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. If this goes without a parameter just based on the implicit association, well, that may not be so desirable as it can complicate the validation of these CG type-1 configs. 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 mode 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. |
| Fujitsu | 1/1B/1D > 1A/1C | Supportive Options:**Option 1:** From high-level perspective of resource pre-allocation, we are fine.**Option 1B:** The pre-allocated CG resources would be have some relationship with RLC entities to ensure that those resources are only used during ST mode. For example, a CG resource would be associated with an RLC entity that is only used during ST mode. Here, we say terminology “used”. Depending on discussion, “used” may mean “activated” or “valid”, but the exact wording can be fixed during Stage 3 discussion.**Option 1D:** This option seems to have also some relationship between CG resources and RLC entities, which is supportive to us.Need considerations:**Option 1A:** Seems no relation between CG resources and RLC entities.**Option 1C:** CG resources may not be always dedicated resources. Depending on resource deployment, those CG resources is better to be allowed to use other UEs or outside ST mode. |
| Lenovo, Motorola Mobility  | 1/1B | We don’t see a need for new LCP restrictions. Existing framework is sufficient. Also we don’t think that a new parameter in configuredGrantConfig IE is required.  |
| Qualcomm | Open to Option 1,1A and 1C | If network implementation solution of configuring a CG type 2 and activating it simaltanuously with duplication activation or activation (and overbooking) a CG Type 1 is not sufficient, we are open to options that: 1. Have no RAN1 impact. 2. Do not require the MAC to track or be aware of the survival state, since that would be complex and not clean in terms of layer separation. We think the following options 1A/1C ca be dowscoped for selection.Option 1A: CG Type 2 can be configured and activated conditionally by a DCI2 and a HARQ-NACK indicating entry into a survival state, then later deactivated by a legacy DCI. This keeps the CG type 2 mechanism mostly in tact while slightly modifying the mechanics of activation signal at MAC. The challenge with that option is complicating a CG activation signal which is has been very stable since Rel-15Option 1C: A CG Type 2 can be configured and activated to only carry duplicated traffic with a UE MAC restriction that disallows the MAC from passing the grant to the PHY outside of survival time. The challenge with that solution is that the MAC need to now track the survival state which it would naturally should be transparent to and adds a lot of MAC/PDCP coupling to continuously signal entry/exit of survival state.Thus we would consider this solution workable only if its designed in a way that does not require a MAC state machine. We do not support option 1B/1D. The issues with Option 1B/1D here is that it locks the solution into CG type 1 which is not very flexible, CG type 1 has no notion of activation/deactivation so this will be a big change to CG type 1 (almost a new CG type), and this would need the MAC to track the survival state with no fail-safe DCI to deactivate the resource if the UE and gNB fall out of sync. We also think that RAN1 may have issues with that solution. |
| Intel | 1/1B | We don’t think new LCP restriction or new parameter in *configuredGrantConfig* IE is needed. |
| Huawei, HiSilicon | None or 1E | We prefer to leave the issue to network implementation (see our reply for Question 1c) and we understand the added 1E as network implementation. Besides, we disagree with the rapporteur on “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.” Actually, RAN2 agreed that gNB implementation solutions on their own are not sufficient for overall Survival Time support, and understandably as mainly for Survival Time state triggering. On this specific resources provisioning issues discussed here, gNB implementation would be sufficient. |
| Samsung | None or 1E | Same understanding as LG and Huawei. In our view, the CG resource without any received data from PDCP will most likely be skipped, and the CG transmission with empty data will not happen. Since the NW should in any case track the UE’s ST state, NW can use the same time-frequency resource for another UE. |
| OPPO | None  | In general, we think current LCP restrictions can work well, and no new LCP restrictions or new parameters in CG config is necessary. The gNB can link the dedicated LCH of a DRB of ST requirement with a dedicated CG via the current *allowedCG-List.* For the detailed solutions, our preference is to leave this issue to gNB implementation, especially when we focus on type 2 CG. But, if the majority wants some solutions especially for type 1 CG, we are open to discuss Option 1/1B.  |
| InterDigital | 1/1B | We don’t believe there is a need for new LCP restrictions, though.If support of duplication is acceptable with CG type 2 only, we are okay with “None” or “Option 1E” |
| III | At least Option 1 | We think option 1 can become the baseline.  |
| Futurewei | 1/1B | Similar view as InterDigital. |
| vivo | 1E | NW knows when UE should enter Survival Time state and can active the CG resources for dupliation leg accordingly. The CG resource activation can be performed via type 2 CG activation mechanism requiring no extra specification work. |
| ZTE | Option 1/1B + Option 1A | We understand Option 1 is a high level option. Option 1B is a detailed option which can be feasible under the existing framework. We are fine with both of them.We think both of CG type-1 and CG type-2 can be used for PDCP duplication to fulfill the ST requirement. Yes, here the CG type-1 can be a kind of “variant” as we assume the initial state of a CG type 1 is set to “deactivated”. But we also think not all the configured CG type-1 and CG type-2 are dedicated for ST usage. Therefore we agree with some above views that UE needs to identify which configured CG resources need to be activated when entering ST state.But this does means Option 1/1B can only be combined with LCP restriction. We think Option 1A may be a bit straightforward, e.g., without LCP restriction configuration/support, CG resource(s) can be configured with a (new)Survival Time attribute for identifying this CG can be used in Survival Time only.If LCP restriction configuration is also provided, we agree with CATT and some other companies that the current LCP restriction already can be used to identify which CG resources are for ST only and no new LCP restriction is needed (a new allowedCG-List in Option 2A might be seen as a sub list which seems not so necessary). |
| MediaTek | None or 1E | For the same reasons as Huawei |
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***Summary of Question 1:***

*18 companies provided views to Q1. Company counts in brackets include views that apply under certain conditions or circumstances as indicated in the comments above.*

* *11 (12) companies support option 1. Considering comments in questions 1A-1C there are 2 additional companies that may support option 1, so overall we are at close to 14 companies.*
* *4 (3) companies support option 1A, however, one of them wants to downscope this option.*
* *9 (10) companies support option 1B.*
* *1 (2) companies support option 1C, however, one of them wants to downscope this option.*
* *3 (4) companies support option 1D.*
* *5 companies indicate new LCP restrictions are not required and the existing Rel-16 framework can be reused.*
* *A number of companies want to focus on CG type-2 or at least not exclude this type of CG.*
* *1 company thinks that option 1/1B can also work with CG type-2.*
* *5 (7) companies support option 1E, however, this option is understood as network implementation, which was not the question here.*
* *5 (7) companies do not support any other options except option 1E*

***It seems there is a majority for option 1 that in the best case 14 companies may prefer.***

*Among the supporters of this family of solutions, Option 1 (as an umbrella) and option 1B received the highest support. Option 1C and 1A received comparatively low support. Potentially option 1 could become baseline for CG type-1 in Survival Time. In addition, a CG-type 2 may be used depending on the situation, this may require more discussion or could be addressed as part of Proposal 1C.*

**Proposal 1 (14/18): Dedicated CG resources can be configured for the duplication paths and their activation is conditional on entering Survival Time state at least for CG type-1.**

**Proposal 1-1 (10/18): To provide radio resources on the legs used for PDCP duplication and to guarantee CG resources are not used outside of Survival Time, RAN2 to discuss whether a CG can be considered deactivated outside of Survival Time and activated in Survival Time only. Other similar variants are not precluded (for example, where a CG associated with one LCH is activated/deactivated when the associated RLC entity is activated/deactivated).**

**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.  |
| Fujitsu | None | It is good to clarify if one LCH / RLC entity which is “used” in ST mode can be associated with multiple CG resources.Once the RLC entities associated with the CG resources is not “used” i.e. outside ST mode, those CG resources do not be also used. It would be appreciated to clarify why LCH restriction is needed. |
| Lenovo, Motorola Mobility | None | We don’t see a need for new LCP restrictions or a new parameter in configuredGrantConfig IE. Existing LCP restriction, i.e. CG-allowedList, can be used to map LCH to CG configuration(s). For cases that CG activation/deactivation is linked to the ST state, no new LCP restriction is necessary. |
| Qualcomm | None | Agree with Nokia, CATT and Ericsson. |
| Intel | None | Agree with Nokia. As long as the CG is deactivated outside of surivival time statue, there is no need to define additional LCP restriction. |
| Huawei, HiSilicon | None | We prefer to leave the issue to network implementation. Even RAN2 could specify e.g. that a CG associated with one LCH is activated/deactivated when the associated RLC leg is activated/deactivated, it is not necessary to introduce such additional LCH restrictions. |
| Samsung | None | Agree with CATT. |
| OPPO | None  | Similar view as Nokia, CATT and Ericsson |
| InterDigital | None | Agree with Nokia and CATT. |
| III | None |  |
| Futurewei | None | Agree with Nokia and CATT. |
| vivo | None | We think LCP restriction enhancement is not needed. In order to avoid the CG resources are not used outside of Survival Time, the most straightforward way is that the CG resource are deactivated when the corresponding RB is out of ST state. As mentioned in Q1, we think CG type 2 should be pre-allocated to the additional legs which needs to be activated when entering the ST state. Thus, NW can independently control the activation/deactivation of CG. |
| ZTE | None | Similar view as CATT.  |
| MediaTek | None | Agree with Nokia and Ericsson |
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***Summary of Question 1A:***

*18 companies provided views to Q1A.*

* *14 companies indicated that existing LCP restrictions would be sufficient*
* *1 company indicated support for option 2A*

*It seems clear that LCP restrictions are not seen as a standalone solution. A majority of companies thinks an enhancement of LCP restrictios is not needed. Thus no proposal is given for Question 1A.*

**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 3Option 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. |
| Fujitsu | None | It is assumed that survival time has length (STL) e.g. 0.5ms, 1ms, and 2ms. The CG resources can be only used during STL. |
| Lenovo, Motorola Mobility | None |  |
| Qualcomm | None | We don’t see a need for such enhancements. PDCP duplication can already be enabled upon receiving a HARQ-NACK by DRB configurationper earlier agreements and exit can be left to NW implementation.  |
| Intel | None | We don’t think additional mechanisms are not needed. |
| Huawei, HiSilicon | None | We prefer to leave the issue to network implementation. Even RAN2 could specify e.g. that a CG associated with one LCH is activated/deactivated when the associated RLC leg is activated/deactivated, we fail to see the necessity for further enhancements like Option 3/3A. |
| Samsung | Option 3A | We see value in having a UE rule for exiting the ST state. The specific rule can be FFS. |
| OPPO | None | We do not see a clear benefit to having such enhancement. |
| InterDigital | None | This is implicitly implemented by our preferences in Q1. Option 1/1B is sufficient to specify. Specifying UE behaviour outside of survival time state or on exiting survival state is not needed, as ST is maintained per TB. |
| III | None |  |
| Futurewei | None |  |
| vivo | None |  Exiting from Survival Time can be left to NW implementation |
| ZTE | None | Agree with most of above views that no additional mechanism is needed. Deactivating the relavant CG resources can be aligned with exiting from ST state. How to exit from ST state can be discussed separately.  |
| MediaTek | None |  |
|  |  |  |

***Summary of Question 1B:***

*18 companies provided views to Q1B.*

* *1 company supports option 3*
* *2 companies support option 3A*
* *1 company is not sure*
* *All other companies do not support any of the options*
* *1 company would like to leave this issue to network implementation*

*3 companies see value in having a UE rule for exiting the ST state. How to exit from Survival Time state may be discussed separately. Another 3 companies mention that exiting from Survival Time state can be left to network implementation. There is no majority and it seems clear the options here are not seen essential in the context of provisioning of resources in Survival Time. Thus no proposal is given for Question 1B.*

**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).

|  |  |  |
| --- | --- | --- |
| **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 4BOption 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?  |
| Fujitsu | All | What solution the gNB would be used is fully implementation issue. No solution discussion is needed. |
| Lenovo, Motorola Mobility | None |  |
| Qualcomm | Option 4A/4B | Option 4A/4B should be available as a fallback if the network is unwilling to schedule a conditional CG activation as is described in Q1 or if none of the options of Q1 are available. Whether the gNB can do this fast enough is likely problem specific. The other issues with 4A/4B may be with creating a PDCCH bottleneck by having to send out multiple DCIs (one for every RLC being activated and the HARQ-NACK one) with the complications of what if UE misses one of the PDCCH DCIs activating CG/DG? What if the UE has multiple flows configured with survival times that need even more CG activations? Etc, and of course the need to do all the activations within 0.5ms.  |
| Intel | None | Agree with Nokia. |
| Huawei, HiSilicon | 4A, 4B | Considering RAN2 has already agreed that Survival Time state is triggered by CG retransmission scheduling, we understand that the network can schedule a CG retransmission grant when it fails to decode a TB on a CG occasion associated to the DRB with Survival Time support. Also we believe that the network has the capability to provide enough resources to transmit the duplicated packets from the additional activated legs when it detects that the DRB enters Survival Time state. We see that it is more suitable and sufficient to allocate a DG on the duplicated leg with robust MCS to guarantee the transmission reliability of the next message. If the next message is successfully received, the network can control the DRB to exit Survival Time state, and then resources on the duplicated leg are not needed anymore. Nonetheless, from the network implementation’s perspective, relying on CG resources, e.g. activate/deactivate a type 2 CG with DCI when entering/exiting Survival Time state, is another alternative that is also feasible. In fact, entering Survival Time state would be a low probability event. Even if the DRB enters Survival Time state, the network can guarantee to provide resources timely via its implementation. We think any other enhancements for CG operation or LCP restrictions are optimizations and not preferred. |
| Samsung | None | Same understanding as Fujitsu. |
| OPPO | Option 4A | When type 2 CG is used, Option 4A is always a possible way to assure ST requirements for a DRB. We would like to clarify Option 4B: Does it include a need for new LCP restrictions for LCH and DG? |
| InterDigital | 4A/None | Q1 provides solutions to provide resources when in ST state. As for guaranteeint resources are not used when out of ST state, this seems to be associated with exiting ST state and can be achieved with CG deactivation using existing procedures.  |
| III | 4A/4B |  |
| Futurewei | 4A/4B | Agree with Huawei. |
| Vivo | Option 4A | NW implementation has no spec impacts. We should not spend much time to discuss them. |
| ZTE | None | We have similar understanding as LGE. Therefore, Option 1/1B + Option 1A as mentioned in Question 1 would be enough. |
| MediaTek | 4A/4B | Agree with Huawei |
|  |  |  |

***Summary of Question 1C:***

*18 companies provided views to Q1C.*

* *11 companies support option 4A*
* *7 companies support option 4B*
* *1 company supports option 4C*
* *1 company supports option 4D*
* *9 companies do not support any option. Also 2 companies selected option 4A at the same time.*

***The amount of companies that support these options is slightly higher than the number of companies not supporting them.***

*Four companies indicate that options 4A/4B may create a resource bottleneck (which of course may not be true in all network constellations). Two other companies do not agree. One company also indicated that DG can be sufficient as a solution to provide resources in Survival Time while CG resources can be used as a complement.*

*Three companies indicate that solution 4A/4B is always possible. Three additional companies mention that the options in Q1 are preferred over the options here.*

*Overall the network implementation based solutions 4A/4B are seen as supplementary to the solutions in Q1. One company also mentions that Option 4C alone cannot guarantee that resources are not used outside of Survival Time.*

*It appears that the solutions in this section do not require enhancements, which seems in line with the RAN2 agreement that no specification enhancement will be pursued for CG activation command as Survival Time state trigger.*

**Proposal 1C (11/18): CG type-2 and DG based solutions can be used as a supplement to provide radio resources on the legs used for PDCP duplication in Survival Time.**

**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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Qualcomm  | None |  |
| Intel | None |  |
| Huawei, HiSilicon | None |  |
| Futurewei | None |  |
| vivo | None |  |
| ZTE | None |  |
| MediaTek | None |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

***Summary of Question 2:***

*10 companies provided views to Q2.*

* *All companies indicate that no additional options are needed*
* *1 company reiterates the importance of coupling RLC activation/deactivation status with CG activation/deactivation*
* *1 company reiterates that it is sufficient to activate/deactivate PDCP duplication when entering/exiting the Survival Time state while CG resource can be kept activated regardless of Survival Time state.*

*No proposal is given for these options as views are already discussed as part of the earlier questions/comments under the family of Q1.*

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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Fujitsu | Disagree | MAC CE is a control message, which ssems to be more important than URLLC data. Otherwise, the MAC layer may become uncontrollable, which should be avoided. |
| Lenovo, Motorola Mobility |  | We agree that the issue can be solved by network over-provisioning the CG resources. However it should be clear that over-povisioning comes at the cost of a decreased capacity. Nevertheless since we are approaching the end of the WI, it would be fine not to introduce any optimization at this stage.  |
| Qualcomm | Disagree | As mentioned by Nokia, the gNB can simply hedge that risk by configuring a larger TB to accommodate any possible MAC CE multiplexing. We agree with the rapporteur that the outcome of a restriction like that is unpredictable so we prefer not to address this subject since all earlier URLLC discussions did not perceive that to be an issue. |
| Intel | Disagree | We think that gNB should allocate sufficient resource, as Nokia pointed out.  |
| Huawei, HiSilicon | Disagree | Same view with Nokia. Generally, the CG configuration configured for periodic traffic is large enough to accommodate the data as well as possible MAC CEs. |
| Samsung | Disagree | This is an optimization in our view, and quite a restrictive one at that. |
| OPPO | Disagree | We agree this issue may exist, but we think one way is to rely on the current gNB implementation without any enhancement. |
| InterDigital | Disagree | Agree with Nokia and others that this can be handled by appropriate configuration. |
| Futurewei | Disagree | Agree with Nokia and others that we can leave it to gNB implementation to ensure that the CG resources are large enough to accommodate both MAC CE and data. |
| vivo | Disagree | Agree with nokia that the issue can be handled by network.  |
| ZTE | Disagree | Agree with more above views that imposing such restrictions may be risky. We tend to agree with CATT that the issue may exist in rare case which can be handled by network implementation. |
| MediaTek |  | Agree with Nokia that as we’re approaching the end of the release, we can rely on gNB implementation to ensure that the size of the CG is appropriately set. |
|  |  |  |

***Summary of Question 3:***

*17 companies provided views to Q3.*

* *14 companies disagree, although the issue as such is generally acknowledged*
* *3 companies including the proponent company indicate that an optimization may not be required at this stage as we are approaching the end of the release*
* *No company indicated support for option 3*

*Many companies acknowledge that the issue may exist while highlighting that it can be addressed by network implementation. Overall the solution is seen as an optimization. A few companies pointed out that imposing restrictions on MAC CEs may have side-effects. Considering previous discussions around this subject in URLLC, another attempt to resolve this issue may not yield a quick result. Since RAN2 is nearing the end of the release, a common view expressed was that this issue can be addressed by having the network implementation allocate sufficient resources.*

**Proposal 3 (14/17): For the issue that a CG resource may be insufficient for the UE to include the whole application layer message in one configured grant if a MAC CE is to be transmitted in the same CG, it is up to gNB implementation to ensure CG resources are appropriately configured.**

## 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).**

|  |  |  |
| --- | --- | --- |
| **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 configure 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.**[Nokia]** We would like to clarify that the intention of Option 2 is NOT relating to to “selecting the best subset dynamically”. The intention of Option 2 is for the gNB to boost reliability via using resources that is known to always have higher reliability. For instance, the LCHs of RLC entities indicated in *duplicationStateSurvTime* are associated to configured grants with lower MCS or higher repetition etc (compared to other RLCs for the same DRB), and therefore the the reliability can be boosted upon survival time state by transmitting the packet via more reliable resources. (Another example is switching from FR2 to FR1 to avoid consecutive beam blockage)The fact that these RLC entities have higher reliability than others is already-known and will not change over time due to their nature, and therefore pre-configuration by RRC is sufficient. This simply provides the gNB more flexibility in terms of tactics to improve reliability upon survival time state.One issue with Option 1 is: Why do we have to waste resource/power by keep on transmitting the packet on the lower reliability RLC if we know it has failed the previous transmission already ?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.  |
| Fujitsu | Option 2 | As agreed in RAN2#115-e. We are not quite sure what the discussion point is in this question. |
| Lenovo, Motorola Mobility | Option 1  | We prefer this option for simplicity reasons. We also don’t understand how NW considers actual radio conditions while also honouring spectrum and energy efficienly, if the RLC entities used for PDCP duplication when entering ST are preconfigured. Preconfigured means that it is a RRC configuration, hence there is no possibility to dynamically change the set of RLC entities.  |
| Qualcomm | Option 1 | We do not share the rappoteur’s understanding of the earlier agreement. The agreement states:* The gNB pre-configures which RLC entities can be activated for **duplication** when entering ST state

First we need to agree on the scope/baseline of our survival time solution. According to the earlier agreements:* The agreement is to activate PDCP duplication in survival time. This does not imply “switching” to some arbitrary RLC legs as this falls into some of the earlier adaptive L1 solutions that were not agreed early on. Duplication very clearly means activating one (or more) **additional** RLC legs **aside from the one (or more) RLC leg(s) that is already active.**
* Our Survival Time trigger is effectively a single “HARQ-NACK” bit indicated by a retx DCI. Thus in our L1 signalling, the network can only instruct the UE to activate some additional **pre-configured** RLC legs via a single bit. There is no L1 signalling capability to signal anything more than that such as which RLC legs to activate or switch to, that is why it is “pre-configured”.

Having established those two points, we understand the point of contention between option 1 and option 2 to be whether the network should keep “reconfiguring” the RLC legs that need to be activated in survival time apriori. Since the network does not know when survival time would be entered and as we established above, cannot instruct the UE to do anything more than activate duplication via a single bit, we seriously question the value of tracking an RLC leg state then continuously switching this RLC legs-to-be-activated state in anticipation of survival time entry in some undetermined time in the future. The radio channel may have very well changed so that dynamic RLC selection is based on possibly-outdated channel measurements. To us this is adding an extra layer of RRC signalling complexity with little/no real value. The procedure as we understand it is simple. The network has some higher reliability target to hit in survival time. It configures a set of RLC legs coupled with a conservative L1 configuration to carry the duplicated traffic. Once survival time is entered, the network activates the duplication leg(s) hitting this new \*higher\* reliability target for that survival time mode. We think this would be more than enough for the task at hand.  |
| Intel | Option 1 | We prefer option 1 due to simplicity.Both Option 1 and 2 are configured by RRC, and it is not clear to us why in Option 2, a subset of RLC entities are not used for survival time state, which needs maximum reliability.  |
| Huawei, HiSilicon | Option 1 without “or a subset” | We prefer Option 1 due to simplicity and that the UE will activate all RLC entities configured for the DRB when the RB enters Survival Time state, in such way the complexity caused (as discussed in Q5) could be avoided.As we know, the transmission reliability provided by PDCP duplication increases significantly as the number of used legs increases. It is easier and reasonable to use all legs to achieve the extreme transmission reliability for the subsequent message(s) when entering Survival Time state.Regarding the “pre-configuration”, Network can use legacy MAC CE to “fine-tune” the configured legs, e.g. removing the useless legs, even outside of the Survival Time state. If this is the case, we believe the difference between Option 1 and Option 2 would be minimal from performance perspective. However we are open to adopt Option 2 if majority supports it.  |
| Samsung | Option 1 | We have the same understanding of the agreement in question as CATT, and same understanding of the options as Intel. |
| OPPO | Option 1(a variation of Option 1) | For the agreement achieved in R2#115-e, we understand that preconfigured means that the RLC entities used for ST are configured by RRC signalling. On “FFS the number of supported RLC entities”, we understand both Option 1 and Option 2 are on the table. For the solutions, we prefer a variation of Option 1 for simplicity, i.e. Following the entry into Survival Time, PDCP duplication for all associated RLC entities for the configured DRB(s) is activated. |
| InterDigital | Option 2 | In some conditions (e.g. cell edge) Option 1 may be detrimental due to power headroom limitations. Further, option 1 is effectively supported by option 2. |
| Futurewei | Option 1 but … | without “or a subset” for simplicity. |
| vivo | Option 1 without “or a subset” | We prefer Option 1 without “or a subset”We do not see the motivation for NW to configure a DRB with N legs for duplication but only allows UE to use a subset of the N legs during Survival Time. In our understanding, UE should do its best to improve the reliability of the subsequent packets(i.e. using all confiugred duplication legs) after entering the ST state. Regarding to the previous agreement, we share same view with CATT. |
| ZTE | Option 2 | We initially prefer Option 1 and think even for Option 1, it can allow that the UE only activates part of the configured legs upon entering ST state, e.g., based on UE’s own evaluation and decision.Now we understand Option 2, e.g., network configure different sets of RLC entities, one of which is used in Survival Time state and the UE switches the set of active RLC entities upon changing the Survival Time state, might achieve same effect. |
| MediaTek | Option 1 (without ‘or a subset’) | We prefer Option 1 for simplicity. We agree with Qualcomm that the extra layer of RRC signalling only adds complexity and adds little value as it would most likely be based on outdated channel measurements. |
|  |  |  |

***Summary of Question 4:***

*17 companies provided views to Q4. Company counts in brackets () include views that apply to this option under certain conditions or circumstances indicated in comments.*

* *11 companies think option 1 is suitable. This includes companies that responded to option 1 without “or a subset” as well as companies that indicated option 1 with or without or a variation.*
* *6 to (8) companies think option 2 is beneficial.*
* *No company indicated support for option 3.*

*First, to clarify “all or a subset”, thanks for the comments! Indeed, this may be misunderstood. "All or a subset" was meant to indicate the set of associated RLC entities configured for PDCP duplication in normal state. It is the rapporteur’s understanding that is there is only one RRC configuration for PDCP duplication. If only 2 legs are configured then no more than 2 legs can be activated. Of course there might be a case where only 2 legs are activated but 4 legs configured. In this case the UE should switch to 4 legs upon entry to Survival Time. Likewise we might have a case where only 3 associated RLC legs are configured for the DRB. In this case, if only 2 legs were activated prior to the entry to Survival Time via MAC CE, then the UE may activate all 3 legs upon entry to Survival Time. The latter case (with 3 legs) was meant by “or a subset”. If any company thinks all 4 legs have to be activated always (even if only 3 associated RLC entities are configured), please indicate this in phase 2.*

*Although the number of companies supporting option 1 is slightly higher, views are very strong on either side. Thus there is no clear majority. Proposing one way or another may only cause disagreement from the opposing companies. Therefore, it seems possible to conclude that option 2 could be defined as a separate optional feature in a compromise. At the same time, option 1 may serve the most basic cases, or possibly serve as baseline. A UE may not have to support both options, this could be discussed later.*

**Proposal 4: The number of associated RLC entities that can be activated upon entry into Survival Time are supported by either one of two variants. The second variant can be optionally configured.**

1. **Following entry to Survival Time, PDCP duplication is activated for all associated RLC entities that are configured for a DRB. The RLC entities are identified using the Rel-15/16 options for RRC configuration of associated RLC entities.**
2. **Following entry to Survival Time, PDCP duplication is activated for a separately configured set of associated RLC entities that are configured for a DRB. The RLC entities are identified using a new RRC configuration option which can be optionally present. The separate set is used in Survival Time only.**

## 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?**

|  |  |  |
| --- | --- | --- |
| **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.  |
| Fujitsu | Yes | It is aligning with our understanding that ST is per DRB. The exact parameter name may be decided in detailed Stage 3 discussion. |
| Lenovo, Motorola Mobility  |   | Same opinion as expressed by CATT.  |
| Qualcomm | No | Disagree with option 2 in Q4 |
| Intel | Yes | We prefer Option 1 in Q4, but are OK to use *duplicateStateSurvivalTime* to configure survival time for DRB if Option 2 is agreed. |
| Huawei, HiSilicon | No | Agree with the rapporteur’s comment that such a field cannot cover the case where a DRB with Survival Time support is configured with only two legs, then moreThanTwoRLC-DRB will not be configured for the DRB. Some extra conditional operation would be needed. Can adopt Option 1 in Q4 to avoid such complexity.  |
| Samsung | No | Please see our answer to previous question. |
| OPPO | No | It can not cover the 2-leg duplication configuration case. |
| InterDigital | Yes |  |
| Futurewei | No | Disagree with option 2 in Q4. |
| vivo | No | Disagree with option 2 in Q4 |
| ZTE | Yes | We are fine with a separate field (such as “*duplicationStateSurvTime*”) to be configured for the set of active RLC entities used in Survival Time state.We assume such parameter is also configured in PDCD-config and therefore it can be used to (implicitly) indicate whether the related DRB has a Survival Time requirement. So we agree with LGE that with this parameter, additional parameter of *survivalTimeSupport* may not be needed.We assume one such parameter can be applied to both *moreThanOneRLC* and *moreThanTwoRLC-DRB* scenarios. But anyway this can be later discussed in stage-3. |
| MediaTek | No | Disagree with option2 in Q4 |
|  |  |  |

***Summary of Question 5:***

*16 companies provided views to Q5. Company counts in brackets () include views that apply under certain conditions or circumstances indicated in the comments above.*

* *6 (7) companies agree to use a parameter similar to duplicationStateSurvTime.*
* *9 companies do not think this is necessary mainly because they do not support option 2.*
* *2 companies think that non-presence of duplicationStateSurvTime can be used as a fallback to option 1.*

*This question is connected with the earlier question 4. Therefore, following the proposal in Q4 and considering that option 2 may be optionally enabled, the following proposal seems possible. The proposal implies that potentially two parameters may be needed, one for option 2 and one for option 1 (which then may serve as an explicit indicaton that the DRB is configured with Survival Time). Details can be sorted in stage-3.*

**Proposal 5: A new field (such as “duplicationStateSurvTime”, name FFS) is optionally configured to indicate a dedicated set of associated RLC entities configured for activation of PDCP duplication upon entry to Survival Time. The field enables Option 2 (in Q4). If the field is not present then Option 1 (in Q4) is used. Details can be sorted out in stage-3.**

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).**

|  |  |  |
| --- | --- | --- |
| **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. |
| Fujitsu | Option 1 | The level of RadioBearerConfig seems to be a bit high. The impact of ST is on PDCP layer, so that PDCP duplication configuration seems to be proper. |
| Lenovo, Motorola Mobilty | Option 1 |  |
| Qualcomm  | Option 1 | Option 1 seems like the natural option, option 2 is unclear to us. |
| Intel | Option 1 |  |
| Huawei, HiSilicon | Option 1 | Option 1 is more straightforward. |
| Samsung | Option 1 |  |
| OPPO | Option 1 |  |
| InterDigital | Option 1 |  |
| III | Option 1 |  |
| Futurewei | Option 1 |  |
| vivo | Option 1 |  |
| ZTE | Option 1 | Same view as LGE. |
| MediaTek | Option 1 |  |
|  |  |  |

***Summary of Question 6:***

*18 companies provided views to Q6. All companies prefer option 1.*

**Proposal 6 (18/18): Survival Time support is configured at DRB level and a new RRC parameter is added in PDCP-Config.**

## 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).**

|  |  |  |
| --- | --- | --- |
| **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? |
| Fujitsu | Option 3 > Option 1 | Whether or not the UE will enther ST mode is better to be fast as much as possible. Among all options, Option 3 seems to be fastest since the UE can recoginized to transfter to ST mode immediately after decoding the DCI. Option 1 is also considered to be a basic solution. |
| Lenovo, Motorola Mobility  | Option 1 | We think that Option 1 is the most accurate solution.  |
| Qualcomm | Option 1 | The survival time state is LCH specific so that should be how the spec is presented, i.e, activating the state once the LCH faces a loss. The internal mapping of how the MAC should identify this LCG be it via HARQ PID or CG index (assuming proper restrictions of LCH mapping) is left for UE implementation. |
| Intel | Option 1 | Option 1 is straightforward.  |
| Huawei, HiSilicon | Option 1 or 2 | In the last meeting, RAN2 has agreed that CG retransmission grant can be used for Survival Time state triggering. When a CG is associated to a DRB with Survival Time support and used for data transmission from this DRB, the UE can easily determine that the Survival Time state is triggered for the corresponding DRB when receiving a retransmission grant for a CG. Thus Option 2 is preferred. Option 1 is also workable. If a MAC PDU contains data from a DRB with Survival Time support, i.e. according to the LCHs of data in the MAC PDU, and when a retransmission grant is scheduled for the MAC PDU, the UE is aware that the DRB shall trigger Survival Time state. For Option 3, it is a bit unclear how much effort/complexity for the UE that it needs to identify that a retransmission grant shall trigger Survival Time state according to the HPID indicated in the retransmission grant. |
| Samsung | Option 2, then Option 1 |  |
| OPPO  | Option 1 | Option 1 directly targets what we want.  |
| InterDigital | Options 1 and 3 | The UE knows the DRBs multiplexed in the TB/HARQ Process and can determine whether to trigger ST upon reception of a HARQ-NACK. ST should be maintained per TB; since NACK is the trigger, UE determines whether to trigger ST state based on the HARQ process for which NACK is received and whether it carries any data from DRBs configured with ST.There should not be any spec additions for this, as the UE can determine if the TB involves a DRB configured with survival time. |
| Futurewei | Option 2, then Option 1 | Agree with Huawei. |
| vivo | Option 1 | Option 1 is the most straightforward way. |
| ZTE | Option 1 | Agree with Ericsson and some other companies that Option 1 is straightforward. |
| MediaTek | Option 1 | This option targets exactly what is intended. |
|  |  |  |

***Summary of Question 7:***

*17 companies provided views to Q7. Company counts in brackets include views that apply to the respective option under certain conditions or circumstances indicated in the comments above.*

* *12 (15) companies prefer or can accept Option 1 which uses the LCID in the MAC PDU.*
* *4 companies prefer option 2 which uses the index of the CG.*
* *3 (4) companies prefer or can accept option 3 which uses the HARQ PID.*
* *1 (2) companies think the determination can be left to UE implementation.*
* *No other options are suggested.*

***It seems there is a majority for option 1 that in the best case is preferred by up to 15 companies.***

*A number of companies indicated that Option 1 is the most accurate and straightforward solution. The MAC layer can receive information from upper layers as to which LCIDs are associated with survival time and what is the value of N for the HARQ-NACK counting.*

**Proposal 7 (15/17): The index of LCHs in the MAC PDU that a retransmission grant relates to is used to identify triggering of Survival Time state of a DRB. The MAC layer can receive information from upper layers as to which LCIDs are associated with Survival Time and what is the value of N for the HARQ-NACK counting in case N>1 is required.**

## 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?**

|  |  |  |
| --- | --- | --- |
| **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, 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. |
| Fujitsu | Abstain | We are not sure if the inteition of this quesiont is to specify new specification e.g. reserce LCID spaces for DRBs with ST requirement. It is sufficient to resue the existing *allowedCG-List*. |
| Lenovo, Motorola Mobility | No | Existing LCP restriction are sufficient to configure a mapping between DRBs with ST requirements and CG(s) |
| Qualcomm | No (Existing config options work) | We think one or more CGs should be designated to carry one or more survival time flows as good practice/configuration. From a spec point of view, as other companies have mentioned existing LCP restrictions are sufficient, no need to identify new mappings/restrictions. |
| Intel | No | Given that LCH to CG mapping is already supported in Rel-16 via *allowedCG-List*, we are not sure whether additional specification impact is needed.  |
| Huawei, HiSilicon | No extra enhancements needed | In Rel-16, the mapping relationship between CG configurations and DRBs can be one-to-one, many-to-one, and one-to-many. The network is able to configure one or multiple CG configurations to a DRB with Survival Time support. And we don't think any enhancements for relations between DRBs and CGs are needed.(we notice that companies may have different understanding of “specific mapping”: for us no extra enhancements are needed however there shall still be a “specific mapping” between CG config and DRB needing ST support, based on existing *allowedCG-List*) |
| Samsung | Yes | Same view as LG. This does not appear to be an optimization or a simple “enhancement” in our view. |
| OPPO | No | We understand current LCP restrictions can work well and no extra LCP restriction is needed.  |
| InterDigital | No | We are unclear of the purpose of this. Is it to ensure that when a UE receives a HARQ-NACK for a TB that includes at least one ST-supporting DRB that it would not unnecessarily use PDCP duplication for the other (non-ST supporting) DRBs transmitted in the same TB? This seems like an unnecessary optimization. The purpose of ST state is to ensure that the ST-supporting DRB achieves the required performance. Whether ST state also inadvertently improves the performance of non-ST supporting DRBs (for a limited time) is not a big problem. And if it is deemed a problem, this can be handled by existing LCH to CG mapping (*allowedCG-List*), as pointed out by Ericsson. |
| Futurewei | No  | Same view as Ericsson. |
| vivo | No | The existing LCP restriction (i.e., *allowedCG-List*) is enough. |
| ZTE | Yes | As answered in Q1, the following ways can be used for this purpose:* Without LCP restriction configuration/support, CG resource(s) can be configured with a (new) Survival Time attribute for identifying this CG can be used in Survival Time only.
* Making use of LCP restriction.
 |
| MediaTek | No | Same view as Ericsson, i.e. this can already be done using existing LCH restrictions and no further enhancements are needed. |
|  |  |  |

***Summary of Question 8:***

*17 companies provided views to Q8. Company counts in brackets include views that apply to the respective option under certain conditions or circumstances indicated in the comments above.*

* *5 (7) companies think that some mapping restrictions will be needed.*
* *10 companies think there should not be a specific mapping between DRBs and CGs.*
* *14 companies think that there is no need for an enhancement to enforce a specific mapping between a DRB and a CG, and that existing mapping restrictions are sufficient.*

*Question 8 intends to identify whether any additional configuration restrictions or requirements on specification are needed in order to ensure a smooth identification of DRBs in the TB. No specific restrictions have been identified, however, almost all companies indicate that LCH restrictions can be used.*

**Proposal 8: Existing LCH to CG mapping restrictions are used to ensure DRBs in support of Survival Time are mapped to one or multiple CGs. No specification change is foreseen.**

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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Fujitsu | No | This seems to be gNB configuration issue. Basic configuration in Rel-17 would be that a CG would be dedicated to a DRB with ST requirement. Other configuration can be allowed depending on gNB configuration. |
| Lenovo, Motorola Mobility  | No | Don’t see any issue here |
| Qualcomm | No | Not a good implementation but if it happens, no spec issue or solution needed. |
| Intel | No | Our understanding is that the mapping restriction configuration is up to gNB implementation. |
| Huawei, HiSilicon | No | We have the same view as Nokia. |
| Samsung | No | Even if this happens (e.g. bad implementation), the ST support is per DRB as agreed in the previous meeting. Please also see our response to Q8. |
| OPPO | No | A proper gNB configuration should avoid such configuration. |
| InterDigital | No | Same answer as in Q8. |
| III | No |  |
| Futurewei | No |  |
| vivo | No | Agree with QC, there is no additional spec impact even though this use case happens. |
| ZTE | No | Same view as Nokia. |
| MediaTek | No | This should be handled by gNB implementation |
|  |  |  |

***Summary of Question 9:***

*17 companies provided views to Q9.*

* *17 companies think there is no need to address this case.*
* *1 company thinks that the specification should contain rules about which mapping restrictions can be expected.*
* *5 companies think such a mapping where DRBs with and without Survival Time requirement are mapped to the same CG is not a good implementation.*
* *10 companies indicate the configuration of suitable mapping restriction should be left to gNB implementation.*

*The general general understanding is that multiple DRBs with and without a Survival Time requirement are not expected to be mapped to the same CG. An assumption is that one CG should be dedicated to one DRB. However, the actual mapping is up to gNB implementation.*

**Proposal 9 (17/18): RAN2 assumes that Rel-16 LCH to CG mapping restrictions can be used to prevent a case where DRBs with and without a Survival Time requirement are mapped to the same CG. The setup of mapping restrictions is up to gNB implementation. No specification change is foreseen.**

**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).**

|  |  |  |
| --- | --- | --- |
| **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 PDUIn 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. |
| Fujitsu | None > Option 2 | Basic configuration in Rel-17 would be that a CG would be dedicated to a DRB with ST requirement. However, if this case is deploye, Option 2 is the only consequence. |
| Lenovo, Motorola Mobility | Option 2 (if needed) | Not sure that there is really an issue here. This should be avoided by gNB implementation. But it’s clear anyway that only DRBs configured with STsupport should enter ST. |
| Qualcomm | Option 2 | According to our input in Q7, MAC identifies the need for survival time by mapping the HARQ-NACK to the proper LCH. Thus the MAC knows which DRBs exactly are affected by the NACK and should only target these for survival time activation, otherwise, if this case happens, the UE needs to many resources to carry duplicated traffic of all ST flows so that option should be avoided. |
| Intel | Option 2 |  |
| Huawei, HiSilicon | None, (Option 2 if needed) | Agree with Nokia. If the question is further clarified such that a solution is indeed needed, we agree with Fujitsu and we are open for Option 2. |
| Samsung | Unclear | Not sure what the question is asking (similar to LG’s understanding). |
| OPPO | Other | Not sure we have clearly understood the question. Is it for the case that LCHs with and without ST requirements are multiplexed in one CG? Logically, we think it should be avoided by gNB implementation. But if this case exists, we think Option 2 is a proper way. |
| InterDigital | Option 2 | Unsure what “Survival State time is triggered for all DRBs” means in a DRB is not configured with survival time. That being said, as discussed in Q8, a non-ST supporting DRB may be retransmitted along with an ST-supporting DRB. But it need not be considered to be in ST state. |
| Futurewei | None | Agree with Nokia. |
| vivo | Option 2 | As mentioned in Q7, we think MAC entity can identify triggering of Survival Time state via the index of LCHs in the MAC PDU that this retransmission grant is related to, which is aligned with option 2. |
| ZTE | Option 2 | Agree with Apple. |
| MediaTek | Option 2? | Option 2 seems reasonable, but unclear what exactly is the expected behaviour with Option 1. |
|  |  |  |

***Summary of Question 10:***

*17 companies provided views to Q10. Company counts in brackets include views that apply to the respective option under certain conditions or circumstances indicated in the comments above.*

* *9 (14) companies indicated support for option 2.*
* *No company supports option 1.*

***It seems there is a majority for option 1 that in the best case 14 companies can agree to.***

*Question 10 tries to address the question which DRBs should enter Survival Time state when the UE receives a retransmission grant for a CG from a different angle. It is an add-on to question 7 as well as other questions above. Both Option 2 and especially Option 1 were brought up in [19] and [28] and the question was also touched upon during the phase 2 discussion of the RAN2#116 draft TP [3] for the MAC spec. However, as no conclusion had been made, these two options were added here again.*

*From the responses and also considering the earlier question 7, option 2 seems most straightforward. If proposal 7 is agreed then the behavior follows logically, otherwise, it may be good to clarify what is the intended operation. Therefore, following proposal is given.*

**Proposal 10 (14/17): Following a HARQ-NACK, entry to Survival Time state is triggered only for the DRBs (with a requirement for Survival Time) which are included in the MAC PDU associated with the grant used for transmission of the TB.**

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?**

|  |  |  |
| --- | --- | --- |
| **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.  |
| Fujitsu | No | Basic configuration in Rel-17 would be that a CG would be dedicated to a DRB with ST requirement. |
| Lenovo, Motorola Mobility | No | Agree with others |
| Qualcomm | No | No clean solutions if that happens. MAC is not aware of those ST requirements so can’t really selectively activate duplication for “failed” DRBs. |
| Intel | No additional standardization wok | Our understanding is that configuration is up to gNB implementation and there is no additional standardization work for the case. |
| Huawei, HiSilicon | No |  |
| Samsung | No |  |
| OPPO | No | Such DRBs should allocate or link with different CGs, which can rely on gNB implementation. |
| InterDigital | No | Similar to our answer in Q8, the worst thing that can happen here is that all DRBs enter ST, meaning some DRBs enter ST state early. In which case they would benefit form unnecessary added reliability for a limited time. This may not be a big problem. Otherwise it can be avoided using existing procedures.  |
| Futurewei | No |  |
| vivo | No | We do not think this is good implementation. |
| ZTE | No | Agree with others. |
| MediaTek | No |  |
|  |  |  |

***Summary of Question 11:***

*17 companies provided views to Q11.*

* *15 companies think that a case where SDUs from multiple DRBs with a different Survival Time requirement are contained in the same CG does not need to be considered for RAN2 work, and 2 additional companies think that there is also no specification impact.*
* *1 company would like to define the anticipated use cases more clearly.*
* *2 companies thinks such a mapping is not a good/clean implementation.*
* *Multiple companies think that we can rely on gNB implementation, similar to other questions above.*

*Question 10 tries to clarify whether anything extra is required for the mapping, especially as there are many possible cases, so there is a potential for a slightly higher effort to validate a given configuration and its associated DRBs. If Proposal 7 is agreed then there should be no problem anyway.*

**Proposal 11 (17/18): RAN2 assumes that SDUs from multiple DRBs with a Survival Time requirement (potentially with a different transfer interval and/or lead time for Survival Time entry) are not intended to be mapped to the same CG. Setup of appropriate mapping restrictions is up to gNB implementation. No specification change is foreseen.**

## 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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Fujitsu | Agree | The couting of N would be separately handled per MAC. Then nothing special seems to be needed to the entering ST mode for the DRB.. |
| Lenovo, Motorola Mobility | Agree | This case of DC duplication should not be optimized, as we also wonder whether DC would be a common deployment for IIoT considering all the implications coming from the DC operation. |
| Qualcomm | Agree | Evn though activating duplication with DC already running may be an overkill from reliability point of view, we don’t think duplication activation which comes from the MAC should be DC dependent. We prefer the simplicity of activating duplication upon receiving HARQ-NACK then tracking a state across different MAC entities. |
| Intel | Agree | One note is that the question assumes N HARQ NACK solution for survival state trigger, while we propose combined HARQ NACK and Tx-side timer solution, as in Q16. |
| Huawei, HiSilicon | Agree | From our perspective, we don’t prefer to specify detailed and complicated UE/gNB behaviours for N>1. For the scenario N>1 would be needed, we believe the network has enough flexibility and capability to satisfy Survival Time support, even without HARQ-NACK based ST solution. We think, for the most stringent use case where network implementation only solution is not sufficient, N=1 shall be adopted.To this question, we prefer to minimize dependencies between MAC entities. |
| Samsung | Agree | We are supportive of N>1 but do not think DC deployments are likely in this scenario. |
| OPPO | Agree, but | It depends on whether N can be larger than 1. If it is agreed that N >1 and duplication is already activated, we think that either MAC entity needs to evaluate the ST entering based on the HARQ-NACK feedback from its own side. The interaction between MAC entities should be avoided.  |
| InterDigital | Comments | Agree with LG and CATT. No agreement about support of N>1 anyway. No need to optimize for DC. |
| Futurewei | Agree |  |
| vivo | Disagree | DRB configured with DC duplication will enter ST state twice as frequently as UE configured with single leg, if we agree the UE enters Survival Time when at least one MAC entity reaches the Survival Time count N, It is illogical. In our understanding, DRB configured with DC duplication should enter ST state less than UE configured with single leg.Hence, we propose following:When DC duplication is already activated before entering ST state, one MAC only determines whether the triggering condition of survival state for its cell group is fulfilled based on receiving N HARQ-NACKs. Then the PDCP entity decides finally whether to trigger survival state of the corresponding DRB based on the fulfillments of two MAC entities. |
| ZTE | Disagree | According to the previous discusseion, we understand more companies can agree that in the simplest case, MAC entity needs to send an indication to PDCP when it determines to trigger survival state based on HARQ-NACK as PDCP duplicapition should finally be activated in PDCP layer.For the Question12, Question12A and Question13, we understand the main discussion point is that in different scenarios with multiple activated RLCs/LCHs, how the MAC layer send such indication to PDCP and how the PDCP determine to activate the PDCP duplication based on the received indication (s). This question is different from or irrelevant to the question about how to counting N.We prefer a consistent process for all these scenarios. We suggest the following general steps that is very similar as the scheme mentioned by Nokia in Question 12A (it can also be seen as a “AND process” in PDCP entity as mentioned by some company), e.g., * MAC can send an indication to PDCP (or raise a flag as mentioned by Nokia) of survival time state triggering once N is reached for one of the already-activated RLC/LCH (no matter N is equal to 1 or larger than 1, it’s same).
* PDCP should wait until all already-activated RLCs/LCHs send such indications (or raise such flag) in MAC, before entering survival time state for this DRB. If any already-activated RLC/LCH has transmitted successfully, we assume PDCP duplication would not be activated as PDCP entity would not collecte all the indications/flags (PDCP eneity can know how many indications/flags it needs)

Back to the DC duplication scenario in this Question 12, we assume PDCP entity would receive indication(s)/flag(s) from different MAC entities as activated RLCs/LCHs are associated with different MAC entities. |
| MediaTek | Comments | Agree with LGE that we haven’t agreed to support the case of N>1. For the case where N=1, there is no issue. |
|  |  |  |

***Summary of Question 12:***

*17 companies provided views to Q12. Company counts in brackets include views that apply to the respective option under certain conditions or circumstances indicated in the comments above.*

* *15 companies agree that the UE enters Survival Time when at least one MAC entity reaches the Survival Time count with N=1.*
* *9 to (11) companies agree that the UE enters Survival Time when at least one MAC entity reaches the Survival Time count N , that is, regardless of N=1 or N>1.*
* *5 companies indicate that they either do not support N>1 or don’t prefer to specify this case for N>1. A further comment is that we have not agreed on N>1.*
* *2 companies disagree with Q12 and propose that the PDCP entity consolidates the counting of N.*

***It seems there is a majority for no interaction between MAC entities, only two companies disagreed with that view.***

*Question 12 aims to see whether there is a common ground to achieve a solution that can be generic enough to cover cases of both N=1 and N>1, potentially in some form of a forward compatible manner. From a number of comments companies either do not anticipate a common design for N>=1 or would like to limit complexity.*

*Moreover, the case is valid for N=1 as well. A majority of companies prefer to minimize dependcies between MAC entities, thus it seems sufficient to do the counting in the MAC entity at least when N is equal to 1. Therefore the following proposal is given.*

**Proposal 12 (15/17): When PDCP duplication is already activated in dual connectivity, in order to minimize dependencies between MAC entities in a configuration with N=1 the UE enters Survival Time when at least one MAC entity reaches the Survival Time count N.**

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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Fujitsu | Agree | The couting of N would be separately handled per CC. Then nothing special seems to be needed to the entering ST mode for the DRB.. |
| Nokia | See comments | We think the MAC can raise a flag of survival time state triggering once N is reached for one of the already-activated RLC/LCH.However, the PDCP should wait until all already-activated RLCs/LCHs raised such flag in MAC, before entering survival time state for this DRB.On the other hand, we think N=1 is sufficient, because the gNB may only send a retransmission grant when it is needed. This up to gNB implementation to decide whether it should issue the retransmission grant. |
| Lenovo, Motorola Mobility | No | Agree with CATT |
| Qualcomm | Yes | Same view as last question. We prefer N=1 and prefer to keep things simple at the MAC/PDCP, which would not be achieved by having cross-RLC dependency. We also don’t prefer the feature be dependent on CA/DC configuration. The MAC have no notion of which RLC carry the same traffic and we don’t prefer the PDCP apply some AND condition between activation signal. This will also some issues/ambiguity: did those HARQ-NACKs come for the same PDU, should the condition be “if the NACKs arrive withing a certain time bound” which would also be hard to synchronize with gNB knowledge of the state. |
| Intel | Agree | Same note as Q12 rearding combined HARQ NACK and Tx-side timer solution. |
| Huawei, HiSilicon | Agree | Again, we don’t prefer to specify detailed and complicated UE/gNB behaviours for N>1. For the scenario N>1 would be needed, we believe the network has enough flexibility and capability to satisfy Survival Time support, even without HARQ-NACK based ST solution. We think, for the most stringent use case where network implementation only solution is not sufficient, N=1 shall be adopted.For this question per se, we don't prefer to incur interactions between different CC.  |
| Samsung | Agree | Same view as Apple. |
| OPPO | Agree, but | It depends on whether N can be larger than 1. If it is agreed that N >1 and CA duplication is already activated, we think it is a simple way since MAC entity can not distinguish whether the received HARQ-NACKs from different CCs are for the same PDCP PDU or not. |
| InterDigital | Comments | Agree with LG and CATT. No agreement about support of N>1 anyway. No need to optimize for this. |
| Futurewei | Agree |  |
| vivo  | See comment | For this use case, UE enters the ST state when all the CC reaches the survival time counting N, in order to avoid entering the ST state too early. |
| ZTE | Disagree | Same scheme as mentioned in Question 12.For the CA duplication scenario in this Question 12A, we assume PDCP entity would receive indication(s)/flag(s) from one MAC entity. But several indication(s)/flag(s) are still possible and each indication/flag is triggered by counting N on each CC.For such process, the issue that the MAC entity is not aware that two RLC PDUs are actually from the same PDCP for duplication mentioned by Ericsson would no exist. |
| MediaTek | Comments | Agree with LGE that we haven’t agreed to support the case of N>1. For the case where N=1, there is no issue. |
|  |  |  |

***Summary of Question 12A:***

*17 companies provided views to Q12A. Company counts in brackets include views that apply under certain conditions or circumstances indicated in the comments above.*

* *8 to (12) companies agree that the UE enters Survival Time when at least one CC reaches the Survival Time count N.*
* *3 to (5) companies disagree. Except for 1 or (2) companies, most companies in this group prefer that Survival Time is triggered if a HARQ-NACK is received for each of the activated legs while the HARQ-NACK counting and consolidation still happens in the MAC entity.*
* *4 companies mention that for a more accuate solution the counting would need to be done in PDCP, which in turn would require a slightly more complex design.*

***It seems there is a slight majority for no interaction between CCs, as most companies agreed to the question.***

*Even though Question 12A does not say anything about N>1 and applies to N=1 as well, ideally the solution should be scalable in the sense that it can apply to different cases in the future. For now it seems the only conclusion / agreement can be on N=1 (which is in line with the agreements so far). Therefore the following is proposed.*

**Proposal 12A (12/17): 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 with N=1, the UE enters Survival Time when at least one CC reaches the Survival Time count N.**

**Proposal 12A-1: RAN2 may discuss whether Proposal 12A can be extended to N>1 after reaching a conclusion on the support of N>1.**

## 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).



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).**

|  |  |  |
| --- | --- | --- |
| **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. |
| Fujitsu | Option 1 + Oprion 2 | Same view with the above i.e. Option 1 in case of one MAC and Option 2 in case of two MACs. It is ok with the consequence that PDCP has the responsibility of counting of N. |
| Lenovo, Motorola Mobility  | Option 1 | We don’t think specs should be optimized for this case.  |
| Qualcomm | Option 1 | Same view as Q12. This is also bearer specific behavior so that optimization across MCG/SCG is not needed. |
| Intel | Option 1 | Same note as Q12 rearding combined HARQ NACK and Tx-side timer solution. |
| Huawei, HiSilicon | Option 1 | Again, we don’t prefer to specify detailed and complicated UE/gNB behaviours for N>1. For the scenario N>1 would be needed, we believe the network has enough flexibility and capability to satisfy Survival Time support, even without HARQ-NACK based ST solution. We think, for the most stringent use case where network implementation only solution is not sufficient, N=1 shall be adopted.To this question, even if we agree that N can be larger than 1, we prefer to minimize dependencies and interactions between MAC entities.Further, we support Ericsson’s proposal to down prioritize this case.  |
| Samsung | Deprioritize this case |  |
| OPPO | Option 1, but | It depends on whether N can be larger than 1. If it is agreed that N >1, we think Option 1 is simple to avoid the interaction between MCG and SCG.  |
| InterDigital | Comments | Agree with LG and CATT. No agreement about support of N>1 anyway. No need to optimize for this. |
| Futurewei | Option 1 |  |
| vivo | Option 1 | Option1 is ok since one PDCP SDU is transmitted via only one MAC in split bearer case. |
| ZTE | Option 1 | Similar scheme as mentioned in Question 12.For the DC split-bearer scenario in this Question 13, one different is, it’s possible different traffic are on different bearers. For this case, PDCP entity don’t need “AND process” for different bearers. It can activate PDCP duplication upon receive indication from one bearer. But if same traffic are on different bearers, we assume same scheme as mentioned in Question 12 would be applied. We agree with Option 1 that N counting should be in MCG only or on SCG only, not on both MCG and SCG. |
| MediaTek | Comments | Agree with LGE that we haven’t agreed to support the case of N>1. For the case where N=1, there is no issue. |
|  |  |  |

***Summary of Question 13:***

*17 companies provided views to Q13. Company counts in brackets include views that apply under certain conditions or circumstances indicated in the comments above.*

* *7 (9) companies agree to option 1.*
* *No company agrees to option 2.*
* *3 companies think that options 1+2 are both needed, or a combination thereof. Two companies also mention that the PDCP entity (may) need to be involved.*
* *Views are split on other aspects, including N>1.*

***There is no clear majority here, it seems suitable to continue the discussions online.***

*As opposed to Q12 and Q12A, Question 13 deals with a case where PDCP duplication is not already activated. This scenario has no problem if the Survival Time count is N=1. If N is meant to be configurable such that N>1 will be required in the future, then this case needs to be addressed. From the comments received it looks like we cannot agree anything other than N=1. Therefore the following proposal is given.*

**Proposal 13 (9/17): For a DC split-bearer in a configuration with N=1 when PDCP duplication is not yet activated, the UE enters Survival Time state upon reception of one HARQ NACK at either MCG or SCG.**

**Proposal 13-1: RAN2 may further discuss the counting of N in a split-bearer scenario with N>1 after reaching a conclusion on the support of N>1.**

## 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. |
| Fujitsu | Yes | In general, it should be ok to inform RAN3 of RAN2 agreements which have RAN3 impact. |
| Lenovo, Motorola Mobility | No strong opinion |  |
| Qualcomm | No | Agree with Ericsson |
| Intel | No | Our understanding is that if RAN3 identifies any impact, they can work on their own without RAN2 LS. |
| Huawei, HiSilicon | Neutral | We could send RAN2 agreements to RAN3 if they are critical for RAN3 study. |
| Samsung | FFS | At this stage impact on RAN3 is unclear. We could of course send a very simple LS listing only the agreements made, as a compromise. |
| OPPO | No strong view |  |
| III | No |  |
| Futurewei | Neutral |  |
| vivo | Yes | We see there is a need to send LS to RAN3 at least for the following two issues:Issue 1: the pre-allocated CG for duplication legs may not be guaranteed.There is a use case that the RLC entities for DRB in ST state belong to different NW nodes(i.e. MN and SN). When the ST state triggered, both NW nodes need to guarantee that the pre-allocated CG is not allocated to other UE. However, the current agreement is that MAC entity determine the triggering of ST state, Thus, node1 has no way to know whether the ST state is triggering by node2. Then, the pre-allocated CG from node1 may still be allocated by node1 to other UE even UE is entering ST state according to N HARQ NACK from node2. Transmission collision may occur.Issue 2: NW may deactivated duplication legs by mistake.Currently, MN and SN transmit the MAC CE for duplicaion activation and deactivation without coordination. It may happen that MN deactivated duplication legs by mistake as PDCP duplication is activated by transmission in SN(i.e. UE enters ST state according the transmission with SN). Hence, we should tell RAN3 the status information of Survival Time support and the potential risk mentioned above. It can be left to RAN3 to decide whether to handle the issues. |
| ZTE | Neutral | Agree with Huawei. |
| MediaTek | No | Agree with Ericsson |
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***Summary of Question 14:***

*17 companies provided views to Q14. Company counts in brackets include views that apply under certain conditions or circumstances indicated in the comments above.*

* *4 (7) companies agree to send an LS to RAN3.*
* *6 companies do not think an LS is needed at this time.*
* *7 companies are neutral or suggest it FFS. Among these companies, 3 companies would be also open to consider a simple LS with merely agreements only.*

***There is no clear majority here, it seems suitable to continue the discussion online or postpone.***

**Proposal 14: RAN2 to monitor the situation and decide (potentially at a later time) whether a LS to RAN3 is needed.**

## 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 |  |
| Fujitsu | Agree |  |
| Lenovo, Motorola Mobility | Agree |  |
| Qualcomm | Agree |  |
| Intel | Agree |  |
| Huawei, HiSilicon | Agree |  |
| Samsung | Agree |  |
| OPPO | Agree |  |
| InterDigital | Agree |  |
| III | Agree |  |
| Futurewei | Agree |  |
| vivo | Agree |  |
| ZTE | Agree |  |
| MediaTek | Agree |  |
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***Summary of Question 15:***

*18 companies provided views to Q15. All companies agree that a new UE capability is needed.*

**Proposal 15 (18/18): RAN2 to introduce a new UE capability for support of Survival Time.**

## 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. |
| Intel | Missing HARQ NACK | In email discussion “[Post115-e][513][IIoT] QoS survival time”, several companies (vivo, ZTE, Intel, InterDigital, OPPO, TCL, Apple) agree that there is missing HARQ NACK issue, and propose combined solution of HARQ NACK and Tx-side timer for survival time state trigger. We proposed to discuss this issue. |
| InterDigital | Missing HARQ NACK and unnecessary reTx grants | As Intel mentions, there is an issue with missing HARQ-NACK. A Tx-side timer can safeguard against missing HARQ-NACKs and ensure ST expiration is avoided.Furthermore, a Tx-side timer can address CATT’s issue with ST-state triggering reTx grants unnecessarily scheduling a possibly useless retransmission. The NW can decide whether to transmit a reTx grant (if a reTx is desired) or to simply let the Tx-side timer elapse (thus triggering ST-state) if it does not desire a retransmission. |
| ZTE | Missing HARQ NACK | Same view as Intel. |
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***Summary of Question 16:***

*6 companies provided views to Q16.*

* *1 company raises the issue of ‘interpretation of the retransmission grant’, 2 companies indicate alternative solutions*
* *3 companies indicate that the issue of ‘missing HARQ NACK’ needs to be discussed, potentially along with a Tx-side timer for Survival Time state trigger*

*Given that the timeframe for phase 2 is very short the rapporteur thinks it may not be reasonable to start a fresh discussion on the items in this list. These issues do not appear as a blocking point to making progress on a first TP. We can tag these topics for the online discussion if time permits.*

**Proposal 16: RAN2 to discuss whether any additional topics can be addressed.**

# Discussion – phase 2

## Easy agreements

This section lists the proposals that are potentially easy to agree on. Please refer to the respective section in the phase 1 discussion for a summary on each of the questions and proposals. Companies can indicate in the table if any adjustments are needed/preferred to the proposals, or indicate additional comments.

**Proposal 3 (14/17): For the issue that a CG resource may be insufficient for the UE to include the whole application layer message in one configured grant if a MAC CE is to be transmitted in the same CG, it is up to gNB implementation to ensure CG resources are appropriately configured.**

**Proposal 6 (18/18): Survival Time support is configured at DRB level and a new RRC parameter is added in PDCP-Config.**

**Proposal 8: Existing LCH to CG mapping restrictions are used to ensure DRBs in support of Survival Time are mapped to one or multiple CGs. No specification change is foreseen.**

**Proposal 9 (17/18): RAN2 assumes that Rel-16 LCH to CG mapping restrictions can be used to prevent a case where DRBs with and without a Survival Time requirement are mapped to the same CG. The setup of mapping restrictions is up to gNB implementation. No specification change is foreseen.**

**Proposal 11 (17/18): RAN2 assumes that SDUs from multiple DRBs with a Survival Time requirement (potentially with a different transfer interval and/or lead time for Survival Time entry) are not intended to be mapped to the same CG. Setup of appropriate mapping restrictions is up to gNB implementation. No specification change is foreseen.**

**Proposal 15 (18/18): RAN2 to introduce a new UE capability for support of Survival Time.**

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| --- | --- | --- |
| **Company** | **Proposal** | **Comments** |
| Futurewei | P11 | On “are not intended to be mapped to”, do we need such subtle difference of “intended to” here, comparing to “are (not) mapped to” in P9? What makes them different? If we really think such softening of words is needed in P11, suggest that we at least replaces the word “intended” with “expected” so that the sentence is described from a UE’s perspective (the UE performs the CG-to-LCH-to-DRB mapping based on the expectation that the gNB will comply with such). |
| CATT | P11 | As correctly mentioned by Rapporteur in his summary, “*If Proposal 7 is agreed then there should be no problem anyway*” so maybe we could postpose P11 after P7 rather than bringing NW restrictions that would be useless. |
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**Summary:** TBD.

**Proposals: TBD.**

## Review of proposals requiring more discussion

This section lists the proposals that require more discussion (we can do this online). Please refer to the respective section in the phase 1 discussion for a summary on each of the questions and proposals. Companies can indicate in the table if any adjustments are needed/preferred to the proposals, or indicate additional comments.

**Proposal 1 (14/18): Dedicated CG resources can be configured for the duplication paths and their activation is conditional on entering Survival Time state at least for CG type-1.**

**Proposal 1-1 (10/18): To provide radio resources on the legs used for PDCP duplication and to guarantee CG resources are not used outside of Survival Time, RAN2 to discuss whether a CG can be considered deactivated outside of Survival Time and activated in Survival Time only. Other similar variants are not precluded (for example, where a CG associated with one LCH is activated/deactivated when the associated RLC entity is activated/deactivated).**

**Proposal 1C (11/18): CG type-2 and DG based solutions can be used as a supplement to provide radio resources on the legs used for PDCP duplication in Survival Time.**

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| --- | --- | --- |
| **Company** | **Proposal** | **Comments** |
| LGE | 1, 1-1 | Amongst 18 companies who provided answers to Q1, we see at least 8 companies (Ericsson, LGE, Huawei, Samsung, Oppo, Vivo, MediaTek) see no need of coupling CG activation with entering or exiting ST state. The rapporteur mentioned that 1E is not relevant to this question but it is certainly related since Q1 is asking whether any kind of implicit CG activation or deactivation is necessary linked to ST state and 1E is saying nothing is needed and the NW can do it.So, we have concern on the current P1 and P1-1, and suggest to change as follows:Proposal 1: Dedicated CG resources can be configured for the duplication paths.Proposal 2: RAN2 to discuss whether a CG can be considered activated/deactivated depending on Survival Time.  |
| LGE | 1C | Amongst 18 companies who provided answers to Q1C, 8 companies indicated that no option needs to be selected. Additionally, the company who answered 'All' actually intends that no solution is to be specified. We fail to understand the point of making or agreeing on possible NW implementation solutions here. So we suggest not to make any proposal regarding Q1C, i.e., to remove proposal 1C. |
| CATT | 1C | We agree with LG. Network is always free to implement the solutions discussed in this option. But the point is we cannot rely on these options only. We understand it is the intention of “as a supplement” but then we are not sure if the proposal is really useful once we have P1. |
| Qualcomm | 1, 1C | We are fine with exploring the idea of conditional CG activation more as a means to quickly allocate resources to carry the duplicated traffic. However, we think it’s too early to restrict this for CG type 1 (which has no notion of being “activated” to begin with), so we are not supportive of P1 in it’s current form of specifying this mechanism to CG type 1. We think P1-1 which is perceived to be more general should be the baseline for now, and if agreed, we can move on into discussing whether this is something that works with CG type 1 and/or type 2, how would the MAC know it’s in survival state to activate CG (active RLC vs explicit L1 signalling? vs new CG configuration), so for now we think the possibly agreeable proposal should be shortened version of P1-1 “To provide radio resources on the legs used for PDCP duplication and to guarantee CG resources are not used outside of Survival Time, RAN2 to discuss whether a CG can be considered deactivated outside of Survival Time and activated in Survival Time”. Now to the issue at hand, it seems there is a bit of a split on whether implementation is sufficient (quick activation of CG/allocation of DG) vs the need to eliminate this extra DCI and go with some flavor of conditional activation. This is the critical question to be discussed from our standpoint:- Is network implementation solutions sufficient for activating resources quickly enough upon entering survival time? Our understanding is that companies do not accept always allocating resources to be only used in survival state since this is understood to be unacceptably wasteful. Thus the only acceptable implementation solution(s) are 1. Activating DG or CG Type 2 within the remainder of survival time after accounting for the time it takes for the first TB Tx and the associated HARQ-NACK.
2. Configuring & Activating CG Type 1 then allowing the gNB to “reschedule” those CG type 1 resources outside of survival time to other UEs, knowing that the UE would not be using those resources outside of survival time. However a fix may still be needed to disallow the UE from using these resources outside of survival time for UCI-only or MAC CE transmissions, which can still be thought of as another variant of proposal 1-1.

The issues with implementation are that making the timeline work requires restrictive SCS to fit this whole procedure into 0.5/1/2 ms, since now CC2 resource activation timeline has to go through K2. The second issue is scalability as activating every RLC would need a separate DCI on PDCCH which means that the capacity would be limited. The question for RAN2 is whether we can accept those imitations of implementation solutions. If not, then proposal 1C would be a specific “supplement” that only works for some narrow cases not a general reliable supplement. To summarize, we think restricting P1 to CG type 1 is thinking to far ahead for now since it introduces the concept of activation to CG type 1 (how will deactivation happen if there is no DCI deactivation possibility), and it is sufficient to see if there is an agreement on the idea of conditional activation to begin with vs implementation-only solutions.  |
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**Summary:** TBD.

**Proposals: TBD.**

**Proposal 4: The number of associated RLC entities that can be activated upon entry into Survival Time are supported by either one of two variants. The second variant can be optionally configured.**

1. **Following entry to Survival Time, PDCP duplication is activated for all associated RLC entities that are configured for a DRB. The RLC entities are identified using the Rel-15/16 options for RRC configuration of associated RLC entities.**
2. **Following entry to Survival Time, PDCP duplication is activated for a separately configured set of associated RLC entities that are configured for a DRB. The RLC entities are identified using a new RRC configuration option which can be optionally present. The separate set is used in Survival Time only.**

**Proposal 5: A new field (such as “duplicationStateSurvTime”, name FFS) is optionally configured to indicate a dedicated set of associated RLC entities configured for activation of PDCP duplication upon entry to Survival Time. The field enables Option 2 (in Q4). If the field is not present then Option 1 (in Q4) is used. Details can be sorted out in stage-3.**

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| --- | --- | --- |
| **Company** | **Proposal** | **Comments** |
| Futurewei | P4 | RAN2 has not agreed on supporting both variants. Therefore, suggest changing to “RAN2 to discuss the following two variants regarding the number of …”. And, suggest listing the number of supporting companies for each of these variants. |
| Nokia | 4 | Some comments on companies input in Phase-1:* Several companies think Option 2 is RRC-based and therefore cannot “dynamically select the best subset”. We would like to clarify that the point is never about dynamicity, but rather it provides gNB flexibility in terms of tactics to improve reliability without having to increase the number of duplication copies. For instance, some RLC entities naturally have higher reliability than the others (e.g. associated to CG configurations with lower MCS), or associated to frequency ranges that are less sensitive to blockage problems. And the gNB can simply configure the UE to use these RLC entities when survival time state is triggered, without having to increase the number of duplication copies. This is not related to the instantaneous channel measurements.
* Some companies think the previous agreement already covers “activating duplication upon survival time entry” and stated that “Duplication very clearly means activating one (or more) **additional** RLC legs **aside from the one (or more) RLC leg(s) that is already active.** ”

This is incorrect because duplication means “multiple copies” rather than always having additional legs. Duplication could be already activated before survival time state, and even if the UE does not add any more leg, the agreement about “duplication” would still hold.* Several companies think “maximum reliability” is needed when entering survival time so all legs should be activated. We agree that reliability boost is needed but we also have commented many times that, activating too many legs may actually lead to even worse performance due to power issue, and it may degrade the overall system performance as well due to unnecessary interference to other UEs. Moreover, it is not the UE who should try its best, instead it should be configured by the gNB because the gNB is the only entity who knows about the overall network status (e.g. other UEs in the same cell).
 |
| CATT | P4/5 | From arguments of the proponents so far, we understand that the only benefit brought by this parameter is that it would allow replacing, upon entering ST, some of the active legs with other legs (leg switching). Considering that the primary leg cannot be disabled, this benefit is only potentially relevant when more than 2 legs are associated with the DRB. And even there, we don’t see why we should not give a try on that leg too as the leg weakness maybe temporary. Given the cell size (50m x 10m), the argument of waste of power on the failed leg for a power-limited UE assumes an interference limited “small-cell” scenario (cannot be coverage limited). However, different from typical interference limited scenarios, the case when this happens (when ST is triggered) is expected to be very rare compared to the steady-state case (outside ST). Therefore, the resulting impact on the overall system performance is expected to be marginal. We think the feature should be primarily designed to allow meeting the ST requirement from the UE perspective, and considering the short and rare time expected spent in ST state. We are not convinced system-level optimization bring much gain with this feature.  |
| Qualcomm | P4/P5 | As we extensively mentioned in Phase 1, we prefer option 1 (activating PDCP duplication for all associated RLC entities identified using Rel-16 configuration options) due to its simplicity, low signalling overhead, less spec work and more importantly since we do not stil see the need for continuously reconfiguring RLC legs ahead of anticipated failure and adding both an internal UE state and RRC signalling to change that state. We think the network can just configure the RLC legs that hit the new reliability taget in survival time and the UE should just activate those upon entry into survival state, assuming that any required reliability target can be achieved by configuring the right number/selection of RLC legs including the already active one, we don’t think the added flexibility of disabling the active RLC specifically unlocks new “static” reliability targets, so we don’t see the reliability argument. Also since entry into survival state is rare and not so many UEs are expected to be simaltanuously in survival so we don’t see the interference argument either.  |
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**Summary:** TBD.

**Proposals: TBD.**

**Proposal 7 (15/17): The index of LCHs in the MAC PDU that a retransmission grant relates to is used to identify triggering of Survival Time state of a DRB. The MAC layer can receive information from upper layers as to which LCIDs are associated with Survival Time and what is the value of N for the HARQ-NACK counting in case N>1 is required.**

**Proposal 10 (14/17): Following a HARQ-NACK, entry to Survival Time state is triggered only for the DRBs (with a requirement for Survival Time) which are included in the MAC PDU associated with the grant used for transmission of the TB.**

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| **Company** | **Proposal** | **Comments** |
| LGE | 7 | We suggest to remove “and what is the value of N for the HARQ-NACK counting in case N>1 is required” because support of N>1 is not agreed yet. |
| Qualcomm | 7 | Agree with LGE.  |
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**Summary:** TBD.

**Proposals: TBD.**

**Proposal 12 (15/17): When PDCP duplication is already activated in dual connectivity, in order to minimize dependencies between MAC entities in a configuration with N=1 the UE enters Survival Time when at least one MAC entity reaches the Survival Time count N.**

**Proposal 12A (12/17): 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 with N=1, the UE enters Survival Time when at least one CC reaches the Survival Time count N.**

**Proposal 12A-1: RAN2 may discuss whether Proposal 12A can be extended to N>1 after reaching a conclusion on the support of N>1**

**Proposal 13 (9/17): For a DC split-bearer in a configuration with N=1 when PDCP duplication is not yet activated, the UE enters Survival Time state upon reception of one HARQ NACK at either MCG or SCG.**

**Proposal 13-1: RAN2 may further discuss the counting of N in a split-bearer scenario with N>1 after reaching a conclusion on the support of N>1.**

**Proposal 14: RAN2 to monitor the situation and decide (potentially at a later time) whether a LS to RAN3 is needed.**

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| **Company** | **Proposal** | **Comments** |
| LGE | 12 | Similar to P13, we can rephrase P12 to:*When PDCP duplication is already activated in dual connectivity, in order to minimize dependencies between MAC entities in a configuration with N=1 the UE enters Survival Time upon reception of one HARQ NACK at either MCG or SCG.* |
| LGE | 12A | Similar to P13, we suggest to rephrase P12A to:*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 with N=1, the UE enters Survival Time upon reception of one HARQ NACK at any CC.* |
| LGE | 12A-1, 13-1 | P12A1 and P13 seem not needed. If RAN2 agree to support N>1, it is straightforward to discuss these cases.  |
| Nokia | 12, 12A | Agree with LGE  |
| CATT | 12, 12A | Agree with LGE. |
| Qualcomm | 12, 12A | Agree with LGE |
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**Summary:** TBD.

**Proposals: TBD.**

**Proposal 16: RAN2 to discuss whether any additional topics can be addressed.**

The rapporteur thinks it may not be reasonable to start a fresh discussion on the items in this list, given that the timeframe for phase 2 is very short. We can tag these topics for the online discussion if time permits. However, if any company would like to add extra points or indicate a further view, you may do this here.

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| **Company** | **Issues** | **Comments** |
| Qualcomm | Unlicensed band | We think the current framework can be slightly modified to work for unlicensed band to by expanding what “HARQ-NACK” would mean in unlicensed band, e.g., LBT failures or explicit DFI-NACK, so we propose bringing this to a discussion as well. |
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**Summary:** TBD.

**Proposals: TBD.**

# Conclusions

**Summary:** TBD.

**Proposals: TBD.**

# References

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[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