3GPP TSG-RAN WG2 Meeting #116bis-e R2-21xxxxx

e-Meeting, 17 – 25 Jan 2022

**Agenda item: 8.5.4**

**Source: Apple**

**Title: Report of [Post116-e][513][IIoT] QoS Survival Time (Apple)**

**WID/SID: NR\_IIOT\_URLLC\_enh-Core, Rel-17**

**Document for: Discussion and Decision**

# Introduction

This document collects input on Rel-17 IIoT QoS Survival Time and summarizes the results of the following email discussion prepared for RAN2#116bis-e.

* [Post116-e][513][IIoT] QoS Survival Time (Apple)

**Scope:** Discuss open issues (i.e. remaining FFS) related to QoS.

* Rapporteur should focus and take into account the proposals not treated from the POST 115-e email discussion, propose a way forward. Companies can provide technical comments on why the proposal is not agreeable.

**Intended outcome:** agreeable proposals

**Deadline:** Long

The email discussion is conducted in two phases:

* Phase 1: Collect companies’ comments by Dec 9, 12:00 UTC
* Phase 2: Finalize input by Dec 16, 09:00 UTC

# Participants

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| --- | --- |
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# Overall Description

This discussion focusses on open items, questions, and topics that may be required as a prerequisite for further work.

Based on the proposals in the summary report of the Post115e email discussion in [2] we have reached the following agreements in the RAN2#116e online session:

**Agreements:**

1. A RRC parameter is configured for a DRB with Survival Time support
2. MAC entity shall handle the determination of triggering survival state based on HARQ-NACK
3. For the DRB configured with Survival Time support, the network can control the duplication state for the DRB via legacy activation/deactivation MAC CE. No specification change is foreseen.
4. For the issue that there may be packets already sent to RLC before the pre-configured PDCP duplication configuration is activated, following entry into the Survival Time state, it is up to gNB/UE implementation to handle and no need to specify extra behaviour
5. RAN2 not to consider the interaction between Survival Time solution and handover procedure in Rel-17
6. No specification enhancement will be pursued for CG activation command as Survival Time state trigger
7. The baseline mechanism for Survival Time support is “CG resources will be used for service with Survival Time requirements, such that the mapping relation between the service and the retransmission grant is commonly known to both gNB and UE, and CG retransmission scheduling (addressed by CS-RNTI) can be used for Survival Time state triggering”.
8. FFS how UE identifies the corresponding DRB that should enter Survival Time state and other details (i.e. resource allocation)
9. FFS on unlicensed band
10. Deprioritize autonomous activation of PDCP duplication based on inputs other than retransmission grant

The Post115e email discussion in [2] had a number of other proposals where consensus could not be reached. Those proposals, listed below, may be considered open items.

**Proposal 2: Further discuss on how UE identifies the corresponding DRB that should enter Survival Time state. (11/19)**

**Proposal 3: RAN 2 to decide whether or not to use DG for DRB with Survival Time support in Rel-17.**

**Proposal 5: RAN2 to further discuss and choose between 1) fixing N=1, 2) N can be larger than 1,** **for N HARQ-NACKs as Survival Time state trigger.**

**Proposal 7: Specify, if needed, interaction between lower layer (i.e. MAC layer) and PDCP layer for Survival Time state triggering. (16/20)**

**Proposal 8: RAN2 to further discuss and choose between Option 1) Activate all configured legs, following entry into Survival Time state, and Option 2) Network indicates by RRC, e.g. a bitmap, the PDCP duplication state that the UE should apply upon entry of Survival Time state, the UE changes the duplication state accordingly.**

**Proposal 12: RAN2 further discuss “to specify” or “not to specify” on how to provide radio resources for the activated legs following entry into the Survival Time state.**

**Proposal 15: RAN2 further discuss “to specify” or “not to specify” on how to exit the Survival Time state.**

Out of this list, the following topics are addressed further in this document: P2, P7 (implicitly, in terms of preparations), P8, P12. In addition, a number of extra topics are handled.

Then we also had a discussion phase 2 leading up to the TP in [3]:

**Open issue 1**: Where to place the behaviour description following entry into Survival Time state, e.g. in the clause 5.10 “Activation/Deactivation of PDCP duplication” of TS 38.321, instead of clause 5.2 “Data transfer” of TS 38.323; or in both places?

**Open issue 2**: Shall all MAC specifications related to Survival Time state to be collected in one clause dedicated to e.g. “Survival Time state operation” or to be placed in various clauses?

[**Summary**] Decision on TP could be made after RAN2 further discusses on the related proposals.

Thus a goal of this email discussion, according to the guidance from the session chair, is to conclude on important remaining issues and to capture views and proposals, especially for the ones needed to make progress on a first TP. We can then try to see when/how to move forward in a subsequent step.

Finally some open items and views based in the contributions submitted to RAN2#116e have been considered as well.

There are many more open items, such as operation in unlicenced, the combination of a Tx-side timer and HARQ-NACK, the case for N>1 and how to capture it, use of DG, L1/L2 adpatation, etc. which unfortunately had to be kept FFS at this stage.

# Discussion – phase 1

## Pre-allocation, activation and deactivation of resources in Survival Time

In section 3.3 of [2] and RAN2#116e (as well as in earlier discussions), RAN2 has taken a step to discuss how radio resources should be provided for the duplicated leg in Survival Time and how to ensure the resources are not used outside of Survival Time. Many companies indicated that RAN2 should specify how to provide radio resources while an almost equal number of companies thought that it can be up to network implementation.

A number of solutions are proposed in the contributions in [20][13][5][10][18][19][25]. The solutions can be grouped into two larger groups where either a) there is an implicit or explicit understanding that the resources on the CC used for PDCP duplication cannot be used outside of Survival Time (which requires some form of specification) [20][13][5][10][18][19][25] or b) the provision of respective radio resources is left to network implementation [10].

In an afterthought of the email discussion in [2] and looking at the contributions, the rapporteur observes that we have multiple concrete solutions on the table for group a) while the analyses available for group b) is comparatively small, only one contribution [10] made a proposal in this area. A lower amount of analysis (group b) may bear the risk of issues found at a later stage, which is going to complicate the process. On the other hand, for network implementation there is also not much to discuss.

On the issue whether resource pre-allocation, activation and deactivation are up to network implementation, RAN2 has already agreed that gNB implementation solutions on their own are not sufficient.

The questions below try to take a closer look at the solutions on the table without precluding NW implementation. This may impact the type of interaction required between MAC and PDCP, the configuration by RRC, and it may also have an effect on RAN2’s decision which solution to adopt for the selection of legs (next section).

Note that entry into Survival Time is assumed to be triggered by a HARQ-HACK / retransmission grant in all cases. The selection of RLC entitie(s) that the UE should activate upon reception of a HARQ-NACK/retransmission grant is dealt with in the next section.

Quick summary of related contributions

In [20] it is proposed to adopt a RLC-dependent CG activation/deactivation to ensure immediate resource availability for Survival Time, as well as avoiding resource wastage. [5] follows a somewhat similar path where pre-configured CG resources are deactivated outside Survival Time and implicitly activated when entering Survival Time. The contribution in [19] proposes that dedicated CG resources can be configured for the duplication paths and their activation is conditional upon entering Survival Time state. Another option is that the UE is configured with two transmission configurations (robust and default) to enable PDCP duplication as a function of whether Survival Time expiration is imminent [25][13].

A UE could be pre-configured via RRC with CG resources and PDCP duplication resources in advance, however the resources are not reserved for a dedicated UE until the UE enters Survival Time. The HARQ retransmission grant will implicitly activate these pre-configured resource for a UE that enters Survival Time [18].

Another solution proposed in [5] is that the gNB configures and activates dedicated CG resources in the CCs associated with the secondary RLC entities. LCP restrictions are configured so that only each secondary LCH can use each CG configuration in the corresponding CC. For one approach, MAC is not allowed to multiplex any MAC CE in such CG outside Survival Time and PHY is not allowed to multiplex any UCI in a PUSCH transmission using such CG outside Survival Time.

It is also possible to rely on network implementation, either using a CG type 2, a DG, or a CG type 1 and it is proposed in [10] that RAN2 does not need to specify how radio resources are provided for activated legs as the network implementation can guarantee the availability of resources in survival state without resource wastage outside of survival state.

Pre-allocation, activation and deactivation of resources in Survival Time

**Question 1: To provide resources on the legs used for PDCP duplication and to guarantee dedicated CG resources are not used outside of Survival Time, which of the following options would your company support?**

Note some of the options are a bit similar while different companies may still associate different things with it, so they are all listed here. Please feel free to indicate multiple options.

**Option 1:** Dedicated CG resources can be configured for the duplication paths and their activation is conditional on entering ST state.

**Option 1A:** A CG config may include a Survival Time attribute identifying a CG which can be used in Survival Time only (e.g., through a new parameter in configuredGrantConfig IE).

**Option 1B:** The initial state of a CG type 1 is set to “deactivated”. The UE activates/deactivates the CG autonomously when activating/deactivating PDCP duplication for the associated RLC entity, following a retransmission grant and entry into Survival Time, or following exit from Survival Time. In other words, pre-configured CG resources are deactivated outside Survival Time, and implicitly activated when entering Survival Time. A special mapping (LCP restrictions) may need to be defined for Survival Time.

**Option 1C:** Dedicated CG resources can be configured, mapped and activated for the duplication paths. Specification restricts the UE from using the CG outside of Survival Time. This may include e.g., LCP restrictions, restrictions in RRC/PDCP, or aUE restriction in MAC/PHY.

**Option 1D:** The CG is only considered as “valid” or “activated” from MAC point of view when its associated RLC entity is activated. This defines a RLC-dependent CG activation/deactivation to ensure immediate resource availability for Survival Time, as well as avoiding resource wastage. (This option is similar to Option 1B, but it assumes a parameter in CG config as in Option 1A.)

**Option 1E:** Dedicated CG resource can be configured for the duplication paths but the activation/deactivation of CG is independently controlled by the network.

**Option 1F:** Other (please elaborate).

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| **Company** | **Options**  **(1, 1A, …, 1E)** | **Comments** |
| Nokia | 1/1B/1D | We think all options above are aiming to resolve the problem of over-provisioning radio resources outside the survival time state. From our point of view, the key motivation is to reduce gNB complexity by allowing it not to monitor and decode certain CG resources outside the survival time state.  Note that if we keep these CG resources active outside survival time state, even though we know there is no data, the gNB still has to decode them as the UE may still allocate MAC CE and/or perform UCI multiplexing on these resources, therefore the gNB cannot skip them and it apparently increases gNB complexity unnecessarily. Therefore, coupling the CG activation/deactivation with the RLC seems to be simplest way to resolve this issue.  Essentially it can be seen as an independent and generalized feature that provides a coupling relationship between activation status of CG and RLC, it does not have to strictly used for survival time only. That is, if the gNB activates/deactivates a RLC by MAC CE, the associated CG can be activated/deactivated as well. |
| Apple | 1/1B/1D/1A | We are fine to adopt the options in this category, especially for 1 and 1B/1D.  Option 1B can utilize the existing framework from Rel-16 together with a LCP restriction. How the UE can identify whether the CG operates with automatic activation/deactivation in a new Rel-17 mode needs to be clarified. Linking this CG with a Survival Time specific LCP restriction (such as in Option 2A below) may be one way to achieve this.  Option 1D: If a CG is connected to a dedicated logical channel (associated with a RLC entity) via an LCP restriction using *allowedCG-List* and the RLC entity gets deactivated, assuming there are no connections to other LCHs for this CG, the UE cannot use the CG anyway (at least not for LCH data, we agree with the note from Nokia). The CG may as well considered deactivated in this case. A parameter (e.g., in CG config) may be needed to identify or differentiate such a CG from normal CGs. Otherwise, without an explicit parameter for linking the CG and the RLC entity (based on option 1A), the UE would not know which CG belongs to which RLC entity. Another way is to have a general RRC parameter to enable this option as a new more in Rel-17 (potentially similar to 1B).  Option 1A can work probably in multiple ways as well. It remains to be seen how the connection to the LCH works.  Option 1C is a possible variant too, but we prefer to rely on other options above because 1C may impose restrictions on implementation.  One disadvantage of the options in this category is that it is going to double the amount of CGs required for a LCH, and it is costly to support multiple CGs. |
| CATT | Option 1/1B | But we don’t think any explicit new parameter or new LCP restriction is needed to identify the CGs to be implicitly activated/deactivated by ST activation/deactivation. The ST support can be configured at DRB level, and existing LCP restrictions can be configured to link each secondary LCH to one or more CG configurations, which are, then, implicitly identified. |
| Ericsson | None | For CG type-2, the configuration (e.g., periodicity) is performed by RRC signalling, but the radio resources are allocated by the CG activation DCI. The network always has the choice to first RRC configure and then activate the CG type-2 by DCI at the same time as sending the retransmission grant that triggers PDCP duplication for survival time. RAN2 can further discuss the need for spec enhancements in the light of this network implementation, but it is not clear at the moment in our view.  For CG type-1, “suspend/(re-)initialize” its resources are supported when, e.g., SCell is deactivated/activated. This similar procedure can be adopted, e.g., the CG type-1 resource is suspended if survival time is not entered and the CG type-1 resource is re-initialized if survival time is entered. However, this seems to introduce yet another variant of the CG, and it is not clear that there is a UE/gNB implementation that relies only on the CG type-1. In other words, using the implementation based on CG type-2 is sufficient. |
| LGE | 1E | We agree that dedicated CG resources can be configured for the duplication paths but we don’t think the CG activation/deactivation needs to be dependent to ST state.  If PDCP duplication is deactivated when existing Survival Time state, the PDCP SDU will not be delivered to lower layers and the associated CG will not be used accordingly. Therefore, it is sufficient that ST state only controls the activation/deactivation of PDCP duplication. |
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***Summary of Question 1:***

*TBD*

**Proposal 1: TBD**

**Question 1A: To provide resources on the legs used for PDCP duplication and to guarantee resources are not used outside of Survival Time, which of the following LCP restrictions would your company support?**

Please feel free to indicate multiple options.

**Option 2:** Add a LCH restriction to not to use the radio resources outside of Survival Time on the CC used for PDCP duplication. The network can configure a type 1 CG and add LCP restrictions to guarantee the CG is not used outside of Survival Time.

**Option 2A:** New CG-list: separate allowedCG-List, which indicates the CGs to be used in ST. The CGs in this list are only allowed to be used in ST.

**Option 2B:** Other (please elaborate).

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| **Company** | **Options**  **(2, 2A, 2B)** | **Comments** |
| Nokia | None | We are not sure why any enhancement for LCP restriction is needed. As long as the CG restricted to a LCH is deactivated outside survival time state (and hence no data from this LCH is expected), everything works fine with framework in Q1. |
| Apple | Option 2A | LCP restrictions can be used as part of the framework in Q1 (e.g., 1B) or in a standalone manner. We support both ways.  With option 2A we define an LCP restriction associated with survival time, where such a LCP restriction can only be used in Survival Time. This option enables a cleaner way of configuring and switching the CG resources in/out of Survival Time. This can go also hand in hand with option 2 in Q4.  As an extension, 2A also allows for a use case where one LCH / RLC entity can be connected to two different CGs, where one of them is used in normal mode and one in Survival Time. If the RLC entity is active in normal mode (even as a secondary leg in PDCP duplication), CG1 is used, whereas if the same RLC entity is activated in Survival Time then CG2 can be used (and/or potentially activated). This is another way to achieve more differentiation for the resources. |
| CATT | None | Existing *allowedCG-List* can be reused, which links an LCH with one or multiple CG configurations. If the LCH is associated with a DRB configured with *survivalTimeSupport*, then the one or multiple CG configurations would behave as described in Options 1/1B. |
| Ericsson | None | Agree with Nokia. The existing *CG-allowedList* can be used to configure a mapping between CG and LCH. |
| LGE | None | Existing *allowedCG-List* can be reused to provide a mapping between a certain RLC legs, which is to be used in ST state, and a CG.  As responded to Q1, it is sufficient that ST state only controls the activation/deactivation of PDCP duplication. If PDCP duplication is deactivated when existing Survival Time state, the PDCP SDU will not be delivered to lower layers and the associated CG will not be used accordingly. |
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***Summary of Question 1A:***

*TBD*

**Proposal 1A: TBD**

**Question 1B: To provide resources on the legs used for PDCP duplication and to guarantee resources are not used outside of Survival Time, which of the following options, using modified transmission configs, would your company support?**

Please feel free to indicate multiple options.

**Option 3:** The UE is configured with two transmission configurations (robust and default) to enable PDCP duplication as a function of whether Survival Time expiration is imminent.

**Option 3A:** In order to facilitate exiting from Survival Time, a CG can be supplied with an option to occur one-time or to end after a predefined number or periodicities, e.g., once started, the CG ends automatically after x-number of transmit occasions.

**Option 3B:** Other (please elaborate).

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| **Company** | **Options**  **(3, 3A, 3B)** | **Comments** |
| Nokia | Not sure | Basically if the mechanism in Q1 is adopted, then we can guarantee immediate resource upon survival time triggering and also avoid resource wastage outside survival time state. Nothing else is needed. |
| Apple | Option 3  Option 3A | Option 3 seems good as a general concept. Multiple options are possible to enable this. For example, a CG may be associated with leg1 out of Survival Time and with leg1 and leg2 within Survival Time. This may be achieved through LCP restrictions as well (e.g., option 2A). We are open to other variants as well.  Option 3A can help deactivate resources and exit Survival Time efficiently. With this option, no extra signalling is required every time the UE leaves Survival Time – that is, the exit from Survival time can be triggered automatically. For example, the CG may deactivate automatically if the UE does not receive another HARQ NACK (otherwise, a CG may remain active by whatever is the number of predefined transmit occasions automatically). |
| CATT | None | We don’t see the added value on top of Options 1/1B. For Option 3, it is left to NW to configure the secondary legs with lower MCS (more robust) resources than the primary leg. For Option 3A, we think exiting from ST can simply be left to NW implementation (e.g. deactivating duplication). |
| Ericsson | None |  |
| LGE | None | As responded to Q1, if PDCP duplication is deactivated when existing Survival Time state, the PDCP SDU will not be delivered to lower layers and the associated CG will not be used accordingly. So, there is no need to have additional way of controlling use of CG resources outside of ST state. |
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***Summary of Question 1B:***

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**Proposal 1B: TBD**

**Question 1C: To provide resources on the legs used for PDCP duplication and to guarantee resources are not used outside of Survival Time, would your company support using a form of network implementation?**

Please feel free to indicate multiple options.

**Option 4:** Up to network implementation.

* **Option 4A:** With a type 2 CG, network implementation ensures to activate and deactivate CG instance within and outside of of Survival Time state, respectively.
* **Option 4B:** The network allocates a DG on the duplicated leg.
* **Option 4C:** Rely on LCP restrictions available for PDCP duplication since Rel-15 (such as e.g., allowedServingCells) or using LCP restrictions available for multiple CGs in Rel-16.
* **Option 4D:** Other (please elaborate).

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| **Company** | **Options**  **(4, 4A, …, 4D)** | **Comments** |
| Nokia | None | We don’t think any of these options can really solve the problem:  4A – The gNB may not able to send so many DCI within 0.5ms (including both retransmission grant for survival time state triggering and the Type-2 CG activation command)  4B - The gNB may not able to send so many DCI within 0.5ms (including both retransmission grant for survival time state triggering and the DG)  4C – It cannot resolve the problem of MAC CE allocation onto these CG resources outside survival time which increases gNB burden of blind decoding, as we highlighted in Q1. |
| Apple | Option 4B  Option 4A | We think these solutions can complement the options in Q1/Q1A/Q1B for exceptional situations.  Option 4B: Network implementation can use a DG to provide additional resources in abnormal situations. One example are segmented RLC PDUs, or issues related with the timing of HARQ-NACK sent by the gNB as discussed in Q11 of [2]. Another example is the case discussed in Q3 below.  Option 4A: A type 2 CG + MAC CE for confirmation may be too slow to meet the performance requirement for the most stringent use cases. However, the method can be efficient in cases where the transfer interval / survival time is slightly larger, or potentially also with N>1 if the gNB can proactively enable additional resources once the UE gets close to the threshold (or by configuring a lower threshold in the first place). |
| CATT | None | Options 4A is always possible, but requires that NW sends these type-2 CG activation commands to the UE altogether with the retransmission grant (aka HARQ NACK) which may be tricky (bottleneck) in case of cross-carrier scheduling. This requires more PDCCH transmissions, which, on top of the PDCCH overhead, increases the risk that one is missed at the UE. We think it can be avoided with the implicit CG activation/deactivation discussed in Q1/A-B.  Option 4B is always possible, but should not be regarded as the only solution.  Option 4C cannot, alone, guarantee that resources are not used outside of Survival Time since LCP restrictions do not apply to e.g. MAC CEs. |
| Ericsson | 4A/4B | Not sure we understand Nokia’s comment for 4A/4B. The PDCP duplicates are transmitted via different cells and so the PDCCH capabity issue would not happen in normal cases, e.g.,   * The DCI for retransmission grant is sent on cell a; * The DCI to activate CG type 2 or DG is sent on another cell b.   Don’t understand either CATT’s comment. Cross carrier scheduling should be less common in IIoT. Even if cross carrier scheduling is configured, the network can prioritize which DCIs to transmit and temporarily does not send less important DCIs for eMBB data. |
| LGE | None or 4A | As responded to Q1, if PDCP duplication is deactivated when existing Survival Time state, the PDCP SDU will not be delivered to lower layers and the associated CG will not be used accordingly. So, there is no need to have additional way of controlling use of CG resources outside of ST state. If CG needs to be deactivated, the network can send CG deactivation command, which is sufficient.  We are not sure what option 4B/4C exactly means. For example, is option4B that the RLC leg is not mapped to a certain CG but mapped to a certain DG? |
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***Summary of Question 1C:***

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**Proposal 1C: TBD**

**Question 2: Are there any other options RAN2 should consider to provide resources on the legs used for PDCP duplication and to guarantee resources are not used outside of Survival Time?**

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| **Company** | **Options** | **Comments** |
| Nokia | None | Coupling RLC activation/deactivation status with CG activation/deactivation status as discussed in Q1 is sufficient. |
| CATT | None |  |
| LGE | None | Again., we think It is sufficient to activate/deactivate the PDCP duplication when entering/exiting the ST state. There is no need of activating/deactivating CG resources when entering/exiting the ST state. CG resource can be kept activated regardless of ST state. When PDCP duplication is deactivated upon exiting ST state, PDCP SDU will not be delivered to the lower layers and the relevant CG resources will not be used even if it is kept activated.  In this regards, there is no need of coupling the CG activation/deactivation with PDCP duplication activation/deactivation. |
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***Summary of Question 2:***

*TBD*

**Proposal 2: TBD**

Even if a CG resource on a duplicated leg can become available quickly, the CG resource may be insufficient for the UE to allocate the whole application message in one configured grant to make sure it can be completely transmitted on time [20]. Currently, for LCP it is specified in TS 38.321 that MAC should prioritize MAC CEs over data. As the result, the application may enter a down state following the Survival Time for very stringent cases, when the CG resource is available for a single message only.

To avoid this issue, a simple way is to limit MAC CE allocation to such CG when the DRB has entered Survival Time state. However, the impact of such restrictions might seem hard to predict, since a MAC CE may indeed be required to be sent more urgently than data, for a variety of functions. The scenario is implicitly covered also in option 1C above.

**Question 3: Would your company agree that MAC CEs that can be allocated to the CG resources associated to LCH/RLC entities for Survival Time support may be limited, in order to make sure the critical message for Survival Time can be completely transmitted in time?**

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| **Company** | **Agree/Disagree** | **Comments** |
| Nokia |  | As the proponent, we think this is an important to make sure the message can be completely transmitted on time when survival time state is triggered. However, as we are approaching the end of this WI, there is no need to optimize and can be left to gNB implementation. i.e. The gNB ensures that the CG resources are large enough to accommodate both foreseeable MAC CE and data when configuring it. |
| Apple | Disagree | It seems risky to impose such restrictions, since a MAC CE may indeed be required to be sent more urgently than data, for a variety of reasons / in support of other MAC functions. In other words, there is a reason for a MAC CE to have higher priority than data. Besides, the network can keep the duplicated leg active for a longer time, make sure the CG resources contain sufficient space for a potential MAC CE, or provide additional resources in a DG.  This issue is also somewhat related to Q11 in [2] for which R2#116e reached following agreement: “For the issue that there may be packets already sent to RLC before the pre-configured PDCP duplication configuration is activated, following entry into the Survival Time state, it is up to gNB/UE implementation to handle and no need to specify extra behaviour”.  Thus we think this issue is better addressed by implementation. |
| CATT | Disagree | It seems this is a general issue of periodic traffic with stringent e2e latency. That is, if the NW strictly configures the CG resources to fit the expected data only, any MAC CE inclusion will result in missing the e2e latency for the application message. So it seems reasonable that NW should cope with the possible inclusion of MAC CEs by slightly over-provisioning the CG resource. In addition, the traffic would miss the ST deadline only if all legs require sending MAC CEs during ST, which likelihood is low. So addressing this issue by specification sounds more like an optimization. |
| Ericsson |  | The priority comparison of the MAC CE in light of the high priority URLLC data has been discussed in Rel-16 IIoT. We prefer no to re-discuss again, and can be left for network implementation. |
| LGE | Disagree | The intention is understood but we see this as an optimization. |
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***Summary of Question 3:***

*TBD*

**Proposal 3: TBD**

## Pre-configuration of PDCP duplication for Survival Time state

This question was discussed in [2] and during the online discussion at RAN2#116e. Following is the status that we have reached [1].

*Proposal 8: RAN2 to further discuss and choose between Option 1) Activate all configured legs, following entry into Survival Time state, and Option 2) Network indicates by RRC, e.g. a bitmap, the PDCP duplication state that the UE should apply upon entry of Survival Time state, the UE changes the duplication state accordingly.*

- Nokia thinks that option 2 covers option 1 and is more flexible and further points out that option 2 is the only option that aligns with the previous agreement. LG agrees. Samsung doesn’t have the same understanding of that agreement. Nokia explains that the agreement states which LCH should be activated and option 1 activates all of them.

- Qualcomm thinks that option 1 is more simple and trigger to enter survival time is one bit and option2 complicates the procedure. Nokia doesn’t think we should limit gNB to use only PDCP duplication and there is no extra complexity. Samsung, Oppo, Intel and mediatek agrees with Qualcomm. Apple,InterDigital agrees with Nokia.

- CATT would also like to go with the simpler approach. LG explains that PDCP duplication, we already have a mechanism that selectively activates RLC legs. option 2 adds no additional complexity to what we have already. So, simplicity shouldn't be the right argument.

- Futurewei asks “why would the NW configure some LCH(s) that it doesn't plan to use when in the most critical moment?”. Ericsson explains that there are very many reasons for gNB.

During phase 2 of email discussion in [2] it was pointed out that there is the word “configured” in both option 1 and option 2. It is the rapporteur’s understanding that “configured” reflects the different configurations that are possible, such that a UE or gNB may support duplication over either 2 or upto 4 legs. Further, as explained in [2] and according to Rel-16 specs, if PDCP duplication is configured for the DRB, the network can configure the initial duplication state for the DRB, e.g. through the *PDCP-duplication* parameter in *moreThanOneRLC* IE if only two legs are configured, or through the *duplicationState* parameter in *moreThanTwoRLC*-DRB IE if more than two legs are configured. Thus the use of “configured” seems correct.

Based on previous RAN2 agreements, the gNB pre-configures the set of RLC entities used for PDCP duplication in Survival Time state. Pre-configuration of a dedicated set of RLC entities for Survival Time allows to configure a subset that is not necessarily the maximum number of RLC entities supported by the UE for PDCP duplication. This offers some flexibity to accommodate actual radio conditions as well as the reliability required for the service, while also honouring spectrum and energy efficienly. There is some extra complexity involved but RAN2 agreed this in RAN2#115e, as shown below.

In RAN2#115, we have agreed that

1. Following entry into the Survival Time state, PDCP duplication for ST configuration is activated. The gNB pre-configures which RLC entities can be activated for duplication when entering ST state. FFS the number of supported RLC entities.

The “gNB pre-configures which RLC entities can be activated for duplication” indicates a configuration that is dedicated to Survival Time state and there is also an FFS on the number of RLC entities. In another interpretation, the agreement might be interpreted as a re-confimation of what is also done for normal PDCP duplication where the network configures the initial state, but the rapporteur thinks this was not the initial intention.

Thus in the question below we can try to close on the FFS.

From the contributions submitted to RAN2#116e the views are evenly split. The tdocs in [19][10][27][5] prefer to activate all configured legs - mostly aiming for a simple solution and [12][20][28][29] prefer not to preclude the option to also utilize a subset of legs, for better performance (where needed), spectrum efficiency and flexibility. When Survival Time is triggered while PDCP duplication is already activated, another aspect is whether the number of RLC entities could be increased swiftly (if needed).

The contribution in [16] observes that the understanding of duplication activation state between UE and network may not be consistent the certain cases. It proposes a third option where the UE decides to activate which pre-configured RLC legs based on the channel condition and report the activated RLC legs to network (e.g. using Duplication RLC Activation/Deactivation MAC CE).

Questions and options for consideration

**Question 4: On pre-configuration of RLC-entities, please indicate your view on the agreement from RAN2#115e and consider whether your company supports any of the following options. Which of of the options would you prefer?**

**Option 1:** PDCP duplication in Survival Time uses whatever RLC entities are configured for normal PDCP duplication – that is, if the UE were to activate duplication outside of Survival Time, the same configuration is used in Survival Time also. The network configures all or a subset of available RLC legs for the UE to activate upon entry to survival state. The UE activates all configured legs, following entry into survival state.

* **Following entry into Survival Time, PDCP duplication for all or a subset of associated RLC entities for the configured DRB(s) is activated.**

**Option 2:** Apply a separate PDCP duplication state in Survival Time. The network indicates (e.g., by RRC in a bitmap or via another mechanism), the PDCP duplication state that the UE applies upon entry to Survival Time state. This means to configure different sets of RLC entities, one of which is used in Survival Time state and one that is used out of Survival Time state. In such a scheme, the UE switches the set of active RLC entities upon changing the Survival Time state.

* **Upon changing the Survival Time state, the UE switches the set of active RLC entities used for PDCP duplication for the configured DRB(s).**

**Option 3: To avoid misalignment of duplication activation state between UE and network, the UE upon entering Survival Time state reports which pre-configured RLC entities have been activated to the network [16].**

**Option 4: Other (please elaborate).**

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| **Company** | **Options** | **Comments** |
| Nokia | 2 | Let’s first look at the RAN2 115e agreement wordings:   * The gNB pre-configures which RLC entities can be activated for duplication when entering ST state   “Pre-configure” = The gNB indicates/signal something to the UE in advance.  “which RLC entities” = A subset of RLC entities out of a finite number of possible subsets.  So it is very clear the agreement says the gNB is able indicate/signal a subset of RLC entities that the UE should activate upon survival time state, where **the target of this pre-configuration signaling is clearly “which RLC entities.”** (Note that this agreement does not say this preconfiguration is relating to whether a DRB has survival time state or not)  If we go for Option 1 where the UE activates all RLC entities in all cases, it is basically a fixed UE behaviour for DRB with survival time requirement (i.e. the UE’s behaviour does not change regardless what the gNB has pre-configured), then we wonder why we need this “pre-configuration” in the agreement ? Therefore it cannot be more clear that only Option 2 is aligned with the agreement.  Moreover, Option 1 has the following disadvantages:   1. It forbids the gNB to utilize the time-frequency resources on some of the legs for other UEs, which reduces gNB flexibility of resource allocation. 2. It enforces the gNB to fulfil QoS only by “increasing the number of duplication copies”, while in fact there are many other options that the gNB can use to cope with any QoS parameter including PER, PDB, and survival time. The reduces gNB implementation flexibility. 3. The survival time state is triggered by NACK, meaning an error is already observed on one of the previously activated legs due to poor channel quality. The time difference between 2 packets is as short as 0.5ms and for IIoT the mobility level is typically low, it is extremely likely the poor link quality will remain to be poor even for the next packet. So why should we ask the UE to still transmit the next packet on this poor link leg again when we know it is likely to fail anyway, and unnecessarily wastes UE power as well as creating interference ?? 4. Activating all RLC entities by UE imprudently may lead to even worse performance if the UE does not have sufficient power headroom.   Lastly, what companies want from Option 1 can be achieved by Option 2 anyway, so obviously Option 2 is the best compromise and a win-win situation for all companies.  The argument about “complexity” for Option 2 is not valid, because in Rel-16 we already have the UE behaviour of following a bitmap to decide which RLC is activated, and Option 2 is basically a same behavior of existing spec. |
| Apple | Option 2 | A dedicated set of RLC entities that is pre-configured for survival time offers some flexibity to accommodate actual radio conditions as well as the reliability required for the service, while also honouring spectrum and energy efficienly. We think this is according to the above agreement 3 from RAN2#115. As for the FFS, the gNB can configures the number of RLC entities used in Survival Time dynamically. Moreover, option 1 can be considered a subset of option 2 which is more general. |
| CATT | Option 1 without “or a subset” | First, related to the discussion of the previous RAN2 agreement: it is clear that different companies interpreted this agreement in different ways. And I admit we are part of those considering that “*which RLC entities can be activated for duplication*” could very well be “*all the associated RLC entities*” in case we decide to go for “*all*” rather than “*a subset*”. We see ne contradiction whatsoever.  Then, considering the difference between Option 1 and 2:  In our understanding, the intention of Option 1 is to activate all RLC entities associated with the DRB (PDCP entity) upon entering ST.  We prefer this option for its simplicity, + we don’t get the argument of NW leveraging the “best subset” at any time since this subset is pre-configured by RRC and so not dynamically decided when entering ST.  In other words, both the (new) parameter *duplicationStateSurvTime* and the set of RLC entities associated with a DRB are RRC configured. Hence, updating the former requires reconfiguring the IE *PDCP\_Config* via the DRB addition/modification procedure while adding/removing an RCL entity to a DRB requires reconfiguring the IE *RLC-BearerConfig* via the RLC bearer addition/modificationprocedure.  Therefore, even if all associated RLC entities are activated upon entering ST, it is always possible to reconfigure at anytime by RRC the set of such associated RLC entities, in the same way as RRC would reconfigure *duplicationStateSurvTime*. Hence we just don’t see the added value and need of this new parameter. |
| Ericsson | Prefer (a variation of) option 1 and would be okay for (a variation of) option 2. | We are fine to only one of the below two options:   1. Option 1 with all configured RLC enities for PDCP duplication being activated; 2. Option 2 with a RRC configured activation/deactivation status of secondary RLC entities in the survival time state. The essence is to mirror what can be achieved in the duplication RLC activation/de-activation MAC CE, see clause 6.1.3.32 of TS 38.321. This MAC CE is implicitly triggered by the retransmssion DCI.   The “FFS the number of supported RLC entities. “, in our view, means that both option 1 and option 2 are on the table.  For option 1, the network can RRC reconfigure (add or release) different RLC entities (with de-activated state) when the UE is not in the survival time mode. This is what we understand as “pre-configure”.  Option 2 could be useful to de-activate some secondary RLC entities for PDCP duplication due to UL transmission power limitation. But UL transmission power limitation has never been considered an issue in PDCP duplication or in the IIoT WI. We do understand the flexibility it can bring for the network, and would be okay if majority wants this. |
| LGE | 2 | Given that it is already possible to selectively activate RLC legs for PDCP duplication and activating all RLC legs can be achieved in option 2, we cannot argue that option 1 is simple to go.  In addition, in option 1, if PDCP duplication is already activated, the only way to be benefit from ST PDCP duplication is to switch to another CG, which is different from the previously used CG. This may need more discussion such as how to handle the packets already delivered/strored in lower layers before switching the CG.  We also agree with the disadvantages listed by Nokia. |
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***Summary of Question 4:***

*TBD*

**Proposal 4: TBD**

## RRC parameters for a DRB with Survival Time support

In [20] the use of a separate field (such as “*duplicationStateSurvTime”*) is indicated as a simple and flexible option that covers possibilities of increasing the number of active legs as well as switching duplication state. It is pointed out that this new parameter may be used to indicate whether the related DRB has a Survival Time requirement. From a rapporteur point of view we would like to mention that this does not cover the case of a DRB with a Survival Time requirement for a UE or a gNB supporting PDCP duplication over only two legs (*moreThanOneRLC*).

**Question 5: If Option 2 in Q4 was agreed, would your company support to use this new field to indicate whether the related DRB has a Survival Time requirement?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes | The field does not have to be coupled with *moreThenTwoRLC* or*moreThenTwoRLC*, it can be an independent field and the presence of which indicates survival time requirement.  If this field is present and there are only 2 RLC for the DRB, the UE activates duplication when entering survival time state, without considering the actual parameter values within this field.  If this field is present and there are more than 2 RLC for the DRB, the UE activates RLC entities according to the indicated bitmap in this field when entering survival time state. |
| Apple | Yes (see comment) | We are in general OK to use this parameter in PDCP-config. Details can be finalized during stage-3.  To address all cases for a) *moreThanOneRLC* and b) *moreThanTwoRLC*, either the parameter is defined one level up as indicated by Nokia or two parameters are required, one under *moreThanOneRLC* and one under *moreThanTwoRLC*.  Presence of this parameter can indicate Survival Time support is configured at DRB level. |
| CATT | No | We do not support Option 2 (see Q4), but even if that would be the case we prefer to have an explicit parameter *survivalTimeSupport* indicating that the DRB supports survival time. Then, when *duplicationStateSurvTime* would not be configured, this would mean implicit fallback to Option 1. |
| LGE | Yes | If Option2 in Q4 is agreed, it is necessary to indicate which RLC entities are to be used for PDCP duplication in ST state. With this parameter, additional parameter of *survivalTimeSupport* may not be needed.  This parameter may need to be included in *moreThanOneRLC* as well as indicated by Apple. |
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***Summary of Question 5:***

*TBD*

**Proposal 5: TBD**

In the RAN2#116e meeting it was agreed that “a RRC parameter is configured for a DRB with Survival Time support”. As PDCP duplication is at DRB level, it makes sense that Survival Time is also configured at DRB level. A new RRC parameter to indicate the support of Survival Time and related operations for a given DRB could be added in PDCP-Config [21][5] or RadioBearerConfig [21]. As further pointed out in [5], to perform HARQ-NACK based implicit duplication activation, a DRB configured with a Survival Time requirement must also be configured with PDCP duplication via either *moreThanOneRLC* or *moreThanTwoRLC-DRB*, and the associated RLC entities.

**Question 6: What would be your preference on the location of the RRC parameter that configures a DRB with Survival Time support?**

**Option 1: Survival Time support is configured at DRB level, and a new parameter (e.g., *survivalTimeSupport*) can be added in PDCP-Config along with PDCP duplication configuration.**

**Option 2: RAN2 considers to use RadioBearerConfig to include the Survival Time enabler for the corresponding DRB.**

**Option 3: Other (please elaborate).**

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| **Company** | **Options** | **Comments** |
| Nokia | Option 1 | Same comments as our response in Q5 |
| Apple | Option 1 | If Option 2 in Q4 is agreed then one of the options in Q5 can be used, presence of this parameter can indicate Survival Time support. Otherwise, if Option 2 in Q4 is not used, a simple flag (without duplication state) would be sufficient. |
| CATT | Option 1 | Simple and straightforward. |
| Ericsson | Option 1 |  |
| LGE | Option 1 | However, if *duplicationStateSurvTime* is used, *survivalTimeSupport* may not be needed as responded to Q5. |
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***Summary of Question 6:***

*TBD*

**Proposal 6: TBD**

## MAC behaviour upon identification of a retransmission grant that triggers Survival Time state for a DRB

So far RAN2 has agreed to consider the support of Survival Time as a property that is configurable for a DRB. We have also agreed that Survival Time is triggered upon reception of a UL retransmission grant and that the “MAC entity shall handle the determination of triggering survival state based on HARQ-NACK”.

In this section, we try to tackle how the UE and the gNB can identifiy the corresponding DRB that should enter Survival Time state. This question was initially discussed in [2] with a view to specification impact. It is is also slightly related to the allocation and use of resources in Survival Time. In addition to an association between Survival Time and a DRB, Survival Time might be considered with a link or in some form be associated with a dedicated set of CGs, a special LCP restriction, or even an UL grant. Some details may be left to stage-3.

RAN2#116e agreed the following

1. The baseline mechanism for Survival Time support is “CG resources will be used for service with Survival Time requirements, such that the mapping relation between the service and the retransmission grant is commonly known to both gNB and UE, and CG retransmission scheduling (addressed by CS-RNTI) can be used for Survival Time state triggering”.
2. FFS how UE identifies the corresponding DRB that should enter Survival Time state and other details (i.e. resource allocation)

Let’s consider that Survival Time is associated with a per DRB requirement and there is a Tx-side HARQ-NACK counter controlling the entry into Survival Time [20][19][28][10][12].

**Question 7: Which of the options listed below would you think should be used to identify triggering of Survival Time state of a DRB?**

In principle, there are at least three options that could be used to identify whether a received retransmission grant should trigger Survival Time state.

**Option 1: The index of LCHs in the MAC PDU that this retransmission grant is related to.**

**Option 2: The index of CG where this retransmission grant is related to.**

**Option 3: The HARQ PID indicated in the retransmission grant.**

**Option 4: Other (please elaborate).**

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| **Company** | **Options** | **Comments** |
| Nokia | Option 3 | All options will probably work, but Option 3 seems to be more efficient because the UE can trigger survival time state directly after decoding the DCI of the retransmission grant, without having to check the MAC PDU contents as in Option 1.  Option 2 is a bit too restrictive as it is only applicable to CG. Although we have agreed that CG is the baseline mechanism, we think from specification perspective we should keep it open. |
| Apple | Option 1 (or 3) | Option 1 seems the most general variant. From a UE and DRB mapping flexibility point of view, this option is preferred.  The complexity to identify the DRBs is manageable as the UE anyway has to write MAC headers and identify the DRB. The gNB also needs to decode/parse MAC headers anyway. The LCID is part of the MAC header, thus there is not necessarily a need for interaction (feedback loop) between PDCP and MAC.  Option 1 is also forward-compatible in the sense that RAN2 may want to extend the Survival Time to DGs in the future. Further, a DRB in Survival Time may even need to use a DG (e.g., in abnormal cases as mentioned in our response in Q1C).  A bit of a challenge though is that both UE and gNB should have the same understanding of the Survival Time state at any given time. Assume multiple DRBs are multiplexed in the same TB - some with a Survival Time requirement and some without. If the TB was not received correctly and the gNB sends a HARQ-NACK, the UE can record the relationship between the multiplexed DRBs in the TB but the gNB may not be able to identify MAC headers. Thus, if option 1 is used in Q7, the gNB may not know whether the TB carried a DRB with a survival time requirement. Obviously the gNB can take a conservative approach and assume Survival Time was entered, but it may still lead to a misalignment. The same problem may also exist in Option 3.  Option 2 can work but it is not preferred because it is going to cause more multiplexing/mapping restrictions as to which DRBs can be multiplexed in a grant, and implicitly increase the number of multiple CGs required for support of Survival Time. Plus, this option is not scalable for DGs.  Option 3 may be problematic if HARQ processes are shared (e.g. between DG and CG or in NR-U, so it may lead to complications later on). Option 3 can also work with DGs. Even in option 1 the component dealing with the HARQ-NACK needs to know when to watch out for an entry into Survival Time. This process might seem slightly more efficient in option 3. |
| CATT | Option 1 | Option 1 is the most accurate as it exactly addresses the point: Survival Time is triggered in the UE by receiving a dynamic grant for a retransmission of a MAC PDU carrying an LCH associated with a DRB configured to support Survival Time.  We don’t buy the complexity argument as an HPID can be flagged by implementation as carrying an ST-LCH at the time the MAC PDU is generated (Multiplexing and assembly), so there is no need to explicitly check back the MAC PDU content upon receiving the HARQ-NACK for the HPID. |
| Ericsson | Option 1 | Option 1 is more straightforward, as it links to the actual cause of the need for PDCP duplication.  Option 2 and opion 3 might also work, but it relies on a more implicit link or further RRC configuration , e.g., CG to LCH mapping, the configuration of which subset of HARQ process IDs |
| LGE | Option 2 | Option1: The network does not know which LCHs are included in the failed MAC PDU. It means that the NW may need to look at all possible CGs unnecessarily. The possible CG is identified based on implicit link between HPID, CG, and LCH. Furthermore, it is complex from UE perspective as well because the UE has to check the content of MAC PDU. Regarding CATT’s comment, it is not sufficient just to flag the HPID when carrying an ST-LCH but the MAC should know exactly which LCHs are included in the MAC PDU to trigger ST state only for the concerned RBs.  Option2: Option 2 is to activate PDCP Duplication for the DRB associated with the CG used for the transmission on the identified HARQ process. In order not to waste resources, it would be better to have a 1:1 mapping between RB and CG but it could be up to NW implementation.  Option3: We’re not sure what option 3 exactly means. What is the difference between option 2 and 3? |
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***Summary of Question 7:***

*TBD*

**Proposal 7: TBD**

## Mapping relationship between LCID and a DRB configured for support of Survival Time in a MAC PDU

Depending on the LCH to CG mapping (e.g., through *allowedCG-List*) a transport block can contain a mix of SDUs from different DRBs. Among the MAC SDUs contained in the TB only a subset of of SDUs might belong to a DRB configured with Survival Time.

**Question 8: Does your company think there should be a specific mapping between DRBs in support of Survival Time and one or multiple CGs?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes | It should be needed, otherwise the MAC does not know which DRB should enter survival time state upon reception of a retransmission grant. |
| Apple | No (ideally) | Ideally a mix of SDUs from different DRBs in a CG/TB should be possible, at least RAN2 should consider this case in a forward-looking way considering that DGs may be used in the future. Further, specific mapping restrictions would increase the amount of multiple CGs required in a cell and reduce flexibility for the CG mapping. Another aspect is that a UE or gNB may support a limited amount of multiple CGs per BWP / per UE. Obviously some mapping restrictions may be needed for example for those used on the duplicated leg in Survival Time only.  In another aspect though, we agree the challenge mentioned in our response in Q7 for option 1/3 (and also by Nokia above) would need to be addressed. |
| CATT | Yes | Existing LCP restrictions such as *allowedCG-List* (the most obvious one) but also *configuredGrantType1Allowed* can be used for such mapping. There is no need to specify any additional LCP mapping restriction. |
| Ericsson | No | There is no need for a specific mapping and can be achived by the existing LCP restriction, i.e., *allowedCG-List.* For example, for other DRBs/SRBs, it is not allowed on the indicated CG while for the DRB with survival time, it is only allowed on the indicated CG. |
| LGE | Yes | It is sufficient to resue the existing *allowedCG-List*. However, there can be some mapping restrictions to be considered such that:  - SDU from ST DRB and non-ST DRB are not mixed into one TB.  - SDU from different ST DRBs are not mixed into one TB.  One simple option is that one CG is mapped to one RB, which avoids multiplexing SDUs from different RBs. However, this can be done by NW implementation. |
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***Summary of Question 8:***

*TBD*

**Proposal 8: TBD**

Obviously one option is to map DRBs with similar Survival Time entry (number of HARQ NACKs) and reliability requirements onto the same CGs.

**Question 9: Should RAN2 address the case where DRBs with and without Survival Time requirement are mapped to the same CG, and if so, how?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | No | We don’t think this problem would exist. A smart gNB implementation would not configure in this way. Essentially we think one CG should be dedicated to one DRB with survival time requirement, because we are dealing with critical traffic and it is not desirable to mix up traffics onto single resource. We prefer to handle the issue by implementation. |
| Apple | Yes | It should be made clear in the specification what is the general kind of mapping expected, so there could be a configuration restriction. |
| CATT | No | We fail to see a problem. Even if two DRBs are multiplexed in the same MAC PDU, mapped on one CG, HARQ-NACK reception for the failed PDU will only trigger duplication for the DRB configured with *survivalTimeSupport*. The other DRB (which may not even be configured with duplication) is not impacted. |
| Ericsson | No | See answers to question 8. |
| LGE | No | As responded to Q8, it should be avoided by the NW implmenetation. |
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***Summary of Question 9:***

*TBD*

**Proposal 9: TBD**

**Question 10: In case multiple LCHs are mapped to the same CG, which of the following options would your company prefer?**

**Option 1: Entry to Survival Time state is triggered for all DRBs mapped to the MAC PDU to which retransmission scheduling is applied for a CG.**

**Option 2: Following a HARQ-NACK, entry to Survival Time state is triggered only for DRBs (with a requirement for Survival Time) which are included in the MAC PDU transmitted using this CG.**

**Option 3: Other (please elaborate).**

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| **Company** | **Options** | **Comments** |
| Nokia | None | We don’t think this problem would exist. A smart gNB implementation would not configure in this way. Essentially we think one CG should be dedicated to one DRB with survival time requirement, because we are dealing with critical traffic and it is not desirable to mix up traffics onto single resource. We prefer to handle the issue by implementation |
| Apple | Option 2 | Ideally the mapping should be kept flexible and the Survival Time triggering would need to reflect this. |
| CATT | Option 2 | Option 1 makes little sense for the DRBs multiplexed in the MAC PDU, which are not configured with *survivalTimeSupport*. |
| Ericsson | Other | Not sure I understand the question.  Option 2 seems to be reasonable. Not sure how option 1 would work, if that DRB does not have “survival time” related configuration. |
| LGE | Other: Following a HARQ-NACK, entry to Survival Time state is triggered to DRBs (with a requirement for Survival Time) which are associated with the CG used for transmission of the MAC PDU | The question is not clear.  Is it to ask whether PDCP duplication is triggered also for the DRBs not configured with survivalTimeSupport (option1) or to trigger PDCP duplication only for the DRBs configured with survivalTimeSupport (option2)? If it’s correct understanding, option 1 seems not reasonable. However, it doesn’t mean that option 2 is straightforward because it depends on Q7.  As responded Q7, we think the MAC idendifies the RBs for which ST PDCP duplication is activated based on the mapping between CG and LCH. In other words, following HARQ-NACK, entry to Survival Time state is triggered to DRBs (with a requirement for Survival Time) which are associated with the CG used for transmission of the MAC PDU  In the meanwhile, we don’t think there is such case that DRBs configured with survivalTimeSupport and without survivalTimeSupport are mixed into one TB or mapped to the same CG. |
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***Summary of Question 10:***

*TBD*

**Proposal 10: TBD**

In a more extreme case the same TB might even carry multiple DRBs configured with Survival Time. The transfer interval associated with some of these DRBs may tolerate just a single HARQ-NACK and while the transfer interval associated with other DRBs tolerates a different amount of HARQ-NACKs.

**Question 11: Should RAN2 consider a case where SDUs from multiple DRBs with a Survival Time requirement are contained in the same CG, potentially each of them having different transfer interval and/or lead time for Survival Time entry? And if so, how?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | No | Again we think this problem does not exist, as we commented above. |
| Apple | Yes | If this case exists then the assumption can be made that the DRB with the most stringent (smallest number of N tolerable HARQ NACKs) Survival Time requirement triggers the entry into Survival Time for all respective DRBs. |
| CATT | No additional specification impact | We fail to see a problem. Even if two DRBs, multiplexed in the same MAC PDU, mapped on one CG, and both configured with *survivalTimeSupport*, but with different transfer intervals, the single HARQ-NACK reception for the failed PDU will trigger duplication for both DRBs. The DRB with larger transfer interval will just get its duplication effective later than the DRB with smaller transfer interval. |
| Ericsson | No | Multiple CG configuration were introduced in Rel-16 and so this case might not happen. |
| LGE | No | As responded to Q8, SDUs from different DRBs (with *survivalTimeSupport* configured) should not be mapped to one CG. |
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***Summary of Question 11:***

*TBD*

**Proposal 11: TBD**

## On entering Survival Time when PDCP duplication is already active

This topic was touched upon during the discussion that the MAC entity shall handle the counting of N [2]. RAN2 subsequently agreed that “MAC entity shall handle the determination of triggering survival state based on HARQ-NACK” [1]. The discussion in [2] was driven from the context in which specification to define the trigger/functionality. Thus the counting of HARQ-NACK when PDCP duplicaton is activated may still require some clarification.

Since PDCP duplication involves sending copies of PDCP PDUs over different RLC legs and the same PDU is transmitted multiple times, one approach is to use the same HARQ-NACK trigger threshold on either side. That is, whichever RLC leg arrives first at the configured number of HARQ-NACKs N triggers entry into Survival Time. For example, if the configured number of N=2 and PDCP duplication was active over two legs, reception of one HARQ-NACK on leg1 and one HARQ-NACK on leg2 does not trigger an entry into Survival Time. Whereas, if either of the two legs reaches two HARQ-NACKs in response to a TB, the criterion to enter Survival Time is fulfilled. This approach minimizes dependencies between the two MAC entities in DC duplication.

It maybe worthwhile to review another approach in the following section (question 13, option 2), in which case an entry into Survival Time can be triggered in a different manner, but this requires interaction between the two MAC entities in DC duplication.

**Question 12: When DC duplication is already activated, do you agree that the UE enters Survival Time when at least one MAC entity reaches the Survival Time count N (similar to option 1 in Q13), in order to minimize dependencies between MAC entities?**

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| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments** |
| Nokia | Depends | Assuming DC duplication configured - We think it depends on how many MAC entities are involved for the legs that are already activated before survival time state triggering.   * If only one MAC is involved for active RLCs before survival time triggering (e.g. primary path), the UE should only determine the state based on the primary MAC only. * If only both MAC are involved for active RLCs before survival time triggering, the UE should only determine the state based on at least one of the MAC. |
| Apple | Agree (see comment) | When two MAC entities are involved in DC duplication, RAN2 may have to define a rule how the counting is supposed to happen as a trigger to enter Survival Time, that is, which legs participate in the counting. We think the counting should be done separately on each leg so that no interaction is required between different MAC entities. This is also following the agreement that the MAC entity shall handle the determination of triggering survival state based on HARQ-NACK.  However, if this option is agreed the UE may enter survival time a bit early in some cases or even unnecessarily (e.g., when one leg is still fully operational without any HARQ NACKs). Option 2 of Q13 can avoid this problem, but it would require interaction between MAC entities or counting in PDCP (e.g., when multiple MAC entities are involved). |
| CATT | Agree | First, we do not support N>1 as it artificially introduces complexity and is an argument to add a useless timer to trigger ST.  Second, we think a DC deployment is unlikely to be seen in the deployment areas assumed for the traffic cases we are focusing on (50m x 10m).  As a result there is no reason to optimize the specification to address this case and we think it is simpler that each MAC triggers duplication independently of each other, based on the received HARQ-NACKs in its own RLC entities. |
| Ericsson | Agree and down prioritize this DC duplication case | We don’t think DC duplication is common in IIoT deployment. |
| LGE | See the comment | First of all, it is not yet decided whether DC duplication can be activated already.  Secondly, we do not support N>1.  If DC duplication is already activated and N>1 is supported, we think ST is triggered when any HARQ process reaches the ST count N. |
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***Summary of Question 12:***

*TBD*

**Proposal 12: TBD**

To confirm the understanding when PDCP duplication happens in scenarios where only one MAC entity is involved, we also have the following question for completeness.

**Question 12A: When CA duplication is already activated and only one MAC entity is involved, do you agree that the UE enters Survival Time when at least one CC reaches the Survival Time count N?**

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| **Company** | **Agree/Disagree** | **Comments** |
| Apple | Agree (see comment) | The simplest option is that the UE enters Survival Time when any CC (whichever side is first) reaches the Survival Time count N. This option is acceptable to us. (It would be simple and aligned with the DC case in Q12.)  However, the MAC entity can collect HARQ NACKs from different CCs and the UE is already duplicating PDUs. Therefore, in order to be more resource efficient we can use another option where the UE enters Survival Time when the Survival Time count is greater than N. |
| CATT | Disagree | Again, we do not support N>1 for the reasons indicated above.  Then, when duplication is already activated in CA, ST should only be triggered if HARQ-NACK is received for each of the activated legs. Indeed, even if only one leg could transmit the traffic message, there is no need to trigger ST. |
| Ericsson | Agree and down prioritize this CA duplication case | Even in the CA duplication, the MAC entity is not aware that two RLC PDUs are actually from the same PDCP for duplication. MAC entity only knows that they have to be sent on differet cells, by LCP restriction configuration. The counting seems better to happen on the PDCP entity. Given the complexity of this issue and less typical scenario (i.e., PDCP duplication is already activated), we prefer to down prioritize this case.  To consider this case seems to support N>1 counting at the PDCP entity and has the same problem that a PDCCH carrying retransmission grant might be lost and the counting at the gNB and the UE would mis-match. |
| LGE | See the comment | First of all, it is not yet decided whether CA duplication can be activated already.  Secondly, we do not support N>1.  If CA duplication is already activated and N>1 is supported, we think ST is triggered when any HARQ process reaches the ST count N. |
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***Summary of Question 12A:***

*TBD*

**Proposal 12A: TBD**

## On entering Survival Time in DC split-bearer scenarios

This section discusses the triggering of Survival Time for a DRB in dual-connectivity [16][11][20]. If a DC split bearer is configured with Survival Time support, the UE may receive a retransmission grant from both MN and SN side. In a way, the scenario may be akin to a situation when PDCP duplication is already activated (e.g., in CA or over DC), as in the previous section (Q12).

A picture containing text, clock, screenshot

Description automatically generated

Figure1 UE receives HARQ NACK at both MCG and SCG legs in case of DC split bearer [16]

The question may not be so relevant if N is kept to 1, however, there are also implications on RAN3 (as can be seen in the next section) and the case seems important to consider from a systems point of view.

**Question 13: For DC split bearer, do you prefer the UE enters Survival Time based on option 1 or based on option 2 below?**

**Option 1: The UE enters Survival Time state on reception of the required number of N HARQ NACKs at either MCG or SCG. For example, for N=2 Survival Time is entered when two UL retransmission grants are received on MCG only or on SCG only. With only a single retransmission grant on both MCG and SCG, Survival Time is not entered.**

**Option 2: The UE enters Survival Time state on reception of HARQ NACKs at both MCG and SCG legs and the total NACK count is larger than N times (as shown in the picture).**

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| **Company** | **Options** | **Comments** |
| Nokia | Depends | We think it depends on how many MAC entities are involved for the legs that are already activated before survival time state triggering.   * If only one MAC is involved for active RLCs before survival time triggering (e.g. primary path), we should use Option 1 * If only both MAC are involved for active RLCs before survival time triggering, we should use Option 2 |
| Apple | See comment | A split-bearer involves sending different PDCP PDUs of the same DRB over different legs and the Survival Time requirement typically applies to consecutive PDUs. If the UE splits consecutive PDUs over different legs (e.g., above *ul-DataSplitThreshold*) and the Survival Time count N is greater than 1, a counting strictly based on option 1 may not be correct. In this case, some interaction between MAC entities would be required. Or alternatively, the counting of N has to happen in PDCP. Option 2 is a close fit for this case although ideally the UE needs to enter Survival Time at exactly N, not at N+1.  If the UE is below *ul-DataSplitThreshold*, only one MAC entity is involved and we can use option 1 on the primary path.  If the UE is above *ul-DataSplitThreshold*, there could be an option 3 where the UE enters Survival Time state on reception of HARQ NACKs at both MCG and SCG legs and the total NACK count is N times.  Another option is that a split-bearer config always has to use N=1 for simplicity (but this is not resource efficient). |
| CATT | Option 1 | Again, we do not support N>1 for the reasons indicated above and we think a DC deployment is unlikely to be seen in the deployment areas assumed for the traffic cases we are targeting (50m x 10m).  In addition, we think configuring DC with split bearer makes little sense for the traffic cases we are discussing which are deterministic and periodic, hence very steady sate data rate. Thus it is not expected that a burst of data would trigger the activation of the secondary leg at any time. Or it would activate it always.  As a result there is no reason to optimize the specification to address this case and we think it is simpler that each MAC triggers duplication independently of each other, based on the received HARQ-NACKs in its own RLC entities. |
| Ericsson | Down prioritize this case. | If PDCP duplication is not activated, then PDCP PDUs are transmitted via either MCG or SCG. The couting, in our understanding, is only relevant for one PDCP PDU. In this case, option 2 does not seem to make sense and option 1 seems okay.  If the question is more on when the PDCP duplication is already activated, see answers to Q12. |
| LGE | See the comment | First of all, it is not yet decided whether DC duplication can be activated already.  Secondly, we do not support N>1.  If DC duplication is already activated and N>1 is supported, we think ST is triggered when any HARQ process reaches the ST count N. |
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***Summary of Question 13:***

*TBD*

**Proposal 13: TBD**

## RAN3 impacts

In [11], the question is raised whether different network nodes (over F1 or Xn interfaces) would benefit to exchange Survival Time state related information. For instance, when Survival Time state is triggered at the UE side, the gNB may also need to coordinate its protocol layers (e.g., connected via IAB) to receive uplink data properly. If the gNB is deployed with CU-DU architecture, or if the duplication is configured with dual-connectivity, then some impacts in Xn and F1 interfaces may be foreseeable [20]. It is proposed to send an LS to RAN3 to consult and inform RAN3 of possible impacts.

**Question 14: Would you agree to send an LS to RAN3 in order for RAN2 to provide status information of Survival Time support?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes | We should at least let RAN3 know what we have agreed as RAN3 is one of the WG involved for this objective. Whether there is any impacts to RAN3 is up to their own assessment. |
| Apple | Yes | Survival Time may indeed impose some impact to RAN3. RAN2 should inform RAN3 in due time, so that RAN3 can evaluate the impact. |
| CATT | FFS | We can see the progress on all above discussed issues to first see the impact on RAN3. |
| Ericsson | No | We are not in favour of creating unnecessary LS traffic which contains just the RAN2 agreements. In our understanding, RAN3 can start the work on their own. The LS should serve a particular purpose.  PDCP duplication with four RLC entities have been agreed in Rel-16. The RAN2 agreement in Rel-17 is essentially to activate PDCP duplication with DCI instead of MAC CE. It is not clear for us additional impacts for RAN3. |
| LGE | No | So far we don’t see any specific information that needs to be sent to RAN3. |
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***Summary of Question 14:***

*TBD*

**Proposal 14: TBD**

## UE capability

RAN2 agreed on the introduction of a network configuration parameter to enable Survival Time mode for a DRB. The implementation of the Survival Time feature requires cross-layer interaction and some complexity on both UE and network side. Thus the UE’s ability to support operation in Survival Time can be captured in a new UE capability [12].

**Question 15: Would you agree to introduce a new UE capability for support of Survival Time?**

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| **Company** | **Agree/Disagree** | **Comments** |
| Nokia | Agree | A natural outcome of this WI |
| Apple | Agree |  |
| CATT | Agree | Makes sense. Note though we disagree with Rapporteur’s comment that “The implementation of the Survival Time feature requires cross-layer interaction”. In our view, if everything is handled in MAC, there is no PDCP specification impact and no cross-layer interaction is foreseen on top what is currently needed in legacy PDCP duplication activation. |
| Ericsson | Agree |  |
| LGE | Agree |  |
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***Summary of Question 15:***

*TBD*

**Proposal 15: TBD**

## Other issues

This discussion focusses on open items and some procedural topics that may be required as a prerequisite for the initial steps in formulating first TPs. There are many more open items, including those we have identified in previous meetings. If there are further immediate issues to be raised, companies may indicate it here.

**Question 16: Are there any other issues that you think are necessary to discuss, in order to complete the design of Survival Time solution?**

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| **Company** | **Issues** | **Comments** |
| CATT | Interpretation of the retransmission grant | It was challenged by some companies that the HARQ-NACK based ST trigger mandates NW to always schedule a dynamic retransmission of the failed transmission (even though NW strategy may be to abandon the failed PDU). This can be addressed by adding a parameter (e.g. *applyRetransmission*) in PDCP\_Config along with *survivalTimeSupport* indicating whether to apply or not the retransmission upon receiving a retransmission grant for a DRB configured with Survival Time support. In the letter case, the retransmission grant would only trigger ST. |
| Ericsson |  | Just to follow up on the comment by CATT above:  What RAN2 has agreed is to ***add*** another interpretation of the retransmission grant, but no change to its existing functionality. To change the legacy meaning of this DCI must involve RAN1. For example, the new functionality seems to enable another variant of the UL skipping and RAN1/2 has spent a long long time to sort out this issue in Rel-16..  As the original proponent company of this issue, we do not prefer retransmission grant at all. Since it was agreed, given the complexity involving RAN1, we are fine to rely on network implementation, e.g., network send a retransmission grant with one PRB only. |
| LGE |  | Regarding CATT’s issue – We don’t think it is necessary. Although retransmitting a MAC PDU is not essential for ST, it is just one time hence not a big problem. The NW implementation mentioned by Ericsson seems to be one option as well. However, in S5.3.2.2, Note is saying that:  NOTE: If the MAC entity receives a retransmission with a TB size different from the last TB size signalled for this TB, the UE behavior is left up to UE implementation.  We may need to clearly specify that retransmnission itself is UE implementation but ST triggering is not up to UE implementation.  In the meanwhile, considering the remaining time, we have concern on considering complex cases and functionalities in Rel-17 ST mechanism. For example,  1) N>1 - It should be discussed whether it is per MAC, per Cell, per HARQ process, or per CG. What if RB requiring different N are mixed into one TB?  2) DRBs configured with survivalTimeSupport are mapped to one CG and mixed into one TB.  For simplicity, we suggest to limit N to 1 and a maping between CG and RB to 1:1. |
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***Summary of Question 16:***

*TBD*

**Proposal 16: TBD**

# Conclusions

**Summary:** TBD.

**Proposals: TBD.**

# References

[1] R2-2111294, Report for Rel-17 Small data, URLLC/IIoT and RACH partitioning, Session Chair (InterDigital)

[2] R2-2109602, Summary of [Post115-e][513][IIoT] QoS Survival Time, Huawei, HiSilicon

[3] R2-2109603, TP of baseline CR for Survival Time state operation, Huawei, HiSilicon

[4] R2-2109601, Discussion on two-level PERs for Survival Time handling, Huawei, HiSilicon

[5] R2-2109654, HARQ NACK solution: addressing concerns and design details, CATT, CMCC

[6] R2-2109655, TPs capturing HARQ-NACK solution, CATT

[7] R2-2109709, L1/L2 configuration adaptation, Fujitsu

[8] R2-2109710, Additional thought on supporting N>1, Fujitsu

[9] R2-2109778, RAN enhancements based on new QoS related parameters, Ericsson

[10] R2-2109927, RAN Enhancement to support Survival Time, Qualcomm Incorporated

[11] R2-2109992, Discussion on HARQ NACK solution, vivo

[12] R2-2110067, Remaining QoS solution aspects, Apple

[13] R2-2110068, Adaptive configuration for CG/SPS, Apple

[14] R2-2110069, Further considerations on Survival Time for new QoS, Apple

[15] R2-2110108, N and combined Tx-side timer for IIoT QoS, ZTE, Sanechips, China Southern Power Grid Co., Ltd, TCL Communication Ltd., vivo

[16] R2-2110201, Discussion on Survival Time state, NTT DOCOMO INC.

[17] R2-2110227, Remaining issues on the support of Survival Time, Lenovo, Motorola Mobility

[18] R2-2110263, Discussion on the RAN solution for introduction of new QoS parameters, CMCC

[19] R2-2110345, Finalising Survival Time related enhancements, Samsung Electronics GmbH

[20] R2-2110444, An Overview of Survival Time Enhancements, Nokia, Nokia Shanghai Bell

[21] R2-2110589, Consideration on the support of Survival Time, OPPO

[22] R2-2110673, Clarification on the Survival Time requirement, Xiaomi Communications

[23] R2-2110791, On counting HARQ-NACKs for triggering Survival Time state, Futurewei Technologies

[24] R2-2110802, Survival Time handling, Intel Corporation

[25] R2-2110913, Enhancements based on new QoS requirements, InterDigital

[26] R2-2110918, Issues with UE Survival Time support, Sequans Communications

[27] R2-2110965, Discussion on RAN enhancement to support Survival Time, China Telecommunications

[28] R2-2111167, Remaining aspects in ST mechanism, LG Electronics Inc.

[29] R2-2111183, Discussion of RAN Enhancements to Support Survival Time, TCL Communication Ltd.

# Annex: RAN2 agreements

RAN2#112e:

**Agreements**

=> Time period during which “message loss” can be tolerated is adopted as the preferred format for Survival Time. FFS how this will be achieved and what message loss means in RAN2

RAN2#113e (after email discussion [AT113-e][506] Offline on RAN enhancements QoS (Nokia), captured in R2-2102074 and R2-2102254):

**Agreements**

- Communication service availability (CSA) is not needed on top of Survival Time. Send a reply LS to SA2 to notify such confirmation

*-* RAN2 confirms that specification enhancement for Survival Time support may only needed for uplink. Downlink is addressed by implementation and no specification impacts.

*-* Support for Survival Time in UCE is up to network configuration.

- Continue discussing whether burst spread and burst ending time is beneficial from RAN2 perspective, but trigger the discussion after SA2 progress in February

- Communication service reliability (CSR) is not needed on top of Survival Time

- Only periodic traffic is considered for Survival Time work in Rel-17

- RAN2 assumes one application message is conveyed by one PDCP SDU, and may further consider the cases where one application message is conveyed by varying number of PDCP SDUs depending on the progress

RAN2#114e (after email discussion [POST113bis-e][506][R17 IIoT] Enhancements based on QoS (CATT), captured in R2-2104897):

**Agreements**

1. RAN2 does not consider the Burst Spread parameter in RAN
2. The Burst End Time parameter in RAN is out of scope for Rel-17 IIoT WI.
3. 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
4. When Survival Time information is provided in TSC AI, RAN action (gNB and/or UE) can utilize it to improve the associated link reliability so that the Survival Time requirement is met
5. Study fast mechanisms for Survival Time handling and the need

RAN2#114e (following a subsequent email discussion, captured in R2-2106558):

**Agreements**

1 RAN2 takes the performance requirements of the top 3 rows of Table 5.2-1 from TS 22.104 (transfer interval = Survival Time = 0.5/1/2ms)

2 Survival Time triggered proactively based on Sequence Number is deprioritized

3 UE-based reactive solution based on RLC-NACK is not pursued

4 RAN2 will work/study UE-based reactive solutions to address Survival Time on top of gNB implementation. RAN2 assumes that gNB implementation solutions on their own are not sufficient.

RAN2#115e (after email discussion [Post114-e][511][URLLC/IIoT] QoS Solutions (Samsung), captured in R2-2107173):

**Agreements**

1. RAN2 does not assume that physical HARQ-NACK messages are always available, i.e. RAN2 will not mandate explicit HARQ-NACK feedback
2. Given the application message size range under study, RAN2 will not optimize the ST design based on case of segmentation of message into multiple TBs. (This does not preclude the use of RLC segmentation; instead, it rules out optimizations for the case with RLC segmentation)
3. Following entry into the Survival Time state, PDCP duplication for ST configuration is activated. The gNB pre-configures which RLC entities can be activated for duplication when entering ST state. FFS the number of supported RLC entities.
4. RAN2 will at least continue working and discussing the HARQ NACK solution. Details are FFS.

RAN2#116e (after email discussion [Post115-e][513][IIoT] QoS Survival Time (Huawei), captured in R2-2109602/3):

**Agreements**

1. A RRC parameter is configured for a DRB with Survival Time support
2. MAC entity shall handle the determination of triggering survival state based on HARQ-NACK
3. For the DRB configured with Survival Time support, the network can control the duplication state for the DRB via legacy activation/deactivation MAC CE. No specification change is foreseen.
4. For the issue that there may be packets already sent to RLC before the pre-configured PDCP duplication configuration is activated, following entry into the Survival Time state, it is up to gNB/UE implementation to handle and no need to specify extra behaviour
5. RAN2 not to consider the interaction between Survival Time solution and handover procedure in Rel-17
6. No specification enhancement will be pursued for CG activation command as Survival Time state trigger
7. The baseline mechanism for Survival Time support is “CG resources will be used for service with Survival Time requirements, such that the mapping relation between the service and the retransmission grant is commonly known to both gNB and UE, and CG retransmission scheduling (addressed by CS-RNTI) can be used for Survival Time state triggering”.
8. FFS how UE identifies the corresponding DRB that should enter Survival Time state and other details (i.e. resource allocation)
9. FFS on unlicensed band
10. Deprioritize autonomous activation of PDCP duplication based on inputs other than retransmission grant