3GPP RAN WG2 112e R2-20XXXXX

Online November 2nd – 13th, 2020

Agenda Item: 8.10.2.2

Source: MediaTek

Title: [POST111e][909][NTN] RLC and PDCP aspects (MediaTek)

Document for: Discussion, Decision

# Introduction

Non-Terrestrial Networks (NTN) differ from terrestrial networks (TN) in terms of large propagation delay and wide geographical coverage of beam-spots (cells), thereby resulting in significant increase in round-trip delay (RTD). This high RTD calls for some changes and enhancements in RLC and PDCP. The Rel-16 Study Item (SI) on NR-NTN [1] concluded with some major recommendations for RLC and PDCP in Section 9.2 of 3GPP TR 38.821 [1]. Furthermore, the work item description (WID) [2] for Rel. 17 NR-NTN clarifies the assumption of UEs with GNSS capabilities. This document discusses proposals from [7 – 12] with focus on RLC and PDCP aspects in NTN. Some additional issues, identified in [8] and corresponding candidate solutions are also included for companies to provide views for potential down-scoping:

* **[POST111e][909][NTN] RLC and PDCP aspects (MediaTek)**
* Scope: Discuss the proposals in contributions in 8.10.2.2 of RAN2-111e, focusing on RLC and PDCP aspects of NR-NTN. The intention is to identify design alternatives and, whenever possible, also narrow down the proposals.
* Intended outcome: summary of the offline discussion with:
  + List of agreeable proposals (if any)
  + List of proposals that require online discussions in RAN2-112e

Please note the following deadline:

* Deadline (for companies' feedback): **Thursday, OCT-15 UTC 07:00**

# Contact Information:

Name: Abhishek Roy

Organization: MediaTek Inc.

Email: Abhishek.Roy@mediatek.com

Name: Geumsan Jo

Organization: LGE

Email: geumsan.jo@lge.com

# Enhancements in RLC

## Updating RLC Timers

High RTD in NTN might result in expiry of some RLC timers. Thus, it is necessary to look into the major RLC timers and check if any possible extensions or updates are needed.

### *RLC t-Reassembly Timer*

RLC t-Reassembly timer is started when a PDU segment is received from lower layer, is placed in the reception buffer, at least one byte segment of the corresponding SDU is missing and the timer is not already running. The procedure to detect loss of RLC PDUs at lower layers by expiration of timer t-Reassembly is used in RLC AM, as well as in RLC UM [3]. The timer t-Reassembly can be configured by fixed values between *0 and 200ms* [3]. In terrestrial networks this timer covers the largest time interval in which the individual segments of the corresponding SDU have to arrive out of order at the receiver due to SDU segmentation and/or HARQ retransmissions. However, if HARQ is supported by NTN, an extension of the t-Reassembly timer is necessary, because *the timer should cover the maximum time allowed for HARQ transmissions*, which will probably be a value larger than the Round Trip Delay (RTD). Considering the maximum RTD for the NTN reference scenarios, defined during the Study Item phase (see Table 1), it is obvious that the maximum value of 200ms is not enough, if HARQ is supported by NTN.

Table 1: Maximum Round Trip Delay for different reference scenarios, see Table 4.2-2 in [2]

|  |  |  |
| --- | --- | --- |
|  | Orbit, payload | Max. RTD |
| Scenario A | GEO, transparent | 541.46ms |
| Scenario C | LEO, transparent | 25.77ms (600km)  41.77ms (1200km) |

The following contributions in RAN2-111e proposed an extension of RLC t-Reassembly Timer: R2-2006640, R2-2006703, R2-2006782 and R2-2007785. On the other hand R2-2007889 mentions the extension of value for timers if a new QoS requirement for NTN is defined.

**Question 1: Do companies agree that RLC t-Reassembly timer needs to be extended in NR-NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The value range of t-Reassembly timer should be extended to accommodate the maximum delay of successful transmission of all SDU segmentations of a SDU, which is related to RTD while HARQ feedback is enabled. |
| LG | Agree | Considering the RTD in NTN, the current maximum value 200ms is not sufficient. Larger value may need to be introduced. |
| Xiaomi | Agree | If HARQ is enabled. |
| CMCC | Agree | To ensure correct PDU segments reassembling, the RLC t-Reassembly timer is needed to be extended in NTN system. |
| Panasonic | Agree | If HARQ feedback is enabled, the t-Reassembly timer should be extended probably larger than the RTD to cover maximum time allowed for HARQ retransmission. |
| Ericsson | Agree | Larger values are needed for t-Reassembly, the range shall be studied.  Data that is delivered without HARQ feedback should probably use a short t-Reassembly value to allow for short retransmission delays.  For data delivered with HARQ feedback we need to extend t-Reassembly to allow for HARQ retransmissions also when the RTD is 541 ms to avoid RLC status reporting requesting retransmissions too early. |
| CATT | Agree | It is necessary to extend t-Reassembly timer since the RTD of GEO is larger than the current maximum value of t-Reassembly. |
| APT | Agree | From RAN1 consensus, at least one HARQ-ACK shall be enabled. In this case, RLC t-Reassembly timer shall be extended to be functional for GEO. |
| Nomor Research | Agree | The value range of t-Reassembly needs to be extended to support HARQ retransmissions in NTN. |
| Thales | Agree | If HARQ feedback is enabled, an extension of the t-Reassembly timer is necessary to cover the maximum time allowed for HARQ transmissions |
| NEC | Agree | The value range of this timer needs to be extended since HARQ retransmission can be enabled by network for NTN scenario |
| Lenovo | Agree | t-Reassembly timer needs to be extended to cover the maximum time for HARQ transmissions, if HARQ feedback is enabled. |
| Loon, Google | Agree | Agree with views expressed by other companies |
| Nokia | Agree |  |
| Samsung | Agree |  |
| ZTE | Agree |  |
| OPPO | Agree | The t-Reassembly value range should be sufficient to cover the largest HARQ retransmission delay in NTN if HARQ feedback is enabled. |
| Huawei | Agree |  |
| Intel | Agree | It needs to be extended for the case where HARQ feedback is enabled. However, it will be a large value. In reality, HARQ feedback should be disable and HARQ retransmission doesn’t have to be RTD. |
| Turkcell | Agree |  |
| China Telecom | Agree |  |
| Qualcomm | Agree | Yes in case of GEO. |
| Sequans | Agree |  |
| Apple | Agree |  |

#### *Modification of RLC t-Reassembly Timer*

Based on the Tdocs submitted in RAN2-111e, RLC t-Reassembly timer could be updated in different ways:

* **Option 1**: Reuse the same formula of TR 38.821 using maximum RTD (common to all UEs), number of allowed HARQ retransmission attempts and offset to account for possible delays on UE and network side. This is mentioned in R2-2006640.

*t-Reassembly = RTD \* NHARQ-ReTx + scheduling\_offset (1)*

* **Option 2**: Modification of the formula, given in TR 38.821, according to R2-2006703, considering UE specific one way propagation delay from UE to gNB or vice versa, number of allowed HARQ retransmission attempts and scheduling offset per transmission.

*t-Reassembly = (2 \* ntn-propagationDelay + schedulingOffset) ∙ nrofHARQ-Retransmissions (2)*

* **Option 3**: Use a UE-specific offset for the start of t-Reassembly, as mentioned in R2-2006782.

From the options submitted, we first need to decide whether the extension of RLC t-reassembly timer will be UE-specific or common across all UEs in the same cell.

**Question 2a: Should the RLC t-reassembly timer be extended by using UE-specific delay or cell-specific (maximum) delay?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| Spreadtrum |  | The formula of option 2 takes schedulingOffset into consideration for every HARQ feedback, which is more reasonable than option 1. Option 3 is less friendly than expanding the timer from implementation perspective. However, UE is agnostic to the formula. It’s up to gNB implementation to configure the t-Reassembly to UE. |
| LG |  | We do not understand the question. The extended value should be introduced in RRC IE and the network just configures the UE’s t-reassembly using the extended value. |
| Xiaomi | depends on network implementation | From UE point of view, it only knows that a specific t-Reassembly timer is configured, without knowing whether it is a UE specific value or cell specific value.  From network point of view, it can decide whether to use a UE specific value or cell specific value depends on range of the differential delay. But anyway, the t-Reassembly is per UE per RB configured. |
| CMCC |  | The calculation formula of the t-Reassembly timer is not perceptible to the UE and depends on the network implementation. |
| Panasonic |  | t-Reassembly timer is per RLC entity, configured by RRC. The value of t-Reassembly timer can be left up to network implementation. |
| Ericsson | UE specific | The gNB shall configure the wanted t-Reassembly for each radio bearer. The formulas above are not needed in the spec, but may be used for indicating the value range needed. |
| CATT | depends on network implementation | It’s up to gNB implementation to configure the t-Reassembly to UE. |
| APT | UE-specific | in RRC\_CONNECTED, NW shall have UE-specific delay information for a scheduling purpose. |
| Nomor Research | UE specific | The gNB shall configure the value for t-Reassembly per UE. As there are many different scenarios in NTN which differ significantly in propagation delay (LEO 600 vs LEO1200 vs GEO; transparent vs regenerative etc.), we propose to enhance the set of configurable values by formula of option 2. Therefore, the necessity to list a large set of configurable values can be avoided. |
| Thales | UE specific | The value range of t-Reassembly timer needs to be extended by considering UE-specific RTD, number of maximum allowed HARQ-retransmission attempts and a configurable offset to account for possible delays on UE and network-side |
| NEC |  | Agree with the other companies that we need to specify the value range but not the formula. |
| Lenovo | NW implementation | Configuration of t-Reassembly is gNB implementation so we only need to define the value range. |
| Loon, Google | UE specific | There is no need to specify a formula but to agree on the extended range. |
| Nokia |  | The timer is configured by network via RRC per RLC entity. |
| Samsung | New option | All these options need continuous UE processing to update the t-Reassembly timer. Please see the Samsung response to Question 2b for a brief description of a new option. |
| ZTE | Up to NW implementation | Share with majority view that only the value range needs to be extended, and the exact value is configured by the NW. |
| OPPO | UE specific | Since it is configured per radio bearer per UE, UE-specific delay should be taken into account. |
| Huawei | NW implementation | The timer is configured per UE per RLC entity. It is up to NW implementation to configure the value. Like TN, the network is able to configure a UE specific value. |
| Intel | UE specific | Agree with other companies that no need for formula. It can be configured by the network. |
| Turkcell | UE specific |  |
| China Telecom | NW implementation |  |
| Qualcomm | - | The formula is just for a rough estimation for us to define maximum range and simply option 1 works for that purpose.  The value range of t-ReassenblyTimer should cover the RTD. But obviously it is up to network what value to configure to UE. |
| Sequans | - | It should be configured on a per RLC entity basis, as in legacy. |
| Apple | UE Specific | But configured by network. No need of the formula. |

If extension of t-reassembly timer is common across all UEs, the network can configure the UEs with the extended value range of RLC t-reassembly timer. However, for UE-specific t-reassembly timer, following Question 2a, we also need to decide the principle to be used for the extension.

**Question 2b: Companies are invited to select a principle for extending RLC t-reassembly timer:**

* **Option 1: Reuse the same formula of TR 38.821 (mentioned in Equation (1) above);**
* **Option 2: Modify the formula, given in TR 38.821 (mentioned in Equation (2) above), according to R2 2006703;**
* **Option 3: Use an offset for the start of t-Reassembly, as mentioned in R2-2006782;**
* **Option 4: Any other option.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| Spreadtrum |  | UE is agnostic to the formula. It’s up to gNB implementation to configure the t-Reassembly to UE. |
| LG | Option 4 | Introduce extended value in RRC IE. |
| Xiaomi | Network implementation | There is no need to capture the formula in the spec. But the values to be extended can be based on either option 1 or option 2, not much difference. |
| CMCC |  | Please see our comments to Question 2a. |
| Panasonic | Option 4 | Network configures extending timer value by a fixed set of value. |
| Ericsson | Option 4 | Extend the value-range with higher values. The formula shall not be included in the spec. |
| CATT | Option 4 | No need to capture the formula in the spec and the value will be extended in IE. |
| APT | Option 4 |  |
| Nomor Research | Option 2 | As there are many different scenarios in NTN which differ significantly in propagation delay (e.g. LEO 600 vs LEO1200 vs GEO; transparent vs regenerative; number of possible HARQ retransmissions), we prefer a formula instead of a huge set of values. If the UE is informed about number of HARQ retransmission and scheduling offset, it can calculate the configured by itself. Scheduling offset is still configurable by network. |
| Thales | Option 2 | A formula should be used to compute the offset in order to avoid a high number of value sets to be configured. |
| NEC | Option 4 | Agree with the other companies that we need to specify the value range but not the formula. |
| Lenovo | Option 4 | Configuration of t-Reassembly is gNB implementation so we only need to define the value range. |
| Loon, Google | Option 4 |  |
| Nokia | Option 4 | No need to include formula in the specification. To extend the range of t-Reassembly value, it can be done by enumerating more large values or adding offset to the current values. For this timer, we prefer to list more large values as a simple method. |
| Samsung | New Option | We suggest the following generic framework for timer values that can benefit from the range extension in the NTN. The actual timer value can be “(minimum\_NTN\_delay + scaling factor\*R16 timer value)” or “(minimum\_NTN\_delay + R16 timer value)\*scaling factor” depending on the timer under consideration. The parameter “minimum NTN delay” is the minimum expected round-trip-delay (including the propagation delays and processing delays). The parameter “scaling factor” is used to fine tune the overall delay. The default value of “scaling\_factor” is 1.0. The parameter “minimum NTN delay” is a function of NTN Type (e.g., GEO, LEO, or HAPS) and is transmitted only if necessary (e.g., only if the default value is inadequate per gNB determination). Furthermore, the parameter “scaling\_factor” is transmitted only if necessary (e.g., only if the default value of 1.0 is inadequate per gNB determination). Such framework is reusable for various timers. Furthermore, this framework enables reuse of existing R16 timers and provides a better time resolution for a given NTN type compared to the case when timer values are extended by adding new numerical values. The framework is more efficient from signaling and processing perspectives. For example, there is no need to keep recalculating and updating t-ReassenblyTimer due to the ever-changing propagation delay for quasi-Earth-fixed beams and Earth-moving beams. This option enables both the gNB and the UE to know the exact timer value. |
| ZTE | Option 4 | Share majority view, larger values can be defined for NTN |
| OPPO | Option 3 | Considering that *t-Reassembly*’s value needs to accommodate different scenarios, which means that the set of configurable values has to be extended by a large number of different values, so we prefer Option 3, where the offset value directly reflects the RTD\* *nrof\_HARQ\_retrans*. |
| Huawei | Option 4 | Prefer to extend the value range, which is also in line with WI guidance. |
| Intel | Option 4 | No need to specific formula. Only value range needs to be extended. |
| Turkcell | Option 4 |  |
| China Telecom | Option 4 | The key issue is the range of t-reassembly timer. |
| Qualcomm | Option 1 | We assume it should only assist us to define maximum value range of the t-ReassenblyTimer. |
| Sequans | ? | As a baseline, we should just extend the range of possible values  (not sure which option this corresponds to).  This could be revisited if this really yields too many values. |
| Apple | Option 4 | Extend the range and define larger values for NTN. |

### *RLC t-PollRetransmit Timer*

As mentioned in 3GPP TS 38.322 [3], an Acknowledged Mode (AM) RLC entity can poll its peer AM RLC entity in order to trigger status reporting at the peer AM RLC entity. The RLC layer uses the Polling flag in the header to solicit a STATUS PDU from the peer RLC. This timer is used by the transmitting side of an AM RLC entity to retransmit a poll. The t-PollRetransmit timer is started after a poll has been sent. If the t-PollRetransmit timer expires, the transmitting RLC entity sends a poll and considers un-acknowledged SDUs for retransmission. As discussed during the Study Item, the current range for t-PollRetransmit Timer is large enough to cover all NTN deployments. Hence, as mentioned in R2-2006640, the t-PollRetransmit Timer does not need any extension.

**Question 3: Do companies agree that there is no need to extend t-PollRetransmit Timer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The maximum configurable expiration time for *t-PollRetransmit* timer is 4000ms which covers the RTD of NTN. |
| LG | Agree |  |
| Xiaomi | agree |  |
| CMCC | Agree | The current value range for t-PollRetransmit Timer is sufficient in NTN system. |
| Panasonic | Agree | The current value range i.e. 4000 ms is sufficient to cover RTD of NTN. |
| Ericsson | Agree |  |
| CATT | Agree |  |
| APT | Agree |  |
| Nomor Research | Agree |  |
| Thales | Agree | No modification of the RLC t-PollRetransmit timer is needed to support NTN |
| NEC | Agree |  |
| Lenovo | Agree | Current value range (4000ms) is sufficient. |
| Loon, Google | Agree |  |
| Nokia | Agree |  |
| Samsung | Agree | Toward the higher side, this timer can be set to at least 4 s. Hence, there is no need to extend t-PollRetransmit. |
| ZTE | Agree |  |
| OPPO | Agree | The current value range of t-PollRetransmit is sufficient to cover the largest RTD in NTN. |
| Huawei | Agree |  |
| Intel | Agree |  |
| Turkcell | Agree |  |
| China Telecom | Agree |  |
| Qualcomm | Agree | Existing values should be sufficient. |
| Sequans | Agree |  |
| Apple | Agree |  |

### *RLC t-statusProhibit Timer*

A STATUS PDU is sent to the peer RLC layer to acknowledge received RLC SDUs and RLC SDU segments. A STATUS PDU is triggered when (a) the peer RLC layer sets the Polling flag (P) in an AMD PDU, thus, soliciting a STATUS PDU, (b) t-Reassembly timer expires, or (c) t-StatusProhibit timer expires. RLC t-StatusProhibit timer is used by the receiving side of an AM RLC entity in order to prohibit transmission of a STATUS PDU. Status report is not triggered when timerStatusProhibit is running. As discussed during the Study Item, the current range for t-statusProhibit timer is large enough to cover all NTN deployments. Hence, it is mentioned in R2-2006640 that t-statusProhibit timer does not need any extension in NR-NTN.

**Question 4: Do companies agree that there is no need to extend t-statusProhibit timer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The maximum configurable expiration time for *t-statusProhibit* is 2400ms which covers the RTD of NTN. |
| LG | Agree |  |
| Xiaomi | Agree |  |
| CMCC | Agree |  |
| Panasonic | Agree | The current value range i.e.2400 ms is sufficient to cover RTD of NTN. |
| Ericsson | Agree |  |
| CATT | Agree |  |
| APT | Agree |  |
| Nomor Research | Agree |  |
| Thales | Agree | No modification of the t-statusProhibit timer is needed to support NTN |
| NEC | Agree |  |
| Lenovo | Agree | Current value range (2400ms) is sufficient. |
| Loon, Google | Agree |  |
| Nokia | Agree |  |
| Samsung | Agree | Toward the higher side, this timer can be set to at least 2.4 s. Hence, there is no need to extend t-PollRetransmit. |
| ZTE | Agree |  |
| OPPO | Agree | The current value range of t-statusProhibit timer is sufficient to cover the largest RTD in NTN. |
| Huawei | Agree |  |
| Intel | Agree |  |
| Turkcell | Agree |  |
| China Telecom | Agree |  |
| Qualcomm | Agree |  |
| Sequans | Agree |  |
| Apple | Agree |  |

## Extending RLC Sequence Numbers

According to 3GPP TR 38.821 [3], RLC sequence number space needed for a radio bearer depends on supported data rates, retransmission time, as well as the average size of the RLC SDUs. The basic formula for calculating the supportable RLC bit rate for one radio bearer is given by:

*RLC\_data\_rate = RLC\_SDU\_size ∙ 2SN\_length -1 / RetransmissionTime*,

3GPP TS 38.322 [3] specifies a RLC AM sequence number (*SN*) field length of 12bits and 18 bits. Depending on typical values of RLC\_SDU\_size, SN\_length, RTD, maxRetxThreshold and RetransmissionTime, the following values of RLC data rates are estimated in Section 7.2.2.2 of 3GPP TR 38.821[1].

Table 2: Supportable RLC bit rates for GEO NTN with transparent architecture

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| RLC\_SDU\_size | SN\_length | RTD | maxRetxThreshold | RetransmissionTime | RLC\_data\_rate |
| 500Byte | 18 | 541.46 ms | 1 | 1.5 s | 350 Mbps |
| 1500Byte | 18 | 541.46 ms | 1 | 1.5 s | 1 049 Mbps |
| 500Byte | 18 | 541.46 ms | 4 | 3.0 s | 175 Mbps |
| 1500Byte | 18 | 541.46 ms | 4 | 3.0 s | 524 Mbps |

Table 3: Supportable RLC bit rates for LEO NTN with transparent architecture

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| RLC\_SDU\_size | SN\_length | RTD | maxRetxThreshold | RetransmissionTime | RLC\_data\_rate |
| 500Byte | 18 | 25.77 ms | 1 | 75.0 ms | 6 991 Mbps |
| 1500Byte | 18 | 25.77 ms | 1 | 75.0 ms | 20 972 Mbps |
| 500Byte | 18 | 25.77 ms | 4 | 150.0 ms | 3 495 Mbps |
| 1500Byte | 18 | 25.77 ms | 4 | 150.0 ms | 10 486 Mbps |

For GEO satellite system with transparent architecture, having a retransmission time of 3.0s or 1.5s and an RLC SDU size of 500 bytes, the NTN target data rate of 360Mbps for airplanes connectivity cannot be achieved. As mentioned in R2-2007785, this is a motivation for extending the RLC SN.

However, it is mentioned in R2-2006640 that considering typical TCP segment sizes and usage of PDCP packet aggregation schemes, in almost all practical scenarios the possibility of getting a stream of consecutive 500bytes packets in airplanes connectivity is very less likely. Thus, in almost all practical scenarios, the average RLC SDU size will be much higher than 500bytes. On the other hand, applications involving small data packets (e.g. voice) typically does not have a high target data rate of 360 Mbps. Based on these observations, it is also argued that there is no need to extend the RLC SN length. Moreover, it is also mentioned in R2-2006782 that longer SN field length leads to larger AM\_Window\_Size, which would increase the amount of required memory for the UE buffer. This is not desirable from the perspective of UE implementation complexity. This conclusion is supported in R2-2006703, and R2-2007889.

**Question 5: Do companies agree that there is no need to extend RLC SN length?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The 18-bit RLC SN can support most of scenarios. For airplane, more than one UE can be set in a plane if more data rate is needed. |
| LG | Agree |  |
| Xiaomi | Agree |  |
| CMCC | Agree | NTN Scenarios with insufficient data rate are very limited, and it is unnecessary to extend SN for the corner cases. |
| Panasonic | Agree |  |
| Ericsson | Agree | No need to extend RLC SN length. |
| CATT | Agree |  |
| APT | Agree |  |
| Nomor Research | Agree |  |
| Thales | Agree | The current specification is applied for NTN without any changes |
| NEC | Agree |  |
| Lenovo | Agree |  |
| Loon, Google | Agree |  |
| Nokia | Agree |  |
| Samsung | Agree |  |
| ZTE | Agree | If majority consider current SN is sufficient for most of scenarios, then we are fine to keep current SN length. |
| OPPO | Agree |  |
| Huawei | Agree |  |
| Intel | Agree |  |
| Turkcell | Agree |  |
| China Telecom | Agree |  |
| Qualcomm | Agree |  |
| Sequans | Agree |  |
| Apple | Agree |  |

# Enhancements in PDCP

## Updating PDCP Timers

Similar to RLC, high RTD in NTN might result in expiry of some PDCP timers. Thus, it is necessary to look into the major PDCP timers and check if any possible extensions or updates are needed.

### *PDCP Discard Timer*

In PDCP layer, a timer *discardTimer* is configured for each DRB. Upon reception of a PDCP SDU from upper layer, the transmitting PDCP entity starts the *discardTimer* associated with this PDCP SDU. As mentioned in 3GPP TS 38.323 [4], when the *discardTimer* associated with a PDCP SDU expires, or the successful delivery of a PDCP SDU is confirmed by PDCP status report, the transmitting PDCP entity shall discard the PDCP SDU. The discardTimer is configured in the range of *0.5ms and 1500ms* or can be switched off by choosing infinity [4]. The discardTimer mainly reflects the QoS requirements of the packets belonging to a service. In NTN, due to long propagation delay, HARQ and ARQ retransmission delay will increase greatly. So one open issue is whether to extend the value range of PDCP *discardTimer* to support NTN.

In order to prevent unnecessary expiry of PDCP discardTimer, it is proposed to extend the PDCP discard timer in R2-2006640 and R2-2006705. One possible solution is to extend the discardTimer by the UE’s pre-compensated RTD. On the other hand, it is mentioned in R2-2006782 and R2-2007889 that as QoS requirement is a main factor in the *discardTimer* configuration, for some delay sensitive service, *discardTimer* should be configured to a relatively small value, while for some other delay tolerant services *discardTimer* could be configured even to infinity, if the value of 1500ms is still not enough and there is no need to extend the PDCP Discard timer, at least until new QoS requirements are defined.

**Question 6: Do companies agree that PDCP Discard timer needs to be extended?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | No | The PDCP discardTimer mainly reflects the QoS requirements of the packets belonging to a service. So the timer is not related to the RTD in NTN. We think that it may be extended only if a new 5QI is defined. |
| LG | Disagree | The value of the discardTimer is configured based on the QoS requirement. Thus, without changing the QoS requirement, the discardTimer should not be extended. |
| Xiaomi | Depends on SA2 | Discard timer mainly relates to QoS requirement of service, i.e. whether service can endure a packet arriving with certain delay without disfunction. It is SA2’s responsibility to decide whether NTN service requirement would be different from the existing one. |
| CMCC |  | DiscardTimer modification needs to be considered as a compromise with required memory and QoS requirements. |
| Panasonic | Disagree | Same view as LG. the PDCP discard time is configured based on QoS requirement associated with a service. If the discard timer expires, it means the packet can no longer meet the QoS requirement. Since NTN doesn’t change QoS traffic, the discard timer should not be extended.  If new 5QI is defined for NTN, the discard timer should be extended. |
| Ericsson | Disagree | The PDCP discard timer shall correspond to QoS requirements, and there are no new QoS requirements defined by for NTNs. We may revisit this if there are new QoS requirements defined. |
| CATT | Disagree | The PDCP discard Timer is defined based on QoS requirement. |
| APT | No | Agree LG |
| Nomor Research | Agree | Although, there are no new standardized NR QoS requirements defined, operators can define their own specific 5QIs. In order to support NTN scenarios (including GEO), PDCP discardTimer needs to be extended. |
| Thales | Disagree | First suitable values for 5QI requirements to support GEO scenario need to be defined then we can define a set of configurable values for the PDCP discardTimer reflecting the identified requirements. |
| NEC | Disagree | Agree with above companies, discard timer corresponds to QoS requirement. |
| Lenovo | Disagree | PDCP Discard timer is associated to QoS requirement. Extension should be based on new QoS requirement (i.e. new 5QI) which is SA2 work. |
| Loon, Google | Disagree |  |
| Nokia | Disagree | Similar view as LG. If new QoS requirement is defined for NTN, then the modification to the timer can be re-visited. |
| Samsung | Wait for SA2 | In general, 1500 ms is fine. However, for GEOs and delay-tolerant services that can benefit from few HARQ and RLC retransmissions, 1500 ms may not be adequate. Hence, RAN2 can wait for SA2 to update QoS parameters (if any), and, we can revisit this parameter at that time. |
| ZTE | Disagree | It is unnecessary to extend PDCP discard timer at this stage. We may revisit it if new QoS requirement is defined. The same comment also applied to PDCP t-Reordering timer. |
| OPPO | Disagree | The configuration of discardTimer mainly considers the QoS requirements of the service, and it is not related to RTD. So there is no need to extend the value range of discardTimer if there is no new 5QI definded in NTN. |
| Huawei | Disagree | Agree with others that this is related to QoS requirement. |
| Intel | maybe | Even though we agree with most companies that the PDCP discard timer is related to QoS requirement. However, NTN delay will significant delay the package. Most likely new requirement will need to be defined for NTN. Therefore, we should wait for SA2 or send LS to SA2. |
| Turkcell | Disagree | We share QoS concerns. |
| China Telecom | Depend on SA2 | PDCP Discard Timer is related to QoS requirement. If SA2 defines new QoS requirement for NTN, the Timer needs to be modified. |
|  |  |  |
| Qualcomm | Wait for SA2 | We also agree to wait any update in QoS requirements by SA2 as QoS for which requirement cannot be met is not used. |
| Sequans | No strong view |  |
| Apple | Disagree | Wait for SA2 to check if any QoS concerns are present. |

#### *Modification of PDCP Discard Timer*

If the companies agree Question 6, then it should be noted that PDCP Discard timer could be updated in different ways.

* **Option 1**: Extend the value-range of the PDCP discard timer by a fixed set of values.
* **Option 2**: Extend the discard timer by UE-specific RTD.

**Question 7: Companies are invited to select a preferred method for extending the PDCP Discard timer:**

* **Option 1: Extend the value-range of the PDCP discard timer by a fixed set of values**
* **Option 2: Extend the discard timer by UE-specific RTD**
* **Option 3: Any other option.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| LG | Option 1 | If the extension of the PDCP discard timer value is needed, new extended value should be introduced in RRC IE. |
| Xiaomi | option 1 | option 1 is enough, network configures UE specific discard timer value from the value set based UE specific RTD. |
| CMCC |  | Please see our comments to Question6. |
| Panasonic | Option 1 |  |
| Ericsson | Option 1 | The PDCP discard timer shall correspond to QoS requirements, and the QoS requirements are not dependent on the actual RTD. Only with new QoS requirements there is a need for extension. |
| CATT | Option 1 | If PDCP Discard timer is needed, option 1 is enough. |
| APT | Option 1 | Agree Ericsson |
| Nomor Research | Option 1 | PDCP discard timer is related to QoS requirements. Therefore, we propose to extend the value range by a fixed set of values. |
| Thales | Option 1 | We can define a set of configurable values for the PDCP discardTimer reflecting the yet-to-be defined new 5QI requirements (for GEO scenario) |
| Lenovo | Option 1 | Extension should be based on new QoS requirement (i.e. new 5QI) which is SA2 work, and Option 1 will be sufficient. |
| Samsung | New Option | We suggest the following generic framework for PDCP discardTimer (and RLC t-Reassembly): “(minimum\_NTN\_delay + scaling factor\*R16 timer value)” or “(minimum\_NTN\_delay + R16 timer value)\*scaling factor.” Please see Samsung response to Question 2b. The applicability of this framework to PDCP discardTimer can be determined once SA2 completes its work on QoS. |
| ZTE | Option 1 | As commented above, we don’t think an extension is needed at this stage. But an extension is needed due to new QoS requirement defined, then we prefer simple extension with larger values. |
| OPPO | Option 1 only if new 5QI is defined |  |
| Huawei | Option 1 | Option 1 is simple. The configured value is up to NW implementation. |
| Intel | Option 1 or 2 | Option 1 seems more reasonable because the new QoS requirement may be defined for NTN. Then the PDCP discard timer will be adjusted accordingly based on the new requirement. However, I wonder if the PDCP discard timer will work better if it is UE specific. This will need to be FFS. |
| Turkcell | Option 1 |  |
| China Telecom | Option 1 if needed | Extend the value-range if enough for new 5QI |
| Qualcomm | Option 1 | It should be configured by network. |
| Sequans | Option 1 | If it is decided to introduce new values, we prefer to keep existing configuration mechanism. |
| Apple | Option 1 | Only if needed. |

### *PDCP t-Reordering Timer*

In order to detect loss of PDCP Data PDUs, PDCP *t-Reordering* timer is started or reset when a PDCP SDU is delivered to upper layers [4]. The maximum configurable expiration time is 3000ms [5].

During the Study Item phase, a possible limitation regarding overall number of retransmissions in NTN has been identified. Like PDCP *discardTimer*, the PDCP *t-Reordering* timer is also related to the QoS requirements and should be modified, if new 5QI requirements are defined or to meet operator-specific 5QIs, as mentioned in R2-2006705. Thus the open issue is whether the PDCP *t-Reordering* timer should be extended for NR-NTN.

**Question 8: Do companies see a need to extend PDCP t-Reordering timer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Additional comments** |
| Spreadtrum | No | The PDCP t-Reordering timer mainly reflects the QoS requirements of the packets belonging to a service. So the timer is not related to the RTD in NTN. We think that it may be extended only if a new 5QI is defined. |
| LG | No | The value of the t-Reordering is configured based on the QoS requirement. Thus, without changing the QoS requirement, the t-Reordering should not be extended. |
| xiaomi | depends on SA2 | Similar to discard timer, it mainly relates to QoS requirement of service, i.e. whether service can endure a packet arriving with certain delay without disfunction. It is SA2’s responsibility to decide whether NTN service requirement would be different from the existing one. |
| CMCC |  | How to modify the t-Reordering timer demands comprehensive consideration of QoS requirements. |
| Panasonic | No | NTN doesn’t change QoS traffic. Hence, the t-Reordering Timer should not be extended.  If new 5QI is defined for NTN, t-Reordering Timer should be extended. |
| Ericsson | No | We may revisit if new QoS requirements are defined. |
| CATT | No | The PDCP t-Reordering timer mainly reflects the QoS requirements of service. |
| APT | No |  |
| Nomor Research | Yes | Besides, standardized 5QIs, there is the possibility to define operator-specific 5QIs. In order to support all NTN scenarios, PDCP t-Reordering timer should be extended. |
| Thales | No | PDCP t-Reordering timer need to be extended only when new QoS requirements that can meet NTN including GEO scenarios are defined |
| NEC | No | no need to extend it as of now since it corresponds to QoS |
| Lenovo | No | Similar to PDCP Discard timer, PDCP t-Reordering timer is also associated to QoS requirement. Extension should be based on new QoS requirement (i.e. new 5QI) which is SA2 work. |
| Loon, Google | No |  |
| Nokia | No | Same comments as Question6. |
| Samsung | Yes | For most cases, the maximum value of 3 s is adequate for t-Reordering timer. Since we may allow up to 4 s at the RLC per Release 16 38.331, a larger t-ReorderingTimer can be considered. We suggest the following generic framework for PDCP t-Reordering timer (and RLC t-Reassembly and PDCP discardTimer): “(minimum\_NTN\_delay + scaling factor\*R16 timer value)” or “(minimum\_NTN\_delay + R16 timer value)\*scaling factor.” Please see Samsung response to Question 2b for details. |
| ZTE | No | Please refer to our comments in Q6. |
| OPPO | No | The configuration of t-Reordering mainly considers the QoS requirements of the service. So there is no need to extend the value range of t-Reordering if there is no new 5QI definded in NTN. |
| Huawei | No | Similar to PDCP discard timer, this is related to QoS requirement. |
| Intel | maybe | We think that if new requirement is defined by SA2, then we should re-visit if it is needed to extend the r-reorderingTimer. |
| Turkcell | No |  |
| China Telecom | No | Same with Q6 |
| Qualcomm | No | Given the maximum configurable value of t-Reordering timer is 3000 ms, we can wait any update from SA2 on QoS requirement. |
| Sequans | No strong view | The maximum value being already 3000ms, we are not sure why a larger value would be required. |
| Apple | No | Wait for SA2 decisions |

## Extending PDCP Sequence Numbers

Similar to RLC sequence number space, PDCP sequence number space also depends on supported data rates, retransmission time, as well as the average size of the PDCP SDUs. The basic formula for calculating the supportable PDCP bit rate for one radio bearer is given by:

*PDCP\_data\_rate = PDCP\_SDU\_size ∙ 2PDCP\_SN\_length -1 / PDCP\_RetransmissionTime*,

3GPP TS 38.323 [5] specifies a PDCP sequence number (*SN*) field length of 12bits and 18 bits. Depending on typical values of PDCP\_SDU\_size, PDCP\_SN\_length, and PDCP\_RetransmissionTime, the following values of PDCP data rates are estimated in 3GPP TR 38.821[1].

Table 4: Supportable PDCP bit rates for GEO satellite systems with transparent architecture

|  |  |  |  |
| --- | --- | --- | --- |
| PDCP\_SDU\_size | pdcp-SN-Size | PDCP\_RetransmissionTime | PDCP\_data\_rate |
| 500 Byte | 18 | 1.5 s | 350 Mbps |
| 1500 Byte | 18 | 1.5 s | 1049 Mbps |
| 500 Byte | 18 | 3.0 s | 175 Mbps |
| 1500 Byte | 18 | 3.0 s | 524 Mbps |

Table 5: Supportable PDCP bit rates for LEO satellite systems with transparent architecture

|  |  |  |  |
| --- | --- | --- | --- |
| PDCP\_SDU\_size | pdcp-SN-Size | PDCP\_RetransmissionTime | PDCP\_data\_rate |
| 500 Byte | 18 | 75 ms | 6991 Mbps |
| 1500 Byte | 18 | 75 ms | 20972 Mbps |
| 500 Byte | 18 | 150 ms | 3495 Mbps |
| 1500 Byte | 18 | 150 ms | 10486 Mbps |

For GEO satellite system with transparent architecture, with a retransmission time of 3.0s or 1.5s and a PDCP SDU size of 500 bytes, the NTN target data rate of 360Mbps for airplanes connectivity cannot be achieved. As mentioned in R2-2007785, this could be a motivation for extending the PDCP SN.

However, similar to RLC SN, it is mentioned in R2-2006640 that considering typical TCP segment sizes in almost all practical scenarios the possibility of getting a stream of consecutive 500bytes packets in airplanes connectivity is very rare. Thus, in almost all practical scenarios, the average PDCP SDU size will be much higher than 500bytes. On the other hand, applications involving small data packets (e.g. voice) typically does not have a high target data rate of 360 Mbps. Based on these observations, it is also argued that there is no need to extend the PDCP SN length. Moreover, it is also mentioned in R2-2006782 that longer SN field length leads to larger AM\_Window\_Size, which would increase the amount of required memory for the UE buffer. This is not desirable from the perspective of UE implementation complexity. This conclusion is supported in R2-2006705, and R2-2007889.

**Question 9: Do companies agree that there is no need to extend PDCP SN length for NR-NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The 18-bit SN can support most of scenarios. For airplane, more than one UE can be set in a plane if more data rate is needed. |
| LG | Agree |  |
| xiaomi | agree |  |
| CMCC | Agree | Please see our comments to Question5 for RLC SN. |
| Panasonic | Agree |  |
| Ericsson | Agree | No need to extend PDCP SN length. |
| CATT | Agree |  |
| APT | Agree |  |
| Nomor Research | Agree |  |
| Thales | Agree | The NR PDCP sequence number field length is applied for NTN |
| NEC | Agree |  |
| Lenovo | Agree |  |
| Loon, Google | Agree |  |
| Nokia | Agree |  |
| Samsung | Agree |  |
| ZTE | Agree |  |
| OPPO | Agree |  |
| Huawei | Agree |  |
| Intel | Agree |  |
| Turkcell | Agree |  |
| China Telecom | Agree |  |
| Qualcomm | Agree |  |
| Sequans | Agree |  |
| Apple | Agree |  |

# Other Open Issues

Additional issues regarding QoS requirements are raised in R2-2006705. It is argued in R2-2006705 that no new QoS classes have been defined for NTN in Release 17 by SA2. Considering GEO-NTN with transparent payload, the maximum round trip delay (RTD) is around 541.46 ms (i.e. maximum one-way propagation delay of 270.73 ms). This results in only the standardized 5QI 4, 72, 73, 74, 76, 6, 8 or 9 as candidate for selection. However, as the packet delay budget for these services is either 300ms or 500ms, neither HARQ nor RLC retransmission seems possible with current 5QI specifications.

Note: While 5QI requirements are not in the scope of RAN2, the timer values (e.g. PDCP t-Reordering Timer) should be discussed in RAN2.

Therefore R2-2006705 suggests the following options for discussion:

* Option 1: Send an LS to SA2, requesting to define new 5QI values for NR-NTN.
* Option 2: Discuss reasonable values for PDCP *t-Reordering* Timer to support NTN, including GEO scenarios for operator defined 5QIs.

As Option 2 is already included in Section 4.1.2, the only question remaining is whether an LS to SA2 is needed.

**Question 10: Should RAN2 send an LS to SA2 requesting to define new 5QI values that can meet NTN requirements (including GEO).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Disagree | SA2 will decide if a new 5QI is needed. If a new 5QI is defined, an LS will be sent to us. |
| LG | Agree |  |
| xiaomi | Agree to send LS | We only agree to send the LS to ask whether new 5QI is needed or not. It is SA2’s responsibility to decide whether to introduce new 5QI for NTN. |
| CMCC | Agree | RAN2 could consult whether the SA2 will define new 5QI for NTN. |
| Panasonic | Agree to send LS |  |
| Ericsson | Disagree | SA2 are already working on Rel 17. |
| CATT | Disagree | SA2 is already working on it. If a new 5QI is required, SA2 will send a LS to us. |
| APT | Agree | LS shall be considered. |
| Nomor Research | Agree | Ask SA2 to discuss new 5QI requirements. If SA2 will not consider it in Rel17, they could consider it as a topic in Rel 18. |
| Thales | Agree | RAN 2 to send a LS to SA2 sharing above observations and requesting respectfully to define new 5QI values that can meet NTN service requirements including GEO scenarios |
| NEC | Neutral |  |
| Lenovo | Disagree | It should be SA2 to see if new 5QI is needed for NTN. |
| Loon, Google | Disagree |  |
| Nokia | No strong view | It is up to SA2 to decide new QoS requirement/5QI should be defined or not. |
| Samsung | Agree | Different NTN Types (e.g., GEOs vs. LEOs) have different delays. Some of the relatively delay-sensitive services may be supported with HAPS and LEOs. Furthermore, compared to a TN, due to long propagation delays, an NTN has relatively less processing time available if standardized Release 16 5QIs are used. RAN2 can request SA2 to develop a flexible QoS framework to provide relaxed-QoS for an NTN for multiple/all 5QIs instead of developing a specific solution only for a delay-tolerant service in GEOs. |
| ZTE | Disagree | Share other companies view, an LS will be sent to RAN2 if SA2 agree to have new 5QI. |
| OPPO | Disagree | If new 5QIs are defined, SA2 will send a LS to RAN2. |
| Huawei | No strong view |  |
| Intel | Agree | We think sending LS to SA2 is a good idea to trigger the discussion since we think that new QoS most likely will need to be defined. |
| Turkcell | No strong view |  |
| China Telecom | Agree | We should ask SA2 whether new 5QI is needed for NTN. |
|  |  |  |
| Qualcomm | Agree | Yes we should send LS to SA2. |
| Sequans | No strong view |  |
| Apple | No strong view |  |

# Summary

<To be generated pending outcome of company inputs>

# Conclusions

<To be generated by pending outcome of company inputs>

# References

1. 3GPP TR 38.821-g00, “Solutions for NR to support non-terrestrial networks”, Technical Report, (Release 16)
2. RP-193234, “New WID: Solutions for NR to support non-terrestrial networks (NTN) (WID)”.
3. 3GPP TS 38.322 V15.2.0, “NR; RLC protocol specification (Release 15)”
4. 3GPP TS 38.323 V15.2.0, “NR; PDCP protocol specification (Release 15)”
5. 3GPP TS 38.331 V15.8.0, “Radio Resource Control (RRC) protocol specification (Release 15)”
6. 3GPP TS 23.501 V16.4.0, “System architecture for the 5G System (5GS); Stage 2 (Release 16)”
7. R2-2006640, “RLC and PDCP Enhancements in NR-NTN” (MediaTek Inc.)
8. R2-2006703, “Enhancements for NTN on RLC Control Loops and Timers” (Nomor Research GmbH, Thales)
9. R2-2006705, “Enhancements for NTN on PDCP Control Loops and Timers” (Nomor Research GmbH, Thales)
10. R2-2006782, “Consideration on RLC and PDCP enhancements for NTN” (OPPO)
11. R2-2007785, “Consideration on UP timers and RLC/PDCP SN for NTN” (ZTE Corporation, Sanechips)
12. R2-2007889, “Discussion on RLC and PDCP aspects for NTN”, (LG Electronics Inc.)