3GPP TSG-RAN WG2 Meeting #117 Electronic R2-220xxxx

Elbonia, 21 February – 03 March 2022

**Agenda item: 8.5.4**

**Source: Nokia, Nokia Shanghai Bell**

**Title: [DRAFT] Summary of [AT117-e][504][IIoT] QoS Additional Open Issues (Nokia)**

**WID/SID:** **NR\_IIOT\_URLLC\_enh – Release 17**

**Document for: Discussion and Decision**

# 1 Introduction

This document is the report of the following email discussion:

* [AT117-e][504][IIoT] QoS additional open issues (Nokia)

Remaining Tsynch open issues

Deadline: Proposals by rapporteur by Friday (intermediary deadlines for comments to be set by rapporteur)

In Rel-17 RAN2 has agreed to introduce a mechanism to support the new QoS requirement of survival time for uplink periodic traffic. Specifically, when the UE receives a retransmission grant relating to a configured grant associating to a LCH of DRB with survival time requirement, all the RLC entities configured for that DRB should be activated for duplication of subsequent packet(s), in a bid to prevent consecutive error that would eventually result in survival time violation. Although this scheme should work in principle and could be considered completed for Rel-17 (apart from Stage-3 details), some companies think some further enhancement to the feature is needed. Since these further enhancements are not considered as critical issues for WI completion in either UP or CP email discussions of open issues ([16] and [17]) they can be treated via company contributions. This document aims to summarize and resolve the remaining issues identified by the submitted papers. **The companies should provide their comments before 1200 UTC on Friday 25/Feb.**

Based on the review conducted by the rapporteur on the papers submitted to the Agenda Item 8.5.4 for RAN2 #117e ([1]-[15]), the identified issues are classified into either **Category-A** or **Category-B**, as enumerated below.

**Category-A: The issues that are either highlighted by more companies, or has direct impacts to Stage-3 implementation**

1. Whether survival time state could be triggered with N>1 consecutive retransmission grants,
2. Whether survival time state entry/exiting can be controlled by a timer, and
3. Whether retransmission grant addressed to C-RNTI can trigger survival time state (i.e. if survival time can be supported by dynamic grants).

**Category-B**: **The issues that receive relatively less attentions (mentioned by only one or two companies) and is proposed mainly for optimization**

1. Whether RAN2 should consider survival time support during the measurement gaps,
2. Whether adaptive L1/L2 configuration should be considered on top on PDCP duplication,
3. Whether prioritization mechanisms can be adapted to support timely transmission for survival time,
4. How survival time is supported in unlicensed band operation,
5. How to avoid unnecessary PUSCH retransmission, and
6. Coordination with RAN3 for DC-based duplication

This email discussion will specifically ask companies to provide their views on the issues in **Category-A**. For the issues in **Category-B**, companies may only respond if they see a critical need to address.

Moreover, this email discussion will also cover some of the U-Plane open issues that have been raised during the online session for the NR IIoT/URLLC WI in Week 1, including UE behaviour on *drx-HARQ-RTT-timerDL* in cases of HARQ codebook retransmission and SPS HARQ feedback dropping.

# 2 Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
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# 3 Discussions for Category-A Issues

## 3.1 Survival Time State Triggering with N>1 NACK

According to RAN2 #116bis-e agreements, it is confirmed that RAN2 will support survival time state entry upon reception of N=1 retransmission grant. However, there is an FFS on whether the value of N can be (configured to be) greater than 1:

We will support the case where N=1. FFS if cases with N>1 are supported

In that case, when PDCP duplication is already activated in dual connectivity, in order to minimize dependencies between MAC entities in a configuration with survival time the UE enters Survival Time upon reception of one HARQ NACK at either MCG or SCG.

Within a MAC entity, the determination of HARQ-NACKs does not incur interaction between different CCs. When PDCP duplication is already activated in CA duplication for a configuration of survival time, the UE enters Survival Time upon reception of one HARQ NACK at any CC.

During the email discussion on UP open issues [16], 9 out 14 companies did not agree this is a critical issue, and hence this is to be discussed based on company Tdocs. A host of companies have expressed the views on this issue in their papers, and the following two camps are identified:

* **Survival Time State can be configured to be triggered with N>1 consecutive retransmission grants:**
  + R2-2202523 (Apple) [5]
  + R2-2202751 (ZTE, Sanechips, China Southern Power Grid Co., Ltd, TCL Communication Ltd., vivo) [8]
  + R2-2203125 (Xiaomi) [12]
  + R2-2203144 (Samsung) [13]
* **Survival Time State is only triggered with N=1 consecutive retransmission grants (or N>1 should be deprioritized):**
  + R2-2202283 (Fujitsu) [1]
  + R2-2202438 (OPPO) [3]
  + R2-2202709 (Huawei, HiSilicon) [6]
  + R2-2202726 (CMCC) [7]
  + R2-2202785 (CATT) [9]
  + R2-2203198 (Nokia, NSB) [14]

In general, the companies supporting N>1 think “early entry” to survival time state is very inefficient it may be triggered too frequently and unnecessarily, especially for the use cases where the transfer interval is particularly large (e.g. up to 60 seconds) or the use cases with relatively relaxed survival time requirement, which leaves some time for two (or more) transmission before survival time triggering that could be successful. On the other hand, the companies, that do not support N>1 think this is not necessary to further complicate the agreed scheme to optimize only a few use cases especially the WI is approaching the end, and N=1 is anyway sufficient to accommodate all use cases in terms of meeting survival time requirement even if there could be some resource efficiency degradation. Besides, resource efficiency optimization is not included as the objective of this WI, and such use cases could be handled by gNB implementation rather than relying on the adopted survival time mechanism. In this email discussion, we will first check if majority of companies intend to support “N>1” cases in Rel-17.

**Question 1: Do you agree that RAN2 should further pursue survival time state triggering with N>1 retransmission grants in Rel-17 (i.e. the NW can further configure the value of N per DRB) ?**

|  |  |  |
| --- | --- | --- |
| Answers to Question 1 | | |
| Company | Yes/No | Technical Arguments |
| Fujitsu | No | The reason is provided in [1] with mathematical analysis. In short, it is extremely hard to support N>1 from the NW perspective. In addition, rather than relying on HARQ for error recovery which causes RTT latency, it is much beneficial to apply N=1 + time domain repetition of STS PUSCH. |
| ZTE | Yes | The problem of relying on only one HARQ-NACK to enter ST status has been mentioned by several companies for many times. So we strongly suggest to address this issue in this release. The benefit of N>1 scheme is also obvious, e.g., can avoid too early/unnecessary triggering of entry into ST state and avoid waste of resource (in most cases).  As mentioned before, considering that there will be no enhancement for IioT in the scope of R18, we assume the current R17 enhanced QoS scheme will be used in a certain period time in future (if deployed). So we strongly suggest to make this enhanced QoS feature as complete as possible when it’s done in this release (e.g., to make this feature more future-proofed). Therefore, we think it is important to have a scheme which can not only guarantee to fulfil the UE’s requirement of survival time but also ensure optimal use of network resources (we don’t think it’s a valid comment that resource efficiency optimization is not included as the objective of this WI. Generally, for any objective in WID, radio resource efficiency should be taken into account when we are looking for the solution).    We know some companies has commented that the current N=1 scheme can mainly use for the most stringent case and in other cases NW-based solution can be used. At now, we don't think this is a suitable guideline. Since UE-based scheme can not only be also suitable to other cases with a bit loose survival time requirement, but also have advantage of less delay, robustness and higher reliability (This is a relative saying compared with the reliability issue in NW-based scheme as the trigger from NW for PDCP duplication may be lost due to poor radio quality), why not to let this UE-based scheme be used in more (or all) cases?  About the calculation in [1, R2-2202283], we can agree for ST of 0.5ms, N=1 would be preferred. But we also can see the possibility that the total time can be less or around 1ms even with N=3. This helps to demonstrate the feasibility of N>1 in most cases except ST of 0.5ms. Furthermore, we think the less stringent the ST requirement for a case, the more obvious the benefits of avoiding waste of resource for N>1 scheme. Please note according to the “*Table 5.2-1: Periodic deterministic communication service performance requirements*” in TS 22.104, there are a lot of/diverse ST requirements which may need to be covered by the enhanced QoS scheme in the future. |
| CATT | No | We show in [9] that configuring the 1ms and 2ms usecases with N=2 and 4, respectively, would only save transmitting ~10 packets out of 1000 with duplication. And this, only when the most stringent numerology (60kHz) is used for such use cases (otherwise there is no time for retransmissions, i.e. N can only be 1). Therefore, considering the timeline and the complexity listed below, there is no reason to consider the optimization. |
| Samsung | Yes | With regards to mathematical analysis in [1] referred to by Fujitsu above, our understanding of it is that it does not show that N>1 is **universally** hard to support; [1] only draws that conclusion for ST of 0.5ms. This scenario is anyway not the main use case for N>1 configuration. Essentially, [1] makes the assumption that the value of N should be able to be/always will be universally configured regardless of ST values, and this is not our understanding.  Moreover, we do not agree with views claiming that cases where N>1 would be beneficial can simply be resolved by gNB implementation, or that supporting N>1 means that the NW has sufficient time to react – even with N>1, time constraints are quite stringent for the 3 use-cases at the top of the relevant Table.  Based on calculations done early on, N=1 is only really required for the most stringent case (at the top of the Table of use-cases). For the other two cases we would end up with over-triggering the entry to ST state. We do not agree however with the concerns to do with ‘complexity’ of supporting N>1, which we think is comparatively small, while introducing potentially significant efficiency improvement.  Implementing a counter does not add significant complexity in our view, while allowing flexibility and preventing too frequent triggering of entry into ST state. Limiting N to 1 would be wasteful in many applicable scenarios, except the most stringent ones (which admittedly are the benchmark – but **not** the sole focus – of the ST framework).  We additionally agree with ZTE about the importance of having N>1 in this Release. |
| Xiaomi | Yes | The HARQ feedback timing could be much less than the survival time requirement, which can be up to 60 seconds according to 3GPP TS 22.104. It is too aggressive to use only N=1 which will waste lots of resource and the UE power/processing for transmitting some redundant duplicated PDCP PDU when the UE does not need to do so. And one using N=1 may cause the function not used at all. |
| Ericsson | No | The network can configure repetitions within the PDB (say 1 millisecond or 2 milliseconds) and so that the survival time is triggered (sending re-tx grant) upon the failure to decode the packet when all repetitions are received. In other words, there are ways for network to avoid excessive survival time state triggering. |
| MediaTek | No | From our perspective the issues with implementing the N>1 case (coordination across legs, counter/timer/window maintenance, maintaining sync with the gNB etc) significantly outweigh the potential gains from covering the N>1 case (reducing frequency of entering ST, which is a rare case to start with). |
| Qualcomm | No | Survival time feature is supposed to operate for the scenarios where the gNB has no sufficient time to transmit a MAC CE activating PDCP duplication, i.e., the implementation solution. This solution can work for flows with ST constraint around 5ms, so the feature is relevant only for very short survival times.  For those use cases with high CSA requirement and low ST, we see no reason why the NW may want to delay entering Survival time to N>1 failures to slightly optimize radio resources. Note that a HARQ-NACK for those high-reliability flows is already a rare event, so the optimization would save limited radio resources at the cost of risking ST expiry which we do not think a reasonable configuration should do and definitely not an essential feature that is needed that late in the WI.  Furthermore, in case ST should be entered after N>1 failures for one reason or the other, having the gNB delay the triggering retx grant to the Nth failure to trigger ST i.e. getting the N>1 effect with implementing N=1 differently is a technically better solution. To see this, we must consider that comparison under two scenarios:  Scenario 1: (the retx DG is useful since it can take place before PDB expiry): In this case for N>1, the UE would perform N>1 useful retransmissions with high reliability. If one of those retxs is useful, then ST need not be entered. However, the UE only counts CG failures so in this case the UE enters ST unnecessarily compared to the implementation solution whereby the gNB only prompts the UE to enter ST only after N>1 REAL PDU failures. Thus, the N>1 solution suffers from exactly the problem it is trying to solve by entering ST unnecessarily compared to the implementation solution.  Scenario 2: (the retx DG is not useful as it takes place after PDB): In this case the N>1 solution comes at the cost of N>1 “useless” retransmissions on DG that also potentially take up more resources compared to the implementation solution as there would be N wasted DG transmissions just for the MAC to count to N compared to the implementation solution.  Finally, the details of implementing N>1 are not trivial as they would require keeping a MAC counter then discussing in depth how the counter is started, maintained, stopped and reset. Aside from that some discussions would be needed to ensure the counter state is aligned in both UE and gNB and the operation of the counter with CA/DC. These are all involved discussions that are not technically motivated in our views to spend time on. |
| LGE | No | For stringent case such as 0.5ms of ST, N=1 is sufficient. For non-stringent case, N=1 may trigger ST earlier than necessary. But, in case of non-stringent case, we think network can handle this. There is no reason to transmit retransmission grant to activate PDCP duplication in this case as well. Thus, we don’t think it is an essential thing that should be done in Rel-17. |
| Apple | Yes | Our understanding of the R2#114e agreement to focus on the performance requirements in the top 3 rows of table 5.2-1 in T2 22.104 is that these requirements were selected to provide a starting point for a survival time framework (which N=1 certainly is). At the same time, the agreement does not preclude the use of survival time feature for other, less stringent cases. This is also in line with survival time requirements from SA1.  Even though the gNB may have time to adapt the configuration for rows > 3 in the table in 22.104, as some companies mentioned earlier, that may not always be preferred. A complete reconfiguration (or other gNB implementation-based solutions) may, in many cases, end up to be more cumbersome than simply extending the survival time concept to include the use of N>1. Besides the second and the third row in the table also require N>1, as indicated by Samsung.  Moreover, the support of N>1 has bearings much beyond an efficiency optimization.  To restrict the solution to N=1 renders survival time a feature of very narrow scope as the solution is not scalable for different services or even a range of scenarios. In our understanding, N=1 is mainly required for the top 3 rows in the table of 22.204. This is a very confined set of use-cases.  For the survival time to become a useful feature RAN2 should widen the scope by considering proper support for not just a few but a range of IIoT features. The most stringent use-cases are anyway less likely to be fully realized in 5G. We would like to see survival time as a feature that is adopted by many players. Therefore, it makes sense not to exclude the use of N>1. We think this is within the scope of the Rel-17 WID.  We strongly support the comments made by ZTE that RAN2 should aim to make the Rel-17 IIoT feature more future proof.  N>1 can be supported for example with a counter in MAC, and it is our view that this should not encompass a very big effort. N>1 can be made an optional feature as well, and it seems feasible within the scope of the work item. RAN2 can start by adding the configurability.  In summary RAN2 can start with a simple mechanism such as allowing N to be configurable where the counting of consecutive HARQ-NACKs is done in MAC. |
| Intel | Yes | In TS 22.104, there are use cases with survival time requirement larger than 500us, and we think such use cases should be supported. In these use cases, HARQ retransmission can be utilized for reliability, and only supporting “N=1” results in unnecessary resource consumption. |
| Huawei, HiSilicon | No | As we clarify in [6], the additional gain to support N>1 is limited. Besides, configurable N (≥1) would bring more spec impacts and standard efforts, e.g. counter design, which entity maintains the count, etc. |
| InterDigital | No | N>1 may be beneficial to reduce the likelihood of entering ST state too early. This is an optimization that need not be addressed at this point in the release. |
| III | No | We prefer not to discuss N>1 in this release. |
| Vivo | Yes | Share same view with ZTE. |
| Lenovo / Motorola Mobility | No | Agree with CATT |
| OPPO | See comments | Although we mentioned in our paper that the case of N >1 can be deprioritized in Rel-17, we also understand there is some benefit to support it, considering there is no Rel-18 TU for this topic and if we can conclude to a simple/workable solution. With this in mind, we can say Yes if a simple/workable solution can be concluded. |
| Nokia | No | If “early entry” of survival time state is really an issue in certain use cases, then the gNB may choose not to rely on survival time feature defined in Rel-17, but simply send a dynamic grant with higher reliability target for subsequent packets on appropriate resources to override the configured grant in time, thus ensuring the next packet after N consecutive errors is transmitted with higher reliability on this DG. Note that dynamic grant is also provided by DCI, which is as fast as HARQ NACK.  Therefore we do not see a need to further examine this case, especially in the late stage of this WI. Nothing is broken with the already defined feature even if only N=1 is supported. |
| Sequans | No | If "early entry" is a problem because of resource waste, then for those cases MAC CE could be used (as there is more time). In case of short transmission interval, we believe the point is to try transmission on a different carrier rather than still rely on the failed carrier, so alternating allocations on different CCs would still answer the problem without activating the feature at all. |

According to the agreement in RAN2 #116bis-e, it is apparent that RAN2 considers the cases where PDCP duplication is already activated in either CA or DC configurations before survival time state entry (i.e. at least two RLC entities are already activated for the DRB). If N>1 is supported, then it is unclear how the value of N is defined in this case. On one hand, the value of N could be the number of consecutive retransmission grants received for one of the already-activated LCH. On the other hand, the value of N could be the sum of the number of consecutive retransmission grants received for all of the already-activated LCHs. The rapporteur thinks this should be clarified if RAN2 intends to support N>1 cases.

**Question 1a: If your answer to Q1 is YES, how is the value of N defined for cases where duplication is already activated before survival time state entry ?**

* **Option 1: The value of N is defined as the number of consecutive retransmission grants received for one of the already-activated LCHs for the DRB.**
* **Option 2: The value of N is defined as the total number of consecutive retransmission grants received across all already-activated LCHs for the DRB.**
* **Option 3: Other (Please explain)**

**Note: If possible, please also suggest the value range of N.**

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| Answers to Question 1a | | |
| Company | Option | Technical Arguments (with value range of N) |
| ZTE | Option 1 | In our assumption, N should be counted on each LCH independently. |
| Samsung | Option 1 | A question for our understanding: doesn’t this issue exist for N=1 as well? Not in the sense that the value of N is unclear/needs to be defined (of course, as it is 1), but in the sense that even in case of N=1 and the scenario described above, we will need a rule to decide whether to enter ST state if PDCP duplication is already active.  Rapporteur:  For N=1, it is already clear with the agreement made in RAN2#116bis-e:   * *We will support the case where N=1. FFS if cases with N>1 are supported*   *In that case, when PDCP duplication is already activated in dual connectivity, in order to minimize dependencies between MAC entities in a configuration with survival time the UE enters Survival Time upon reception of one HARQ NACK at either MCG or SCG.*  *Within a MAC entity, the determination of HARQ-NACKs does not incur interaction between different CCs. When PDCP duplication is already activated in CA duplication for a configuration of survival time, the UE enters Survival Time upon reception of one HARQ NACK at any CC.* |
| Xiaomi | Option 1 |  |
| Apple | Option 1 | The value of N may apply to the same TB and in most cases, it would also be without SDU segmentation. There would be some inaccuracies with option 1 depending on the scenario, but we aim for a solution that limits interactions between different MAC entities.  Note that option 2 might be more appropriate in some cases, as discussed in Q13 (as well as Q12/Q12A) in R2-2200003, however, we are OK with option 1 for the sake of simplicity. |
| Intel | Option 1 |  |
| vivo | Option 1 |  |
| OPPO | Option 1 | If N >1 is agreed. |

Additionally, R2-2202438 (OPPO) [3] has proposed a timer catering to cases where survival time state triggering N>1 HARQ NACK is supported. Specifically, the proposed timer assists the UE to determine when it should reset the number of HARQ NACK counting. However, it is worth highlighting that R2-2202438 (OPPO) [3] has also proposed that “N>1” cases should be de-prioritized in Rel-17.

**Question 1b: if RAN2 decides to support “N>1”, do you agree to introduce a timer that assists the UE to determine when to reset the number of HARQ NACK counting?**

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| Answers to Question 1 | | |
| Company | Yes/No | Technical Arguments |
| ZTE | Can be yes but this is not main point.  The main point is whether or not to trigger entry into ST state and PDCP duplication upon expiry of this timer. | We understand not only [R2-2202438], most or all the solutions on table for avoiding “too early” triggering PDCP duplication suggest to have a combined Tx-side timer.  Per our understanding, the Tx-side timer in all these solutions have a similar purpose, e.g., UE is allowed to wait for more time or more HARQ-NACKs (N>1) before entering ST state (to avoid unnecessary entering ST), but such wait cannot be too long. So a (protect) timer is introduced to stop the N counting.  But the UE behaviour upon the expiry of Tx-side timer is a bit different in different solutions (please note same process is, if N has been completely counted before expiry of this timer, the timer would be stopped and expiry would not occur, PDCP duplication also be triggered):   * **Alt1:** In [R2-2202438, OPPO], upon the expiry of Tx-side timer, N counting can be seen as stopped. Furthermore, they may have an assumption that UE think the packet has been sent successfully and do nothing (besides reset N), e.g., not triggering entry into ST state and PDCP duplication. But Alt1 may have the risk of missing PDCP duplication even it’s needed (if some HARQ-NACKs are lost or delayed). * **Alt2:** In [R2-2202751, ZTE, vivo, TCL], upon the expiry of Tx-side timer, N counting can also be seen as stopped. But they assume it’s still possible a (delayed) HARQ-NACK would arrive. So if a (delayed) HARQ-NACK is received after expiry of timer, UE still trigger entry into ST state and PDCP duplication. If no such (delayed) HARQ-NACK is received, UE would do nothing, same as Alt1. We think Alt2 can cover Alt1 and alleviate the risk of Alt1. * **Alt3:** In [R2-2203144, Samsung], upon the expiry of Tx-side timer, N counting can also be seen as stopped. But they assume the packet has finally failed to send. UE can just trigger entry into ST state and PDCP duplication. As in licensed spectrum case, this also can happen if the packet has been sent successfully and UE cannot distinguish, the risk of Alt3 is entry into ST state would be triggered in some successful packet transmission case. So for licenced spectrum case, Alt3 is not preferred. But it’s preferred for unlicensed spectrum case as explicit ACK is supported there.   In summary, N>1 and combined Tx-side timer can be supported to achieve a complete HARQ-NACK based solution. For details of timer, Alt2 is preferred in licensed spectrum case and Alt3 is preferred in unlicensed spectrum case. |
| CATT | Yes | If a counter is implemented, a timer is required to be able to reset the counter. |
| Samsung | Can be Yes, but please see comment | Isn’t this covered in Section 3.2? Combinations of “HARQ-NACK” counting and the TX-side timer are covered in Section 3.2. Why is this particular timer being singled out here?  In any case we do support use of Tx-based timer and our views are in Section 3.2.  Rapporteur:  It is our understanding that the timer proposed in [3] is used to reset the counter, not exactly used for survival time state entry/exit as the timers described in Section 3.2 (i.e. in [3] the UE determines to enter survival time state based only on whether N is reached, rather than based on whether the timer is expired or not). Also, [3] mentioned this timer is used for N>1 cases only which is the focus on Section 3.1, while the timers discussed in Section 3.2 can be used for N=1 cases as well. Perhaps the proponent of [3] can clarify if this is the correct understanding.  [OPPO] Thanks to the Rapporteur for helping us to clarify. Yes, we confirm the Rapporteur’s understanding. |
| Xiaomi |  | Agree with the comments provided by Samsung. |
| Qualcomm | No | Prefer a gNB instruction to reset the counter to ensure alignment between UE and gNB. |
| Apple | Yes/No | We prefer a Tx-side timer that assists in the survival time entry. However, a timer to reset the counter might be discussed in more detail, we are open to that. We would like to note that introduction of a timer is not necessarily required to increase the value of N. |
| Intel |  | Agree with Samsung’s comments. |
| vivo | Yes for combination with timer and counter,  No for reset of counter. | Agree with ZTE that reset of counter is not the main point. The main point is to introduce the combination with timer and counter, which can avoid UE waiting too long for NACK.  Per RAN2 previous agreement, RAN2 focus on the use case that survival timer equals to transfer interval. For these use case, once one PDCP PDU is transmitted unsuccessfully, the corresponding DRB shall enter the ST state. This means that counter is actually per PDCP PDU or per MAC PDU, which is not needed to be reset. |
| OPPO | Yes | If N >1 is agreed.  We understand that, without solutions such as the TX-side timer, it may be possible that the several HARQ-NACKs of one HARQ process received at any time are used for the judgement of the survival time entering, even if the specific HARQ-NACKs are received after the PDB or the transmission of another packet. |
| Nokia | No | Again there is no need to further complicate the adopted feature. A smart UE implementation should be sufficient |
| Sequans | No |  |

## 3.2 Timer-Controlled Survival Time State Entry/Exiting

In addition to the reception of a retransmission grant, quite a few companies are interested in the concept of controlling survival time state entry or exiting based on a timer. In particular, the timer is said to be useful for the cases where the UE fails to receive the retransmission grant from the gNB and hence cannot enter the survival time state when it is needed. These papers are summarized below:

* **R2-2202751 (ZTE, Sanechips, China Southern Power Grid Co., Ltd, TCL Communication Ltd., vivo) [8]**
  + In this paper, it is proposed that a timer should start when a PDCP PDU is submitted to the lower layer, or when a new packet arrives from the upper layer. The timer should be stopped when N retransmission grant is received when it is running, and the DRB should enter the survival time state. The DRB should also enter the survival time state when the timer is expired regardless if N retransmission grants have been received. The detailed proposel from [8] is:

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| **Proposal 2: To introduce a combined Tx-side timer for the HARQ-NACK-based option. The following details can be further discussed and agreed:**   * **The Tx-side timer could be configurable by the network if a scenario requires it.** * **The Tx-side timer is configured with length equal or less than AN PDB.** * **The Tx-side timer is started when a PDCP PDU is delivered to lower layer or upon being received from the upper layer.** * **When the Tx-side timer is running:**    + **If a new transmission grant is received, the Tx-side timer should be stopped.**   + **If N retransmission grants or explicit HARQ-NACKs have been received, UE should trigger ST state. And the Tx-side timer should be stopped.**   + **In unlicensed spectrum case, if HARQ-ACK is received, the Tx-side timer should also be stopped.** * **When the Tx-side timer expires:**   + **If a retransmission grant is received after expiration of timer, MAC entity in UE would trigger ST state, regardless of whether the counting on retransmission grants reaches the threshold N (or even no any retransmission grant has been received during timer is running). Otherwise, UE doesn’t trigger ST state.**   + **In unlicensed spectrum case, UE should trigger ST state.** |

* **R2-2202523 (Apple) [5]**
  + A mechanism similar to [8] has been proposed (i.e. Survival Time State entry upon timer expiration). Moreover, it also considers an “exiting timer” which allows the UE to leave the survival time state upon timer expiration. In particular, the timer value can be set to take “Application Recovery Time” into account.
* **R2-2203144 (Samsung) [13]**
  + This paper mentioned that there could be issues of delayed indication to PDCP if N>1 is adopted, and hence survival time state entry based on the timer can be complementary. On the other hand, akin to R2-2202523, it also supports autonomous survival time state exiting based on a timer.
* **R2-2203460 (InterDigital) [15]**
  + This paper suggests that the UE (re)starts a timer whenever a confirmation of successful transmission is received, and the UE should enter the survival time state when the timer expires. However, the paper has explicitly indicated that its preference is to exit survival time state based on network control signaling.

For exiting from survival time state, it is mentioned in R2-2203198 (Nokia, NSB) [14] that leaving from survival time state is basically equivalent to changing duplication pattern of the DRB, and currently it is entirely possible for gNB to dynamically control the duplication state using Rel-16 MAC CE. Thus, when the DRB should leave survival time state is an implementation issue and no specification enhancement is needed. Other than these, not many companies have expressed their views on whether the timer-controlled survival time state entry/exit should be supported in Rel-17. Hence, the rapporteur think it is worth checking with RAN2 whether the companies think it is beneficial to have a TX-side timer for survival time state entry in addition to HARQ NACK, as well as if a UE can leave survival time state autonomously based on a timer status or we can simply rely on network signalling. Furthermore, some details about the timer operations (if to be supported) should be clarified.

**Question 2: Do you agree that RAN2 should further pursue timer-controlled survival time state entry/exit in Rel-17 (i.e. the DRB enters or leaves the survival time state upon expiration of the corresponding timer(s))?**

|  |  |  |
| --- | --- | --- |
| Answers to Question 2 | | |
| Company | Yes/No | Technical Arguments |
| Fujitsu | No | For STS entry, the already agreed HARQ-NACK solution is sufficient. There may be the case that the HARQ-NACK signalling is erroneous for which gNB should ensure HARQ-NACK signalling reliability by using e.g. L1 signalling repetitions.  For STS exit, as we mention in [1], the gNB can control PDCP duplication status by sending Rel-16 MAC CE when exiting STS as this is also mentioned in [14]. |
| ZTE | Yes for entry  Neutral for exit | As mentioned in Q1b, with introduction N>1, UE is allowed to wait for more time or more HARQ-NACKs (N>1) before entering ST state (to avoid unnecessary entering ST), but such wait cannot be too long. So a (protect) timer is needed to stop the N counting and control timely triggering of ST state and PDCP duplication when needed.  A timer for exiting ST state is not as critical as the timer for entry. But it still has benefit. A timer for exiting ST can enable UE autonomously exiting from ST state, without the need of explicit signalling for deactivating PDCP duplication. And it has less risk of causing inconsistence between UE and gNB (the explicit signalling may have more risk as it may be lost). |
| CATT | No | Regarding the timer controlling survival time state entry:  We showed in RAN2#116bis-e’s R2-2200322 that the L1 NACK reliability does not prevent the HARQ-NACK solution from meeting the SA1 requirements for Survival Time. So the case when UE fails to receive the retransmission grant from the gNB is a non-issue. On the other hand, it has already been extensively discussed that such timer requires an explicit HARQ-ACK to be reset. So we don’t see the need for such timer.  Regarding the timer controlling survival time state exit:  We agree with Rapporteur’s analysis that the feature works fine with gNB controlled return to normal state and see nothing to be fixed here. |
| Samsung | Yes for entry  Possibly for exit | We note that even companies opposing N>1 (see e.g. comment from Fujitsu) acknowledge the issue with the “HARQ-NACK” solution but seem to prefer to leave it to network implementation. For us it is critical to provide enough normative support to ensure proper functioning of the ST feature and this is what timer control does. |
| Ericsson | No | We understand that the configured grant is the baseline resource allocation for the UL periodic traffic. It is not clear for us what it means in the below in the proposal  **If a new transmission grant is received, the Tx-side timer should be stopped** |
| MediaTek | No | Same view as CATT |
| Qualcomm | No | **Survival Time state entry**: We still do not see what the timer is supposed to do to facilitate ST entry. If the goal is to ensure that the UE does not lose a HARQ-NACK PDCP activation by maintaining a timer, then this would necessitate some timer restarting mechanism. To us this would mean mandating the gNB sends a HARQ-ACK (or some equivalent indication) so that the timer does not expire every time. To us, this both contradicts the agreement from RAN2 115e:   1. RAN2 does not assume that physical HARQ-NACK messages are always available, i.e. RAN2 will not mandate explicit HARQ-NACK feedback   And also is a big change with RAN1 spec that should not be pursued. Other than that, we think the feature is simple enough with N=1 that a HARQ-NACK failure activates PDCP duplication. A timer does not solve the HARQ-NACK loss potential problem except if a HARQ-ACK is mandating every transmission (otherwise every Tx is assumed a loss, and a HARQ-ACK is not feasible for many reasons, and if it was, a timer would not be needed either.  **Survival Time state exit:** gNB can just send a MAC CE to deactivate PDCP duplication when it is sufficiently confident a single RLC entity can go back to transmitting reliably. This implementation-based solution is both the simplest and the best as it gives gNB time to probe radio conditions before exiting survival state. No technical need to override this process with UE autonomous exit based on a configured timer |
| LGE | No | For entry, it is sufficient to activate the PDCP duplication based only on retransmission grant because the network can ensure reliable transmission of PDCCH (retransmission grant) for PDCP duplication activation. Also, we assume in Rel-17 only a periodic traffic for survival time support, hence no need to consider a case that only UE knows that the transmission is failed and NW controlled ST entry is sufficient.  For exit, it is sufficient to change or turn off the PDCP Duplication to exit the survival time, which requires no additional mechanism. |
| Apple | Yes | **Survival time entry:** A Tx-side timer can help avoid cases where the UE missed a HARQ-NACK on the DCI. Another scenario where a Tx-side timer helps is when a HARQ-NACK gets sent too late - either because multiple carriers are involved or because there was no earlier opportunity to provide it. The impact is potentially more pronounced with N>1 but in principle the problem can also occur at N=1. Having a timer also somewhat relaxes the requirements imposed on the gNB to always provide a HARQ-NACK within a relatively stringent timeframe.  Furthermore, a Tx-side timer can be a supplementary method to help enter survival time on time, as shown earlier by many companies. URLLC is not only about latency but also about reliability. Not entering survival time at the right point in time is going to reduce reliability, which may not be desired/expected.  **Survival time exit:** We are in favour of a mechanism that does not require control signalling every time the UE enters survival time, especially if N has a value as small as N=1, which also means the UE can enter survival time rather frequently. Not having a timer bears the potential for the UE to have PDCP duplication activated for longer than needed, and this would drain the battery faster than needed. So, we support an exit timer. Furthermore, an exit timer can be defined in a way that it also takes care of to the application recovery time and/or avoids ping-pong between duplication on/off. |
| Intel | Yes for entry | We think the combination of timer and HARQ-NACK can avoid the issue of missing HARQ NACK, and is needed to guarantee the entry into survival time. |
| Huawei, HiSilicon | No | For timer-controlled survival time state entry, it shall depend on N>1 case. We think it complicates the mechanism with N>1 as well as with timer-controlled survival time state entry, but with limit gain. We suggest to not pursue N>1 case anymore.  For survival time state expiry, it has been discussed in previous meeting, and we have already agreed that network can control. |
| InterDigital | Yes for entry, No for exit. | As we discuss in our contribution, there are many error cases with relying solely on Re-Tx grant. This includes UE misdetection, and failed channel access in unlicensed spectrum. To improve PDCCH reception, repetition can be used, however this may lead to a detrimental increase in ST state entry latency. Furthermore, requiring a Re-Tx grant may lead to unnecessary signalling for cases where retransmissions are not actually needed (i.e. the PDB has been exceeded).    Therefore, to ensure robust and timely ST state entering, it is best to use a Tx-side timer. This timer not only covers error cases and reduces signalling, it covers the case of unlicensed channel access without requiring further optimizations.  As for ST state exiting, we don’t think it is time critical to exit ST state and staying in ST state has no negative effect on robustness. |
| Futurewei | No |  |
| vivo | Yes for entry  Neutral for exit |  |
| Lenovo / Motorola Mobility | No |  |
| OPPO | No | Several cases exist, e.g. the gNB does not provide any feedback if the packet is transmitted correctly, or, the gNB does not indicate HARQ-NACK to the UE due to no retransmission is expected. It all depends on the gNB implementation. We understand that the solution on timer-controlled survival time state entry/exit can not suit all cases. |
| Nokia | No | Our understanding is that, timer-based approach mainly target at the cases where the UE may fail to receive the retransmission grant for survival time state triggering. However, we think PDCCH reception failure is a very rare event, and it is not clear why we should complicate the specification to handle such corner cases ?  If the air interface is really that unreliable, then the gNB should simply (by implementation) set a very high reliability target for all packets from this DRB instead of relying on the adopted feature based on NACK. It could be less efficient, but in our view the top priority for the stakeholders of such use cases (i.e. the verticals) is to make sure survival time requirements can be fulfilled, resource efficiency is a secondary issue. |
| Sequans | No | Regarding entry:  "cases where the UE fails to receive the retransmission grant from the gNB": indeed, it is strange to have a "safety feature" triggered by sending a signal on a carrier where UE just failed transmission (especially in TDD). I don't recall any RAN1 analysis on L1 NACK reliability **conditional** to previous transmission failure (it's on their realm, not RAN2).  However, we believe timer-controlled survival time state entry is not an appropriate solution. If this is really a problem, we believe alternating allocations on CCs would solve it.  Regarding exit:  MAC CE can be used instead. |

**Question 2a: If your answer to Question 2 is NO, do you think any specification change is needed to define exiting condition of survival time state? (It is based on gNB implementation if no specification change is foreseen)**

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| --- | --- | --- |
| Answers to Question 2a | | |
| Company | Yes/No | Technical Arguments |
| Fujitsu | Yes/No | It depends on how to specify STS in MAC and Stage-2 specification. If Stage-2 specification mentions STS entry, it is also natural to mention STS exit. On the other hand, if MAC specification doesn’t mention STS entry, there seems no impact. |
| CATT | No | The gNB implementation is enough for the UE to exit ST state. |
| Ericsson | No |  |
| MediaTek | No | gNB implementation is sufficient to control ST exit |
| Qualcomm | No | gNB can just send a MAC CE to deactivate PDCP duplication when it is sufficiently confident a single RLC entity can go back to transmitting reliably. This implementation-based solution is both the simplest and the best as it gives gNB time to probe radio conditions before exiting survival state, or alternatively keep UE in survival state as long as bad radio conditions persist. Also, a MAC CE every ST exit is not high-overhead so no issues with implementation. |
| LGE | No | The legacy MAC CE for PDCP duplication works fine. It is totally up to gNB implementation when to send it to exit ST. |
| Huawei, HiSilicon | No |  |
| InterDigital | No | No specification change is needed for ST state exiting. |
| Futurewei | No |  |
| vivo | No |  |
| Lenovo / Motorola Mobility | No |  |
| OPPO | No |  |
| Nokia | No |  |
| Sequans | No |  |

**Question 2b: If your answer to Question 2 is YES, which option do you prefer:**

* **Option 1: Both survival time state entry and survival time state exiting can be controlled by timer(s).**
* **Option 2: Only survival time state entry can be controlled by a timer, as survival time state exiting can be controlled by the gNB.**
* **Option 3: Other (Please explain)**

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| Answers to Question 2b | | |
| Company | Option | Technical Arguments |
| ZTE | Option 1 or Option 2 | See our comments for **Question 2.** |
| Samsung | Option 1 | Will consider Option 2 if this is the majority view. |
| Apple | Option 1 (or 2) | There can be different timers (and separate sub-features) for survival time entry and survival time exit. However, whether a Tx-side timer is used for survival time entry can be a separate topic, so option 2 is not precluded. |
| Intel | Option 3 or Option 2 | For survival time exit, we think that PDCP duplication can be activated for one PDCP SDU only, and then PDCP duplication is deactivated autonomously without signalling (MAC CE) from gNB.  We’re also OK with Option 2 if this is majority view. |
| InterDigital | Option2 | See our comments in Question 2. |
| vivo | Option 2 |  |

**Question 2c: If your answer to Question 2 is YES, what should be the condition(s) for the survival time entry state timer to start/restart ?**

* **Option 1: The timer start/restart when the DRB is outside the survival time state and a new packet arrives at the upper layer**
* **Option 2: The timer start/restart when the DRB is outside the survival time state and a packet is submitted to the lower layer**
* **Option 3: The timer start/restart when the DRB is outside the survival time state and confirmation(s) of successful transmission is received.**
* **Option 4: The timer start/restart when the DRB is outside the survival time state and at least one retransmission grant for the data from this DRB is received.**
* **Option 5: Others (please explain)**

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| Answers to Question 2c | | |
| Company | Option | Technical Arguments |
| ZTE | Option 2 | We understand Option 2 is more straightforward for such timer and more companies have this kind of thoughts. |
| Samsung | Option 2 or Option 4 | All of these options could work. Option 2 is quite straightforward but Option 4 seems most aligned with keeping the ST operation within MAC layer. |
| Apple | See comment | We are open to all options (they can all work depending on the framework), but option 2 is most straightforward. |
| Intel | Option 1 | The time is related to the survival time requirement, and it is better to start the timer when new packet arrives at upper layer (burst arrival time). |
| InterDigital | Option 2 | Option 2 is sufficient, assuming the timer value is shorter than the periodicity of the data (otherwise it keeps getting restarted and would never expire) |
| vivo | Option 2 |  |

**Question 2d: If your answer to Question 2 is YES and you have selected Option 1 for Question 2b, what should be the condition(s) for survival time state exiting timer to start/restart ?**

* **Option 1: The timer start/restart when the DRB is in the survival time state and a new packet arrives at the upper layer**
* **Option 2: The timer start/restart when the DRB is in the survival time state and a packet is submitted to the lower layer**
* **Option 3: The timer start/restart when the DRB is in the survival time state and confirmation(s) of successful transmission is received.**
* **Option 4: The timer start/restart when the DRB is in the survival time state and at least one retransmission grant for the data from this DRB is received.**
* **Option 5: Other (Please explain)**

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| --- | --- | --- |
| Answers to Question 2d | | |
| Company | Option | Technical Arguments |
| ZTE | Option 5 | We assume a simple way is that this timer is started upon entry of ST state. Is it similar as Option 2? |
| Samsung | Option 3 |  |
| Apple | Option 3 | The exit timer may start when survival time begins. However, if radio conditions continue to be insufficient, a UE better stays in survival time state for a prolonged period of time. To avoid having to restart the exit timer multiple times, perhaps a straightforward solution is to start the exit timer upon detection of the first successful message transmission. The timer stops if the UE continues to experience transmission failures. For example, the exit timer is stopped if the UE receives another HARQ-NACK (or a configurable number of HARQ NACKs), similar to the condition to enter survival time. And the UE exits survival time on expiry of the timer. The application recovery time may be included in the exit timer (preferred). Another option is to use different exit timers for survival time and application recovery time. |
|  |  |  |

## 3.3 Survival Time State Entry based on Retransmission Grant addressed to C-RNTI

The baseline mechanism for the agreed survival time feature essentially assumes the related services are dedicated to configured grant resources, and therefore retransmission grant addressed to CS-RNTI can be used as the trigger for survival time state entry. It is still unclear whether the agreed survival time scheme can be supported using dynamic grant, i.e. if a retransmission grant addressed to C-RNTI can be used as the trigger. R2-2202709 (Huawei, HiSilicon) [6] has argued that this should not be allowed as it is more difficult for the network to know what LCHs are mapped to a dynamic grant, as the existing LCP restrictions may not be sufficient. Conversely, R2-2203144 (Samsung) [13] claims that there is no need to intentionally restrict the usage of dynamic grants for survival time support. Although this issue has been mentioned by two companies only, the rapporteur tends to think this is important to clarify as it may directly impact how Stage-3 specification is implemented for WI completion. Therefore, companies in RAN2 are asked to provide their views on the following question.

**Question 3: Do you agree that retransmission grant addressed to C-RNTI can be used to trigger survival time state entry (i.e. if data from a DRB configured with survival time state support can be transmitted on dynamic grants)?**

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| --- | --- | --- |
| Answers to Question 3 | | |
| Company | Yes/No | Technical Arguments |
| Fujitsu | No | We have similar view mentioned in [6]. If C-RNTI/UL grant is used, the question is how to identify the LCH to which the C-RNTI/UL grant is applied. |
| ZTE | No? | Honestly to say, we are not so sure about the mapping issue of DG. But if more companies confirm this issue, we are fine not to pursue DG. |
| CATT | See comment | We were initially supporting this option but considering the late stage, we are OK to abandon this approach in R17, for the sake of progress. |
| Samsung | Yes | We agree with the rapporteur that this is very important to clarify for finalizing stage-3 work. We see no need to explicitly rule our dynamic grants.  Huawei and Fujitsu argue that the network may not be able to identify LCHs mapped to a dynamic grant. However, for UEs supporting IIoT – especially the extremely time sensitive services such as those for which ST may be configured – the number of different types of traffic and QoS requirements may be quite limited and the NW can in that case infer with a certain degree of certainty which LCHs are likely to be included, even without changing LCP restrictions. The ‘damage’ could be that ST is applied to a LCH which may not strictly require it, but this is better than not using a scheduling opportunity for a LCH that does require it in our view. |
| Xiaomi | No strong view | We can follow the majority view if the DG-based solution is also needed. |
| Ericsson | No | RAN2 agrees to focus on UL periodic traffic with known packet size. Relying on configured grants seems to be sufficient. |
| MediaTek | No | At this late stage, we would rather not add more cases to Rel-17 |
| Qualcomm | Yes | In principle, it should be fine to transmit DRBs with survival time support on dynamic grants. Although it is makes more sense to use a CG for that for all the mentioned reasons (types of traffic, LCH restriction), the feature can also be somewhat deployed on a DG by a UE implementation if for example ‘*allowedPHY-PriorityIndex*’ is used in place of CG LCH restrictions or for simple IIoT deployments where the UE has one DRB configured with Survival time, Thus, we can focus our spec work on common CG deployments but not specifically rule out SG. |
| LGE | No strong view | We basically think it is sufficient to use retransmission grant addressed by CS-RNTI is sufficient. However, there seems to be no harm to use retransmission grant addressed by C-RNTI as well. When the gNB provides the uplink grant it is based on BSR so the gNB may estimate which LCH is likely to be included in the MAC PDU. Thus, we don’t think LCP restriction is a critical issue for DG. |
| Apple | Yes | We are fine to consider use of a DG as an option. To include cases where a DRB is not associated with a CG allows for more flexibility to utilize the survival time feature. Moreover, the UE/gNB does not even need to support configured grants in such case.  Usage of a DG may also be required to provide radio resources for PDCP duplication. If PDCP duplication is already active before entry into survival time, the UE may have to take HARQ-NACKs given on a DG into account.  How to identify the DRB based on HARQ-NACK when the gNB does not have prior knowledge of the association of a TB with a DRB may require an enhancement. For example, the Tx-side timer may be used to mitigate this issue. |
| Intel | No | For retransmission grant addressed to C-RNTI, initial transmission is also dynamic grant scheduled with C-RNTI. There is no LCH to DG mapping rule defined, so it is not clear how network can guarantee DRB configured with survival time support can be mapped to the DG. |
| Huawei, HiSilicon | No | Agree with Ericsson and MediaTek.  As we clarified in [6], there may exist a risk of violation of Survival Time requirement when adopting DG-based solution, which shall be paid attention to.  As commented by Apple, an enhancement may be required for the gNB to be aware of the association of a TB with a DRB. But we prefer to stick to a simple solution and try to not incur any risk or enhancement to resolve the risk anymore, for the sake of progress. |
| InterDigital | No | At this point in the release we should focus on critical/necessary topics. |
| Futurewei | No | Agree with Ericsson. |
| vivo | No |  |
| Lenovo / Motorola Mobility | No |  |
| OPPO | No | If DG is supported for ST, we should further discuss how to know the mapping between LCH with ST and DG. For the sake of progress, we suggest not to consider this case. |
| Nokia | Yes, but we can follow majority | We agree that configured grant will be the main type of resources for this feature, but at the same time we do not see the need to restrict the gNB/UE from using dynamic grants. Allowing the possibility of using dynamic grant would provide better flexibility for the gNB in terms of resource allocation strategies.  Having said that, we are okay to follow the majority view. |
| Sequans | No |  |

# 4 Discussions for Category-B Issues

Based on the review of all submitted papers, the rapporteur has identified the following issues that seem to be more optimization-oriented, and have been raised by only one or two companies in their papers.

* **Issue 1: Survival Time State Triggering in Measurement Gaps**

Both R2-2202284 (Fujitsu) [2] and R2-2202445 (Lenovo, Motorola Mobility) [4] have highlighted a potential problem where the survival time state is triggered but the PUSCH for the next message overlaps with a measurement gap, and hence it cannot be delivered in a timely manner to fulfil survival time requirement. From the rapporteur perspective, the mentioned issues of measurement gap could be applicable to URLLC/IIoT use cases in general (not only for survival time), but none of the enhancement introduced in Rel-15 or Rel-16 has targeted to tackle measurement gaps. Thus, it is questionable why RAN2 should specifically consider such issue for survival time in Rel-17.

* **Issue 2: Adaptive L1/L2 Configuration**

It has been suggested by R2-2202523 (Apple) [5] that adaptive L1/L2 configuration can be added as an optional approach to support survival time, in addition to PDCP duplication. Meanwhile, R2-2202709 (Huawei, HiSilicon) [6] has expressed its opposition to consider adaptive L1/L2 configurations in Rel-17. Although the rapporteur generally agrees that PDCP duplication is not the only way to boost the required reliability target, and L1/L2 adaptation may also be applied to reach the same goal, ultimately it is up to gNB implementation how the target is met. Therefore, it is probably not worthwhile for RAN2 to further pursue specification change catering to adaptive L1/L2 configurations at this late stage.

* **Issue 3: Adaptive Prioritization**

R2-2202284 (Fujitsu) [2] has proposed that LCH priority can be re-assigned in survival time state to make sure the urgent transmission is not de-prioritized. Similarly, R2-2202834 (III) [10] think the L1 grant prioritization mechanism may need to be revisited to make sure survival time support can be fulfilled. The rapporteur thinks all these may be some forms of L1/L2 adaptation, and therefore akin to Issue 2, it does not seem to be a critical issue that should be pursued.

* **Issue 4: Unlicensed Band Operation**

RAN2 has previously agreed that optimization for survival time is not needed for unlicensed band operation, but there is also an FFS relating to how the baseline scheme based on retransmission grant can work in unlicensed band. R2-2202438 (OPPO) [3] has suggested that the survival time state can be explicitly triggered by DFI-NACK or implicitly triggered by expiration of configured grant retransmission timer. On the other hand, R2-2203198 (Nokia, NSB) [14] has mentioned that survival time can be anyway supported by gNB implementation in unlicensed band even though it may be less efficient. R2-2202709 (Huawei, HiSilicon)[6] also prefers not to consider survival time support in unlicensed band.

* **Issue 5: Avoidance of Unnecessary PUSCH retransmission**

Previously RAN2 has discussed briefly about how to avoid unnecessary retransmission that is caused by retransmission grant solely as a survival time state trigger. For this issue, R2-2202445 (Lenovo, Motorola Mobility) [4] has suggested that some explicit indication in the retransmission grant DCI can be added, such that the UE knows if a PUSCH retransmission can be skipped. From the rapporteur point of view, such proposal may involve RAN1 and it is not desirable to bring huge impacts to HARQ framework at this late stage of the WI.

* **Issue 6: LS to RAN3 for DC-based PDCP duplication**

The survival time mechanism introduced in Rel-17 is based on PDCP duplication. When it is applied in DC-based duplication, R2-2202895 (vivo) [11] observes that one of the associated network nodes may not have sufficient information about survival time triggering by another node, and therefore it cannot guarantee the resource availability. Hence, it is suggested to send a LS to RAN3 for potential enhancement in the network interfaces. Nonetheless, it is the rapporteur’s understanding that resource provisioning is not a problem as long as survival time state support is based on configured grant. Besides, in fact RAN3 is already working on potential message exchange between MN and SN for survival time support, there is no need to further complicate their scope at this late stage.

The rapporteur would like to check if any company sees the critical need to address any of the Category-B issues listed above. If so, the company should indicate the issue they want to address in Rel-17 and provide technical argument.

**Question 4: Which of the Category-B issues listed above (1-6) should be addressed for Rel-17 WI completion ? Please provide technical arguments to justify your selection. (You can simply indicate “none” if you think none of these issues should be further pursued in Rel-17)**

|  |  |  |
| --- | --- | --- |
| Answers to Question 4 | | |
| Company | Issue(s) out of the list 1-6 that should be addressed | Technical Arguments |
| Fujitsu | 1,2,3 | **Issue 1:** In Rel-17, STS is new feature that has not been considered in Rel-16. The overlapping between STS PUSCH and MG causes problem to meet survival time requirement – in the current specification, STS PUSCH is de-prioritized over MG, resulting in the IIoT application/system is going to be down. This would be avoided. Simply, it is better that STS PUSCH is better to be prioritized over MG.  **Issue 2/3:** These issues can be categorized as same issue. Especially, it is worth considering STS PUSCH re-prioritization over other data (e.g. new UL data arrival and MAC CE) to meet the survival time requirement. |
| ZTE | 1, 4, 6 | Fine to pursue:   * **Issue 1:** We see at least two companies mentioned this issue. We are fine to address it with a simple way. * **Issue 4:** We support to have necessary adaptation specification changes for UCE as we think this may be a scenario/use case for industrial IoT. We can agree the related proposals in R2-2202438 (OPPO) [3]. * **Issue 6:** Neutral, can follow majority view.   Fine not to pursue:   * **Issue 2:** We are fine not to pursue specification change for adaptive L1/L2 configurations * **Issue 3:** Fine not to pursue * **Issue 5:** Tend to agree with rapporteur’s analysis |
| CATT | None | The feature can be implemented without above optimizations |
| Samsung | 2 | We agree with the rapporteur that L1/L2 adaptation could also be applied to boost reliability while in ST state. We do not agree however that this can be solely left to the network. It would be faster if the UE applied a certain L1/L2 adaptation rule (could be very simple) upon entering ST state. |
| Ericsson | None | Agree with the rapporteur’s analysis. |
| MediaTek | Maybe 2 | Issue 2: We have some sympathy for this train of thought (i.e. duplication is not the only means to improve reliability). However, we might be quite late in the release cycle to introduce such a feature. |
| Qualcomm | Issue 4 | In the RAN 114e meeting, the following agreement was reached [5]:  “No specific enhancements in support of Survival Time in UCE will be studied in R17, but we should aim for solutions for Survival time that also work in UCE”  Since this agreement, the scope of the survival time procedure has been refined to the basic operation of activating PDCP duplication after receiving a HARQ-NACK on a CG transmission. At a high-level, this operation does not distinguish between Licensed band and UCE. The difference would come down to the interpretation of the “HARQ-NACK” term. In the licensed band, this HARQ-NACK is interpreted to be a retransmission grant. No such interpretation is necessary in UCE (provided CG-retransmission grant is configured) since an explicit DFI is available in this case as well as LBT failure indication. Thus, all we have to do is use the exact same framework while:   1. Using the term HARQ-NACK to reflect an explicit HARQ-NACK instead of an implicit reTx grant which should be very straightforward. 2. Discuss if the HARQ-NACK trigger needs to be generalized to include LBT failure and/or CGRT expiry.   In fact, the implementation of the feature would be much cleaner in unlicensed band. Since ST has not been explicitly precluded from operating in UCE, we think a small generalization in the feature to cover UCE would be worth from a use case standpoint. |
| LGE | None | Agree with the rapporteur. |
| Apple | 2, 6 | **Issue 2:** According to the top 3 rows in 22.104 the requirements are very stringent not only for the transfer interval but also regarding the number of UEs (>20 or even >100 in a small service area). 5G NR already reached a capacity bottleneck for even less stringent cases such as XR, where the number of UEs per base station is not as high. RAN2 considers the use of PDCP duplication, which can be waste of capacity. Having said this, alternative methods to enhance the reliability in survival time are needed.  Furthermore, there are many other cases. L1/L2 adaptive methods allow to tune reliability parameters for various service requirements, radio conditions, or a specific deployment environment. It can efficiently cover a wide range of use-cases and services where configuration of survival time state is required. Adaptive transmission can provide a benefit where a flexible, yet fast reliability adjustment is required.  Finally, a UE may enter survival time without any actual retransmission in special cases, either because a retransmission is not required anymore (as a function of the delay budget) or the survival time may be zero and the gNB can proactively adjust. These are also cases where L1/L2 adaption can help.  **Issue 6:** We are fine to inform RAN3, can follow majority. |
| Intel | None | We don’t think those issues are essential to be resolved. |
| Huawei, HiSilicon | None | Agree with the rapporteur. |
| InterDigital | None | We think that a Tx-side timer can, on top of improving robustness of ST operation, also addresses Issues 4 and 5. |
| Futurewei | None |  |
| III | Issue 2 and 3 | We share the similar views as Fujitsu in Issue 2 and 3. Mechanisms of adaptive L1/L2 Configuration and adaptive prioritization can help meet the strict survival time requirement. |
| vivo | 6 | Issue 6:  Regarding to resource provisioning for the duplicated legs used in ST, dynamic grant cannot work as NW node may not know when UE enters the ST state. Similarly, it also cannot rely on CG type 2 which is needed to be activated upon the entry of ST state. The feasible solution is that CG type 1 or CG type 2 are activated for the duplicated leg in advance, and are always reserved for this UE. Considering that the entry of ST state is a rare case, those solutions will result in larger resource waste. Our main concern is that this kind of resource waste may be not acceptable.  For the message exchange between MN and SN for survival time support mentioned by rapporteur, it is true that RAN3 has discussed it and achieved some agreements. But this is only applied for DL during HO procedure. RAN3 have not yet discussed any issues for UL ST support.  Our view is that we should inform RAN3 of this issue and ask RAN3 to work on some mechanisms for improving resource efficiency. |
| Lenovo / Motorola Mobility | 1 | Even though we are proponent of 5. We are fine to not further pursue this given the late stage of Rel-17. Issue 1 though could be addressed in a simple way. |
| OPPO | Issue 4 | Agree with Qualcomm. |
| Nokia | None |  |
| Sequans | None |  |

Finally, the rapporteur would like to see if there is any other issue (not listed above) that any company would like to address for Rel-17 WI completion.

**Question 5: Is there any other issue that should be addressed for the New QoS objective to complete this Rel-17 WI ? Please provide your technical argument for the issue(s) you would like to raise.**

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| Answers to Question 5 | | |
| Company | Issue | Description & Why it should be addressed in Rel-17 |
| Qualcomm | (Related to U-plane open issues): Efficient RRC Representation of HARQ 3 CB | The issue we mentioned in R2-2203461: Regarding Type 3 HARQ CB construction, for IIoT applications, it is important for RAN2 to ensure that the operation has low overhead, i.e., the Type 3 HARQ CB construction does not incur too much RRC signalling, since a large RRC messages may not have high enough reliability required for the application.  For example, consider a UE with 4 CCs and 16 HARQ Processes per CC, hence in all there are 64 HARQ Processes. In case the network wants to provide full flexibility in terms of Rel. 17 Type 3 HARQ CB construction, then, for each Rel. 17 Type 3 HARQ CB, there is a need for a bitmap equal to 64 bits. If the UE supports 8 Rel. 17 Type 3 HARQ CBs, then, there is a need of 512 bits. In case the network wants to offer some flexibility by allowing different HARQ Process IDs within a given CC, then, there is a need to indicate both:  -CC ID  -bitmap per CC  Obviously, this would be unnecessarily high RRC overhead, that complicates the operation of the feature. In our view, RAN2 should discuss the issue of low-overhead RRC representations of Type 3 HARQ CB to ensure the feature is available with acceptable RRC overhead. |
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# 5 Additional U-Plane Open Issues

## 5.1 HARQ CB retransmission without latest copy of HARQ Process

During the online session in Week 1, the following agreement has been reached in RAN2:

Upon One-shot HARQ-ACK retransmission request, UE starts drx-HARQ-RTT-TimerDL for the HARQ process(es) whose ACK/NACK status is reported.

For this agreement, Qualcomm has proposed to add the following FFS:

* **FFS: UE behavior if the retransmitted HARQ CB does not contain the latest copy of a HARQ Process.**

The reasoning for such proposal is that, there is ambiguity with regards to *drx-HARQ-RTT-timerDL* starting when the UE transmits a copy of the cancelled HARQ CB and some new data occupy some of the HARQ processes of the cancelled HARQ CB, since the initial content of the HARQ CB that is finally transmitted is modified and there would not be any further action from gNB that should affect the DRX timers.

**Question 6: Do you agree RAN2 should further discuss the UE behaviour for cases where the retransmitted HARQ CB does not contain the latest copy of a HARQ process ?**

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| Answers to Question 6 | | |
| Company | Yes/No | Technical Arguments |
| Fujitsu | No, but | As discussed online, the question is RAN2 specification needs to cover all cases defined in RAN1 specification. In our view, system works with only the current agreement. Having said that, we are ok to follow preference of chipset vendors. |
| CATT | No | We can rely on gNB implementation since both DL transmission and one-shot HARQ-ACK retransmission request are sent from gNB. |
| Samsung | No | RAN1 discussed the issue but there was no conclusion whether RAN1 should consider this case. RAN2 does not need to discuss this until RAN1 agrees to support. |
| Xiaomi | No | We can follow what RAN1 agrees. |
| Ericsson | No | Agree with CATT |
| MediaTek | No | Unclear whether this is an important corner case to resolve |
| Qualcomm | Yes | there is ambiguity with regards to drx-HARQ-RTT-timerDL starting when the UE transmits a copy of the cancelled HARQ CB and some new data occupy some of the HARQ processes of the cancelled HARQ CB, since the initial content of the HARQ CB that is finally transmitted is modified and there would not be any further action from gNB that should affect the DRX timers. Thus, starting the drx-HARQ-RTT-timerDL blocks the gNB from scheduling or rescheduling the lasest PDU held in the HARQ buffers, which is detrimental from a latency standpoint. |
| LGE | No | gNB can handle this. |
| Apple | No | Agree with Samsung and Xiaomi |
| Intel | No | Agree with Samsung. |
| Huawei, HiSilicon | No | Prefer to not complicate the case and solution. |
| InterDigital | No | We agree with CATT |
| Futurewei | No | Agree with CATT |
| vivo | No | Rely on gNB implementation. |
| Lenovo / Motorola Mobility | No | Agree with CATT |
| OPPO | No | We can wait for RAN1 progress. |
| Nokia | No | In principle, a one-shot HARQ-ACK retransmission requested by the gNB will most likely contain at least one HARQ-ACK bit of a HARQ process that has not been replaced with new data (otherwise, there is no point in requesting one-shot HARQ-ACK retransmission since no HARQ retransmissions can be performed anyway). In this regard, whether the timer is started for all the HARQ processes in the reported codebook or for only a subset of them will not make any significant difference in performance.  [Apple2] In reference to “whether the timer is started for *all the HARQ processes* in the reported codebook” above, we are not sure if the scenario needs to be clarified. Our initial interpretation of the question (in relation to the agreement) was that it relates to one-shot HARQ-ACK retransmission, which applies to HARQ-ACK codebook of type 1/2 for a single HARQ process only. In our understanding a HARQ-ACK retransmission cannot be requested for a type-3 HARQ-ACK codebook, which applies to all HARQ processes. The CB associated with the HARQ-ACK retransmission will be appended to the previous HARQ-ACK codebook and only a single HARQ-ACK codebook / PUCCH occasion can be retransmitted in a PUCCH slot. Then there is still just a single HARQ process, or are we saying max two HARQ processes? (It is possible I have a misunderstanding.) |
| Sequans | No | Agree with Samsung |

## 5.2 UE Behaviour for SPS HARQ-ACK Dropping

During the online session in Week 1, the following agreement has been reached in RAN2:

RAN2 to confirm that the current MAC specification already captures the behaviour upon SPS HARQ-ACK deferral. FFS whether to capture a NOTE for clarification, similar to non-numerical k1.

According to TS 38.321, the UE should start the *drx-HARQ-RTT-TimerDL* timer immediately after the HARQ feedback is transmitted:

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| When DRX is configured, the MAC entity shall:  1> if a MAC PDU is received in a configured downlink assignment:  2> start the *drx-HARQ-RTT-TimerDL* for the corresponding HARQ process in the first symbol after the end of the corresponding transmission carrying the DL HARQ feedback;  2> stop the *drx-RetransmissionTimerDL* for the corresponding HARQ process.  …… |

However, Ericsson has raised a question about how the UE should behave when the HARQ feedback for SPS could not be transmitted, due to collision with a DL slot in TDD. Note that RAN1 has introduced SPS HARQ feedback deferral in Rel-17, which allows the UE to defer HARQ feedback to the next available UL slot if such collision occurs. However, the HARQ feedback may still be dropped if the time interval of deferral has reached the pre-configured maximum allowed value. In such cases, it is not clear if the UE should still start the *drx-HARQ-RTT-TimerDL* timer if the corrsponding SPS HARQ feedback is dropped. Hence, RAN2 is asked to clarify the intended UE behavior, which should be aligned with Rel-15 baseline.

**Question 7: To clarify the intended UE behaviour on the *drx-HARQ-RTT-TimerDL* timer when the SPS HARQ feedback is dropped,** **which option do you prefer?**

* **Option 1: The UE does not start the *drx-HARQ-RTT-TimerDL* timer if the HARQ feedback is dropped**
* **Option 2: The UE still starts the *drx-HARQ-RTT-TimerDL* timer after the HARQ feedback is dropped**
* **Option 3: Others (Please explain)**

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| Answers to Question 7 | | |
| Company | Option | Technical Arguments |
| Fujitsu | Option 1 | Our reading of the current spec in this case is that the timer doesn’t start because the timer only starts *“…****after transmission****”*. |
| CATT | Option 1 | When the HARQ feedback is dropped, gNB can: 1) request HARQ retransmission, or 2) perform DL retransmission. Anyway, UE needs to be awake to receive PDCCH. So UE should start the drx-HARQ-RTT-TimerDL and then drx-RetransmissionTimerDL. |
| Samsung | Option 1 | The correct interpretation of the current spec is not to start the timer due to the lack of transmission of HARQ FB. In our understanding, expiry of the timer means that gNB gives up the retransmission based on HARQ FB. There is no need to start the timer.  If NW really wants to retransmit the data without FB, gNB may have a chance during UE’s Active Time before the expiry of the timer, or NW could request one-shot feedback. |
| Xiaomi | Option 1 | We think that some clarification is needed in the specification for both the HARQ feedback dropping and the deferred HARQ feedback. |
| Ericsson | Prefer option 2 | The motivation to have SPS HARQ-ACK deferral is to address the HARQ-ACK drop issue in TDD for IIoT traffic. If the HARQ-ACK is dropped, it is better to keep UE awake to monitor PDCCH and receive dynamic retransmissions, since the network is not aware of the transmission outcome and the most likely implementation is to send a retransmission DL assignment. Restarting the *drx-HARQ-RTT-TimerDL* timer and then *drx-RetransmissionTimerDL* ensure that the UE would monitor PDCCH. |
| MediaTek | Option 1 | Agree with Samsung |
| Qualcomm | Option 1 | Agree with Samsung |
| LGE | Option 1 | Our interpretation of the current MAC is that the drx-HARQ-RTT-TimerDL is started based on the real transmission of the feedback. So, if it is dropped, it seems not to start the drx-HARQ-RTT-TimerDL. |
| Apple | Option 1 (and also ok with option 2) | We think some clarification is indeed needed in the specification. |
| Intel | Option 1 | We think current specification already covers Option 1, so no spec change is expected. |
| Huawei, HiSilicon | Option 1 | Agree with Samsung. |
| InterDigital | Option 1 |  |
| Futurewei | Option 1 |  |
| vivo | Option1 | gNB could request one-shot feedback by implementation if NW wants UE to monitor PDCCH. |
| Lenovo / Motorola Mobility | Option 1 |  |
| OPPO | Option 1 | Agree with Samsung. |
| Nokia | Postpone | We think there could be some problems with Option 1 as *drx-RetransmissionTimerDL* may not start, therefore the UE may miss out the opportunity if the gNB wants to schedule retransmission. On the other hand, starting *drx-HARQ-RTT-TimerDL* unnecessarily in Option 2 does not sound reasonable either. Therefore we prefer to postpone this issue to WI maintenance phase for RAN2 to further study. |
| Sequans | See comment | Option 1 is our interpretation of current spec, however we are ok to reconsider if there is an issue as indicated by Ericsson. |

# 6 Conclusion

TBC

# 7 References

[1] R2-2202283, Analysis on N>1, Fujitsu

[2] R2-2202284, Survival Time Mode and Measurement Gap, Fujitsu

[3] R2-2202438, Remaining issues on survival time, OPPO

[4] R2-2202445, Remaining issues on the support of survival time, Lenovo, Motorola Mobility

[5] R2-2202523, Remaining issues on RAN enhancements for new QoS, Apple

[6] R2-2202709, Discussion about UE behaviours for Survival Time state operation, Huawei, HiSilicon

[7] R2-2202726, Remaining Issues on QoS enhancement, CMCC

[8] R2-2202751, N and combined Tx-side timer for IIoT QoS, ZTE, Sanechips, China Southern Power Grid Co., Ltd, TCL Communication Ltd., vivo

[9] R2-2202785, On the support of N>1 for Survival Time solution, CATT

[10] R2-2202834, Additional aspects on resource in Survival Time, III

[11] R2-2202895, Discussion on Radio Resource for the duplicated legs in ST, vivo

[12] R2-2203125, Remaining issues of survival time requirements, Xiaomi Communications

[13] R2-2203144, Finalising Survival Time related enhancements, Samsung Electronics GmbH

[14] R2-2203198, On Closure of Survival Time Objective, Nokia, Nokia Shanghai Bell

[15] R2-2203460, Remaining issues on the support of survival time, InterDigital

[16] R2-2202686, Report of [POST116bis-e][512][IIoT] UP open issue, Samsung

[17] R2-2203302, Summary of [POST116bis-e][513][IIoT] CP open issues (Ericsson), Ericsson