**3GPP T****SG-RAN WG2 Meeting #113-electronic R2-210xxxx**

**Online, January 25th – February 5th, 2021**

**Agenda item: 6.1.3**

**Source: vivo**

**Title: Report of [AT113-e][019][NR16 IIOT] UL Skipping (vivo)**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution is aimed at reporting the discussion and results of the following email discussion:

* [AT113-e][019][NR16 IIOT] UL Skipping (vivo)

Scope: Treat R2-2100028, R2-2100138, R2-2100524, R2-2100218, R2-2101793, R2-2101794, R2-2100340, R2-2101776, R2-2101352, R2-2101377, R2-2101378, R2-2101456, R2-2100341, R2-2100855

Phase 1, determine agreeable parts, Phase 2, for agreeable parts Work on CRs.

Intended outcome: Reports and Agreed CRs if any is agreeable.

Deadline: Schedule A

The rapporteur would like to point out the specific deadline for this discussion with two phases,

* In phase 1, companies are invited to provide their views by Jan. 28th (Thursday), 2021, 12:00 UTC.
* In phase 2, the corresponding summary report, CRs, and draft reply LS will be provided. Any comments on the CRs and draft reply LS are invited to be provided by Feb. 4th (Thursday), 2021, 12:00 UTC.

Hopefully, RAN2 can output agreeable 38.306/321/331 CRs related to the Rel-16 PUSCH skipping feature in this meeting. Otherwise, the corresponding RAN1 correction CR (i.e. R1-2009687) on PUSCH scheduling will not be approved in the RAN plenary again due to a lack of packeted RAN2 CRs. What’s worse, not only the dynamic PUSCH skipping feature but also the whole Rel-16 URLLC Intra-UE prioritization feature can not be implemented based on the PHY spec in the next version.

# 2 Participants

|  |  |
| --- | --- |
| Company name (participant name) | E-mail |
| Yitao Mo (Stephen) | yitao.mo@vivo.com |
| Huawei, HiSilicon (Chong Lou) | louchong@huawei.com |
| Ericsson (Zhenhua Zou) | Zhenhua.Zou@ericsson.com |
| Apple (Ralf Rossbach) | rrossbach@apple.com |
| Xiaomi (Yumin Wu) | wuyumin@xiaomi.com |
| OPPO(Zhe Fu) | fuzhe@OPPO.com |
| CATT (Pierre Bertrand) | pierrebertrand@catt.cn |
| Interdigital (Faris Alfarhan) | faris.alfarhan@interdigital.com |
| Qualcomm (Linhai He) | linhaihe@qti.qualcomm.com |
| Samsung (Jaehyuuk Jang) | jack.jang@samsung.com |
| LG (SunYoung LEE) | ssunyoung.lee@lge.com |
| Nokia (Chunli Wu) | Chunli.wu@nokia-sbell.com |
| MediaTek (Pradeep Jose) | pradeep[dot]jose[at]mediatek[dot]com |
|  |  |

# 3 Discussion

In the previous RAN2#112-e meeting, RAN2 had noted the RAN1 LS (i.e. R1-2007338) regarding DG PUSCH skipping (also namely dynamic UL skipping), After an offline discussion, the corresponding agreements are achieved as follows [1],

|  |
| --- |
| [016] Ph1 General agreements:   * RAN2 confirms that a new UE capability is introduced for Rel-16 dynamic UL skipping. * RAN2 assumes the field name of the new UE capability is *skipUplinkTxDynamic-r16*. * RAN2 assumes that the following is introduced for the field description of the new UE capability (this version is preliminary and the wording may be further updated):   Indicates whether the UE supports skipping UL transmission for a dynamic uplink grant indicated on PDCCH only if no data is available for transmission and no UCI to be multiplexed on the corresponding PUSCH of the uplink grant as specified in TS 38.321 [8].   * RAN2 assumes the Rel-16 dynamic UL skipping isper UE level. FFS whether it is mandatory. * RAN2 assumes the Rel-16 dynamic UL skipping is FDD/TDD differentiation. * RAN2 assumes the Rel-16 dynamic UL skipping is notFR1/FR2 differentiation. * The legacy capability bit (i.e. *skipUplinkTxDynamic*) is not dummified. * A new RRC parameter is introduced to enable Rel-16 dynamic UL skipping. FFS the field name. * The corresponding 38.321/331/306 CR and reply LS for Rel-16 dynamic UL skipping should be done along with the CG case. |

## 3.1 Capability aspects of Rel-16 DG PUSCH skipping

In the previous RAN2#112-e meeting, there was an FFS left that whether the Rel-16 dynamic UL skipping feature is mandatory.

According to the following text quoted from the TR 38.822 [3], we can know that legacy DG PUSCH skipping feature has become mandatory since Rel-16.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Mandatory/Optional |
| 3. MAC | 3-6 | Skipping UL transmission | 1) Skipping UL transmission for dynamic UL grant  2) Skipping UL transmission for configured UL grant | 1) Yes  2) No | No | 1) Optional with capability signalling. Mandatory with capability signalling from Rel-16  2) Conditional mandatory if the UE supports configured grant |

Considering that the new-defined DG PUSCH skipping feature is directly inherited from the Rel-15 feature, thus, rapporteur thinks it might be natural to set the Rel-16 DG PUSCH skipping as mandatory.

### **Q1: Do companies agree to make Rel-16 DG PUSCH skipping feature mandatory?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Detailed comments** |
| vivo | Yes | We can take the legacy feature as a reference and make it mandatory, which matches the conclusion made in RAN#80. |
| HW | No | Note that the legacy DG UL skipping feature has been captured as Optional since the orign of Rel-16. Given that the UL skipping behaviour is dramatically different from the legacy and the late stage (from v16.4.0), we share the concerns as most UE vendors that it should be Optional. |
| Ericsson | Yes | As the legacy dynamic UL skipping is basically not implementable, Ericsson thinks that this updated dynamic UL skipping feature should follow what has been agreed previously.  Note that the legacy DG UL skipping was not correctly captured in Rel-16, since the RAN plenary conclusion was missed in the Rel-16 CR discussion.  Lastly, to be precise, this is mandatory with capability signalling. |
| Apple | No | The RAN#80 agreement to make UL skipping mandatory in Rel-16 is based on the Rel-15 UL skipping functionality. The Rel-15 UL skipping feature is now considered broken and we will have an extended set of sub-features in Rel-16, hence the earlier assumption no longer quite applies.  At this point in time we don’t think the Rel-16 UL skipping feature has reached sufficient maturity for a mandatory feature, as additional aspects need to to be considered (for example TB repetitions). RAN2 should first stabilize UL skipping for Rel-16 and then review the RAN#80 decision at a later point in time. |
| Xiaomi | No | The Rel-16 UL skipping covers more cases than the Rel-15 UL skipping. The extra complexities for the Rel-16 UL skipping would require more implementation efforts, which should not be mandated for the UE. |
| OPPO | No | At least till now, we do not see any requirement to set R16 skipping feature as mandatory. |
| ZTE | Yes | We share the same view with rapporteur, keep aligned with R-15. |
| CATT | No | In our understanding, even the *SkipUplinkTxDynamic* in rel-16 is mandatory with IOT bit, it still could not be set to 1 since IODT is not available/mature. Furthermore, we agree with Apple that this feature in Rel-16 is different from that was agreed in RAN#80 meeting and whether it is mandatory or not should be reconsidered. |
| Qualcomm | No | We share the same view as Apple |
| Samsung | No | We share the view with Huawei and Apple. |
| LG | Yes | We share the view from Rappoteur. |
| Nokia | Yes | It should be mandatory with capability bit for Rel-16 UEs as agreed during the Rel-15 discussions since it is seen as an important feature. |
| MediaTek | No | We agree with others that since the behaviour is significantly different from legacy behaviour, it is too late to introduce this feature as mandatory for Rel-16. |
|  |  |  |

**Conclusion:**

13 companies have provided input on this issue. Amongst them, a majority (8/13) think that the Rel-16 feature should be optional and the previous agreement achieved in RAN#80 cannot be applied since the UE behavior for Rel-16 has been changed.

Therefore, rapporteur proposes:

**Proposal 1: The Rel-16 dynamic UL skipping is optional with capability signaling.**

## 3.2 Rel-16 CG PUSCH skipping

In the RAN1 LS [2] regarding CG PUSCH skipping with UCI, RAN2 is kindly requested to introduce a new capability to differentiate the new UE behavior of CG PUSCH skipping with UCI. Therefore, we need to consider whether to introduce a new UE capability for CG PUSCH skipping.

Amongst all the contributions [4]-[16] talking about the PUSCH skipping with UCI, views (e.g. proposals) on the capability of Rel-16 CG PUSCH skipping are summarized as follows,

|  |  |
| --- | --- |
| **Contribution Number** | **Views** |
| R2-2100138 | RAN2 confirms that a new UE capability is introduced for Rel-16 CG PUSCH skipping. |
| R2-2101794 | Add new UE capabilities to indicate whether the UE supports skipping of UL transmission for a dynamic grant and a configured grant if no data is available for transmission. |
| R2-2100340 | Introduce only one UE capability along with only one RRC parameter to enable Rel-16 UL skipping feature applied for both configured grant and dynamic grant. |
| R2-2101776 | RAN2 assumes that a new UE capability is introduced for Rel-16 dynamic UL skipping for configured grant with the field name of *skipUplinkTxDynamic-CG-r16*. |
| R2-2101352 | Introduce two new capabilities to indicate the support of the uplink skipping enhancement for CG and DG. |

Based on the input contributions, the majority view is that a new capability should be introduced for Rel-16 CG PUSCH skipping. So rapporteur proposes that a new UE capability is introduced for Rel-16 CG PUSCH skipping. Please companies to provide feedback on this.

### **Q2: Do companies agree to introduce a new UE capability for Rel-16 CG PUSCH skipping?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Detailed comments** |
| vivo | Yes | Take Rel-15 NR as the baseline, we think it is natural to separately introduce capabilities for DG PUSCH skipping and CG PUSCH skipping, considering the detailed attributes/execution timeline of these two features can be different. |
| HW | Yes | RAN1 is still discussing the repetition case for CG, so it would be more future-proof to have a dedicated UE cap for CG UL skipping in addition to DG. |
| Ericsson | No | Ericsson prefers one UE capability for Rel-16 UL skipping feature, to avoid the feature fragmentation and the complexity that it brings.  This feature is more related with the UL skipping itself and there is no need for differentiation between configured grant and dynamic grant. The network needs both features to work to alleviate the blind decoding complexity associated with grant skipping that has UCI-multiplexed. From the UE point of view, there does not seem to have any significant implementation challenges to support both dynamic grant and configured grant simultaneously.  If one checks the legacy intention, CG/DG are meant to be mandatory. For CG, it is conditional mandatory if UE supports CG; for DG, it is mandatory with capability bit from Rel-16. There is no intention to have them separately supported. Lastly, it is typically understood that one feature group corresponds to one capability bit and in this case, it is the MAC feature group 3-6.  For more complicated scenarios like reptition and others, it is okay for Ericsion to further discuss if a separate capability on the top of this common one is needed or not. |
| Apple | Yes | Considering that the legacy CG skipping behavior differs from what is envisioned for Rel-16 we think a new UE capability is required for CG PUSCH skipping in Rel-16. We also agree to the suggestion from RAN1 in that respect. Furthermore, we think that a common capability for both DG and CG would complicate the Rel-16 UL skipping feature due to its added implications. |
| Xiaomi | Yes | From our understanding, the Rel-15 CG uplink skipping would be quite different compared with the Rel-15 CG uplink skipping which requires to create a dummy MAC PDU for the UCI. Then a separate capability for the Rel-16 CG uplink skipping is anyway needed. |
| OPPO | Yes | The case in R16 CG skipping is much different from the one in R15, it is better to have a separate capability. |
| ZTE | No | Agree with Ericsson |
| CATT | Yes | We share the same view that CG uplink skipping is different from DG uplink skipping in R16. |
| Qualcomm | Yes | Rel-16 CG skipping requires different UE behavior from Rel-15 CG skipping, as well as Rel-16 DG skipping. It makes sense to introduce a new UE capability for Rel-16 CG skipping. |
| Samsung | Yes | As others said above, a separate capability would make clear the network implementation, as UE behaviour is different between Rel-15 and Rel-16. |
| LG | No | Given that skipping is mainly to remove dummy transmission on dense scheduling, we see no real case that skipping is only useful for CG/DG while not useful for DG/CG. Thus, one common capability for CG and DG seems sufficient. |
| Nokia | Yes | Ok to introduce capability bit for IoT purpose, but it should be mandatory as in Rel-15. |
| MediaTek | Yes | As the behaviour is quite different from legacy NR behaviour, a new UE capability is necessary. |
|  |  |  |

**Conclusion:**

13 companies have provided their views. And, obviously, the majority (10/13) would like to introduce a new UE capability for Rel-16 CG PUSCH skipping. Therefore, rapporteur proposes,

**Proposal 2: A new UE capability is introduced for** **Rel-16 CG PUSCH skipping.**

If the company’s answer to Q2 is Yes, the next coming questions are to discuss attributes of the new UE capability for Rel-16 CG PUSCH skipping.

### **Q3: What are companies’ preferences on the attribute of the new UE capability for Rel-16 CG PUSCH skipping (e.g. Per UE, M, not FDD-TFF DIFF, not FR1-FR2 DIFF)?**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Company** | **Response** | | | | **Detailed comments** |
| **Per** | **M** | **FDD-TDD DIFF** | **FR1-FR2**  **DIFF** |
| vivo | UE | Yes | No | No | We prefer to take the legacy CG PUSCH skipping feature as a reference, which is shown in the following, according to TR 38.822. |
| HW | UE | No | Y? | No | No strong view, but it would be simple to align with DG with respect to the attributes. |
| Ericsson |  |  |  |  | As the answer is No in the previous question, Ericsson’s view here is that CG/DG should be aligned. |
| Apple | UE | No | Yes | Yes | Since the UCI may contain the HARQ-ACK/CSI in another CC with different SCSs in CA mode, and the UE capability of the HARQ feedback timing is different for FR1 and FR2, the UL skipping enhancement capability should be differentiated for FR1/FR2. In addition, due to the different feedback timing, from the testing perspective, the FR specific capability is also required.  We think that FR1/FR2 DIFF should be used not only for the CG capability but also for the DG capability. Plus, FDD-TDD DIFF not can be set for both Rel-16 DG and CG capabilities, also considering that UE capability multipleConfiguredGrants is already defined as FDD-TDD diff. |
| Xiaomi | UE | N | N | N? | More inputs from RAN1 is probably needed. If some FR2 specific UCI is to be considered, maybe we should have FR1-FR2 differentiation. |
| OPPO | UE | No | Yes | No | We prefer to align it with the attributes for DG, unless any issues are found. |
| CATT | UE | No | No | No | We can align with the capability of DG UL skipping to simplify the procedure. |
| Qualcomm | UE | No | Yes | Yes | FDD-TDD DIFF: we think Rel-16 CG skipping should have the same FDD-TDD DIFF attribute as Rel-16 DG skipping, which RAN2 have agreed to be YES in the last meeting.  FR1-FR2 DIFF: Rel-16 CG skipping requires different UE behavior and hence different execution timeline as Rel-15 CG skipping. For example, Rel-16 CG skipping involves interaction between PHY and MAC and hence has more challenging timeline requirement. In addition, in the CA case, UE may multiplex HARQ feedback for a transmission scheduled on a different FR, for which UE may have a different UE capability (for the HARQ timeline). We therefore think UE capability for CG skipping should have FR1/FR2 differentiation. |
| Samsung | UE | No | Yes | No | We have same view as Huawei (and Ericsson). |
| LG |  |  |  |  | Share the view with Ericsson, i.e., common for CG/DG. |
| Nokia | UE | Y | N | N | UL skipping shouldn’t depends on TDD/FDD or FR1/FR2. |
| MediaTek | UE | N | Y? | N | Agree with HW that it would be simple to align with DG with respect to the attributes |
|  |  |  |  |  |  |

**Conclusion:**

* Per UE (12 companies have provided their views): All the 12 companies agree that the new CG PUSCH skipping feature is per UE level, which is the same as the DG PUSCH skipping .
* Mandatory (12 companies have provided their views): 8 out of 12 companies think the new feature should be optional.
* FDD-TDD-DIFF (12 companies have provided their views): Amongst the 12 companies' inputs, 8 companies propose that FDD-TDD DIFF attribute is preferred, which is also aligned with the Rel-16 DG PUSCH skipping feature.
* FR1-FR2-DIFF (12 companies have provided their views): Amongst the 12 companies' inputs, 10 companies prefer it is not FR1-FR2-DIFF.

Based on the above, it is clear that the majority of the companies agree with the Rel-16 CG PUSCH skipping feature is a per-UE level, optional with capability signaling, FDD-TDD-DIFF feature. Also, it is not FR1/FR2 differentiation.

**Proposal 3: The Rel-16 CG PUSCH skipping is per-UE level, optional with capability signaling, FDD-TDD-DIFF, and not FR1-FR2-DIFF.**

For the Rel-16 DG PUSCH skipping feature, it was agreed in the previous RAN2#112-e meeting that a new RRC was introduced to enable Rel-16 DG UL skipping, which helps to distinguish between Rel-15 and Rel-16 UE behavior, and provide more flexibility for network control.

If a new capability for Rel-16 CG PUSCH skipping is introduced, generally, the same logic might be also applied. Amongst all the contributions [4]-[16], views (e.g. proposals) on the RRC parameter for Rel-16 CG PUSCH skipping are summarized as follows,

|  |  |
| --- | --- |
| **Contribution Number** | **Views** |
| R2-2100138 | A new RRC parameter is introduced to enable Rel-16 CG PUSCH skipping. |
| R2-2101793 | Add enable flags and new UE capabilities to indicate whether the UE supports skipping of UL transmission for a dynamic grant and a configured grant if no data is available for transmission. |
| R2-2100340 | Introduce only one UE capability along with only one RRC parameter to enable Rel-16 UL skipping feature applied for both configured grant and dynamic grant. |
| R2-2101776 | RAN2 assumes that a new RRC parameter is introduced to enable Rel-16 dynamic UL skipping for configured grant with the field name of *skipUplinkTxDynamic-CG-16*. |
| R2-2101352 | Introduce two parameters to enable/disable the enhanced uplink skipping feature for CG and DG separately. |

Based on the input contributions, the majority view is that a new RRC parameter should be introduced for Rel-16 CG PUSCH skipping. So rapporteur proposes that a new RRCparameter is introduced for Rel-16 CG PUSCH skipping. Please companies to provide feedback on this if their answer to Q2 is Yes.

### **Q4: Do companies agree to introduce a new RRC parameter to enable Rel-16 CG PUSCH skipping?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Detailed comments** |
| vivo | Yes | A new RRC parameter is needed to indicate whether the Rel-16 CG PUSCH skipping is implemented. Otherwise, it is hard for the UE to distinguish whether to perform the Rel-15 behavior or the Rel-16 behavior, leading to potential misalignment between UE and NW. |
| HW | Yes | Agree as in R2-2101776 |
| Apple | Yes | In order to achieve configuration flexibility, UL skipping for CG and DG should be configured via a different parameters separately, as indicated in our contribution in R2-2101352. |
| Xiaomi | Yes |  |
| OPPO | Yes |  |
| ZTE | Yes |  |
| CATT | Yes |  |
| Qualcomm | Yes |  |
| Samsung | Yes |  |
| Nokia | Yes | In Rel-15, CG skipping is always enabled. Ok with configuration to distinguish between Rel-15 or Rel-16 operation. If not configured, the UE applies Rel-15 way. |
| MediaTek | Yes |  |
|  |  |  |
|  |  |  |

**Conclusion:**

11 companies have provided their views. All companies think a new RRC parameter is needed for the CG PUSCH skipping feature. Rapporteur also notices that 2 companies do not provide their understandings on this issue since they think one capability for both DG and CG is sufficient. Since the majority view is clear, the rapporteur proposes that,

**Proposal 4: A new RRC parameter is introduced to enable Rel-16 CG PUSCH skipping.**

## 3.2 Rel-16 PUSCH skipping with Intra UE prioritization

In the RAN1 LS [2][17], all the UE behaviors for Rel-16 DG/CG PUSCH skipping are defined under the conditions that Rel-16 URLLC Intra-UE prioritization (including PHY layer prioritization and LCH-based prioritization) is not configured. Thus, it is worthy for RAN2 to discuss whether the defined UE behaviors are still reasonable and acceptable when LCH-based UE prioritization is configured.

In [15], it is proposed that RAN2 should firstly clarify the UE MAC behavior when LCH-based prioritization is not configured and overlapping PUSCH transmissions have two PHY priorities with UCI, as depicted in the following figure 1. And it held a view that there is no need to consider PHY priority in the MAC grant prioritization procedure considering that the Rel-16 function had been stable and an overhaul of the grant prioritization in terms of the PHY-defined procedure and MAC-defined procedure should be avoided. In other words, from the MAC perspective, DG is always prioritized over CG when *lch-basedPrioritization* is not configured. As a result, the CG PUSCH is ignored (i.e. no MAC PDU will be generated even though it is overlapping with UCI) and does not participate in subsequent physical layer procedure.

On the other hand, in [11], a concern is raised that it is not reasonable to let an empty DG PUSCH override over CG PUSCH with data. Besides, it proposes that UE should select CG when CG has available data but DG has not in CG&DG overlapped case.



Figure 1 overlapping PUSCH transmissions have two PHY priorities with UCI

### **Q5: Do companies agree that DG always overrides CG when LCH-based prioritization is not configured (i.e. no MAC spec change is needed)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Detailed comments** |
| vivo | Yes | No further enhancements for Rel-16. |
| HW | Yes | Agree with the analysis from the rapporteur. No change is needed to MAC spec and it is the consequence of the existing procedure. |
| Ericsson | Yes | The concern of the other alternative proposal is that it contradicts the intention in the LS R2-2100028 |
| Apple | No | When LCH-based prioritization is not configured and CG and DG overlap, regardless of whether single or multiple PHY priority levels are used, if the CG has data available but the DG has not, based on the current specification the UE transmits padding in the MAC PDU together with the UCI over the DG and does not select the CG transmission. From transmission efficiency perspective the problematic case shown in Figure-2 of [11] should be avoided and UL grant selection should take the available data into account.  Furthermore, when different PHY priority levels are used for the UL transmission as in the rapporteur example above, the DG might be restricted to a single PHY priority through LCP restriction allowedPHY-PriorityIndex-r16. Here a potential problem exists when a LCH is mapped to DGs of low PHY priority only and there is no data available for this LCH while another LCH mapped to an overlapping CG (and mapped to DGs of high PHY priority only) has data available. Then if the DG (of low PHY-priority) is meant to carry UCI and cannot be skipped, the data available on the overlapping CG cannot be sent due to the DG taking precedence over the CG, according to the fallback to Rel-15 behavior when LCH-basedPrioritization is not configured. |
| Xiaomi | Yes | The gNB knows the CG occasion. The dynamic grant overriding the CG would be most likely that the gNB wants to schedule a dynamic grant for the URLLC data. It is rare that the gNB blindly schedules an dynmic grant to override a CG without knowing whether a URLLC data arrives. |
| OPPO | Yes | No enhancement is needed for this case. |
| ZTE | Yes | Legacy behavior shall be followed. |
| CATT | Yes | When LCG-based prioritization is not configured, we think R15 principle can be reused, i.e. DG always overrides CG. |
| InterDigital | Yes | No change is needed. It’s not typical to schedule an overlapping DG if there is no data. |
| Qualcomm | Yes | Agree with the rapporteur’s analysis |
| Samsung | Yes | Agree with rapporteur and Xiaomi. |
| LG | Yes | no MAC spec change is needed. |
| Nokia | Yes | Same as legacy. |
| MediaTek | Yes | The baseline assumption in the MAC specification should stay the same. The gNB has scheduled the DG to overlap with the CG, and we assume that this is an intentional choice made by the gNB. |
|  |  |  |

**Conclusion:**

14 companies have provided their views. 13 companies agree that the MAC entity will not take the PHY priority into account for overlapping DG PUSCH and CG PUSCH according to the current MAC spec. Only 1 company thinks that some enhancement is needed for resource efficiency. It is clear RAN2 understanding that DG always overrides CG when LCH-based prioritization is not configured, which is specified in the current MAC specification. No spec change is needed.

**Observation 1: DG always overrides CG when *lch-BasedPrioritization* is not configured, as specified in the current MAC specification.**

Before going into the details of UE behaviors for Rel-16 DG/CG PUSCH skipping with LCH-based UE prioritization, it might be better to first clarify the understanding of the current MAC spec with LCH-based UE prioritization. Rapporteur understands that the main preparation steps for the generation of the MAC PDU to be transmitted on DG/CG PUSCH are given as follows,

1. The MAC entity receives the UL grants including both dynamic grants and configured grants;
2. The MAC entity delivers the UL grants and the associated HARQ information to the HARQ entity;
3. The MAC entity determines whether a dynamic grant/configured grant is a prioritized uplink grant;
4. The corresponding HARQ entity instructs the multiplexing and assembly entity for the prioritized uplink grant;
5. Then the multiplexing and assembly entity performs the Logical Channel Prioritization (LCP), logical channel (LCH) selection, and resource allocation procedures (including determining whether the PUSCH skipping conditions are met or not);
6. The corresponding HARQ entity obtains the MAC PDU to transmit from the multiplexing and assembly entity;
7. The corresponding HARQ entity triggers a new transmission.

It is the rapporteur’s understanding that the LCH-based prioritization mechanism takes precedence over the PSUCH skipping conditions. In other words, even though the new Rel-16 PUSCH skipping conditions are introduced to MAC spec, the MAC entity will not generate a MAC PDU for a deprioritized uplink grant even though its associated PUSCH is overlapping with PUCCH.

### **Q6: Do companies agree with** **the understanding that LCH-based prioritization mechanism takes precedence over the PUSCH skipping conditions according to the existing MAC spec?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Detailed comments** |
| vivo | Yes | We agree with the above view. |
| HW | Yes | We share the view from rapporteur and don’t prefer to revisit the LCH-based prioritization in Rel-16 at this late stage. But it can be further discussed in Rel-17 in the context of intra-UE multiplexing where high priority UCI may be multiplexed on low priority data, in order to achieve a optimial solution of intra-UE from system performance perspective. |
| Ericsson |  | Although Ericsson agrees that this is what the MAC spec has been written, it is Ericsson’s view that “the MAC spec can also easily support that the UL-skipping condition related with UCI takes precedence over the LCH-based grant prioritization.” |
| Apple | See comment | We agree with the above rapporteur understanding on the procedure and steps for creation of a MAC PDU in the current MAC spec. However, while LCH-based prioritization takes precendence and happens before LCP and MAC PDU creation, RAN2 should try to accommodate the requirement from RAN1 while limiting the impact to both UL interference and gNB complexity.  The case where UCI is to be multiplexed in an UL transmission requires a balance between a) *‘always generating a MAC PDU’* (i.e., no skipping, no matter what’s the LCH priority and regardless whether or not there is data available) and b) *‘always giving full precendence to LCH-based prioritization’* as per the current MAC spec. |
| Xiaomi | Yes | We understand that always letting the LCH-based grant prioritized precedence over the UCI may not be optimum. However we also do not see a big issue with such approach. Maybe this can be discussed in the Rel-17 IIOT if companies consider some enhancments are needed. |
| OPPO | Yes | We agree with rapporteur’s understanding. |
| ZTE | Yes | The understanding on the UL grant operation from Rapporteur is correct. |
| CATT | Yes | But we think RAN2 should not discus this until RAN1 progresses further on UL skipping with/without UCI overlap when *lch-basedPrioritization* is configured and/or different priorities are configured in PHY. This to avoid inconsistent RAN1/RAN2 decisions. |
| InterDigital | Yes | LCH-based prioritization prioritizes grants considers buffered data to be multiplexed on each grant before selection anyway. |
| Qualcomm | Yes, but | We agree that the rapporteur’s understanding of the current MAC spec is correct. However, depend on the final outcome of the RAN1 discussion, the current MAC spec may (or may not) need to be changed. |
| Samsung | - | We share the view with Ericsson that to prioritize the UCI-multixed MAC PDU would be easily captured to the specification. Furthermore, we think it is the simplest solution considering impacts to both RAN1 and RAN2 specifications. |
| LG |  | In 5.4.1, the spec says that  The priority of an uplink grant for which no data for logical channels is multiplexed or can be multiplexed in the MAC PDU is lower than either the priority of an uplink grant for which data for any logical channels is multiplexed or can be multiplexed in the MAC PDU or the priority of the logical channel triggering an SR.  The above text is used to determine the priority of skipped grant.  It would imply that the MAC already knows whether the grant is to be skipped or not in LCH-based prioritization (in step3 of Rapporteur’s summary) although the skipping itself is handled in M&A (step5 of Rapporteur’s summary).  Strictly speaking, in this sense, it cannot be said that LCH-based prioritization mechanism takes absolute precedence over the PSUCH skipping conditions. |
| Nokia |  | Ok. We we understood RAN1 is still discussion different cases with LCH-based prioritization. Can also wait for further RAN1 input. |
| MediaTek | See comments | We agree with the principle that LCH-based prioritisation takes precedence over **legacy** PUSCH skipping conditions.  However there are **new** skipping/cancellation rules associated with the L1 priority indicator, that is prioritised over LCH-based prioritisation.  For example, if there’s a high L1 priority UCI and low L1 priority PUSCH in PHY, then the PUSCH is skipped (see 38.213, section 9).  These conditions are prioritised in MAC at step 3 above. Prior to determining whether a grant is a prioritised uplink grant or not, we check these L1 conditions as shown in the excerpt below:  ‘*When the MAC entity is configured with lch-basedPrioritization, for* ***each uplink grant whose associated PUSCH can be transmitted by lower layers****, the MAC entity shall:*  *…*  *3> consider this uplink grant as a prioritized uplink grant;*  *3> consider the other overlapping uplink grant(s), if any, as a de-prioritized uplink grant(s);*’ |
|  |  |  |

**Conclusion:**

14 companies have provided their views. 12 companies generally agree with the rapporteur’s understanding of UE MAC behavior of Rel-15 PUSCH skipping when LCH-based prioritization is configured. At the same time, several companies have come concerns that the details for Rel-16 PUSCH skipping with UCI is still discussed in RAN1 and the legacy principle might be revised with little normative work.

**Observation 2: LCH-based prioritization mechanism takes precedence over the Rel-15 PUSCH skipping conditions, as specified in the current MAC specification.**

Next, we come to discuss the UE behavior of PUSCH skipping when *lch-basedPrioritization* is configured. Contributions [4][10] propose the MAC entity does not generate a MAC PDU for a deprioritized uplink grant (i.e. DG and CG) when its associated PUSCH is overlapping with PUCCH (i.e. no spec change on the LCH-based prioritization mechanism). The basic intention is to reduce the spec impact and keep the general principle of the current LCH-based prioritization mechanism that data of higher priority should be prioritized over data of lower priority. Taking Figure 2 as an example, the MAC entity firstly performs the LCH-based UE prioritization procedure at the T1 moment, prioritizing the DG and deprioritizing the CG. As the CG is a deprioritized UL grant, the multiplexing and assembly entity will not be called. Consequently, no MAC PDU will be generated for the CG PUSCH even though there is a PUCCH overlapping with the CG PUSCH. From the PHY layer perspective, the UE transmits the DG PUSCH and the PUCCH (if timeline permits). On the NW side, once successfully decoded the DG PUSCH, it can know that the CG PUSCH is deprioritized and will detect the UCI on the PUCCH.

On the contrary, contributions [15][16] propose that a UCI-to-be-multiplexed grant should be prioritized even though no data is available. Otherwise, the gNB needs to blindly decode two hypotheses in each serving cell, i.e., one hypothesis is that UCI is multiplexed on CG PUSCH and another hypothesis is that the UCI is transmitted on PUCCH, which may highly increase the complexity of network detection in CA case. Taking Figure 2 as an example, the MAC entity should first prioritize the CG grant (e.g. with the highest priority) at the T1 moment, then the DG will be deprioritized. Finally, the UE can multiplex the UCI on CG PUSCH and transmit the CG PUSCH. On the network, double-decoding is not needed for the UCI.



Figure 2. PUSCH overlapping with PUCCH with LCH-based prioritization

Rapporteur thinks this is hard to conclude since both options are feasible and have their advantages. Anyway, a decision is needed and other potential options are not precluded for now. So the rapporteur thinks the following options can be considered:

- **Option 1:** The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH (i.e. no spec change on the LCH-based prioritization mechanism).

- **Option 2:** Prioritize the uplink grant for which there is UCI to be multiplexed (i.e. spec changes on the LCH-based prioritization mechanism is needed).

* Option 2.1: the highest priority can be used for a UCI-to-be-multiplexed grant;
* Option 2.2: network configurable priority adjustment (e.g. different priorities for PUSCH with data of lower priority and empty PUSCH);
* FFS other options.

- **Option 3:** …

### **Q7: What are companies’ preferences?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Which option(s) do you prefer?** | **Detailed comments** |
| vivo | Option 1 | If option2 is adopted, the MAC may prioritize an empty PUSCH (e.g. no data available) overlapping with a HARQ feedback for data of low priority over a PUSCH with data of higher priority. The general principle of Intra-UE prioritization would be broken, which definitely requires a lot of discussion on the new principle and spec polishment. We think it is too late for Rel-16.  For simplicity, we prefer Option1. Other enhancements can be further discussed in Rel-17 IIoT/URLLC WI. |
| HW | Option1, but | Again, we prefer not to revisit the LCH-based prioritization in Rel-16 at this late stage, and any optimization can be discussed in Rel-17. But we understand RAN1 is discussing the issue in parallel, so it would be good to indicate our RAN2 assumption to RAN1 a.s.a.p to avoid back and forth discussions. The most issential work in this meeting is to approve the package of RAN2 CRs to make UL skipping feature work together with RAN1 CRs. |
| Ericsson | Optoin 2.1 | As the raportuer concludes, both options are feasible. Option 2.1 has very little spec impacts as shown in the Ericsson’s TP.  @Vivo: The case indicated might not happen, since in that case the empty PUSCH should have the low PHY priority and the other PUSCH should have the high PHY priority. Even though the low PHY priority PUSCH grant has UCI multiplexed on it, according to the MAC spec, it cannot be transmitted due to overlapping with another high PHY priority grant and thus discarded. There are numerous other corner cases discussed in RAN1.  @HW: Option 2.1 is not revisiting the LCH-based prioritization. It is more a harmonization of the features between PHY and MAC.  More importantly, in the LS R2-2100026, it is written that RAN1 is further discussing the issues. It is preferable not to have parallel discussions in both groups.   |  | | --- | | When the MAC entity is configured with *lch-basedPrioritization*, for the collision scenario between CG and DG with same/different PHY-priority index, and when there is collision between PUCCH and the CG with the same priority and/or there is collision between PUCCH and the DG with the same priority, RAN1 is still discussing the related PHY layer behaviour. |   If consensus cannot be reached, Ericsson is fine to leave this to RAN1 with the indication that both options are feasible from Ran2 point of view. Ericsson also wonders the urgency to submit the CRs to the next RAN plenary, since, in addition to this intra-UE features, there is a further discussion on the repetiton. Thus, the submitted CRs would anyhow not be complete. |
| Apple | Conditional LCH priority adjustment | The network can configure through RRC a LCH priority adjustment applicable to UL grants with multiplexed UCI. As a result, UL grants with multiplexed UCI get a higher probability to become the prioritized grant. Since the priority adjustment happens before LCH-based prioritization, the change to the MAC spec is simple. The process of LCH-based prioritization itself is not changed. All that is required is a reference to the new RRC parameter indicating the rule used to adjust the LCH priority.  Our preference is Option1a-Alt-2 described in section 3.2 of [16] where the network configures a priority adjustment for HARQ-ACK and CSI.  Alternatively Option1-Alt-2 is possible as well.  If these two solutions are not agreeable then Option2 or Option3, which are also listed in [16], are further possibilities (in this order).  Note: If an UL grant with multiplexed UCI generally gets the highest LCH priority (like in Option 2.1), the UE ends up transmitting more ‘empty' PUSCH with multiplexed UCI (but no data) while overlapping PUSCH (with data) is not transmitted. This would increase power consumption for the UE and raise UL interference for the network.  We agree with Ericsson that the urgency to submit CRs to the RAN plenary is questionable due to the ongoing discussions in RAN1 and the need for additional aspects to be addressed in the UL skipping design (such as TB repetitions, and additional corner cases). We prefer a complete solution rather than a quick fix. |
| Xiaomi | Option 1 | We share the same view with Huawei. The potential enhancments can be discussed in the Rel-17 IIOT. |
| OPPO | Option 3 (i.e. Wait for RAN1 progress) or Option 1 | RAN1 is now discussing the same issue in parallel in the email discussion [104-e-NR-L1enh-URLLC-06]. Considering UCI multiplexing issue is triggered by RAN1 and it is better to avoid parallel discussion between RAN1 and RAN2, our first preference is to wait for RAN1 input firstly.  If majorities want to make a decision in RAN2, we agree with Huawei and Xiaomi, i.e. not to revisit the LCH-based prioritization at this late stage in Rel-16, and any optimization can be discussed in Rel-17. So. our second preference is Option 1. |
| ZTE | Option 1 | From the LS R2-2100026   * When the MAC entity is configured with *lch-basedPrioritization*, for the collision scenario between CG and DG with same/different PHY-priority index, and when there is collision between PUCCH and the CG with the same priority and/or there is collision between PUCCH and the DG with the same priority, RAN1 is still discussing the related PHY layer behaviour.   And take the below spec into account we think the priority handling procedure (i.e step 3 as above) may be changed if RAN1 achieve some interesting conclusion of PHY layer behavior (i.e the DG/CG multiplexing PUCCH shall be sent in the case that the MAC entity is configured with lch-basedPrioritiziation).  When the MAC entity is configured with *lch-basedPrioritization*, for each uplink grant whose associated PUSCH can be transmitted by lower layers, the MAC entity shall:  1> if this uplink grant is addressed to CS-RNTI with NDI = 1 or C-RNTI:  2> if there is no overlapping PUSCH duration of a 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  2> if there is no overlapping PUCCH resource with an SR transmission which was not already de-prioritized and the priority of the logical channel that triggered the SR is higher than the priority of the uplink grant:  3> consider this uplink grant as a prioritized uplink grant;  3> consider the other overlapping uplink grant(s), if any, as a de-prioritized uplink grant(s);  3> consider the other overlapping SR transmission(s), if any, as a de-prioritized SR transmission(s).  Hence we think it should be up to RAN1’s discussion, and no change is needed in MAC spec. |
| CATT | Wait for RAN1 | Same comment as Q6. |
| InterDigital | Option 1 or wait for RAN1 | It’s preferred not to drastically change LCH-based prioritization in Rel-16 at this point. Optimization can be discussed in Rel-17 |
| Qualcomm | Wait for RAN1 | This issue currently is being discussed in RAN1, and it is not clear yet whether the final solution would require change to the MAC spec or not. Since it is more of a RAN1 centric issue, we think RAN2 should wait for RAN1’s decision, to avoid potential inconsistent conclusions between RAN1/2. |
| Samsung | Option 2.1 | We have same understading as Ericsson. |
| LG | Option 1 | The problematic case would be that a MAC PDU for a PUSCH overlapped with PUCCH for UCI has lower priority (including skipped case) than a MAC PDU for a PUSCH not overlapped with PUCCH for UCI.  In option 1, UCI can be transmitted whichever grant is prioritized. In our view, it is not reasonable to deprioritize higher priority MAC PDU just because it cannot carry UCI even when UCI can be transmitted separately. Having a configurable priority even adds more and more conditions on prioritization procedure, which is not preferred from our side. |
| Nokia | Option 1 | Option 2.1 might not always work since as show in the figure, there might be no overlapping for the high priority grant for some cases. We understood RAN1 is discussion different cases, can wait for RAN1 conclusion. |
| MediaTek | Option 1 | The fundamental principle of LCH based prioritisation is that high priority information always takes priority regardless of whether it is transmitted on a CG or a DG. This operation implies that anytime prioritisation is configured, the NW is required to blindly decode multiple hypotheses.  If we go with Option 2, we break this fundamental principle of prioritisation, resulting in a system that is no longer suitable for operation in highly demanding IIoT scenarios. |
|  |  |  |

**Conclusion:**

14 companies have provided their views. 9 companies can go with option 1 since the fundamental principle of LCH based prioritization should not be broken in the late Tel-16 stage. Meanwhile, 5 out of these 9 and another 2 more companies think that the final decision anyway should be made by RAN1 (e.g. RAN2 wait for RAn1 input). Three companies think the double decoding issue on the network side should anyway need to be avoided because this is the original motivation of the enhanced Rel-16 PUSCH skipping feature. Rapporteur also noticed that RAN1 is still discussing the UE behavior when Intra-UE prioritization is applied. So the following is proposed,

**Proposal 5: Working assumption: The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH (This working assumption shall be confirmed with RAN1).**

## 3.3 Other potential impacts/enhancements

Last but not least, companies can provide their comments on the remaining issues of Rel-16 PUSCH skipping if they are not covered by this discussion.

### **Q8: Are there any additional comments on the remaining issues of Rel-16 PUSCH skipping?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Detailed comments** |
| vivo | Yes | Regarding the PUSCH repetition/aggregation impacts, we can wait for more RAN1 input and maybe discuss the potential RAN2 impacts in round 2 based on the RAN1 LS (if any). |
| HW | Yes | Agree with vivo. |
|  |  |  |
|  |  |  |
|  |  |  |

**Conclusion:**

**No proposal or observation is made.**

# 4 Conclusion

The contribution is summarized with observations and proposals as follows,

*DG PUSCH skipping:*

**Proposal 1: The Rel-16 dynamic UL skipping is optional with capability signaling.**

*CG PUSCH skipping:*

**Proposal 2: A new UE capability is introduced for Rel-16 CG PUSCH skipping.**

**Proposal 3: The Rel-16 CG PUSCH skipping is per-UE level, optional with capability signaling, FDD-TDD-DIFF, and not FR1-FR2-DIFF.**

**Proposal 4: A new RRC parameter is introduced to enable Rel-16 CG PUSCH skipping.**

*PUSCH skipping with LCH-based prioritization:*

**Observation 1: DG always overrides CG when *lch-BasedPrioritization* is not configured, as specified in the current MAC specification.**

**Observation 2: LCH-based prioritization mechanism takes precedence over the Rel-15 PUSCH skipping conditions, as specified in the current MAC specification.**

**Proposal 5: Working assumption: The MAC entity does not generate a MAC PDU for a deprioritized uplink grant even when its associated PUSCH is overlapping with PUCCH (This working assumption shall be confirmed with RAN1).**

# 5 References

[1] RAN2 112-e Chairman Notes EOM Corr w ChMark 2020-11-17.

[2] R2-2100028, LS on PUSCH skipping with UCI in Rel-16, vivo.

[3] 3GPP TS 38.822, User Equipment (UE) feature list, V15.0.1.

[4] R2-2100138, Remaining Issues on PUSCH Skipping with UCI in Rel-16, vivo.

[5] R2-2100524, Draft Reply LS on PUSCH skipping with UCI in Rel-16, vivo.

[6] R2-2100218, Correction for DG and CG UL skipping with UCI overlap, CATT.

[7] R2-2101793, Correction on CG-DG skipping capabilities and configuration when PUCCH with UCI overlaps with PUSCH, CATT.

[8] R2-2101794, Correction on CG and DG skipping capabilities when PUCCH with UCI overlaps with PUSCH, CATT.

[9] R2-2100340, UL PUSCH skipping without intra-UE prioritization, Ericsson.

[10] R2-2101776, Updates to RAN2 aspects of PUSCH with UL skipping, Huawei, HiSilicon.

[11] R2-2101352, RAN2 Impact on UL Skipping Enhancement, Apple.

[12] R2-2101377, MAC CR on UL skipping enhancement, Apple.

[13] R2-2101378, RRC CR on UL skipping enhancement, Apple.

[14] R2-2101456, UE capability on UL skipping enhancement, Apple.

[15] R2-2100341, UL PUSCH skipping with Intra-UE prioritization, Ericsson.

[16] R2-2100855, UL skipping and intra-UE prioritization, Apple.

[17] R1-2007338, LS on PUSCH with UL skipping, vivo.