDataRate\_MN* \* *RLCRTT\_MN* + *MaxDLDataRate\_SN* *\** (*RLCRTT\_MN* + *X2/Xn delay* + *Queuing in MN*)  Otherwise it is calculated by *MaxDLDataRate \* RLC RTT + MaxULDataRate \* RLC RTT*. |
| **Table 4.1.4-1: RLC RTT for NR cell group per SCS**   | **SCS (kHz)** | **RLC RTT (ms)** | | --- | --- | | 15KHz | 50 | | 30KHz | 40 | | 60KHz | 30 | | 120KHz | 20 | |

**Question 7.1: What RLC RTT value(s) should be used in L2 buffer requirement calculations in 38.306 table 4.1.4-1 for NTN?**

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| **Company** | **Views** | **Additional comments** |
| InterDigital |  | The RTT depends on the propagation delay and number of HARQ retransmissions used. If HARQ feedback is disabled then the RTT is equal to the HARQ RTT. If HARQ feedback is enabled then the RTT is equal to HARQ RTT \* number of retransmission.  For this release it may be OK to use the HARQ RTT with a note that this refers to the case of no HARQ retransmission.  Another way is to somehow re-use the currently specified RTT for the buffer size calculation (even though it’s clearly wrong for NTN), but add a note that the NW restricts throughput based on the actual RTT to avoid buffer overflow. |
| MediaTek | Re-use existing RTT and buffer | The UE buffer size requirements should not change for NTN (as this can set unreasonable assumptions for UEs). Re-use the currently specified RTT for the buffer size calculation. NW will restrict throughput based on the actual RTT to avoid buffer overflow. We can add a note to capture that. |
| Qualcomm |  | We are also ok not to change L2 buffer requirement in Rel-17 as anyway HARQ feedback can be disabled, and also maximum data rate will probably be lower in NTN |
| Apple | No change to exisiting L2 buffer requirement |  |
| Huawei, HiSilicon | No change is needed | We think the agreement of IoT NTN can be reused, i.e., assume the network will limit the data rate so that L2 buffer is not exceeded. |
| Lenovo, Motorola Mobility | No change is needed | NW can restrict date rate. |
| OPPO |  | Same view as Qualcomm. |
| Xiaomi |  | The supported maximum data rate for NR NTN is considerably lower than NR, reuse the current L2 buffer requirement would be enough. |
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**Question 7.2: Is any other change (e.g. data rate limitation) needed for the L2 buffer calculation for NTN?**

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| **Company** | **Views** | **Additional comments** |
| InterDigital | Yes | Even if we assume no HARQ retransmissions, the RTT is up to 10 times the value currently specified. Therefore, the memory requirement is 10 times that of the current TN UEs.  This may be an unreasonable high requirement for UE vendors. If we are to take the same approach as for IoT-NTN (I.e. we don’t increase the buffer size) then the data rate has to be scaled down proportional to the RTT e.g. up 10% of the currently specified rates.  Another way is to somehow re-use the currently specified RTT for the buffer size calculation (even though it’s clearly wrong for NTN), but add a note that the NW restricts throughput based on the actual RTT to avoid buffer overflow. |
| MediaTek | No | The UE buffer size requirements should not change for NTN (as this can set unreasonable assumptions for UEs). Re-use the currently specified RTT for the buffer size calculation. NW will restrict throughput based on the actual RTT to avoid buffer overflow. We can add a note to capture that. |
| Qualcomm | No | See response in Q7.1. |
| Apple | No |  |
| Huawei, HiSilicon | No |  |
| Lenovo, Motorola Mobility | No |  |
| OPPO | No |  |
| Xiaomi | No |  |
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# Conclusion

Based on this offline discussion on UE capabilities, the following proposals are made:

** List of proposals for agreement:**

** List of proposals that require online discussions:**