**3GPP TSG-RAN WG2 Meeting #112e R2-20xxxxx**

**Electronic, 2 – 13 November 2020**

**Agenda item: 8.5.3**

**Source: Qualcomm Incorporated**

**Title: [AT112e][501][IIoT]: Summary of URLLC in unlicensed controlled environment**

**Document for: Discussion and decision**

# Introduction

RAN2#111e has discussed the operation of URLCC in “Controlled Unlicensed Environment” and harmonization of Configured Grant (CG) between Rel-16 URLCC and NR-U. No agreements were made but the following points were captured in Chair notes as questions to be answered:

*Question really is:*

- Can IIoT autonomous transmission and NR-U CG retransmission timer can be configured together?

- Do we make the CG retransmission timer optional or not to cover controlled case?

- How do we do HARQ process ID selection?

- Smaller issue – in NR-U retx are always prioritized over initial tx so we need to check if this causing any issue

This document will capture a summary of the papers and proposals submitted to RAN2#112e for Agenda Item 8.5.3, collect further feedback, and suggest compromise proposals.

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# Discussion

## 2.1 Definition of Unlicensed Controlled Environment (UCE)

Even though the WID (RP-193233) has the phrase “unlicensed band URLLC/IIoT operation in controlled environment” in the Objectives, this has not been formally defined.

At least a common understanding of this term will be beneficial in discussing the new work to be done. Since “unlicensed controlled environment” is used in RAN2 Agenda, this will be used in the sequel with the acronym UCE.

In RAN1, it seems that UCE is regarded as semi-static access mode (or so-called FBE) in shared spectrum. This mode is separate from the dynamic (or so-called LBE). Even though these modes do not make any assumption on whether the environment is controlled or not, FBE is regarded to be more suitable when there is no interference from other RATs or technologies. This is also hinted in 37.213, clause 4.3 where it is stated that “Channel assess procedures based on semi-static channel occupancy as described in this Clause, are intended for environments where the absence of other technologies is guaranteed e.g., by level of regulations, private premises policies, etc.”.

This issue was not heavily discussed in the submitted papers and only the following three options were considered.

**Option 1: UCE is defined for spectrum where LBT failures occur quite sporadically.**

HW (R2-2008853) suggests that UCE means LBT failures occur quite sporadically and consistent LBT failure won’t exist.

**Option 2: UCE is defined where Semi-Static or FBE access mode is used.**

QC (R2-2008881) supports this, stating that this is used by RAN1 in their Rel-17 work

**Question 1: Which of the above Options (1, 2) is a suitable definition of UCE in further RAN2 work? Please list other options, if any, in the responses.**

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| **Company** | **Response** | **Comments** |
| Nokia | Option 1 and maybe Option 2 | In our understanding, when operating in unlicensed spectrum, inter-system interference cannot be completely avoided. However, in an unlicensed controlled environment (UCE), it can be assumed that LBT failures due to uncontrolled interference may only sporadically happen. Note that, in presence of inter-system interference from e.g. Wi-Fi, performance with semi-static channel access is severely degraded. In other words, though its use in uncontrolled environments is not precluded by regulations, semi-static channel access can in practice only be used in controlled environments. So, in this sense Option 2 might be okay as well. Moreover, we must point out the specification should not be restricted to FBE or LBE. |
| LG | Option1 | In MAC, we only need a baseline understanding of UCE so that Rel-17 IIOT protocol is enhanced. No need to have a definition based on access mode. |
| Ericsson | No definition needed | While UCE assumptions may be important regarding whether some requirements are achievable, there is no need to define UCE in RAN2. Firstly, definition of physical/channel properties should be discussed in RAN1. Secondly, MAC procedure design does not depend on UCE definition and in any case MAC procedures need to consider potential LBT failure. It is then up to network configuration whether LBT failures are considered and recovered. |
| Sony | Option 2 | Controlled environment can only use Semi-static channel access (SCA) but can SCA be used for other cases, e.g. uncontrolled environment? |
| MediaTek | Option 1  (Option 2 left to implementation) | We agree with Nokia that when operating in unlicensed spectrum, inter-system interference cannot be completely avoided. Therefore option 1 applies to UCE.  We also agree that the specification should not be restricted to FBE or LBE, and that the use of FBE is an implementation choice. |
| CATT | Option 1 | We share the same view as LG. |
| HW | Option 1 | Even for UCE, it does not mean there is no LBT failure at all, but LBT failure is quite rare and sporadic and consistent LBT failure does not exist. |
| ZTE | Option 1 | This is just a common understanding. Mapping to a specific channel access mode is not in RAN2’s scope. |
| OPPO | Option 1 | In our understanding, LBT failure may or may not occur in UCE since some inevitable events, including e.g. error interference detection by physical layer, co-system interference, etc., even if no coexistence with other unlicensed technologies/networks. However, since it is controlled environment, the interference may sporadically happen.  Regarding LBE or FBE, we agree that FBE is more suitable to use in the scenario without inter-system interference from e.g. Wi-Fi, but, there is no conclusion in RAN1 that LBE can not be used in such scenario. In addition, we also think the specification should not be restricted to FBE or LBE, since which mode is used is transparent from RAN2 perspective. |
| Google | Option 1 and 2 | Rel-17 IIoT deals with the scenario where the communications environment can be controlled so that LBT failure sporadically happens. Therefore, FBE is better suit the need of the application. |
| Samsung | Option 1 | We understand “Controlled” here could mean that the performance degradation due to interference. |
| Intel | Option 2 | We think option 2 is more precise but we also acknowledge that there is practically no difference between option 1 and 2 (i.e. we can consider FBE as an environment where LBT failures occur quite sporadically). We also think discussion here is mainly to setup a discussion context in RAN2, and there is no need to define UCE in specifications. |
| Lenovo | Option 1 | We share Nokia’s view with respect to operation of FBE in UCE. Regarding option 2 we are not sure what implication this option would have. We also agree with others that the specification should not be restricted to FBE or LBE. |
| III | Option 1 | We agree with LG that no need to have a definition based on access mode. |
| vivo | No definition needed, but Option1 can be taken as an assumption | For option2, as hinted in 37.213, clause 4.3 that the FBE is more suitable and efficient to be used for unlicensed controlled environment, but using FBE in uncontrolled environment should not be precluded. We prefer not to couple FBE with UCE.  Although option1 is not precise due to unclear threshold of LBT failure probability, it can be taken as an assumption to design some MAC procedures impacted by LBT failure. |
| Apple | Option 1 and 2 | In a strictly controlled environment, the amount of LBT failures is expected to be low but NR-U can be used in different deployments, not all of which are absolutely controllable. For as long as physical layer procedures have to keep using LBT in unlicensed, some LBT failures are likely inevitable.  The exact assumptions and the understanding of what UCE means is probably more relevant to RAN1 and RAN4. We agree with others that the MAC specification should not be restricted to FBE or LBE, and that the network can choose a configuration suitable for the environment.  Note: We assume the reference behind option 2 actually is R2-2008974, since R2-2008881 only confirms the general understanding of FBE. |
| Sequans | Option 1 and maybe Option 2 | From RAN2 perspective Option 1 is enough. Our understanding is that it means environment where FBE could be used (while not being mandated).  However if RAN1 only considers FBE it could make sense to align. |
| Xiaomi | Option | We have some sympathy on Ericsson’s concerns. Option 1 may be just a starting point for RAN2 to make some progresses. |
| InterDigital | Option 1 and 2 | LBT failure can happen sporadically, but it’s safe to say consistent UL LBT failure won’t happen in UCE. FBE or LBE can be assumed and there shouldn’t be a big difference in MAC. |

**Summary:**

**Proposal:**

## 2.2 Configuration of cg-Retransmission Timer

In Rel-16 NR-U, *cg-RetransmissionTimer* is a mandatory IE which means that the auto retransmission is always supported.

The question for Rel-17 is whether to make the timer and thus autonomous transmission optional.

RAN1#102e has also discussed this and agreed on the following:

*At least for FBE, configuration of (cg-RetransmissionTimer) should not be mandated when configured grant Type 1 or Type 2 are configured on unlicensed spectrum.*

It should be noted that RAN1 uses FBE as equivalent to UCE while RAN2 has not agreed on the definition of UCE yet. Since FBE and LBE operation are transparent to MAC, we will use the term UCE whose definition will be clarified according to the discussion in Section 2.1.

There are four options:

1. Make the timer mandatory for UCE (reverts RAN1 agreement)
2. Timer is never configured for UCE
3. Make the timer optional for UCE
4. Make the timer optional for all unlicensed operation

There were no companies which supported Option 1. However, it was listed here for completeness.

The other options were supported in the submitted papers as follows:

**Option 2:**

HW (R2-2008853) proposes that CG autonomous retransmission is not configured for URLLC over unlicensed spectrum.

**Option 3:**

Apple (R2-2009501), QC (R2-2008881), Oppo (R2-2009562), Sony (R-2009900), ZTE (R2-2009912), Google (R2-2009914), III (R2-2010437), Samsung (R2-2010524) support making the timer optional for UCE.

**Optional 4:**

Ericsson (R2-2008881) supports optionality for all unlicensed, arguing that FBE/LBE are not visible to MAC and thus there is no need to differentiate.

MTK (R2-2009117), Sony (R-2009900), ZTE (R2-2009912), Google (R2-2009914), Vivo (R2-2010212), Samsung (R2-2010524) also support optionality for all unlicensed.

**Question 2: Which of the above Options (1, 2, 3, 4) do you support regarding the optionality of *cg-RetransmissionTimer*? Please list other options, if any, in the responses.**

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| **Company** | **Response** | **Comments** |
| Nokia | Option 3 and Option 4 | The network could decide whether the timer should be configured based on its knowledge relating to the unlicensed band operation, e.g. how often or how likely the LBT failure can occur. On the other hand, we are also fine with Option 4, as in the end it is up to gNB implementation to decide if this is configured in any case. |
| LG | Option 3 or 4 | Optionality is useful when R16 NR-U functions are not required, i.e., very low LBT failure environment.  From specification perspective, there may be difference between option 3 or 4, which is currently not clear to us. Need more time to check. |
| Ericsson | Option 4 | RAN1 agreed that the *cg-retransmissionTimer* is optional in some cases (FBE), which means that RAN2 needs to support this case of optional *cg-retransmissionTimer* in MAC anyway. Also, since FBE/LBE operation is not visible on MAC, RAN2 can assume that *cg-retransmissionTimer* is optional in all cases. |
| Sony | Option 3 | RAN1 already agreed to be optional, there is no strong reason to change it. |
| MediaTek | Option 3 (or 4) | The intention is to have the *cg-retransmissionTimer* optional for IIoT operating in unlicensed spectrum. Whether we can differentiate between options 3 and 4, depends on whether we have a clear definition of UCE in the specifications. |
| CATT | Option 3 or 4 | IIoT over UCE can be operated with either NR-U CG protocol (*cg-RetransmissionTimer* configured, with some enhancements) or IIOT CG protocol (*autonomousTx* configured, with some enhancements). Therefore we support optionality of *cg-RetransmissionTimer* at least in UCE). |
| HW | Option 2 | We think only IIoT autonomous transmission is enough for URLLC/IIoT over unlicensed. No matter whether the MAC PDU is deprioritized or LBT failure happens, we can rely on autonomous transmission for non-delay critical service and rely on dynamic scheduled retransmission for delay-critical service since the NW knows which HARQ ID is used for a certain CG.  However, if only NR-U autonomous retransmission is configured, then if LBT failure happens, the NW is not able to schedule a dynamic retransmission as it is not aware of the UE selected HARQ ID which may cause retransmission delay. And the next arrived CG will be used for retransmission of the TB generated for the previous CG, since retransmission is always prioritized over initial transmission. This will cause the transmission delay for later arrived packets and is not suitable for URLLC/IIoT service. Pleased keep in mind, to fulfill URLLC/IIoT performance requirements, any extra latency from protocols shall not be allowed. The delay budget for URLLC/IIoT service is already tight and especially so when URLLC/IIoT service relies upon the rapid retransmissions to survive  If both IIoT autonomous transmission and NR-U autonomous retransmission are configured simultaneously, then the key point is still how to select the HARQ ID, if HARQ ID is calculated on formula, then it makes no difference compared with IIoT only mechanism while if HARQ ID is selected by the UE, then similar as NR-U only mechanism, additional transmission delay cannot be avoided which is not suitable for URLLC service. In addition, if we support simultaneous configuration, it would require scrutiny to assure they don’t interfere each other, which means considerable specification work.  So based on the above analysis, we think only IIoT autonomous transmission is configured for URLLC over unlicensed and we don’t need to support NR-U autonomous retransmission scheme, which means the cg-RetransmissionTimer is never configured for UCE. |
| ZTE | Option 3 or 4 | We would like to insist on the RAN1’s agreements, and if possible, can be extended to UCE. |
| OPPO | Option 3 and Option 4 | As we mentioned in Question 1, Option 3 and Option 4 are fine to us. |
| Google | Option 3 or 4 | Since Rel-17 IIoT focuses on FBE, we support option 3. For LBE case, configuration of CG retransmission can also be optional. |
| Samsung | Option 3 or 4 | Configuration should be left up to NW. Since CGRT can be configured only for unlicensed spectrum, we don’t see difference between 3 and 4. |
| Intel | Option 3 | Given RAN1 agreement, we think *cgRetransmissionTimer* is optional for UCE. We don’t think it can be optional for all unlicensed spectrum, in particular, for LBE. |
| Lenovo | Option 3 and Option 4 | We think it’s up to network implementation to decide whether to configure the  cg-RetransmissionTimer depending on the interference situation. In the end we are not sure whether there will be some difference between option 3 and Option 4. |
| III | Option 3 | If LBT failurehappen sporadically, this timer should not mandatory for UCE. |
| vivo | Option 3 or 4  Can be decided in RAN1 | RAN1 has already agreed the timer is optional at least for FBE and RAN1 will continue discussion on whether to extend this configurability to LBE mode. As FBE/LBE are not visible to MAC, we can wait RAN1 to decide whether option 3 or 4 should be selected. |
| Apple | Option 3 | We think autonomous retransmission is tailored to NR-U and the aim of the work here in Rel-17 is to support URLLC over shared spectrum. Whether or not the timer will be needed depends on the deployment and the environment, hence it should be made optional. This is also in line with the RAN1 agreement. |
| Sequans | Option 4 | This seems the most flexible option. |
| Xiaomi | Option 3 or Option 4 | Both options are acceptable to us. But it seems not very clear how to differentiate the two options. |
| InterDigital | Option 3 | Same view as Intel |

**Summary:**

**Proposal:**

## 2.3 HARQ process ID and RV selection

The main question is the following:

Should HARQ process ID and RV selection be same as Rel-16 NR-U (up to UE implementation) or Rel-16 URLLC (deterministic) for UCE?

Since the main parameter for HARQ handling in NR-U is *cg-RetransmissionTimer*, it makes sense to consider two cases separately:

1. When *cg-RetransmissionTimer* is configured
2. When *cg-RetransmissionTimer* is not configured

For each case, the opinions of companies in the submitted papers are stated as below.

Case 1:

HW (R2-2008853), LG (R2-2010439) support to use Rel-16 URLLC scheme.

The following companies support to use Rel-16 NR-U scheme:

Ericsson (R2-2008881), Intel (R2-2008976), MTK (R2-2009117), QC (R2-2008881), Oppo (R2-2009562), Sony (R-2009900), ZTE (R2-2009912), Google (R2-2009914), Interdigital (R2-201010), Vivo (R2-2010212), Samsung (R2-2010524)

Case 2:

QC (R2-2008881) proposes to use Rel-16 NR-U if CG-UCI is configured and Rel-16 URLLC otherwise

The following companies support to use Rel-16 NR-U scheme:

Sony (R-2009900), Google (R2-2009914), Interdigital (R2-201010), Samsung (R2-2010524)

The following companies support to use Rel-16 URLLC scheme:

HW (R2-2008853), Ericsson (R2-2008881), Intel (R2-2008976), Oppo (R2-2009562), , ZTE (R2-2009912), Vivo (R2-2010212), LG (R2-2010439)

**Question 3.1: In UCE, when *cg-RetransmissionTimer* is configured, which of Rel-16 NR-U or Rel-16 URLLC mechanism is used for HARQ process ID and RV selection?**

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| **Company** | **Response** | **Comments** |
| Nokia | NR-U | If the network decides to configure *cg-RetransmissionTimer* in UCE, it typically means LBT failure could occur and cannot be ignored. Thus, it makes sense to apply HARQ PID selection based on NR-U in this case. |
| LG | Rel-16 URLLC | We see no problem in use of Rel-16 URLLC scheme even if cg-RetransmissionTimer is configured. In addition, no big different in latency aspect is expected because only sporadic LBT failure can be assumed in UCE. Thus, Rel-16 URLLC scheme is sufficient. |
| Ericsson | NR-U | When *cg-retransmissionTimer* is configured, the UE must be able to choose the HARQ process ID itself, in order for the UE to choose between transmission and retransmission (depending on LBT outcome before) and to send a pending HARQ process at a next CG occasion. Otherwise, when a formula is followed, for transmission of a pending HARQ, the UE would need to wait until the next occasion of the HARQ ID according to the formula, which adds delay. In case of consistent LBT failure, this method would be infeasible.  Generally, we think that when *cg-retransmissionTimer* is configured, NR-U Rel-16 behaviour is intended, and no changes are needed. |
| Sony | NR-U | NR-U mechanism is better for HARQ process ID and RV selection. |
| MediaTek | NR-U | Agree with Ericsson |
| CATT | NR-U | *cg-RetransmissionTimer* and UE-based HARQ process ID selection work together. Without UE-based HARQ process ID selection *cg-RetransmissionTimer* is useless and retransmissions can be either scheduled by gNB or via a mechanism like IIOT autonomous transmissions. So if the *cg-RetransmissionTimer* is configured, it makes most sense that Rel-16 NR-U scheme is used for the HARQ process ID and RV selection. |
| HW | / | As we respond in the previous question, we don’t think cg-RetransmissionTimer is configured for UCE. |
| ZTE | NRU |  |
| OPPO | NRU | If network considers LBT failure existing, *cg-RetransmissionTimer* will be configured accordingly. With LBT failure, we should take NRU CG mechanism as baseline to resolve LBT failure issue and to determine HARQ process, including e.g. HARQ process ID determination, HARQ process ID sharing, RV selection, etc. |
| Google | NR-U | NR-U HARQ ID selection provides flexibility for UE to select a HARQ process to transmit data. Therefore, if cg-RetransmissionTimer is configured, NR-U HARQ ID selection should be used. |
| Samsung | NR-U | We already defined the operations for the case that CGRT is configured. Then, there is no reason to define additional URLLC feature which may have additional impact. |
| Intel | NR-U | We note that in RAN1 email discussion *“[103-e-NR-IIoT-URLLC-03] Email discussion/approval for enhancements for unlicensed band URLLC/IIoT*” Discussion point#2-3, one option (Proposal 2-3A) is that HARQ process ID and RV selection is configurable between Rel.16 URLLC and Rel-16 NR-U features by RRC parameter X, which is different from *cg-RetransmissionTimer*. We’re open to either use *cg-RetransmissionTimer* or a different RRC parameter. |
| Lenovo | NR-U |  |
| III | NR-U | Agree with Ericsson. |
| vivo | NR-U | Agree with Ericsson, autonomous retransmission is coupled with UE-based HARQ process ID selection to reduce the retransmission latency. |
| Apple | NR-U | Agree with Sony and Nokia. In addition, some changes may be needed to reduce latency down to a level suitable for URLLC. |
| Sequans | NR-U | Agree with Ericsson. |
| Xiaomi | NR-U | Agree with Ericsson |
| InterDigital | NR-U | Agree with Ericsson |

**Summary:**

**Proposal:**

**Question 3.2: In UCE, when *cg-RetransmissionTimer* is NOT configured, which of Rel-16 NR-U or Rel-16 URLLC mechanism is used for HARQ process ID and RV selection?**

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| **Company** | **Response** | **Comments** |
| Nokia | URLLC | If the network decides NOT to configure *cg-RetransmissionTimer* in UCE, it typically means LBT failure could be very rare and therefore negligible. Thus, determining HARQ PID based on URLLC mechanisms in this case should be preferred as it provides a more deterministic UE behavior from gNB perspective. |
| LG | Rel-16 URLLC |  |
| Ericsson | URLLC | When the *cg-RetransmissionTimer* is not configured, there is no need/cause to deviate from the formula in URLLC, since the assumption is that no method to recover from LBT failure is available. Also, UE choosing HARQ process ID would come with overhead of UCI, which is not necessary. |
| Sony | NR-U | Since the flexibility in HPN determination, management of HPN, and RV determination offered by CG-UCI, is beneficial for URLLC operation in an unlicensed band, Rel-17 unlicensed URLLC should support CG-UCI.   * HARQ process number (HPN) is associated with the configuration in Rel-16 URLLC while HPN/ID can be decided by the UE and reported to network using CG-UCI in Rel-16 NR-U. Hence, flexible HPN determination would be beneficial also for URLLC, and supporting CG-UCI in URLLC is preferable. * HPN cannot be shared between different CG configurations in Rel-16 URLLC since HPN is associated with CG configuration by RRC signaling, while HPN can be shared between different CG configurations by reporting HPN in CG-UCI in Rel-16 NR-U. Hence, flexible management of HPN would be beneficial for URLLC, and supporting CG-UCI in URLLC is preferable. * RV pattern for the CG repetition is configured and associated with transmission occasion in Rel-16 URLLC, while RV can be decided by UE and reported to network using CG-UCI in Rel-16 NR-U. Hence flexible RV determination would be beneficial for URLLC, and supporting CG-UCI in URLLC is preferable. |
| MediaTek | URLLC | If *cg-RetransmissionTimer* is not configured, the implication is that retransmissions of data sent on configured grants are not considered important. In this case, we can rely on the legacy URLLC mechanism to allow new data to go on configured grants with priority. |
| CATT | Rel-16 URLLC | If the *cg-RetransmissionTimer* is not configured, Rel-16 IIoT scheme is the simplest approach for the HARQ process ID and RV selection. |
| HW | URLLC | We support to follow Rel-16 URLLC mechanism to determine the HARQ ID, otherwise dynamic scheduled retransmission is not possible if the NW has no idea which HARQ ID is used by the UE, which may cause additional delay for URLLC service.  Regarding to RV, similar as HARQ ID, we support to follow Rel-16 URLLC mechanism. |
| ZTE | Rel-16 URLLC |  |
| OPPO | URLLC | If network considers LBT failure is negligible and can be ignored, *cg-RetransmissionTimer* will not be configured. Accordingly, it is better to follow HARQ related mechanism in Rel-16 URLLC. |
| Google | NR-U | Although the IIoT approach is simpler, it may incur longer delay which is not desirable for URLLC applications. It may be good to adopt the Rel-16 NR-U approach to select a HARQ ID. |
| Samsung | No strong view | We see both would work. |
| Intel | Formula based similar to Rel-16 URLLC | As discussed in our contribution R2-2008976, HARQ process ID derivation is based on a formula. RAN2 to discuss the modification to HARQ process ID formula to support multi-TB transmission in a CG period.  As in our reply to Question 3.1, We’re open to either use *cg-RetransmissionTimer* or a different RRC parameter. |
| Lenovo | Rel-16 URLLC | Agree with others that not configuring cg-RetransmissionTimer means that gNB assumes that LBT failures occur only occasionally/rarely. Since autonomous retransmission functionality is not supported when not configuring cg-RetransmissionTimer, IIOT protocol is used which means that HARQ processes are determined according to the formula. |
| III | URLLC |  |
| vivo | Rel-16 URLLC | If the *cg-RetransmissionTimer* is not configured, retransmission can only be performed based on dynamic scheduling, hence the network needs to know the HARQ process id UE used for the initial transmission.  If UE selects the HARQ process id by itself (as NR-U), the network cannot deduce which HARQ process id should be used for retransmission. And the dynamic scheduling for retransmission cannot be performed. The issue does not exist in R16 URLLC, which derive HARQ process id from the formula. |
| Apple | Rel-16 URLLC | When cg-RetransmissionTimer is not configured we expect the likelihood for LBT failures to be very low. In this case the URLLC mechanism may be better suited to achieve the low latency requirements. We are nevertheless open to NR-U based solutions if there is a compelling reason. |
| Sequans | URLLC |  |
| Xiaomi | Rel-17 URLLC |  |
| InterDigital | URLLC | Without CGRT configured, it can be assumed that LBT failures are rare or controlled. |

**Summary:**

**Proposal:**

## 2.4 Multiple CG configuration

HARQ processes can be shared between different CG processes in NR-U while this is not allowed in Rel-16 URLLC. The question is which option to use in Rel-17 UCE.

MTK (R2-2009117) supports sharing HARQ processing between multiple CG for UCE.

Nokia (R2-2009758) proposes that *“Different subsets of HARQ processes for a CG occasion may be configured for MAC PDUs with different LCH priorities”*

LG (R2-2010439) proposes not to support HARQ sharing for UCE.

Since HARQ process sharing feasibility is related to HARQ ID selection, there is a dependency here to the outcome of Section 2.3.

**Question 4.1: In UCE, is sharing of HARQ processes allowed between multiple CGs if Rel-16 NR-U HARQ ID selection is used?**

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| **Company** | **Response** | **Comments** |
| Nokia | Yes | This should be aligned with Rel-16 NR-U.  But we think the pool of HARQ PIDs that the UE could select for a CG occasion should depend on the LCHs mapped to the corresponding transport block. More specifically, if the transport block contains higher priority LCHs, it should have a wider range of HARQ PIDs that can be selected, to avoid the issue of “HARQ PID depletion” that is undesirable for URLLC data. |
| LG | No | We see no need of supporting HARQ process sharing regardless of whether HARQ ID selection is Rel-16 NR-U scheme or Rel-16 URLLC scheme.  HARQ sharing aims at satisfying latency requirement even with frequent LBT failure. In UCE, we neither expect frequent LBT failure nor introduce a tighter latency requirement than in Rel-16. Thus, it would be good to keep the protocol as light as possible unless a clear motivation is shown in Rel-17.  We think the proposal in 9758 is an optimization. Even today, the network can map different LCH to different CG by considering LCH priority in order to avoid HARQ process stalling issue for high priority of LCHs. |
| Ericsson | FFS | Postpone. This can be discussed once other design choices regarding combining of *lch-basedPrioritization/autonmousTx* and *cg-RetransmissionTimer* are clearer.  The main issue is that if HARQ process sharing is allowed among CGs, with *lch-basedPrioritization/autonmousTx*, a CG for new data transmission may be prioritized over a CG for which an *autonomousTx* of previously de-prioritized data may happen. If the HARQ process of the CGs is shared, this would lead to unwanted override of the HARQ process buffer. This issue from intra-UE prioritization is independent of HARQ process ID formula and UE-selection usage.  On the other hand, in case the *cg-RetransmisionsTimer* is used (thus UE selects HARQ ID), we don’t see an issue in disallowing the sharing of HARQ process IDs. Assuming separate CG configurations for different LCHs, this may even be a beneficial configuration for the case where interactions between CGs is not wanted. |
| Sony | Yes | HPN cannot be shared between different CG configurations in Rel-16 URLLC since HPN is associated with CG configuration by RRC signaling, while HPN can be shared between different CG configurations by reporting HPN in CG-UCI in Rel-16 NR-U. Hence, flexible management of HPN would be beneficial for URLLC, and supporting CG-UCI in URLLC is preferable. |
| MediaTek | Yes | This would be especially useful for NR-U operation to allow data for which LBT has failed, to be re-transmitted on the earliest opportunity available - which may be a different configured grant configuration.  Furthermore, unlicensed operation is in Rel-16 is expected to use configured grants extensively to overcome LBT failure probability. Similarly IIoT is expected to use configured grants extensively due to periodic TSN traffic. When we combine the two, we are faced with the issue of ‘HARQ PID depletion’, which is undesirable. |
| CATT | No | NR-U protocol allows using a different CG configuration if it has same TBS. But for a same TBS, the reliability of different CG may be different, e.g. the MCS can be different. This is an issue for URLLC traffic. In order to guarantee the reliability, we think parameters related to reliability together with TBS should be considered for shared HARQ processed. So we would not support the current NR-U HARQ sharing design, unless it is enhanced considering the above. |
| HW | No | We don’t support NR-U HARQ ID selection. |
| ZTE | FFS | In technical, this issue is relying on the outcome of above issue (i.e: 2.3), if the NRU pattern HARQ process ID and RV selection is still reused for URLLC on shared spectrum channel, it is benefit for UE to select the most closed CG occasion to send the MAC PDU which is blocked by LBT failure even this CG occasion is not belonging to the original CG configuration. As for the concern from companies say no, we are open to have enhancement for avoiding their concern, and at least, these concerns can be avoided by NW configuration. |
| OPPO | Yes | As we mentioned in R2-2009562, if *cg-RetransmissionTimer* is configured, we can use Rel-16 NRU CG HARQ mechanism, including e.g. HARQ process ID determination, HARQ process ID sharing. |
| Google | Yes | If multiple CGs are configured, it is beneficial to share a HARQ process among configured grants. |
| Samsung | Yes | We can differentiate based on CGRT configuration.  CGRT is configured 🡪 NR-U HPI selection is used (shared HPI)  CGRT is not configured 🡪 IIOT HPI selection is used (not shared)  Then, there is no any serious problem foreseen. |
| Intel | Yes |  |
| Lenovo | FFS | Since this depends on the outcome of section 2.3, we think that those detailed issues should be discussed in a second step. In general, we think that when HARQ processes are selected by the UE implementation HARQ process sharing should be possible. HARQ process sharing was introduced for NR-U in order to provide more transmission opportunities in the presence of LBT failures. |
| III | Yes | III |
| vivo | Yes | If sharing of HARQ processes between multiple CGs is not allowed, it may happen that all HARQ processes associated with some CGs are occupied meanwhile all HARQ processes associated with other CGs are not used. In this case, the new data restricts to CG without HARQ process available has to wait.  In the case of HARQ process id is selection by UE, we see above benefits to support HARQ processes sharing between multiple CGs without any complexity caused by HARQ ID collision. |
| Apple | FFS | We tend to say ‘yes’ but this question can be addressed after selection of the more fundamental design choices with regards to retransmission and priority handling. |
| Sequans | FFS | No strong view for now |
| Xiaomi | Yes |  |
| InterDigital | Yes | Per the NR-U R16 baseline, given the UE selects the HARQ process ID when CGRT is configured and LBT can fail. |

**Summary:**

**Proposal:**

**Question 4.2: In UCE, is sharing of HARQ processes allowed between multiple CGs if Rel-16 URLLC HARQ ID selection is used?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | No | If HARQ PID is determined based on URLLC mechanism, then we can simply follow Rel-16 IIoT/URLLC where each CG has its own HARQ PID set. |
| LG | No | We see no need of supporting HARQ process sharing regardless of whether HARQ ID selection is Rel-16 NR-U scheme or Rel-16 URLLC scheme.  HARQ sharing aims at satisfying latency requirement even with frequent LBT failure. In UCE, we neither expect frequent LBT failure nor introduce a tighter latency requirement than in Rel-16. Thus, it would be good to keep the protocol as light as possible unless a clear motivation is shown in Rel-17. |
| Ericsson | No | This refers to the case where *cg-retransmissionTimer* and all other NR-U features are not used (i.e. no NR-U HARQ process ID selection). In this case, we can apply legacy URLLC handling, i.e. not sharing the HARQ process IDs among CG configurations. This is in order to avoid the issue described with *lch-basedPriortiziation/autonomousTx* in comment to 4.1. |
| MediaTek | No | If Rel-16 URLLC HARQ ID selection is used, then we can follow Rel-16 baseline without any further optimisations |
| CATT | No but | We see no need to introduce such enhancement to the IIOT protocol at this stage. This would be an optimization to consider in later stage if IIOT CG protocol performance needs to be improved considering LBT failures. |
| HW | No | As URLLC HARQ ID is calculated according to the formula, then we don’t think sharing of HARQ process makes sense. The intention to introduce an offset in the formula is to avoid different CGs using the same HARQ ID and a transmission on one CG prevents new transmission on the other CG as the CGT is maintained per HARQ process. In Rel-17, similar principle still applies if we follow URLLC HARQ ID selection mechanism. |
| ZTE | No | No further optimization on the HARQ process ID derived from formula |
| OPPO | No | If *cg-RetransmissionTimer* is not configured, it is better to follow HARQ related mechanism in Rel-16 URLLC. |
| Google | No | For URLLC HARQ selection, we do not see a benefit to support sharing of HARQ process among configured grants. |
| Samsung | No | We can differentiate based on CGRT configuration.  CGRT is configured 🡪 NR-U HPI selection is used (shared HPI)  CGRT is not configured 🡪 IIOT HPI selection is used (not shared)  Then, there is no any serious problem foreseen. |
| Intel | No |  |
| Lenovo | No |  |
| III | No | No need to consider HARQ process sharing in UCE. |
| vivo | No | If HARQ process ID is derived from formula and sharing of HARQ processes between multiple CG is allowed, two CGs (e.g. CG1 and CG2) overlapping in time may be associated with the same HARQ process, which means HARQ process collision between CGs. If there is a TB for CG1 in the buffer of the HARQ process (i.e. the previous resource of CG1 is deprioritized) and the CG1 is deprioritized by CG2 according to R17 URLLC, the TB in HARQ buffer will be replaced by new generated TB for CG2. Data loss occurs. |
| Apple | No | HARQ process sharing while utilizing the URLLC mechanism seems contradictory and can complicate the design. We agree with CATT that HARQ sharing might be considered as an enhancement at a later stage of the design, once we have more clarity on other questions. |
| Sequans | No | We don’t see the need for this. |
| Xiaomi | No |  |
| InterDigital | No | In such case the HARQ process is selected using the formula rather than by UE implementation. |

**Summary:**

**Proposal:**

## 2.5 Autonomous tx and retransmissions

Rel-16 RRC allows simultaneous configuration of autonomous tx and cg-retransmission in Rel-16. There are contributions which propose that this should be changed. From procedural point of view, this should be handled by Rel-16 corrections. However, given the relevance to Rel-17 WI, it would be useful to understand and reach a consensus on the Rel-16 baseline first.

**Question 5.1: Do you agree that simultaneous configuration of *autonomousTx* and c*g-RetransmissionTimer* is allowed in Rel-16? If not, please refer to the specification text which prohibits this.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | Yes | They can be configured together |
| LG | Agree |  |
| Ericsson | Yes | It is allowed right now and should be kept. |
| MediaTek | Yes | While this is allowed, these two mechanisms were independently introduced for different WIs with different goals. In Rel-17, we need to further study if these two mechanisms work together as expected, and if not, what needs to be done to achieve expected behaviour from URLLC on unlicensed spectrum. |
| CATT | Yes | Strictly speaking nothing prevents from configuring both in R16. However we show in R2-2008859 that configuring *autonomousTx* on top of *cg-RetransmissionTimer* is both useless (since all retransmissions on CGs are handled by NR-U mechanism) and, for the only configuration where it works, it defeats the purpose of the configuration, as discussed in Q5.4 |
| HW | Yes but they will not be configured simultaneously | According to the current ASN.1 structure, there is no restriction these two parameters cannot be configured simultaneously but we think a smart gNB will not configure them simultaneously for the same CG.  Actually in the field description of cg-RetransmissionTimer, it is clearly specified that  “*This field is always configured for operation with shared spectrum channel access together with harq-ProcID-Offset. This field is not configured for operation in licensed spectrum or simultaneously with harq-ProcID-Offset2*”,  In Rel-16, unlicensed spectrum is used for eMBB, while CG resources used for URLLC transmission is configured on licensed spectrum, which means cg-RetransmissionTimer will not be configured for URLLC CG configuration.  In addition, autonomous transmission is introduced for URLLC service and should be only configured for CG configuration used for URLLC transmission.  Based on the above analysis, for a certain Rel-16 UE, autonomousTx and cg-RetransmissionTimer can be configured simultaneously for this UE but they should not be configured simultaneously in the same CG configuration. |
| ZTE | Yes |  |
| OPPO | Yes | They can be configured together.  But, from our perspective, IIoT autonomous transmission function is actually out of operation, since MAC layer is required to start CG timer at the beginning of PUSCH transmission once LBT success even if the PUSCH is considered as a deprioritized and cancelled later. |
| Google | Yes | Rel-16 spec allows simultaneous configuration of autonomousTX and cg-RetransmisisonTimer. |
| Samsung | Yes | It is allowed from specification point of view. The background of this is that autonomousTX is configured in licensed spectrum whereas CGRT is configured in unlicensed spectrum. |
| Intel | Yes | Although Rel-16 specification itself does not prevent the simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer*, we don’t think they should be configured together as they are developed for different features. |
| Lenovo | Yes | We agree with Mediatek that we need to further study if these two mechanisms work together as expected, since IIOT and NR-U was introduced as independent features. |
| III | Yes |  |
| vivo | Yes | Already allowed in Rel-16. |
| Apple | Yes | It is not precluded from specification point of view. The two mechanisms were introduced for different modes of operation and for URLLC over NR-U. In our view they should not be configured concurrently unless we further study how they can work together efficiently in Rel-17. Also see Q5.2. |
| Sequans | Yes |  |
| Xiaomi | Yes |  |
| InterDigital | Yes |  |

**Summary:**

**Proposal:**

Several papers propose that simultaneous configuration should not be allowed as an operational principle due to either potential conflict or not being useful. It was not always clear in some papers whether this was intended for Rel-16 or only for Rel-17 UCE.

Ericsson (R2-2008881) says this is already feasible without any specification changes. Google (R2-2009914), QC (R2-2008974), Interdigital (R2-201010) have the same opinion.

Intel (R2-2008976) proposes not to allow configuration of *autonomousTx* for Rel-16 NR-U.

MTK (R2-2009117) thinks *autonomousTx* should not be configured for IIoT URLLC; however, it is not clear if they intend this for Rel-16 or Rel-17.

Lenovo (R2-2009598) proposes that only one type autonomous transmission mechanism should be used for a MAC PDU, when *cg-RetransmissonTimer* and *lch-basedPrioritization* are configured concurrently.

Samsung (R2-2010524) proposes that *autonomousTx* is not supported in unlicensed band.

CATT (R2-2008859) observes that, in R16, IIOT’s autonomous transmissions are useless when *cg-RetransmissionTimer* is configured.

**Question 5.2: Assuming this is already allowed in Rel-16, should Rel-16 specification be modified not to allow simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer*?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | No | The only potential issue we see is delayed autonomous transmission due to *cg-RetransmissionTimer*, which we will discuss more in Q5.5 |
| LG | No | gNB can handle this even though it is not restricted from specification. |
| Ericsson | No | It is allowed right now and should be kept. We don’t see issues. |
| Sony | Yes | We don’t see clear benefit of simultaneous configuration of autonomousTx and cg-RetransmissionTimer. |
| MediaTek | Yes | *autonomous-Tx* was introduced for IIoT, which was only looked at from the perspective of licensed spectrum.  On the other hand, *cg-RetransmissionTimer* was introduced for NR-U, for which Rel-16 IIoT enhancements were not taken into account.  Given that these two mechanisms are very closely related to configured grant operation, we cannot assume that these can work together without unintentional side-effects. |
| CATT | Yes | Again, from R2-2008859’s conclusions, we clearly recommend that both parameters are not configured together, since their functionalities overlap so that *autonomousTx* is useless or behaves inappropriately.  But a more severe issue though comes from the conditional configuration of *autonomousTx* to *lch-BasedPrioritization*. And, as discussed in Q6, concurrent configuration of *lch-BasedPrioritization* and *cg-RetransmissionTimer* in R16 results in undefined UE behavior regarding prioritization of retransmissions. So given, at this late stage of R16, we should get away from functional changes, network implementation/configuration should definitely avoid such concurrent configuration of *cg-RetransmissionTimer* and *lch-BasedPrioritization/autonomousTx* in R16, and some possible RRC clarification might be needed. |
| HW | Yes | If we can reach consensus that for the same CG, autonomousTx and cg-RetransmissionTimer shall not be configured simultaneously, then some update on the spec is needed to restrict simultaneous configuration of these two parameters for the same CG according to the agreement achieved this week.   1. *RAN2 to confirm that for all Rel-15 upper layer features there is no differentiation needed for NR operation in shared spectrum. No changes to the specifications are needed*   *2: RAN2 to confirm that for all Rel-16 upper layer features there is no differentiation needed to NR operation in shared spectrum, unless otherwise captured explicitly in the specifications. No changes to the specifications are needed.* |
| ZTE | No strong point of view, leave it to R16 CR discussion if needed. | Even though according to the current spec 38.331, *autonomousTx* and cg-RetransmissionTimer can be configured together in Rel16 , but NW won’t configure them together since the they have different mechanisms and should be configured in different scenarios. And this shall be the left issue in Rel-16, we think there is no need for us to discuss it in Rel-17, we would like to only focus on the next issue. |
| OPPO | Maybe Yes | No clear benefit is seen for simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer*. |
| Google | No | Since the spec has already allowed the simultaneous configuration, if no issue is identified or gNB implementation can resolve the issue no change is needed. |
| Samsung | Yes | The background of the simultaneous configuration in Rel-16 is that autonomousTX is configured in licensed spectrum whereas CGRT is configured in unlicensed spectrum. Thus, those are not actually configured together.  But we are now introducing URLLC features to UCE. Also, CGRT and autonomousTX will have almost identical purpose, i.e., fast transmission of stored but not transmitted PDU. Then, we don’t need to configure both. |
| Intel | Yes | We prefer to explicitly specify that these two features cannot be configured simultaneously. |
| Lenovo |  | We assume that network won’t configure, *autonomousTx* and cg-RetransmissionTimer concurrently in Rel-16, since these are different independent features. Also for example harq-ProcID-Offset2 is according to TS38.331 not configured for operation with shared spectrum channel access. |
| III | No | From NW/gNB point of view *autonomousTx* and cg-RetransmissionTimer won’t be configured simultaneously. |
| vivo | No |  |
| Apple | No strong view | Strictly speaking Rel-16 should be updated. However, the configuration of *autonomousTx* and *cg-RetransmissionTimer* is bound to licensed/shared spectrum and for Rel-16, it is not expected to have both mechanisms configured together.  See R2-2003952 and the respective agreement in RAN2#109bis: *“We keep ASN.1 as is, capture in TS 38.331 that harq-ProcID-Offset2 and cg-RetransmissionTimer should not be configured simultaneously for a certain configured grant.”*  Hence, we see no major issue in Rel-16 but the problem needs to be addressed in Rel-17. |
| Sequans | No | In our understanding, autonomousTX allows transmission of deprioritized PDUs while cg-RetransmissionTimer allows retransmissions in case of LBT failure. |
| Xiaomi | No | We should keep the current procedural text until we really found a critical issue. |
| InterDigital | No | There aren’t any issues, and this is up to the network to configure. |

**Summary:**

**Proposal:**

Irrespective of Rel-16 behavior, a different mechanism may be an option for Rel-17.

**Question 5.3: Should simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer* be supported for Rel-17 URLLC in UCE and shared spectrum in general?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | Yes | If there is no major issue of configuring them simultaneously and already feasible by the existing specification, then we do not see the reasons why this is not supported. |
| LG | Yes but need more discussion | The detailed MAC procedure needs to be discussed more. Some companies think, when both are configured together, one dominant procedure should be used by e.g., defining URLLC prioritization rule considering LBT failure or defining HARQ pending status considering URLLC prioritization.  Our view is that there is no one dominant procedure used but we can rely on each procedure based on the individual event of de-prioritization or LBT failure. |
| Ericsson | Yes | We believe this behavior is possible without specification changes, for shared spectrum in general. Both parameters can be independently and optionally configured and address their different use-cases i.e. transmission of deprioritized data and retransmission due to LBT failure (or no response from network), respectively. Therefore, this operation should be considered the baseline/starting point in Rel-17, rather than modifying either *autonomousTx* or *cg-RetransmissionTimer* to take over handling for both cases. |
| Sony | No | We don’t see clear benefit of simultaneous configuration of autonomousTx and cg-RetransmissionTimer. |
| MediaTek | Needs further discussion | The expected UE behaviour should be clear. The mechanisms may work alongside each other, but we should discuss if such operation is as intended by RAN2. |
| CATT | No. | As discussed in above questions, both functionalities overlap and we see no performance benefit in getting them to work concurrently. On the contrary the resulting complexity increase is a practical argument making this approach quite unattractive. |
| HW | No | If both IIoT autonomous transmission and NR-U autonomous retransmission are configured simultaneously, then the key point is still how to select the HARQ ID, if HARQ ID is calculated on formula, then it makes no difference compared with IIoT only mechanism while if HARQ ID is selected by the UE, then similar as NR-U only mechanism, additional transmission delay cannot be avoided which is not suitable for URLLC service.  In addition, if we support simultaneous configuration, it would require scrutiny to assure they don’t interfere each other, which means considerable specification work.  We don’t see clear benefit for simultaneous configuration and it may cause additional transmission delay which is not acceptable for URLLC service. |
| ZTE | See comments | In my understanding, this issue shall be split into at least two stage:   * *Stage 1: In R17 URLLC on shared spectrum channel, Should we support simultaneous configuration of autonomous transmission for deprioritized MAC PDU and autonomous retransmission for the MAC PDU without successful transmission for one configured grant configuration ?*   If it is Yes for stage 1, and then we can consider the stage 2, to select one of two existing mechanism or a optimal mechanism based on the two existing mechanisms to implement the autonomous (re)transmission for R17 URLLC on shared spectrum channel:   * *Stage 2,which mechanism shall be the baseline or introducing another optimal mechanism which is a combination between two existed mechanism for performing the autonomous transmission or autonomous retransmission for R17 URLLC on shared spectrum channel*   For the last stage, we can discuss the IE configuration (i.e whether to concurrent configuration of ***autonomousTx and cg-RetransmissionTimer*** ) to implement the outcome of stage 2:   * *Stage 3: To design a new IE or reuse the current IE to make the conclusion from stage 2 work.*   Without any agreements on stage 1 and 2, we cannot go too far to discuss much detail things. |
| OPPO | No but need more discussion | Firstly, from our perspective, no clear benefit is foreseen for simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer.*  Technically, as we mentioned above, when *cg-RetransmissionTimer* is configured, whether IIoT autonomous transmission can work depends on the status of CG timer and the corresponding HARQ process. Thus, RAN2 should firstly clarify whether CG timer is running and what is the status of the corresponding HARQ process for the deprioritized MAC PDU once LBT success. According to current MAC spec, if CG timer is considered as running for the case where LBT succeeds but the corresponding UL grant is deprioritized, NRU autonomous retransmission operation is performed, and there is no need to configure *autonomousTx*. Otherwise, i.e. if CG timer is considered as not running, there is a chance to go to the branch of IIoT autonomous transmission operation, and it is possible to configure *autonomousTx* accordingly. |
| Samsung | No |  |
| Intel | No | We think similar logic for Rel-16 can be applied for Rel-17. These two features should not be configured simultaneously in Rel-17. |
| Lenovo | Yes, but | However we need to further study whether the two mechanism work together as intended. For example autonomous (re)transmission functionalities may overlap. In general the detailed protocol behavior should be further studied. |
| III | No |  |
| vivo | Yes | The function of autonomousTx and cg-RetransmissionTimer are not overlapping.  Autonomous retransmission is applied to the case that transmission has been performed without cancellation in Uu, i.e. LBT is success.  The autonomousTx is applied to handle the case where the transmission has not been performed or been started but not completed (i.e. canceled) in Uu.  To cover both the two cases, allow simultaneous configuration of autonomousTx and cg-RetransmissionTimer is preferred. |
| Apple | No but | We don’t see how the two features can benefit from being configured together unless further enhancements are introduced. |
| Sequans | Yes but | We can analyze potential interactions further. |
| Xiaomi | Yes |  |
| InterDigital | Yes | CGRT can be configured with a value 1 for an immediate autonomous retransmission, thus allowing IIoT autonomous transmission operation. |

**Summary:**

**Proposal:**

CATT (R2-2008860) argues that configuring IIOT’s *autonomousTx* can lead to abnormal behavior in some configurations. The considered scenario is when *cg-RetransmissionTimer* = configuredGrantTimer (i.e. there is no autonomous retransmission). In this case, the paper argues that IIOT autonomousTx will kick in at the next occasion and this is not a desired behavior.

**Question 5.4: Are they any scenarios where configuration of *autonomousTx* and *cg-RetransmissionTimer* can lead to abnormal behavior?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | No | We believe the “abnormal behavior” is mainly discussed in R2-2008859, and it seems the concerned problem occurs when the gNB still decodes the MAC PDU successfully even though its was deprioritized in the middle of its transmission. It seems to be a corner case that rarely happen, and therefore from our perspective we think introducing restriction on configuration to handle such situation may degrade gNB flexibility unnecessarily. |
| LG | No but need more discussion | CGT is always larger than CGRT. Thus, abnormal case pointed in 8859 doesn’t exist.  In the meanwhile, we need to clarify how the current spec reads if both are configured concurrently. An example scenario is given in R2-2010439 and RAN2 need to check if we have the same understanding.  Example in 10439: Assume that an UL grant is 'deprioritized' at T1, 'prioritized but pending' at T2 and then 'prioritized and not-pending' at T3. In this case, it would be good to check if it is new transmission or retransmission. In our view, the MAC performs a new transmission in this case. |
| Ericsson | Generally, no | Our understanding is that with typical configuration the intended behavior is achieved, thus we consider the joint configuration of *autonomousTx* and *cg-RetransmissionTimer* as baseline. If there are corner cases due to how the current spec is written, we could consider them for later.  In reference to CATT’s outlined issue D, we think the timers (both cgTx and cgRetx) should not be started or be kept running, for a de-prioritized HARQ process (which might have been de-prioritized due to another later partially overlapping grant). This is a general intra-UE prioritization issue, and thus it should be clarified as Rel-16 correction. |
| MediaTek | Needs further discussion | CGT is always larger than CGRT, so the case raised by CATT is not a valid case.  Agree with LG that the cross-over of ‘de/prioritised’ and ‘not/pending’ cases will need further discussion, along with its interaction with CGRT. |
| CATT | Yes | As pointed by Ericsson, the usecase we refer to is usecase “D” in R2-2008859. Indeed, as we show in this contribution, when both *autonomousTx* and *cg-RetransmissionTimer* are configured, the only configuration where (IIOT) autonomous transmissions can occur is the configuration which was allowed in RAN2#111-e (RRC CR in R2-2008629) to support “immediate new transmission on CG” (R2-2007884) for traffic types where retransmission is considered useless (e.g. periodic deterministic transmissions with very short latencies). In such configuration, *cg-RetransmissionTimer* = *configuredGrantTimer*, which disallows NR-U autonomous retransmissions on CG in case of transmission failure, because each CG opportunity is expected to be used for new transmissions only.    But with *autonomousTx* configured, as shown in the above figure, the UE behavior on such configuration for a deprioritized CG is that IIOT autonomous transmission is triggered on the first available CGO after CGT expiry and restarts the timers accordingly. However, if the NR-U protocol for this configured grant configuration was configured to disallow any autonomous retransmission on CG, it is questionable whether the pending PDUs due to deprioritized grants should be recovered by autonomous transmissions, thus using a CGO in principle only dedicated to new transmissions in this configuration. So we consider that configuring *autonomousTx* in this configuration results in an inconsistent UE behavior for that configuration. |
| ZTE | - | See above comments, it is too early to discuss such detail things. We still have no idea what mechanism can be applied to the R17 URLLC on share spectrum channel. |
| OPPO | No but need some clarification | Regarding the abnormal behavior, it may not happen since it is required in RRC that CG retx timer is less than CG timer.  In addition, we need to clarify whether CGT/CGRT is running and whether the transmission is considered as performed, when LBT succeeds but the corresponding PUSCH is deprioritized and cancelled in the middle of its transmission. |
| Google | Maybe No | gNB implementation may prevent the “replacement” issue with different lengths of timer and CG periodicity. |
| Samsung | Too early | The impact should be discussed after HPI selection is concluded. Overall procedure is not clear at this moment.. |
| Intel | Too early | Agree with Samsung. |
| Lenovo |  | Not exactly sure what abnormal behavior means. However we need to further check whether there is some undesired behavior when *autonomousTx* and *cg-RetransmissionTimer* are concurrently configured. We also agree that the cross-over of ‘de/prioritised’ and ‘not/pending’ cases require further discussion as also pointed out in R2-2009598. |
| III | Too early | Agree with Samsung. |
| vivo | No | In NR-U, the *cg-RetransmissionTimer* is mandatory configured. Hence, *cg-RetransmissionTimer* = *configuredGrantTimer* is introduced to disable NR-U autonomous retransmissions on CG in case of transmission failure.  In Rel-17, most companies tend to agree the *cg-RetransmissionTimer is optional.* Hence, the autonomous retransmission can be disabled via not configure cg-RetransmissionTimer.  Take the above into account, for the usecase “D” in R2-2008859, cg-RetransmissionTimer should not be configured. Hence, we don’t think the usecase is a typical scenario of simultaneous configuration of autonomousTx and cg-RetransmissionTimer. |
| Apple | Too early | Agree with ZTE. |
| Sequans | Maybe No | We are not sure of any abnormal behavior for now but would be opened to further discussion. |
| Xiaomi | Too early | Agree with Samsung. |
| InterDigital | No | No issues foreseen. If issues arise, they can be discussed. |

**Summary:**

**Proposal:**

Nokia (R2-2009758) proposes the following:

*If both autonomous transmission and autonomous retransmission are configured, and a CG-PUSCH transmission is cancelled/deprioritized after the corresponding cg-RetransmissionTimer has started, the timer should be stopped upon PUSCH cancellation/deprioritization*

This proposal assumes that the UE starts the timer at the beginning of the slot. The rapporteur thinks that a UE implementation may wait for the end of the slot before actually starting the timer. However, it would be good to collect feedback if any other changes are necessary when simultaneous configuration happen.

Lenovo (R2-2009598) observes that there might be cases where it’s ambiguous for the UE to determine whether it should autonomoulsy (re)transmit a deprioritized/pending MAC PDU according to the NR-U autonomous retransmission functionality or the IIoT autonmous transmission functionality.

**Question 5.5: Are any optimizations needed to handle simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer*?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | Yes | At least currently in MAC we specified that the timer should start in the first OFDM symbol of the PUSCH. So it means autonomous transmission of a cancelled PUSCH cannot be applied until expiration of *cg-RetransmissionTimer* and this may be quite inefficient due to unnecessary waiting time. It’s might be true that we could avoid this issue with UE implementation by actually starting the timer in the end, but we are not sure if this is always implemented as such, so we prefer specifying it to avoid ambiguity. Besides, it seems to solve the UE-side ambiguity pointed out by Lenovo in R2-2009598 as well. |
| LG | Yes | It seems to be reasonable behavior to stop the CGRT when transmission is cancelled by CI-RNTI. For this, the timer stopping needs to be addressed explicitly. |
| Ericsson | No | Optimization is not needed, but spec clarification can be beneficial. See also comment on 5.4. |
| MediaTek | Yes | Some optimisations are needed when handling simultaneous configuration of autonomousTx and cg-RetransmissionTimer, such as that raised by Nokia. However this section of the specification is fairly convoluted at this point, and needs further discussion before agreeing to a solution. |
| CATT | Yes but | We agree that enhancements are foreseen for the NR-U CG protocol to properly handle deprioritized and preempted PUSCH transmissions along the lines of Nokia’s proposal but we think it is unrelated to the simultaneous configuration of *autonomousTx* and *cg-RetransmissionTimer.*  It has been specified in MAC that both *cg-RetransmissionTimer* and *configuredGrantTimer* are started at the beginning of the first symbol of the PUSCH transmission. So we agree with Nokia that stopping the timers when PUSCH cancellation/deprioritization happens would allow using a closer CGO for NR-U autonomous ReTransmission. And that’s an NR-U enhancement for handling deprioritized/preempted transmissions. |
| HW | No | We don’t need to support simultaneous configuration, and no optimization is needed. |
| ZTE | Yes for nokia, but it’s too early. | We still need more information or achieve a couple of agreements to determine whether this issue is existing.  As for the suggestion from Lenovo, this is an optimization not hormornization, we can discuss it if we have time to do that. |
| OPPO | FFS | Before we make any conclusions, spec clarification is needed to make us in the same line. Especially for this case where LBT succeeds but the corresponding UL grant is deprioritized, we need to clarify e.g. whether CGT/CGRT is running, whether transmission is considered as performed or not, what is the status of the corresponding HARQ process. |
| Google | No |  |
| Samsung | No | It’s better to support only single configuration at a given time |
| Intel | No | As in our reply to Question 5.3 and 5.4, we don’t think it is needed to configure those two features together. |
| Lenovo | Yes | There are cases which needs to be further studied when both *autonomousTx* and *cg-RetransmissionTimer* are configured. For example there could be the case that a MAC PDU/HARQ process is pending and the associated UL grant is deprioritized. For such scenarios where the two mechanism (IIOT and NR-U) “overlap” a clear UE behavior should be defined. |
| III | No |  |
| vivo | No | Agree with the case Nokia mentioned, the on-going CG cancellation happens only between the CG and CG collision. Cancel the ongoing transmission causes transmission interruption, and retransmission needs to be performed. But even if no stop of CGRT is ok. UE can retransmit the cancelled CG PUSCH after the CGRT expires, just increase some retransmission delay, but considering it is deprioritized data Re-Tx, the delay is acceptable. |
| Apple | FFS | As commented in earlier questions, this depends on design choices and potential enhancements can be studied. |
| Sequans | No but | Depends if abnormal behavior are seen (previous question). |
| Xiaomi | FFS | We think that more analysis is needed on the exceptional cases. |
| InterDigital | FFS | Optimizations can be looked at if needed. |

**Summary:**

**Proposal:**

In Rel-16, it was discussed whether de-prioritized PDU can be handled similar to NR-U LBT failure for example by using a similar timer, but this was not adopted. For Rel-17 UCE, some papers suggest discussing whether there could be any harmonization.

LG (R2-2010439) proposes that

* When an UL grant is de-prioritized by IIOT prioritization, there is no need to consider a HARQ process as pending because it is to be transmitted by IIOT autonomous TX;
* When a transmission is performed and cancelled later by CI-RNTI, there is no need to consider a HARQ process as pending because it is to be transmitted by IIOT autonomous TX

**Question 5.6: Do you support any harmonization between the handling of de-prioritization and autonomous retransmission? No means they are configured separately (possibly simultaneously per above discussion) and follow Rel-16 operation when configured. If Yes, please describe further.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | Yes | As commented above, the only possible issue we can see is that autonomous transmission could be blocked due to cg-retransmission timer, but basically we think they can be harmonized without much problem. |
| LG | Yes | Companies may have different assumption in harmonization from retransmission perspective. Some companies would think there is one dominant procedure when *cg-RetransmissionTimer* and autonomousTx are configured together and specification work is needed to include other procedure in the dominant procedure.  Our thinking is that retransmission is performed based on each event, i.e., autonomous tx if de-prioritized and autonomous retx if LBT failed. |
| Ericsson | No | We don’t see any issues with a joint configuration of *autonomousTx* and *cg-RetransmissionTimer*, and thus no optimization or harmonization where one feature takes over the use-case of other features is needed, as discussed above. |
| Sony | No |  |
| MediaTek | Yes | We see a need to harmonise these procedure, very simply, to ensure that expected UE behaviour is clear, and as intended by RAN2 (i.e. without unintentional side-effects) |
| CATT | No | We understand “harmonizing” in this question as an effort is trying to get features of both protocols to work together. If that is indeed the intention of the question, we don’t support harmonizing. We don’t see the point in trying to mix features of both NR-U and IIOT CG protocols, which will end-up in a suboptimal solution with combined complexities of both protocols. We prefer to address, for each protocol separately (NR-U and IIOT) the missing parts to properly handle IIOT over UCE.  Nokia’s proposal in 9758 is an example of improvement of the NR-U protocol for handling deprioritized transmissions.  On the other side, we propose in 8860 to enhance the IIOT protocol to allow pending PDUs due to LBT failure to be handled by autonomous transmissions. This can be simply fixed by adding LBT failure to the conditions for considering an UL grant as deprioritized. |
| HW | Yes | If only IIoT autonomous transmission mechanism is adopted, then LBT failure can be treated similar as deprioritized grant and can rely on autonomous transmission on CG or dynamic NW scheduled retransmission. |
| ZTE | Partly Yes | If the NRU pattern HARQ Process ID selection is used, and no MAC PDU is generated, the deprioritized UL grant’s HARQ process shall not be pending, otherwise, it need be pending for avoiding the mistake. |
| OPPO | Yes | If only NRU autonomous retransmission mechanism is adopted, the deprioritized MAC PDU is treated as pending even if LBT success, and we can rely on R16 NRU mechanism. |
| Google | No |  |
| Samsung | No |  |
| Intel | No |  |
| Lenovo | Yes | Same opinion as Mediatek |
| III | No |  |
| vivo | No | No issue is found to keep these procedures separately. Harmonization between the handling of de-prioritization and autonomous retransmission leads to more specification work and makes the protocol more complex. |
| Apple | Yes | Same opinion as MediaTek. |
| Sequans | No but | We think they are configured separately (possibly simultaneously). And also that we have “autonomous tx if de-prioritized and autonomous retx if LBT failed”. |
| Xiaomi | No | We should firstly identify whether there is any critical issue if we do not have harmonization for this.. |
| InterDigital | Yes | Optimization can be looked on a per need basis. TBs dropped because of LBT failure or because of intra-UE prioritization can be treated jointly. |

**Summary:**

**Proposal:**

## 2.6 Prioritization of re-transmissions

NR-U CG scheme gives higher priority to retransmission than any transmission. There was a brief discussion in RAN2#111e whether this should be re-visited considering that an initial transmission can have a higher logical channel priority than a retransmission.

Nokia (R2-2009758) proposes to use LCH priorities when comparing initial and re-transmissions. QC (R2-2008881) and Interdigital (R2-201010) also support this.

Ericsson (R2-2008881) does not see the need for any specification changes regarding this prioritization. HW (R2-2008853) also does not support this; however, in their proposal there is no autonomous retransmission for URLCC in unlicensed spectrum, i.e. it behaves as Rel-16 URLLC.

Lenovo (R2-2009598) proposes the following:

UE shall perform the UL grant prioritization functionality defined for Rel-16 I-IOT also for autonomous retransmissions, e.g. retransmission triggered by LBT failure, when *cg-RetransmissonTimer* and *lch-basedPrioritization* are configured concurrently.

ZTE (R2-2009912) suggests discussing this after resolving the simultaneous configuration of autonomous tx and retransmission.

**Question 6: For Rel-17 URLLC, should RAN2 consider methods to allow initial transmissions to have higher priority than re-transmissions in certain scenarios (e.g. considering LCH priorities)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | Yes | The key aspect of URLLC is to allow quicker delivery of higher priority data, so this makes sense to prioritize initial transmission if it conveys any delay-sensitive contents. |
| LG | Already possible | When cg-retransmissionTimer and lch-basedPrioritization are configured concurrently , if two CG, i.e., new transmission by autonomousTx and retransmission due to LBT failure, are overlapped, the current MAC seems already supports prioritizing CG by considering its priority by the following text:  1> else if this uplink grant is a configured uplink grant:  2> if there is no overlapping PUSCH duration of another configured uplink grant which was not already de-prioritized, in the same BWP, whose priority is higher than the priority of the uplink grant; and |
| Ericsson | No | With current specifications, *lch-basedPrioritization* handles the prioritization between overlapping CGs based on LCH priorities of data (of different traffic) that is or can be multiplexed on the CGs, independent of transmission/retransmission. Whereas, NR-U behaviour prioritizes retransmissions but among HARQ processes within one CG. We don’t see an issue arising from the joint configuration of the two operations. For the case where the same CG configuration is used for one traffic/service (e.g. CG periodicity according to this one traffic periodicity), there is no issue anyway. To cater different priority traffic, different CG configurations can be configured.  Moreover, introducing prioritizations according to LCH within one CG occasion would interfere or significantly change the general legacy MAC LCH multiplexing procedure, which is to distribute LCH data to one grant and there is one grant per CG occasion. As there are no clear benefits, we don’t consider this method (if feasible at all) as needed. |
| Sony | Yes | We think this is the best way to handle in order to prioritize the delay critical service. |
| MediaTek | No | As indicated in Q2, CGRT can be made optional. If CGRT is configured, the implicit understanding is that retransmissions are prioritized over new transmissions within the CG (set). If CGRT is not configured, retransmissions are deprioritized over new transmissions.  Furthermore, we agree with Ericsson that across CG configurations, there is no issue as they work independently. |
| CATT | Yes | IIOT over UCE should use *lch-basedPrioritization* rules rather than NR-U rules to handle intra-UE prioritization involving retransmission grants.  We have a different understanding than Ericsson and MediaTek that there is no issue with the different prioritization rules in R16 IIOT and NR-U.   * NR-U: retransmissions are always prioritized over new transmissions (and can use different configured grant configurations):  |  | | --- | | Section 5.4.1  For configured uplink grants configured with cg-RetransmissionTimer, the UE implementation select an HARQ Process ID among the HARQ process IDs available for the configured grant configuration. The UE shall prioritize retransmissions before initial transmissions. | | Section 5.4.2.2:  Retransmissions with the same HARQ process may be performed on any configured grant configuration if the configured grant configurations have the same TBS. |  * IIOT: retransmissions are prioritized based on LCH priorities, same as new transmissions:  |  | | --- | | For the MAC entity configured with lch-basedPrioritization, priority of an uplink grant is determined by the highest priority among priorities of the logical channels with data available that are multiplexed or can be multiplexed in the MAC PDU, according to the mapping restrictions as described in clause 5.4.3.1.2. |   We don’t see from the above texts that it can be interpreted that NR-U prioritizations operate within one CG configuration only, and are orthogonal to lch-based prioritizations. Instead we observe that current R16 specification specifies contradicting behaviors regarding the prioritization of retransmissions when both *lch-basedPrioritization* and *cg-RetransmissonTimer* are configured resulting in an undefined UE behavior thus preventing a network to configure both parameters simultaneously. |
| HW | No | If only autonomous transmission is supported, then this issue does not need to be discussed as this prioritization issue only makes sense when HARQ ID is selected by UE. |
| ZTE | No | If only take the initial transmission and retransmission into account, I think there is no need to discuss this, since the intention of introducing autonomous retransmission is to avoid the MAC PDU loss, we cannot say it is beneficial that higher priority URLLC transmission shall be guaranteed by taking a risk of MAC PDU loss for lower priority URLLC transmission. |
| OPPO | Yes | It may allow quick delivery of a higher priority data. |
| Google | Yes | We also think LCH prioritization can be used to determine the priority of initial transmission and retransmission. |
| Samsung | Too early to discuss | It should be discussed after simultaneous configuration and HPI selection are concluded. |
| Intel | No | Agree with Ericsson and MediaTek. |
| Lenovo | Yes | We think for cases when *cg-RetransmissonTimer* and *lch-basedPrioritization* are configured concurrently, the UE shall perform the UL grant prioritization functionality defined for Rel-16 I-IOT also for autonomous retransmissions, e.g. retransmission triggered by LBT failure. Otherwise it may happen that some high priority initial transmission is delayed due to some retransmission. We have a different understanding as LG on how the current MAC spec is to be interpreted. We have same view as CATT. In our understanding this is exactly one of those cases which needs to be further studied in order to ensure that UE behaves as desired when both *cg-RetransmissonTimer* and *lch-basedPrioritization* are configured concurrently. |
| III | Yes | Agree with Sony. |
| vivo | No | Agree with Ericsson. For new transmission and retransmission conflicts on the same CG configuration, retransmission is prioritized. For transmissions on different CG configurations (grants are overlapping in time), the LCH based prioritization is applied. |
| Apple | Yes | This is clearly one of the areas to be tackled in order to reach the KPIs required for URLLC services in a consistent manner. |
| Sequans | Yes | It makes more sense to respect the LCH based prioritization if configured. |
| Xiaomi | No | Agree with Ericsson and MTK. |
| InterDigital | Yes | For CG operation in UCE, the UE can benefit from prioritization between initial transmission (which may contain higher priority data/control) and retransmissions (due to UL LBT failure, CGRT expiring, or intra-UE de-prioritization). |

**Summary:**

**Proposal:**

## 2.7 LCH-based prioritization

Rel-16 URLLC introduced intra-UE prioritization rule for overlapping uplink grants, called LCH-based prioritization. This allows MAC to resolve conflict between CG-CG, CG-DG, and PUSCH-SR when they overlap based on prioritization rules. The motivation for this feature was to give higher priority to URLLC traffic when they compete for resources with other type of traffic.

The question is whether this should also be supported for Rel-17 URLLC in UCE.

Apple (R2-2009501) proposes to support “LCH-based prioritization as a baseline for intra-UE prioritization in NR-U and also “Investigate means how LCP restrictions can be used for all transmissions in NR-U”.

Samsung (R2-2010524) proposes that “*lch-based Prioritization* can be configured in unlicensed band”.

**Question 7: Should LCH-based prioritization be supported for Rel-17 URLLC in UCE?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | Yes | This feature is already configurable in Rel-16, and we do not see any reason why this is not supported in Rel-17 for UCE. |
| LG | Yes | LCH-based prioritization is a key feature guaranteeing good IIOT service. Thus, it should be supported as well in Rel-17. |
| Ericsson | Yes | The feature is largely independent from NR-U operation. We see it very useful to support. |
| Sony | Yes | As per Q6, it must be supported. |
| MediaTek | Yes |  |
| CATT | Yes | We agree with the above comments. |
| HW | Yes | We support to reuse IIoT intra-UE prioritization mechanism with LCH-based prioritization supported. And actually according to the WID, intra-UE prioritization related discussion will continue in Rel-17. |
| ZTE | Yes |  |
| OPPO | Yes |  |
| Google | Yes |  |
| Samsung | Yes |  |
| Intel | Yes |  |
| Lenovo | Yes |  |
| III | Yes |  |
| vivo | Yes |  |
| Apple | Yes |  |
| Sequans | Yes |  |
| Xiaomi | Yes |  |
| InterDigital | Yes |  |

**Summary:**

**Proposal:**

## 2.8 Other

There were some proposals which were in only one paper and therefore were not included in the discussion above. These are listed below. If there is more support, they can be discussed further. Some of them can also be discussed later when RAN2 makes progress on the more basic issues above.

1. RAN2 should investigate prioritization mechanisms aiming to decrease the likelihood of a collision of transmissions from different UEs for UE initiated CO in semi-static channel access. (Lenovo)
2. Whether the DFI is included in PDCCH DCI could be considered as optimization mechanism in NRU controlled environment. (CMCC) *Rapporteur Note: This seems to be RAN1 scope.*
3. The FFP duration (period) for the gNB and UE can be configured to be different. (Sony) *Rapporteur Note: This seems to be RAN1 scope.*
4. RAN2 should discuss “modification to HARQ process ID formula to support multi-TB transmission in a CG period.” (Intel)
5. RAN2 is kindly requested to discuss how to handle the potential waste of resources for cases when a UL transmission can’t be performed on a prioritized UL grant due to LBT failures. (Lenovo)
6. RAN2 should discuss whether the likelihood of LBT failure should be considered to determine grant priority for intra-UE prioritization. (Nokia)
7. Consistent uplink LBT detection and recovery is not supported for UCE. (LG)
8. RAN2 considers how to handle the received DFI.

**Question 8: Do you support any of the above proposals? Contributing company does not need to respond.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Nokia | 5 and 6 | If the MAC decides to prioritize a grant that cannot be transmitted eventually due to LBT failure, the benefits of intra-UE prioritization for URLLC data is diminished, and the overall efficiency is degraded. Therefore, the likelihood of LBT failure should be taken into account (e.g. the UE could prioritize the grant in the COT to ensure UE can at least transmit a PUSCH, rather than not transmitting anything). |
| LG |  | 7 can be discussed briefly as an implication of decision regarding Question 1. Given that RAN2 starts discussion the optionality of Rel-16 NR-U mandatory function in Rel-17 URLLC, consistent uplink LBT detection and recovery can be discussed as well. |
| Apple | 5 and 6 | These are potential enhancements RAN2 might discuss at a later stage. |

**Summary:**

**Proposal:**

# Conclusion

This contribution captured a summary of the contributions submitted to RAN2#112e for uplink enhancements in unlicensed controlled environments. Based on this, the following are proposed:

# References

R2-2008853 Discussion about uplink enhancements for URLLC in unlicensed controlled environment Huawei, HiSilicon

R2-2008859 Co-existence of NR-U and IIOT in R16 CATT

R2-2008860 Protocol selection for IIoT on unlicensed spectrum CATT

R2-2008881 Harmonizing UL CG enhancements in NR-U and URLLC Ericsson

R2-2008974 CG Harmonization in Unlicensed Controlled Environment Qualcomm Incorporated

R2-2008976 Uplink enhancements for URLLC in unlicensed controlled environments Intel Corporation

R2-2009117 On configured grant harmonization MediaTek Inc.

R2-2009501 Potential UL enhancements for URLLC in unlicensed environments Apple

R2-2009562 Consideration on URLLC over NRU OPPO

R2-2009598 Enhancements for URLLC in unlicensed controlled environments Lenovo, Motorola Mobility

R2-2009758 Uplink CG Harmonization for NR-U and URLLC Nokia, Nokia Shanghai Bell

R2-2009900 Considerations in unlicensed URLLC Sony Europe B.V.

R2-2009912 Considerations on the harmonization of enhanced configured grant on shared spectrum channel ZTE Corporation, Sanechips

R2-2009914 Discussion on CG harmonization for IIoT in unlicensed spectrum Google Inc.

R2-2010110 IIoT operation in unlicensed controlled environments InterDigital

R2-2010212 Harmonizing CG enhancements in NR-U and URLLC/IIoT vivo

R2-2010374 Discussion on CG harmonization for URLLC in unlicensed controlled environments CMCC

R2-2010437 Consideration on timers for URLLC/IIoT in unlicensed controlled environments III

R2-2010439 Harmonized support of IIOT on unlicensed band LG Electronics Inc.

R2-2010524 Uplink Enhancements for Unlicensed Spectrum Samsung