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. |
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## 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?**

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| **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 |  |
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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 | |  |  |
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**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** |
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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 |  |
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### *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 |  |
|  |  |  |

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. |

**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 |  |

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. |
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| 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. |

## *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.**

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| --- | --- | --- | --- |
| **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 |  |

## 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).**

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| --- | --- | --- |
| **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. |

# 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?**

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| --- | --- | --- |
| **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. |

[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)**

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| **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. |

### 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?**

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| --- | --- | --- |
| **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. |

[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 |  |

[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 |  |

### 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. |

## 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. |

## 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 |  |

**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. |

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 |

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. |

## 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. |

# 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