3GPP RAN WG2 Meeting #111e R2-2008188

August 17th – 28th, 2020

Agenda Item: 8.10.2.1

Source: InterDigital

Title: [DRAFT] [AT111][107][NTN] Pre-compensation and other MAC issues (InterDigital)

Document for: Discussion, Decision

# Introduction

This document discusses proposals from [1 – 5] with focus on pre-compensation and offset in NTN. Additional MAC issues identified in the WID [6] and corresponding candidate solutions from TR 38.821 [7] (summarized in [1]) are also included for companies to provide preliminary views for potential down-scoping:

* [AT111][107][NTN] Pre-compensation and other MAC issues (InterDigital)
* Scope: Discuss the proposals in [R2-2007615](file:///C:\Data\3GPP\RAN2\Docs\R2-2007615.zip), [R2-2007616](file:///C:\Data\3GPP\RAN2\Docs\R2-2007616.zip), [R2-2006928](file:///C:\Data\3GPP\RAN2\Docs\R2-2006928.zip), [R2-2007590](file:///C:\Data\3GPP\RAN2\Docs\R2-2007590.zip) (and possibly other proposals from contributions in 8.10.2.1 focussing on pre-compensation and offset calculations), as well as proposals 1 to 5 in [R2-2007784](file:///C:\Data\3GPP\RAN2\Docs\R2-2007784.zip). The intention is to identify design alternatives and, whenever possible, also narrow down the proposals.
* Initial intended outcome: summary of the offline discussion with e.g.:
  + List of agreeable proposals (if any)
  + List of proposals that require online discussions

Please note the following deadlines have also been provided:

* Initial deadline (for companies' feedback): Friday 2020-08-21 08:00
* Initial deadline (for rapporteur's summary in R2-2008188):  Friday 2020-08-21 10:00

# Pre-compensation and Offset

## Pre-compensation and Timing Advance

In the Rel-17 NTN WI, it is assumed that a transparent or “bent-pipe” configuration will be deployed, where the gNB is located on the ground and a satellite relays signalling between the gNB and the UE. This configuration is comprised of two portions of propagation delay: that associated with the connection between the gNB and satellite, defined as the “feeder-link” and that between the UE and satellite. The feeder-link delay component is common to all UEs served by the cell, whereas the **delay between the UE and satellite** can be further broken down into two components:

* a common delay, representing the minimum delay from the satellite to the ground (i.e. the propagation delay between the satellite and a reference point such as the cell or beam centre) and;
* a UE-specific delay, based on the UE-specific distance to the reference point.

The following contributions propose various methods to apply timing pre-compensation, where further details regarding the solution may be found in the original paper:

* From [3]: Network broadcasts a common TA per cell/beam in NTN for REl17, which contains the delay from the gNB to a reference point (feeder-link + common delay);
* From [2]: UE calculates UE-specific timing advance based on distance from the UE to satellite. Feeder-link delay is broadcast to cell, and UE adds this delay to the UE-specific TA for full PD compensation;
* From [4]: SIB9 IE contains the UTC time of the gNB at a given subframe boundary. UEs with GNSS can also estimate its own UTC time reference. UEs can used elapsed propagation time between gNB and UE to acquire relative timing and estimate full TA.

**Question 2.1: Companies are invited to select a preferred method(s) and/or combination of methods for timing advance pre-compensation in NTN:**

* **Option 1: Broadcast of a common TA per cell/beam;**
* **Option 2: Broadcast of feeder-link delay;**
* **Option 3: UE-specific offset calculated by UE based on UE-satellite location;**
* **Option 4: UE-specific offset calculated by UE based on UE-reference point location;**
* **Option 5: UE-specific offset calculated by UE based on UTC time (via IE in SIB9);**
* **Option 6: Wait for RAN1 input.**
* **Option 7: common TA is compensated for at network side by implementation [7]**

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| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| MediaTek | Option 2  Option 3 | UE will use the UE-satellite location information to estimate the access link delay and network can provide the feeder link delay. Using this information, UE can calculate and pre-compensate the complete Round-Trip Delay (RTD). |
| Huawei | Option 2 +3, or  Option 6 | For the feeder link, the delay is common for all UEs, and UEs are unable to calculate it, therefore broadcasting is preferred.  For the service link, since WI assumes UE has GNSS capability, UE can calculate the UE-specific offset. If common TA is adopted, there’re still issues like preamble ambiguity due to the maximum differential delay. |
| Lenovo | Option 2+3 | Option 1 cannot solve the problem alone as the maximum differential delay in an NTN cell is still out of the range of legacy TA adjustment via RAR.  Option 2 is an option of including feeder link delay but it varies as LEO satellite moves (efficiency is to be considered).  Option 3 is an option for service link and is easy to implement, although we have concerns on calculation complexity and validity due to satellite movement.  Option 2+3 is a possible solution under the consumption of GNSS capability at UE.  Option 4 needs to work with a common service link TA as reference. In this question it could be Option 1+2+4, which is of more complexity and is also affected by satellite movement.  Option 5 is interesting, and we have concerns on accuracy.  For Option 6 we think RAN2 can discuss first and see what RAN1‘s option is.  In Option 7 the network needs to know the location of UE. |
| Spreadtrum | Option 3 + Option 7 | We prefer that common TA is compensated by network implementation. The common TA is changing along with the satellite moving because the distance between the satellite and the gNB on ground. So option 7 avoids the signalling overhead to update TA frequently. |
| OPPO | option 1&2&3 | In the WID, UEs with GNSS capabilities are assumed, and both the cases of UE with and without capabilities of timing advance pre-compensation are considered in R17.  For a UE without capability of timing advance pre-compensation, the UE applies the common TA which is broadcasted by network to send Msg1/MsgA.  For a UE with capability of timing advance pre-compensation, the UE specific TA related to service link could be estimated by UE based on UE-satellite location, and the common TA related to feeder link can be either broadcasted by network or compensated at network side. If the common TA related to feeder link is broadcasted, UE needs to apply the estimated TA related to service link plus the common TA related to feeder link to send Msg1/MsgA. Otherwise, UE can only apply the estimated TA related to service link to send Msg1/MsgA, in which case the common TA related to feeder link will be compensated at network side. |
| LG | Option 1+2 | For a UE with and without GNSS capability, a unified and simple solution should be considered, and the Option 1 can be applicable regardless of whether the GNSS is supported or not.  In addition, if we consider Option 1, we do not need to resolve the issue for the Msg3 schduling adaptation. |
| Xiaomi | Option 1 & 3 & 7 | The following analysis is based on UE with pre-compensation capability.  Option 1 is needed for UE to acquire the full TA in order to calculate the offset of RAR window if UE calculates only UE specific TA.  For option 3, we suggest that UE calculates the d1-d0 part, which is also included in msg3, bits can be saved compared to report d1.  For option 4, does it mean d1-d0? If so, it is the same as option 3. See comment on option 3.  For option 5, although it doesn’t require UE to know the location of satellite, but satellite location is still useful for UE when performing cell reseletion or handover, also for UE pre-compensation adjustment. In this sense, pre-compensation based on satellite location will be better. |
| Nokia | Option 5 + 1 or Option 6 | Option5 (via IE in SIB9) removes potential source of errors/inaccuracies when determining the UE-to-satellite distance and delays. Especially for transparent architectures it is important that the total delay on the Uu interface (feeder and service link) can be estimated by the UE with enough accuracy. UE can pre-compensate full TA based on estimated total delay. Additionaly, the use of the SIB9 solves the timing estimation problem in both transparent and regenerative architectures.  Furthermore, we think a common delay can also be broadcasted by the network, for other purposes (e.g. postponement of timers as a common part of offset to reduce the offset value range), or to provide future assistance to UEs with no GNSS capabilities. |
| Thales | Wait for RAN1 input | We suggest to wait for the results from RAN1 on going work on timing advance.  On going RAN1 discussions propose that the initial TA acquisition (before PRACH transmission) is computed as the sum of two distinct contributions :   * The UE specific TA which is autonomously acquired by the UE based on its GNSS capabilities and additional network indications (e.g. satellite ephemeris or time stamp). It corresponds to the service link RTD. * The Common TA which is indicated by the network. It corresponds to the RTD experienced between the RP and the satellite. |
| Nomor Research | Combination of Option 2 and Option 3  Or Option 5 | GNSS based UEs is working assumption for this WI. Meaning the UE has the ability to do pre-compensation. We propose to do pre-compensation either based on UE satellite location and knowledge about feeder-link delay or based on UTC time provided via IE in SIB9. |
| Intel | Option 1,2,3,4,7 | Both common TA and UE specific TA should be supported. Network side can be based on implementation to boardcast common TA and we can further discuss how UE specific TA can be calculated. |
| Loon, Google | Option 6  OR  Option 1 + Option3  OR  Option 1 + Option 5 | Wait for Ran1. Other wise Option 1+3 or Option 1+5 both work.  Not clear on the relative merits between Option 3/5. |
| Apple | Option 1 + Option 2 + Option 3 | Agree with LG here. Options 1 + 2 allow both GNSS and non-GNSS capable UEs to take advantage. Also, no changes are needed to call flows for TA from MSG3. |
| Qualcomm | Option3 | For Rel-17, assumption is UE is capable of GNSS and it should be able to calculate the uplink pre-compensation based on UE-satelite location as the feeder link RTD is common for all UEs.  For TA, option 3 alone should be sufficient as GW can compensate the feeder link delay. |
| CATT | Option 4 or option 3 | UE can estimate the service link or parital service link based on a reference point and pre-compensate it in UL signal transmission. For feeder-link delay, gNB can compensate it based on satellite position and gateway position. UE is not expected to compensate the feeder link delay because UE is not able to get the gateway position information. Broadcasting a feeder-link delay doesn’t help UE to compensate the feeder-link delay with high accuracy due to satellite moving, just wasting the system resource. |

## Offsets and Extensions

### *Ra-ResponseWindow*

The *ra-ResponseWindow* configured in *RACH-ConfigCommon* starts at the first PDCCH occasion from the end of the Random Access Preamble transmission (unless for CFRA for BFR) [8] and has a duration based on number of slots. The network configures a value lower than or equal to 10 ms when Msg2 is transmitted in licensed spectrum and 40 ms when Msg2 is transmitted with shared spectrum channel access [9]. The soonest possible reception time is 2 times the minimum round-trip delay, so under current timing relationships applied to NTN the UE may attempt multiple preamble transmissions before the gNB is able to provide the RA response message (i.e. Msg2) as shown in Figure 1. Current behaviour will therefore lead to unnecessary UL preamble transmission and increments to the preamble transmission counter, possibly leading to RACH failure.



**Figure 1:** Example of current *ra-ContentionResolutionTImer* behaviour applied to an NTN environment.

**Question 2.2: Do you agree that an offset should be applied to the start of *ra-ResponseWindow* as agreed in SI?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes/No** | **Applicable deployments (LEO/GEO)** | **Additional comments** |
| MediaTek | Yes | LEO and GEO | UE can calculate this offset by using its GNSS-based location and PVT (Position, Velocity, Time) information broadcasted by satellite. |
| Huawei | Yes | LEO, GEO |  |
| Lenovo | Yes | LEO and GEO | Offset can be used to avoid most unnecessary monitoring. |
| Spreadtrum | Yes | LEO and GEO | The offset should be fixed value to all UE in the cell. If different UE use different offsets to start RAR window, there will be collisions of RA-RNTI because the length of RAR window matches the repeating period of RA-RNTI. The offset should be workable for all UE in the cell including the UE closest to the gNB and the UE farthest to the gNB. So the offset should take the largest RTT in the cell and processing delay into consideration. |
| OPPO | Yes | Both | Agree to introduce an offset for the start of *ra-ResponseWindow*to compensate the large RTD in NTN. |
| LG | Yes | LEO and GEO |  |
| Xiaomi | Yes | Both | The offset is calculated based the TA instead of network configuration. |
| Nokia | Yes | LEO/GEO | As the start of the ra-ResponseWindow is defined in RAN1 specification TS 38.213, the offset can be adapted by RAN1 . |
| Thales | Yes | LEO and GEO | Offset to be applied to the start of ra-ResponseWindow provided in the SI. The timer value to be broadcasted by the gNB could be the worst case taking into account the cell size. |
| Nomor Research | yes | LEO and GEO | Offset should be of size pre-calculated UE specific RTD. |
| Intel | Yes | Both |  |
| Loon, Google | Yes | LEO and GEO |  |
| Apple | Yes | Both | Agree that offset can be adopted based on RAN1 outcome. |
| Qualcomm | Yes | Both LEO/GEO | When UEs apply the UL precompensation with respect the the DL slot n associated the the PRACH occasion, there should be no preamble ambiguity. |
| CATT | Yes | LEO and GEO | UE calculates the accurate offset by itself based on its location info. |

The maximum differential delay (defined as the minimum one-way delay minus the maximum one-way delay) within an NTN cell can be up to 10.3 ms [7], where two times that delay (20.6 ms) exceeds the current maximum monitoring duration in a licensed spectrum for the ra-ResponseWindow (10 ms). For UEs at cell edge, if the ra-ResponseWindow is started in the first PDCCH monitoring occasion after 2 times the minimum delay, the monitoring duration may therefore expire before reception of the RA response. To resolve this issue, the following solutions have been captured in the TR:

1. Extension of the *ra-ResponseWindow* to at least cover the full duration of the differential delay in an NTN cell.
2. Calculate a UE-specific offset proportional to the 2 times the delay from the UE to the gNB and start the *ra-ResponseWindow* at an appropriate time such that the RAR would fall within the ra-ResponseWindow.

**Question 2.3a: Is an extension required for the *ra-ResponseWindow* in NTN?**

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| --- | --- | --- | --- | --- |
| **Company** | **Yes/No** | | **Applicable deployments (LEO/GEO)** | **Additional comments** |
| MediaTek | No | | LEO and GEO | As mentioned in our comments, provided in Q2.1, UE can pre-compensate the RTD and use it as an offset to delay the start of ra-ResponseWindow. With UE-based pre-compensation, the differential delay will be automatically adjusted, as UE’s with larger RTD will estimate larger offset and UEs with smaller RTD will estimate smaller offset. Hence, there is no need to extend ra-ResponseWindow. |
| Huawei | No | | / | Since the UE has GNSS capability, it can use the ephemeris data and its own location to calculate the delay and apply the offset to the start of *ra-ResponseWindow*, thus the extention is not needed. |
| Lenovo | Depends | | LEO and GEO | If UE pre-compensates (common + UE-specific) TA then it may use the same value as offset, and extension is not needed. Else if UE only pre-compensates the common TA, extension to cover the differential delay is needed. |
| Spreadtrum | |  |  | It’s up to the discussion on whether msg1 transmission without UE specific TA compensation is supported for the case that UE location information cannot be accessed sometime. |
| OPPO |  | | Both | We think whether an extension for the ra-ResponseWindow in NTN is required depends on how to determine the offset for the start of the ra-ResponseWindow.  If the offset for ra-ResponseWindow is broadcasted by network, in order to ensure all the UEs in the cell could receive RAR within the ra-ResponseWindow, the offset value should be equal to the minimum RTD, and the ra-ResponseWindow length should cover at least maximum differential RTD within the cell, which is 20.6ms for GEO. In this case, extension of *ra-ResponseWindow* value is needed.  If the offset for ra-ResponseWindow is dermined by UE, UE could use the estimated RTD related to service link plus the common TA related to feeder link if broadcasted by network as the offset value. For the ra-ResponseWindow length, network could configure it based on the delay for processing Msg1 and scheduling Msg2 as legacy. In this case, extension of *ra-ResponseWindow* value is not required. |
| LG | No | |  |  |
| Xiaomi | No | | LEO and GEO | The following analysis is based on UE with pre-compensation capability.  When UE compensates the RTD, the offset of RAR window can be set according to the RTD. Then, there is no need to extend the RAR window to absorb the RTD. |
| Nokia | depens on offset applied in Question 2.2 | | At least GEO | If the UE can estimate or get the total round-trip delay between UE and gNB and apply the exact total delay as offset to start ra-ResponseWindow, there is no need to extend the window,  otherwise, the window may be extended to cover 2 times of maximum differential delay. |
| Thales | No | | LEO and GEO | Asuming that the UE is capable to autonomously acquire its TA (i.e. UE specific RTD) |
| Nomor Research | No | | LEO and GEO | Due to UE specific offset for start of ra-ResponseWindow, no extension is required |
| Intel | No | |  | We think that extension is not needed with the offset. |
| Loon, Google | No | | LEO and GEO |  |
| Apple | Yes | | Only for GEO | For the GEO case, the 20.6ms differential delay would need an extension. How this can be achieved can be FFS. |
| Qualcomm | No | |  | See our response in 2.2. |
| CATT | No | | LEO and GEO | UE calculates the accurate offset by itself based on its location info, so there is no need to extend the ra-ResponseWindow. |

**Question 2.3b: If ‘Yes’ to the previous question, please indicate a preferred method of extension:**

* **Option 1: 2-bit LSBs of SFN in Msg2, as mentioned in [4];**
* **Option 2: Other (please describe in ‘Additional Comments’);**
* **Option 3: Wait for RAN1 input;**

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| --- | --- | --- |
| **Company** | **Preferred**  **Option(s)** | **Additional comments** |
| Nokia | Option 1 | The mechanism of using LSBs of SFN in Msg2 is supported in Release 16 NR-U and 2-step RACH specifications, which would allow the extension up to 40 ms of the RAR window. |
| Apple | Option 1 | We are also open for other options. |
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### *ra-ContentionResolutionTimer*

*ra-ContentionResolutionTimer* is started after transmission of Msg3 and has duration of up to 64 ms, which under certain satellite deployments such as GEO transparent is less than 2 times the minimum propagation delay.

The TR also notes that although the *ra-ContentionResolutionTimer* duration is sufficient to cover the maximum differential delay, a UE located near cell edge of a large diameter cell may unnecessarily monitor for around 20 ms thus leading to unnecessary power consumption. If the UE can determine its specific timing offset, it may be beneficial to also apply this to the beginning of the *ra-ContentionResolutionTimer* to reduce UE monitoring duration and thus power consumption.

**Question 2.4: Do you agree that an offset should be applied to the start of *ra-ContentionResolutionTimer*?**

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| --- | --- | --- | --- |
| **Company** | **Yes/No** | **Applicable deployments (LEO/GEO)** | **Additional comments** |
| MediaTek | Yes | LEO and GEO | UE will use the same pre-compensated RTD (mentioned in response to Q. 2.1) as an offset to start the ra-ContentionResolutionTimer. |
| Huawei | Yes | LEO, GEO |  |
| Lenovo | Yes | LEO and GEO | The offset may at least cover the common TA to avoid unnecessary monitoring. |
| Spreadtrum | Yes | LEO and GEO | The offset can be the RTT between the UE and the gNB plus processing time. |
| OPPO | Yes | Both | Same as reply to Q2.2 |
| LG | Yes | LEO and GEO |  |
| Xiaomi | Yes |  |  |
| Nokia | Yes | LEO/GEO | The same solution should be applied to decide offset to start ra-ResponseWindow and ra-ContentionResolutionTimer. |
| Thales | Yes | LEO and GEO | Offset should be of size UE specific RTD |
| Nomor Research | Yes | LEO and GEO | Offset should be of size UE specific RTD. |
| Intel | Yes | Both | It should approximate based on the RTD. However, network should configure based on processing time + other consideration. |
| Loon, Google | Yes | LEO/GEO | Same offset can be used for both RA contention resolution timer and window |
| Apple | Yes | Both | Agree with Lenovo that the offset should atleast cover common TA. |
| Qualcomm | Yes | LEO/GEO | See our response in 2.2. |
| CATT | Yes | LEO and GEO |  |

### *DRX Timers*

As concluded in the SI, modification of *drx-LongCycleStartOffset*, *drx-StartOffset*, *drx-ShortCycle*, *drx-ShortCycleTimer*, *drx-onDurationTimer*, *drx-SlotOffset* and *drx-InactivityTimer* is not needed in NTN. Rapporteur suggests that this conclusion be formalized in the WI unless a new issue/motivation has been found.

**Question 2.5: Do you agree that a modification of *drx-LongCycleStartOffset*, *drx-StartOffset*, *drx-ShortCycle*, *drx-ShortCycleTimer*, *drx-onDurationTimer*, *drx-SlotOffset* and *drx-InactivityTimer* is not needed as per SI conclusion? If ‘No’ please indicate which of the above timer(s) should be modified and why in the “Additional Comments” section.**

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| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| Huawei | Agree |  |
| Lenovo | Agree |  |
| Spreadtrum | Agree |  |
| OPPO | Agree |  |
| LG | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |
| Thales | Agree |  |
| Nomor Research | Agree |  |
| Intel | Agree |  |
| Loon, Google | Agree |  |
| Apple | Agree |  |
| Qualcomm | Agree | No modification to timers is needed. |
| CATT | Agree |  |
|  |  |  |

The value range for HARQ RTT Timer UL/DL is maximum 56 symbols [9], which is insufficient for NTN environment given the increased propagation delay over terrestrial networks. As captured in TR 38.821, the following modifications have been proposed to the operation of the *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL* in NTN:

1. If HARQ is enabled, it is proposed that an offset be applied to the start of the timer to compensate for the additional propagation delay in NTN systems.
2. If HARQ is disabled, as the HARQ retransmission will never arrive. It is proposed to not start the RTT timers for the HARQ process that was disabled.

**Question 2.6: Do you agree that if HARQ feedback is *enabled* an offset is applied to the start of *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL*?**

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| --- | --- | --- | --- |
| **Company** | **Yes/No** | **Applicable deployments (LEO/GEO)** | **Additional comments** |
| MediaTek | Yes, but | LEO and GEO | As the purpose of these timers is to account for RTD, these timers can be extended, (instead of an offset) to include the pre-compensated RTD value (mentioned in response to Q. 2.1). |
| Huawei | Yes | LEO, GEO |  |
| Lenovo | Yes | LEO and GEO | The offset may refer to the pre-compensated TA. |
| Spreadtrum | Yes with comments | LEO and GEO | I remember that in TR we agreed to add the offset to the timers instead of apply an offset to the start of the timers |
| OPPO | Yes | Both |  |
| LG | No | LEO and GEO | The puspose of the offset for drx-HARQ-RTT-TimerDL/UL is to delay a time to start of the drx-HARQ-RTT-TimerDL/UL. In other words, the UE does not monitor the PDCCH before starting the drx-HARQ-RTT-TimerDL/UL.  Considering that the purpose of the drx-HARQ-RTT-TimerDL/UL is that the UE does not monitor the PDCCH while running the drx-HARQ-RTT-TimerDL/UL, the UE behaviour is same even if the drx-HARQ-RTT-TimerDL/UL is extended instend of the introduction of the offset for the drx-HARQ-RTT-TimerDL/UL.  Thus, RAN2 should discuss firstly whether the offset for drx-HARQ-RTT-TimerDL/UL should be introduced or the drx-HARQ-RTT-TimerDL/UL should be extended. |
| Xiaomi | Yes | LEO and GEO |  |
| Nokia | Yes | LEO/GEO |  |
| Thales | Yes | LEO and GEO | Offset size should be UE specific RTD. |
| Nomor Research | Yes | LEO and GEO | Offset should be of size UE specific RTD |
| Intel | Yes | Both |  |
| Loon, Google | Yes | Leo/Geo |  |
| Apple | Yes | Both | Offset the size of UE specific RTD. |
| Qualcomm | Yes/No | LEO and GEO | But we wonder why not to apply the offset to start the DRX retransmission timer instead? |
| CATT | Yes | LEO and GEO |  |
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**Question 2.7: Do you agree that if HARQ feedback is *disabled* *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL* are not started?**

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| --- | --- | --- | --- |
| **Company** | **Yes/No** | **Applicable deployments (LEO/GEO)** | **Additional comments** |
| MediaTek | Yes | LEO and GEO |  |
| Huawei | Yes | LEO, GEO |  |
| Lenovo | Yes | LEO and GEO |  |
| Spreadtrum | Yes | LEO and GEO |  |
| OPPO | Yes | Both |  |
| LG | Yes | LEO and GEO |  |
| Xiaomi | No | LEO and GEO | This is related to whether blind retranmission is enabled when HARQ feedback is disabled. We suggest to discuss this together with solutions for blind retransmission if blind retransmission is enabled. |
| Nokia | Yes | LEO/GEO | As the HARQ feedback is disabled, the gNB may reuse the same HARQ ID for (re)transmission before RTT expired , starting drx-HARQ-RTT-TimerDL/UL is not needed. |
| Thales | Yes | LEO and GEO |  |
| Nomor Research | Yes | LEO and GEO |  |
| Intel | Yes | both |  |
| Loon, Google | Yes | LEO/GEO |  |
| Apple | Yes | Both |  |
| Qualcomm | No | LEO/GEO | If blind retransmission is supported, the DRX retransmission timer can be started. From that perspective, the value of timer may be set to zero instead. |
| CATT | Yes | LEO and GEO |  |

In [4], it is further proposed that If HARQ feedback is disabled, to support blind retransmission and improve transmission reliability, one way for UE to start *drx-RetransmissionTimerDL(UL)* is based on offset scheduled by network via PDCCH. It is noted by the contributing company that this is beneficial for UE power consumption and keeping scheduling flexibility.

**Question 2.8: Do you support further study of modifying start of drx-RetransmissionTimerDL(UL) based on network-scheduled offset via PDCCH (further details on solution in [4])?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comments** |
| MediaTek | No | We think such optimizations should not be discussed until the basic functionalities are in place. |
|  |  |  |
| Huawei | No | The motivation is to enable the UE to sleep in between blind HARQ (re)transmissions.  This is an enhancement based on the assumption that HARQ is disabled and blind retransmission is adopted.  We think the gain is not significant and prefer to first focus on the basic features. |
| Lenovo | No | Agree with MediaTek and Huawei. |
| Spreadtrum | No |  |
| OPPO | No | For a UL HARQ process with disabled HARQ, UE starts drx-RetransmissionTimerUL for the corresponding HARQ process directly after PUSCH transmission.  For a DL HARQ process with disabled HARQ feedback, UE starts drx-RetransmissionTimerDL for the corresponding HARQ process after PDCCH or PDSCH reception. |
| LG | No | In order to receive the blind retransmission, the UE should monitor the PDCCH even if the HARQ feedback is disabled. Thus, drx-RetransmissionTimerDL should be started without starting the drx-HARQ-RTT-TimerDL if the HARQ feedback is disabled. |
| Xiaomi | No | This is related to whether blind retranmission is support or not. If we agree to support blind retransmission, then we can consider all the possible solutions. For this meeting, we prefer to discuss only whether blind retransmission is support or not. |
| Nokia | Yes | If HARQ feedback is disabled, the gNB may re-use the same HARQ ID for (re)transmissions before RTT expired. E.g.  - In DL, schedule (re)transmission will not waiting for feedback anymore.  - In UL, NW will schedule one HARQ process consecutively without waiting for the reception of previous PUSCH transmission in the same HARQ process.  With DRX on, one question is that, NW need to decide when to schedule UE’s (re)transmissions. If UE can start the *drx-RetransmissionTimer* based on network scheduling via PDCCH, it can help UE sleep in between blind HARQ (re)transmissions, to enable power saving during blind (re)transmission phase. |
| Thales | Yes | Needs further discussion, agree with Mediatek. |
| Nomor Research | Yes | Need to discuss, if drx-RetransmissionTimer is started directly for blind retransmissions or not. |
| Intel | No | Agree with MediaTek. |
| Loon, Google | No |  |
| Apple | No | It will be good to discuss this case however, it can wait until the discussion of basic procedures is complete. |
| Qualcomm | No | But for blind retransmission, it should be sufficient just to start the DRX retransmission timer. |
| CATT | No |  |
|  |  |  |

## *sr-ProhibitTimer*

Upon transmission of a scheduling request, the UE starts a *sr-ProhibitTimer*, where throughout the timer duration the UE is prevented from transmitting another SR. The current maximum value range is Rel-16 NR is 128 ms which given potential propagation delay in GEO scenario, can result in timer expiry and the UE transmitting additional SRs before the gNB has received the original. To resolve this solution, it is proposed in the TR that the value range of *sr-ProhibitTimer* be extended to compensate for additional propagation delay.

**Question 2.9: Do you agree the value range of the *sr-ProhibitTimer* should be extended? If ‘Yes’ please indicate the preferred method in the ‘Additional comments’ section.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes/No** | **Applicable deployments (LEO/GEO)** | **Additional comments** |
| MediaTek | No, but | LEO/GEO | UE will use the same pre-compensated RTD (mentioned in response to Q. 2.1) to extend the sr-ProhibitTimer. Hence, the value range can still remain the same (max = 128ms). |
| Huawei | Yes | LEO, GEO | It was agreed in SI phase that the value range of sr-ProhibitTimer should be extended to support NTN. |
| Lenovo | Yes | LEO and GEO | The extended range may at least cover the common TA for GEO. |
| Spreadtrum | No | LEO and GEO | Applying an offset to the start of sr-ProhibitTimer is sufficient. |
| OPPO |  | Both | We prefer to introduce an offset for the start of *sr-ProhibitTimer*, which reflects the UE specific RTD, and not to change the existing value range of *sr-ProhibitTimer*. |
| LG | Yes | LEO/GEO |  |
| Xiaomi | Yes | LEO/GEO | The value range needs to be extended. Offset doesn’t work in this case because UE needs to prohibit SR even during the offset period. |
| Nokia | No | LEO/GEO | To avoid unnecessary SR transmission due to high RTT, either of two options can be applied:  Option1: add an offset to sr-ProhibitTimer.  Option2: Value range extension.  As the timer need to be updated regularly to handle the varying delays of NTN, RAN2 need to discuss how to update timer efficiently. We think an offset based solution(Option1) is more feasible to help UE updating UE timers efficiently. |
| Thales | Yes | LEO / GEO |  |
| Nomor Research | Yes | LEO and GEO | Adding the UE specific RTD or a multiple of it to one of the values of the already existing set of configurable values. |
| Intel | Yes/No | Both | Either offset or extension will work |
| Apple | Yes | Both |  |
| Qualcomm | Yes | LEO/GEO | It can be extended based on the common Koffset broadcast in SIB. Applying start offset may not prohibit SR during offset. |
| CATT | Yes | LEO/GEO | sr-ProhibitTimer should be extended to support NTN: the extended range can be [ms256, ms512, ms1024, ms2048] which depends on different senarios. i.e. GEO/LEO |

## General Offset Considerations

If an offset is introduced to e.g. *ra-ResponseWindow*, *ra-ContentionResolutionTimer*, *drx-HARQ-RTT-TimerUL* or *drx-HARQ-RTT-TimerDL* details regarding the precise value, how this value is obtained, and in what scenarios the offset value is applied require further discussion. Rapporteur notes that this discussion may rely on outcome of pre-compensation discussion and further RAN1 input, however companies may provide initial preferences to facilitate further discussion.

**Question 2.10: Companies are invited to indicate a preliminary preference regarding a general method for offset calculation (detailed solutions FFS):**

* **Option 1: Explicit UE calculation (e.g. via location information);**
* **Option 2: Value provided my network (e.g. via a common TA);**
* **Option 3: Wait for RAN1 input;**
* **Option 4: Other (please describe in ‘Additional Comments’ section).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Preferred**  **Option(s)** | **Additional comments** |
| MediaTek | Option 1 | UE will use its GNSS-based location and the PVT information, broadcasted by the satellite, to estimate the access link delay. Network can provide the feeder link delay. Using this information, UE can explicitly calculate the complete Round-Trip Delay (RTD), needed for offset. |
| Huawei | Option 1 | Since the WI assumes UE has GNSS capability, Option 1 is feasible.  Moreover, UE specific offset can avoid issues caused by differential delay (e.g. preamble ambiguity, extension of RAR window). |
| Lenovo | Option 1 | UE can reuse the result of TA pre-compensation. Extension to cover differential delay may be additionally needed if only common TA is considered i.e. Option 2. |
| Spreadtrum | Option 4 | The offset for the start of RAR window should be provided in SI. Others can be the RTT specific to the UE plus processing time. |
| OPPO |  | The offset value for *ra-ResponseWindow* can be UE’s estimated TA (option 1) or can be provided by the network (option 2).  In CBRA, after UE receives Msg2, UE already knows its absolute TA value , so this TA value can be used as the offset value for ra-ContentionResolutionTimer.  UE would maintain its TA in RRC connected mode, so the UE TA can be used as the offset value for drx-HARQ-RTT-TimerDL or drx-HARQ-RTT-TimerUL.  In the latter two cases, UE’s absolute TA is used as the offset value. |
| LG | Option 2 | For a UE with and without GNSS capability, a unified and simple solution should be considered, and the Option 2 can be applicable regardless of whether the GNSS is supported or not. |
| Xiaomi | Option 1 & 2 | To calculate the offset, UE needs to know the full TA. So, anyway network needs to broadcast at least the feeder link delay, or broadcast the common TA. |
| Nokia | Option3 | The offset calculation depends on UE’s pre-compensation solution discussed in RAN1.E.g. the offset can be full RTT estimated by UE *or* common delay broadcasted by NW *or* (common delay+UE estimated differential delay). |
| Thales | Option 1 / Option 2 | RAN1 will specify the method for full TA calculation (common + UE specific).  The offset calculation is derived from the full TA as well as potential margin. |
| Nomor Research | Option 1 | Offset should be of size UE specific RTD (or a multiple of it for sr-ProhibitTimer) |
| Intel | Option 1/2 | UE should use the common TA and add UE specific offset |
| Loon, Google | Option 1/ Option 2 | Option 1 should be baseline. Option 2 can also be studied |
| Apple | Option 4 | We agree with Spreadtrum’s and Oppo’s views here. |
| Qualcomm | Option 4 | Offset and TA are two different things.  The start offset can be simply with respect to the DL time slot where, for example PRACH occasion occurs, a common offset (broadcast) can be applied to determine the DL time slot to start monitoring RAR.  At least in Rel-17, option 2 is not needed. |
| CATT | Option1 |  |

# Other MAC open Issues

Additional MAC issues identified in the WID [6] and corresponding candidate solutions from TR 38.821 [7] (summarized in [1]) are also included for companies to provide preliminary views for potential down-scoping.

## Random Access

### 4-Step RACH

From the WID it is assumed that all Rel-17 NTN-capable UEs have GNSS capability which enables methods of pre-compensation such as TA calculation using UE-satellite location information or UTC time. However, [5] notes that a GNSS-capable UE may not always have available location information should, for example, the GNSS satellite not be visible.

As visibility of an NTN satellite and GNSS satellite is similar, if a UE is unable to acquire GNSS information it is likely it cannot access NTN satellite as well. [5] therefore proposes that RAN2 prioritize the case of UE with valid location information and capability to perform pre-compensation in RACH procedure, and discussion on UEs not able to perform pre-compensation is postponed pending further progress in RAN1

**Question 3.1: Do you agree that RAN2 should prioritize the case of UE with valid location information and capability to perform pre-compensation in RACH procedure?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | Rel. 17 explictly mentions NTN-capable UEs have GNSS capability and RAN2 should prioritize the case of UE having capability to perform pre-compensation in RACH procedure. |
| Huawei | Agree | Note that RAN2 should also allow co-existence with different random access capabilities. If there are both UEs that have GNSS and non-GNSS capabilities and given that the random access scheme for these might be different, then it should be possible for the network to separate the resources and control access to the network given that the random access procedures and the resource may look very different.  Even though the WI assumes UE has GNSS capability, not excluding UEs without GNSS capability is more future-proof.  Therefore the prioritization should be: UEs with valid location information > UEs without valid location information (including UEs without GNSS capability). |
| Lenovo | Agree | At least we can prioritize this in Rel-17 with the current assumption. This does not preclude non-location-based solutions. |
| Spreadtrum | Agree, but | Future proofness should be taken into consideration. |
| OPPO | disagree | We should consider both cases in the WI, i.e. UEs with and without pre-compensation capability. |
| LG | Disagree | Regardless of whether the UE supports the GNSS or not, the common TA should be used for pre-compensation. |
| Xiaomi | RAN1 to discuss | Whether UE can pre-compensate the delay actually impacts the design of preamble, i.e. the CP of the preamble needs to absorb the differential propagation delay if no pre-compensation, which falls into the RAN1 expertise. We do not think RAN2 has the knowledge to decide on this. |
| Nokia | Disagree | The WID describe one possible type of UE that, UE with GNSS capability but without pre-compensation of timing and frequency offset capabilities. We think RAN2 should consider both types of UE (i.e. with and without pre-compensation capabiliy) and make sure they can co-exist in NW. |
| Thales | Agree | The UE with valid location information and capabilities to perform pre-compensation should be analysed in priority.  Further analysis for other scenarios (e.g. UE with location information but no capabilities to perform pre-compensation) should be postponed pending RAN1 decision and results. |
| Nomor Research | Agree | From our perspective valid location information and capability to perform precompensation is a valid assumption for GNSS capable UEs. UE with GNSS capability but without capability to perform pre-compensation should be postponed. |
| Intel | Agree | We think that UE with GNSS should be assumed in the WI. If that is the case, pre-compensation should be considered. |
| Loon, Google | Disagree, but | For the HAPs case, visibility of HAPS and GNSS satellites is not correlated. Having the ability to handle UE without GNSS capability is of interest to HAPs.  We are however ok, postponing discussion of handling UE’s without GNSS visibility to after RAN1 discussions |
| Apple | Disagree | We should consider both cases. |
| Qualcomm | Agree | The case of UE not capable of precompensation in UL (i.e., using common TA) brings a lot of issues such as the need to design new PRACH format, preamble ambiguity and frequent TA updating issues in RRC\_CONNECTED. This can be deprioritized in Rel-17. |
| CATT | Agree | Share the same view as MediaTek. |

[5] further proposes that the following 4-step RACH procedure can be applied for UEs with pre-compensation at UE side:

1. In Msg1 transmission, the UE should estimate the absolute TA (e.g. based on distance between UE and satellite) and apply the TA estimated in the preamble transmission.
2. In Msg2 reception, the UE should apply the TA command received in RAR as a delta adjustment to the TA maintained on UE side (i.e. the TA estimated in Msg1 transmission).
3. For the UL grant in Msg2 for Msg3 transmission, it is up to gNB implementation to ensure a sufficient processing time on UE side for the Msg3 transmission (e.g. gNB can always assume maximum TA is used on UE side, where the maximum TA can be determined based on the coverage of the NTN cell)

**Question 3.2: Do you agree that for 4-step RACH with pre-compensation at UE side, the following procedure can be used as baseline:?**

1. **In Msg1 transmission, the UE should estimate the absolute TA (e.g. based on distance between UE and satellite) and apply the TA estimated in the preamble transmission.**
2. **In Msg2 reception, the UE should apply the TA command received in RAR as a delta adjustment to the TA maintained on UE side (i.e. the TA estimated in Msg1 transmission).**
3. **For the UL grant in Msg2 for Msg3 transmission, it is up to gNB implementation to ensure a sufficient processing time on UE side for the Msg3 transmission (e.g. gNB can always assume maximum TA is used on UE side, where the maximum TA can be determined based on the coverage of the NTN cell)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | In addition to the above points, UE should include the absolute TA value estimated (TA report) in the payload of Msg3 (similar to Q3.4). |
| Huawei | Agree, with comments | Since the TA is varying in some scenarios, UE should be able to report the revised TA to the network afterwards. |
| Lenovo | Agree |  |
| Spreadtrum | Disagree | 1. As comments in Q2.1, common TA compensation by network is preferred. 2. Msg3 modification is a big impact to TS, which should be avoided. |
| OPPO | Agree with comments | For transparent payload, UE could estimate the TA related to service link. The common TA related to feeder link can be broadcasted by network or compensated at network side. If the common TA related to feeder link is broadcasted, UE needs to apply the estimated TA related to service link plus the common TA related to feeder link to send Msg1. |
| LG | Agree | The common TA can be applied to above procedure. |
| Xiaomi | Agree the general procedure but | Whether UE compensates the full TA or UE specific TA is decided based Q2.1. |
| Nokia | Disagree | In Step1, the absolute TA may include feeder link delay on top of serving link delay. The pre-compensation solution is up to RAN1. |
| Thales | Agree with comments | Estimated TA will depend on calculation methods proposed by RAN1. |
| Nomor Research | Agree in principle | Estimated TA consists of distance between UE and satellite and feeder link delay |
| Intel | Agree | We agree the general framework and can be use as a baseline. |
| Loon, Google | Agree |  |
| Apple | Agree in principle but | For MSG1, UE can use common TA. No changes to MSG3 as spreadtrum mentioned in their comments. |
| Qualcomm | Partly agree | In Step 3, a common Koffset should be broadcast for this scheduling purpose, it is up to network to set the proper value of Koffset. |
| CATT | Agree with condition | For absolute TA mentioned in item 1, it can be clarified that it only includes the TA between UE and reference point or the TA between UE and satellite. |

### 2-Step RACH

In SI phase, the use of 2-step RACH in NTN was discussed extensively in NTN, however as 2-Step RACH WI was ongoing, agreement on adoption was postponed until WI completion. As 2-step RACH is now supported in Rel-16 NR, [5] proposes that both 2-step and 4-step RACH be supported in NTN

**Question 3.3: Do you agree that both 2-step and 4-step RACH are supported in Rel-17 NTN, with enhancements to 2-step RACH to accommodate the NTN environment FFS?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | Changes in 2-step RACH should follow the agreements on 4-step RACH. |
| Huawei | Disagree for the moment | 4-step RACH should be prioritized and finished first, and then RAN2 can identify whether the enhancement can be extended to 2-step RACH. |
| Lenovo | Agree |  |
| Spreadtrum | Agree | Sending BSR via 2-step RACH can mitigate the latency and the accurate TA can be applied to the 2-step RACH. |
| OPPO | Agree |  |
| LG | Disagree | Same view as Huawei. |
| Xiaomi | Agree |  |
| Nokia | Agree | We think 2-step RACH can only be applied to specified case. E.g. for cases where the UE is capable of fully aligning the MsgA PRACH and MsgA PUSCH at the gNB (that is for cases with full time compensation) or UE can obtain accurate TA from NW via TA command before sending MsgA (e.g. handover or PDCCH order triggered RACH). The problem being that if MsgA PUSCH receptions are not time aligned, the gNB cannot separate UEs (or will have too much interference).  Also, it should be noted that 2-step RACH is a quite resource requiring feature, so support for 2-step RACH will not come for free. |
| Thales | Agree |  |
| Nomor Research | Agree |  |
| Intel | Agree | We should prioritize 2-step RACH due to the propagation delay issue in NTN. |
| Loon, Google | Disagree | 4 step RACH should be completed. Then we should evaluate if the same work is applicable to the 2 step RACH |
| Apple | Agree |  |
| Qualcomm | Agree |  |
| CATT | Agree |  |

[5] further proposes that the following 2-step RACH procedure can be applied for UEs with pre-compensation at UE side:

1. In MsgA transmission, the UE should estimate the absolute TA (e.g. based on distance between UE and satellite) and apply the TA estimated in both the preamble and PUSCH transmission.
2. In MsgA transmission, the UE should include the absolute TA value estimated in the payload of MsgA.
3. In MsgB reception, the UE should apply the TA command received in RAR as a delta adjustment to the TA maintained on UE side (i.e. the TA estimated in Msg1 transmission).

**Question 3.4: Do you agree that for 2-step RACH with pre-compensation at UE side, the following procedure can be used as baseline:?**

1. **In MsgA transmission, the UE should estimate the absolute TA (e.g. based on distance between UE and satellite) and apply the TA estimated in both the preamble and PUSCH transmission.**
2. **In MsgA transmission, the UE should include the absolute TA value estimated in the payload of MsgA.**
3. **In MsgB reception, the UE should apply the TA command received in RAR as a delta adjustment to the TA maintained on UE side (i.e. the TA estimated in Msg1 transmission).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| Huawei | Disagree | Same answer as Q3.3. |
| Lenovo | Agree |  |
| Spreadtrum | Disagree | We think that 2-step RACH is only used while there is TA maintained to keep the system efficient. |
| OPPO | Agree with comments | See our reply to Q3.2 |
| LG | Disagree |  |
| Xiaomi | Agree with the general procedure but | Same as Q3.2 |
| Nokia | Disagree | Same comment as Question 3.2 for absolute TA in MsgA transmission (e.g. the absolute TA may include feeder link delay on top of serving link delay). |
| Thales | Agree in principle following RAN1 outcomes | The estimation of the full (common + specific) TA should follow RAN1 definitions. |
| Nomor Research | Agree in principle | Estimated absolute TA consists of distance between UE and satellite and feeder link delay. |
| Intel | Agree | We agree the general framework and can be use as a baseline. |
| Loon, Google | Agree |  |
| Apple | Agree in principle but | See comments from 3.2 above |
| Qualcomm | Agree |  |
| CATT | Agree | For absolute TA mentioned in item 1, it can be clarified that it only includes the TA between UE and reference point or the TA between UE and satellite. |

[4] further states that additional considerations for 2-step RACH in NTN should be evaluated, noting the following:

* Assuming NTN introduces additional UL payload in MsgA PUSCH should be considered carefully for the impact to coverage and PUSCH resource consumption.
* The availability and accuracy of the TA pre-compensation before sending MsgA PUSCH needs to be evaluated.
* Adaptive 2-Step or 4-step RA type selection mechanism is one possible way to balance the overall resource overhead and fulfill RACH capacity requirement in NTN.

**Question 3.5: Do you agree one or more of the following considerations for 2-step RACH in NTN should be evaluated as baseline? If so, which ones. Companies are invited to note additional considerations in the ‘Additional Comments’ field.**

1. **Assuming NTN introduces additional UL payload in MsgA PUSCH (e.g. SFN, BSR or TA value) should be considered carefully for the impact to coverage and PUSCH resource consumption;**
2. **The availability and accuracy of the TA pre-compensation before sending MsgA PUSCH;**
3. **Adaptive 2-Step or 4-step RA type selection;**
4. **Other – please describe in the ‘Additional Comments’ section.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Considerations you agree with** | **Additional comments** |
| MediaTek | None | We expect RAN1 will study the availability and accuracy of TA pre-compensation. |
| Huawei | Disagree | Same answer as Q3.3. |
| Lenovo | None | We can evaluate if any specific essential issue is identified. |
| Spreadtrum | 1, 2 | 1. Only sending BSR   Only while accurate TA is available |
| OPPO | 1, 2 and 3 | For 1, the PUSCH coverage issue needs to be evaluated by RAN1.  For 2, we think it also applies to 4-step RA.  For 3, we think the existing RSRP-based selection needs to be adapted to take location information into account. |
| LG | Disagree |  |
| Xiaomi | None | None for RAN2 |
| Nokia | Item1/2/3. | We think item1 should be considered carefully and we should avoid increasing the payload of MsgA if possible. |
| Thales | 3 |  |
| Nomor Research | 3 | Due to the large cell size in NTN, it could be necessary to do RA type selection by the network to avoid too many collisions. |
| Intel |  | Maybe we should wait for RAN1 before RAN2 work starts. |
| Apple | 1,3 | Due to the large size of cell and large delays. 1 helps ensure network can prepare for the traffic volume. 3 helps with reducing collisions. |
| Qualcomm | 1,2, and 3 | 2 step RACH is existing feature. |
| CATT | None | RAN1 should study the availability and accuracy of TA pre-compensation. |

### Preamble ambiguity

Given the large maximum differential delay possible in NTN, it is noted in section 7.2.1.1.1.2 of TR 38.821 [7] that certain RACH occasion periodicities configurable in Rel-16 NR may lead to overlaps in preamble receiving windows between successive RACH occasions. gNB may not know which RO the preamble is associated with in the overlap period, thus may not be able to accurately estimate the appropriate timing advance.



**Figure 2:** Preamble ambiguity due to overlapping preamble receiving windows in NTN.

The following potential solutions have been captured in TR 38.821 [7]:

1. Proper PRACH configuration in the time domain, where the interval between two consecutive RO (RACH Occasions) should be larger than 2 times the maximum differential delay within a cell
2. Preamble division, where preambles are divided into groups and mapped to different RO. ROs with timing separation less than 2 times the maximum differential delay are always assigned with different groups of preambles.
3. Frequency hopping (e.g. identifying RO based on preamble transmission frequency band)
4. 2-step RACH (e.g. including assistance info in MsgA PUSCH).

**Question 3.6: Companies are invited to indicate a preliminary preference to support further study and/or deprioritize the following method(s) regarding RACH preamble ambiguity:**

* **Option 1: Proper PRACH configuration in time;**
* **Option 2: Preamble division;**
* **Option 3: Frequency hopping;**
* **Option 4: 2-Step RACH;**
* **Option 5: Wait for RAN1 feedback.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Option(s) for continued study** | **Deprioritized Option(s)** | **Additional comments** |
| MediaTek | None (Not needed) | Option 1  Option 2  Option 3  Option 4 | As mentioned in our response to Q.2.1, UE’s with GNSS capability wil estimate the access link delay and network will provide the feeder link delay. Using this information, UE can calculate the complete Round-Trip Delay (RTD) and use it as an offset to pre-compensate the RTD. With UE-based pre-compensation, the differential delay will be automatically adjusted, i.e. UEs wih higher RTD will pre-compensate larger RTD and UEs wih smaller RTD will pre-compensate smaller RTD. Thus, there will be no overlap of pre-ambles and preamble ambiguity will not exist. |
| Huawei | None |  | This question depends on the outcome of Q2.1 and Q2.10.  If RAN2 agrees that UE calculates the UE specific offset, then there will be no preamble ambiguity issues. |
| Lenovo | None |  | Preamble division still sacrifices the supported UE density because that the same preambles cannot be reused in the period of 2 \* the maximum delay difference within the cell. So there is no difference between Option 1 and 2.  The main issue is that the size of required preamble receiving window (i.e. 2 \* the maximum delay difference within the cell) is not changed. We think the UE location or propagation delay can be used to help accurate window configuration and thus reduce the size of it. E.g. we can consider location/distance/delay-based PRACH configuration. |
| Spreadtrum | 2, 3 |  | Option1 has latency worse. |
| OPPO | Option 1 |  | Option 1 is the simplest and does not have spec impact.  Option 2 achieves similar RACH performance as option 1, but will lead to more preamble partition and have spec impact.  Option 3 needs RAN1 to define hopping pattern.  Option 4 does not work for 4-step RACH. |
| LG | Option 1 | Option 2, 3 and option 4 | For Option 1, 2 and 4, it reduces the capacity of RACH procedure. However, from specification impact point of view, the option 1 is better than option 2 and 4 because there is no impact on the specification, e.g., the configuration is up to network decision. In addition, the Option 3 requires the RAN1 discussion, and thus, we do not want to introduce option 3. |
| Xiaomi | None |  | Agree with Mediatek and Huawei that if UE calculates the UE specific TA, then there is no ambiguity issue. With precompensation, the preamble arriving at gNB is aligned and also the UL timing. gNB considers the preamble is transmitted at the nearest RO before the reception of preamble(for the case that UE compensates the full TA. This is the same as legacy RA-RNTI calculation behavior). From receiving preamble, gNB cannot know the full TA, but UE can report the UE specific TA in Msg3. |
| Nokia | Option1/2/4 | Option 3 | We understand that the preamble ambiguity only exist for UE without GNSS capability or with GNSS but without pre-compensation capability which are not the majority cases. So we would like to keep the solution simple. |
| Thales | Option 5 |  | PRACH format is RAN1 responsibility. We suggest to wait for the proper PRACH configuration in time to be provided by RAN1 to avoid additional impacts. |
| Nomor Research | Option 5 |  | Applicability of PRACH format is RAN1 responsibility. |
| Intel | 1,2,3,5 |  | In general, network can based on implementation to avoid such issue. RAN1 may also have some solution to resolve such problem. RAN2 should wait for RAN1 works start. |
| Loon, Google | Option1 | Option 2/3/4 | Preamble ambiguity is only for UE without GNSS capability. |
| Apple | Option 1, 2, 4 | Option 3 |  |
| Qualcomm | None |  | At least in Rel-17, we should simplify work by assuming UE capable of calculating precompensated TA. Some errors can be handled by the existing PRACH format.  Therefore, there should be no preamble ambiguity. |
| CATT | None |  | There won’t be preamble ambiguty issues if UE calculates specific offset by itself. |

## Msg3 Scheduling adaptation

If the UE applies UE-specific pre-compensation to Msg1, under current specification the gNB will not be aware of the calculated pre-compensation value and may schedule Msg3 transmission under the assumption that the UE is much nearer to the satellite than it really is, possibly resulting in the UE not being able to transmit in the provided UL grant. Potential solutions captured in TR 38.821 [7] include:

1. The network scheduling Msg3 without knowledge of the absolute TA value, and scheduling Msg3 according to, for example, the maximum propagation delay of the cell or the maximum differential delay. The UE would the provide the gNB its absolute timing advance in Msg3.
2. The UE is restricted to only compensate a UE-specific portion of the timing advance (i.e. the difference between the common TA provided by a gNB and a UE-specific TA.
3. 2-Step RACH, where the UE may provide the UE-specific TA in MsgA PUSCH resource.

**Question 3.7: Companies are invited to indicate a preliminary preference to support further study and/or deprioritize the following method(s) regarding Msg3 scheduling adaptation for UEs applying UE-specific pre-compensation:**

* **Option 1: Network scheduling/implementation (i.e. no modification necessary);**
* **Option 2: Restrictions on UE-applied pre-compensation value;**
* **Option 3: 2-Step RACH.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Option(s) for continued study** | **Deprioritized Option(s)** | **Additional comments** |
| MediaTek | Option 1, Option 3 | Option 2 | We see no need to artificially restrict to UE’s pre-compensation. |
| Huawei | Option 1 |  | It can be left to implementation, no need to over-specify. |
| Lenovo | Option 1 or 3 | Option 2 | Agree with MediaTek. |
| Spreadtrum | Option 2 |  |  |
| OPPO | Option 1 |  |  |
| LG | None | Option 1, 2 and 3 | This issue would not happen if the common TA is applied. |
| Xiaomi | Option 1 |  |  |
| Nokia | Option1 |  | We would assume NW can decide how to schedule Msg3 based on pre-compensation solutions decided by RAN1. |
| Thales | Option 1 | Option 3 | The UE shall support both 4-step and 2-step RACH for NTN. |
| Nomor Research | Option 1 | Option 3 | Deprioritize Option 3 because both 2-Step and 4-Step RACH shall be supported for NTN. |
| Intel | 1,3 | 2 |  |
| Loon, Google | Option 1 | Option 2, Option 3 |  |
| Apple | Options 1, 3 | Option 2 | Agree with Mediatek’s views |
| Qualcomm | Option 1/3 | Option 2 | There is no space to include more information in Msg3 in 4 step RACH. Therefore, simply a common Koffset is used for scheduling. UE may send pre-compensated TA in Msg5. |
| CATT | Option1 |  | It can be implementation work. |

## Enabling/Disabling HARQ Feedback

In the SI, RAN2 agreed that although the HARQ processes remain configured, HARQ feedback may be disabled, for example, on a per-HARQ process basis. It was further agreed that the criteria and decision to enable/disable HARQ feedback is up to the network and will be signaled to the UE in a semi-static manner. Rapporteur suggests that these conclusions be formalized in the WI unless a new issue/motivation has been found.

**Question 3.8a: Do you agree that from a RAN2 perspective, HARQ feedback can be enabled/disabled in Rel-17 NTN, but HARQ processes remain configured. The criteria and decision to enable/disable HARQ feedback is under network control and is signalled to the UE via RRC in a semi-static manner as agreed in the SI?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| Huawei | Agree |  |
| Lenovo | Agree |  |
| Spreadtrum | Agree |  |
| OPPO | Agree |  |
| LG | Agree |  |
| Xiaomi | Agree | We still need to discuss whether blind retransmission is enabled with disabling HARQ feedback. |
| Nokia | Agree |  |
| Thales | Agree |  |
| Nomor Research | Agree |  |
| Intel | Agree |  |
| Apple | Agree |  |
| Qualcomm | Agree |  |
| CATT | Agree |  |

**Question 3.8b: If ‘Agree’ to the previous question, send an LS to RAN1?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| Huawei | No strong view |  |
| Lenovo | Agree |  |
| Spreadtrum | Agree |  |
| OPPO | Agree | Don’t consider DCI-based indication any more. |
| LG | Disagree | RAN1 can refer to RAN2 decision. |
| Xiaomi | Agree |  |
| Nokia | Disagree | The LS to RAN1 can be sent after conclusion reached in RAN2. |
| Thales | Agree |  |
| Nomor Research | Agree |  |
| Intel | Agree |  |
| Apple | No strong view | But prefer RAN2 can also come to a conclusion before sending the LS to RAN1 |
| Qualcomm | No strong view | Unless there is specific action identified for the RAN1, there is no need to send LS just to inform this agreement. |
| CATT | Agree |  |

In Rel-16 NR, a single HARQ process supports one TB (when the PHY layer is not configured with spatial multiplexing), and up to 16 HARQ processes are supported. As HARQ process IDs (PID) assigned to a TB cannot be re-used until the associated TB is flushed from the buffer, for example, after ACK reception or upon timer expiry, in an NTN environment with large propagation delay if a TB requires one or more retransmission(s) it may mean that a HARQ PID is assigned to a TB for a significantly larger duration than in terrestrial networks.

Should this occur for multiple TBs, the UE may run out of HARQ PIDs to assign to new data, thus introducing delay to transmission and requiring the UE to buffer or drop new packets. Possible solutions captured in TR 38.821 [7] include:

1. Intelligent TDM scheduling, where the gNB would only schedule the UE to transmit data sufficiently spaced out in time to ensure that a UE would have available HARQ processes for new data.
2. Increasing the number of HARQ PIDs (e.g. to 32).
3. Disabling HARQ feedback, for example, on a per-HARQ process basis.

**Question 3.9: Companies are invited to indicate a preliminary preference to support further study and/or deprioritize the following method(s) regarding HARQ stalling:**

* **Option 1: Network scheduling/implementation (i.e. no modification necessary);**
* **Option 2: Increased number of HARQ PIDs;**
* **Option 3: Disabling HARQ Feedback;**
* **Option 4: Wait for further RAN1 input.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Option(s) for continued study** | **Deprioritized Option(s)** | **Additional comments** |
| MediaTek | Option 1,  Option 3 | Option 2 | Increasing nmber of HARQ PIDs has signicant negative impacts on UEs implementation complexity, as well as siginificant RAN1 and RAN2 specification impacts. Moreover, it is already shown in R2-1914589 and R1-1910983 that disabling HARQ and relying on RLC retransmissions (ARQ) is capable of achieving similar performance. |
| Huawei | Option 3 | Option 2 | Increasing number of HARQ PIDs is not purely a RAN2 issue. It brings some requirements on the buffer and increases UE complexity, so RAN1 needs to have some discussion first. |
| Lenovo | Option 3 |  | Option 2 should be discussed in RAN1 first. |
| Spreatrum | Option 4 |  | Not sure whether relying on ARQ is sufficient with disabling HARQ. It’s up to RAN1. |
| OPPO | Option 4 |  |  |
| LG | Option 1 | Option 3 | For Option 2, RAN2 cannot decide increasing number of HARQ process IDs because it should be discussed in RAN1. Thus, we should wait for RAN1 decision on Option 2.  For Option 3, we think that HARQ stalling can be prevented by network implementation |
| Xiaomi | Option 4 |  | Depends on the RAN1 discussion on whether HARQ PIDs are extended or not. |
| Nokia | Option4 and Option3 |  | As the increased number of HARQ PIDs will impact RAN1 e.g. DCI format, it’s better wait for further RAN1 input. We also believe disabling HARQ feedback is one baseline solution. |
| Thales | Option 4 |  | Wait for RAN1 decision |
| Nomor Research | Option 4 |  | RAN 1 decision |
| Intel | 1, 3, 4 |  |  |
| Loon, Google | Option 4/1/3 | Option 2 | Wait for RAN1, else option1 else option 3 |
| Apple | Option 4 |  | Depends on RAN1 discussions and decisions |
| Qualcomm | Option 2 and 3 | Option 1 | Option 2 may be decided by RAN1. |
| CATT | Option3 | Option2 | RAN1 should discuss Option2 first. |

Contribution [1] also summarizes various open issues related to HARQ including the granularity that HARQ feedback is enabled or disabled. The options listed in the TR include configuration per UE, per HARQ process, or per LCH.

**Question 3.10: Companies are invited to indicate a preliminary preference to support further study and/or deprioritize the following method(s) regarding the granularity of disabling HARQ feedback:**

* **Option 1: Per UE;**
* **Option 2: Per HARQ process;**
* **Option 3: Per LCH;**
* **Option 4: Wait for further RAN1 input.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Option(s) for continued study** | **Deprioritized Option(s)** | **Additional comments** |
| MediaTek | Option 1,  Option 2 | Option 3 | The SI (TR 38.821) has explicitly recommended Option 1 and Option 2. There is no need to discuss any further optimization. |
| Huawei | Option 2 and 3 | Option 1 | Option 2 and 3 are preferred in case the UE has traffics with various QoS requirements. If adopted, it should be performed as follows: the gNB configures the HARQ function to be disabled for some HARQ processes and some LCHs, so that MAC can match the data from the LCHs with the HARQ processes during LCP procedure.  Option 1 is not flexible. UE either disables or enables all HARQ processes, without considering that some services are delay sensitive whereas others are not. |
| Lenovo | Option 2 |  | Per HARQ process granularity is necessary. |
| Spreadtrum | Option 2 and 3 | Option 1 | Agree with HW. |
| OPPO | Option 1/2/3 |  | For both UL and DL, disbling HARQ feedback can be configured on a per-UE or per-HARQ process basis.  For UL, if disbling HARQ feedback is configured on a per-HARQ process basis, disbling HARQ feedback configuration on a per-LCH basis should also be needed. |
| LG | Option 1  Option 2 | Option 3 | Option 3 is unnecessary optimization. |
| Xiaomi | Option 2/3 |  | we prefer per HARQ process and per LCH |
| Nokia | Option1/2/3/4 |  |  |
| Thales | Option 1, Option 2 |  |  |
| Nomor Research | Option 1, Option 2 |  |  |
| Intel | 1,2 |  |  |
| Loon, Google | Option 1, 3 | Option 2 | HARQ has implications on QoS. In general we do not restrict logical channels from using any HARQ process so option 2 does not make sense |
| Apple | Options 1, 2 |  |  |
| Qualcomm | Option 2/3 | Option 1 | It should be sufficient to enable/diabled per HARQ process. Disabling HARQ feedback for all HARQ processes can achieve per UE option 1. HARQ is lower layer configuration and LCH is higher layer configuration so option 3 is not clear. LCP is needed anyway. |
| CATT | Option 2 and 3 | Option 1 | For LCH, HARQ enable/disable should be configured as LCH restrictions. For each HARQ process, whether HARQ should be enable/disable depends on the LCHs transmitted using this HARQ process. |

## UL Scheduling Enhancements

In Rel-16, upon arrival of a packet in a UE buffer for UL transmission, the UE may send a buffer status report (BSR) to the gNB to allow for proper allocation of UL grant resources. However, if the UE does not have UL resources configured for transmission of the BSR, the UE may first need to send a scheduling request (SR). Due to the much larger propagation delay in non-terrestrial networks, requiring the UE to wait two RTTs before transmitting UL data may introduce significant latency to data transmission.

The following solutions have been captured in Table 7.2.1.5-1: Scheduling enhancement options in TR 38.821:

Table 1 [7]: Scheduling enhancement options

|  |  |  |  |
| --- | --- | --- | --- |
| Scheduling option | Pros | Cons | Delays\* |
| SR-BSR procedure | - Low resource overhead required | - Large delays | At least 2 RTTs of delay |
| Sending large grant in response to SR | - Potentially low resource overhead | - Still takes 2 RTTs before UE has the BSR  - Might be a waste in terms of resources since network is still not aware of the buffer situation of the UE | 1 – 2 RTTs |
| Configured grant | - Low latency with right configuration | - Large overhead  - Trade-off between latency and overhead | 0 – 1 RTT\*\* |
| BSR-indication in SR | - Low latency with correct configuration | - Large spec-impact  - Resource overhead impact unclear, larger than SR | 1 RTT |
| BSR over 2-step random access | - Low latency  - Low overhead | - RACH resources required | 0 – 1 RTT\*\* |
| \* the number of RTTs before full scheduling based on BSR can begin.  \*\* if configured grant/2-step allocation is large enough and data can be transmitted in the grant. | | | |

**Question 3.11: Companies are invited to indicate a preliminary preference to support further study and/or deprioritize the following method(s) regarding UL scheduling enhancements:**

* **Option 1: SR-BSR procedure;**
* **Option 2: Sending large grant in response to SR;**
* **Option 3: Configured Grant;**
* **Option 4: BSR-indication in SR;**
* **Option 5: BSR over 2-step RACH.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Option(s) for continued study** | **Deprioritized Option(s)** | **Additional comments** |
| MediaTek | Option 1  Option 2  Option 3  Option 5 | Option 4 | BSR-indication in SR (Option 4) will have major (significant) changes in standards and should be de-prioritized.  Regarding the other options, there are discussions ongoing in the Small Data Enhancements Work Item and solutions from there can be taken into account. |
| Huawei | Option 2/3 | Option 4 | Option 2/3 can be based on the current NR mechanism and will not cause much spec modification. The implementation can fix the issue. |
| Lenovo | Option 2 or 3 |  | Less spec impact. |
| Spreadtrum | Option 5 | Option 4 | Option 2/3 are up to network implementation.  Option 4 bring big impacts to the spec |
| OPPO | Option 2/3/4 | Option 1/5 | Option 2 and 3 are up to NW configuration and do not have spec impact.  For option 4, a UL logical channel is configured with multiple PUCCHs, each of which represents a UL buffer amount level, so that UE could provide a rough UL buffer amount to network via SR based on the selected PUCCH for sending SR.  Option 1 is the existing procedure and has long scheduling delay.  Option 5 is inferior to option 3 as it requires additional RO resources. |
| LG | Option 3 and 4 | Option 5 | Option 1 and 2 are legacy behaviour, and should be baseline.  Options 3, 4, and 5 are enhancement, and we are open for discussing enhancement. However, we think 2-step RACH should be deprioritized as explained in Q 3.2. |
| Xiaomi | Option 1 & 3 & 5 |  | Option 1 is the baseline.  Option 3 anyway needs to be supported as it is already supported in R15/R16. We just need to decide if enhancement is necessary or not.  Option 5 anyway needs to be supported as it is already supported in R16. We just need to decide if enhancement is necessary or not. |
| Nokia | Option1,Option4 |  | Option1 is the baseline solution and Option4 will save the scheduling delay in a simple way. |
| Thales | 2,3,5 | 4 | Proposed to deprioritized Option 4 due large spec impact. |
| Nomor Research | 2, 3, 5 | 4 | Option 1 is already supported in current release, no further specification necessary, Option 4 has large spec impact and should be deprioritized due to limited time budget |
| Apple | Options 1, 2, 3, 5 | 4 | We will have big impacts to standards for any SR changes. |
| Qualcomm | Option 3/5 | Option 2/4 | Sending large grant in response to SR is not solution. If network wants, this is already possible solution but network does not know how large TBS UE needs.  BSR indication in SR will carry very coarse BSR information, so option 4 is also not good. |
| CATT | Option 2,  Option 3，  Option 5 | Option 4 | Option 2/3 are current NR mechanism, no new methods are needed. |

# Offline Summary

<To be generated by email discussion Rapporteur pending outcome of company input>

# Conclusions

<To be generated by email discussion Rapporteur pending outcome of company input>

# References

1. R2-2007615 – “Summary of MAC open issues in NTN” InterDigital
2. R2-2007616 – “Pre-compensation and offset calculation in NTN” InterDigital
3. R2-2006928 – “Timing advance for NTN” Intel Corporation
4. R2-2007590 – “Timing Advance, Random Access and DRX aspects in NTN” Nokia, Nokia Shanghai Bell
5. R2-2007784 – “Consideration on MAC enhancements for NTN” ZTE Corporation, Sanechips
6. RP-201256 – “Solutions for NR to support non-terrestrial networks (NTN)” Rel-17 NTN WID
7. TR 38.821 – “Solutions for NR to support non-terrestrial networks (NTN)”
8. TS 38.321 – “Medium Access Control (MAC) protocol specification” v16.1.0
9. TS 38.331 – “Radio Resource Control (RRC) protocol specification” v16.1.0