**3GPP TSG-RAN WG1 Meeting #101-eR1-200xxxx**

**e-Meeting, May 25th – June 5th, 2020**

**Agenda Item:** 7.2.5.7

**Source:** Moderator (LG Electronics)

**Title:** Summary of [101-e-NR-L1enh-URLLC-IIoTenh-04]

**Document for:** Discussion and decision

# Introduction

According to discussion at the preparation phase, the following email thread is allocated by Chairman for further discussion:

[101-e-NR-L1enh-URLLC-IIoTenh-04] 6.1. Discussion on CG-CG/DG with same priorities and drafting reply LS for R1-2003259 by 5/29 and corresponding TP (if any) by 6/5 – Duckhyun (LGE)

To address the identified issues from companies’ contributions related to the above email thread, the suggestions for the issues are provided in Section 2. [In Section 3, a few open issues identified are listed up so companies are encouraged to provide your input/feedback in the next meeting in order to facilitate the discussion]. In section [4], the outcome from [101-e-NR-L1enh-URLLC-IIoTenh-04] are provided including all the agreements and all the endorsed TPs.

# Email discussions

## Issue 6.1: Collision between CG and CG/DG with same priorities (including LS R1-2003259)

In this meeting, there is incoming LS from RAN2 (R1-2003259), regarding intra-UE prioritization cases with uplink grants overlapping in time. According to the LS, some undesirable behavior could occur due to inconsistent conflict handling between RAN1/RAN2. To resolve this inconsistency, two options which are specified by RAN2 as following.

1. RAN2 changes MAC specification to accommodate current PHY behaviour. With this option, MAC will avoid providing second MAC PDU with the same L1 priority to PHY, meaning that PHY would transmit the packet with lower LCH priority data.
2. RAN1 changes PHY specification to accommodate current MAC behaviour of prioritizing the second MAC PDU provided from MAC.

In [21-25], some companies provide drafts of reply LS.

In order to reply the LS, we would like to collect companies’ preference on those options.

* Option 1
  + Support: ZTE[1,21], Ericsson[3], Samsung[8], LG[10], MTK[12], Qualcomm[16,20], vivo[17,22 ], Nokia[19,24](no change RAN1 spec.)
* Option 2
  + Support: CATT[5,23] (only if no UCI multiplexing), Huawei[17], Sony[13] (for UE supporting or configured with L1 priority), oppo[25]

Main discussion point would be a feasibility of the cancellation via second MAC PDU. Here is companies’ view on the feasibility

* The reason of infeasibility
  + Timeline won’t be guaranteed
  + A moment when MAC PDU is delivered cannot be specified
  + It needs to redesign entire UCI multiplexing/prioritization behavior at the very late CR phase.
    - Especially, it may potentially produce the unintended dropping of a high-priority HARQ multiplexed onto the deprioritized PUSCH.
  + It will lead to unnecessary increase in gNB complexity, DL control load, reduced DL & UL system efficiency, and reduced inter-UE CG PUSCH multiplexing capabilities

As an additional discussion point, vivo[17] suggest to ask RAN2 how to handle the collision case in MAC layer if MAC layer intra-UE prioritization is not supported or not configured, i.e., LCH-based prioritization is not configured

## FL’s suggestions on the issue 6.1

In order to discuss the LS, R1-2003259, we need to conclude whether or how to support CG-DG/CG collision with same priority since we haven’t discussed these aspects. If there is no overlapping grant, the issue in the LS needs not to be discussed.

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| **In 38.214, Section 6.1:**  A UE is not expected to be scheduled by a PDCCH ending in symbol 𝑖 to transmit a PUSCH on a given serving cell overlapping in time with a transmission occasion, where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321], starting in a symbol 𝑗 on the same serving cell if the end of symbol 𝑖 is not at least 𝑁2 symbols before the beginning of symbol 𝑗. The value 𝑁2 in symbols is determined according to the UE processing capability defined in Clause 6.4, and 𝑁2 and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH. |

Considering current specification above, it is already supported for dynamic grant to override configured grant if the timeline satisfies. With same priority, it would be common understanding to follow Rel-15 CG-DG behavior.

**Proposed Conclusion: For the collision between DG PUSCH and CG PUSCH with same priority, the DG PUSCH can be scheduled overlapping in time with CG PUSCH occasion if Rel-15 timeline satisfies.**

Companies are encouraged to provide your preference or editorial correction if any on above proposal.

**Comment:**

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| Company | Comment if any |
| Nokia, NSB | Support the conclusion.  The Rel-15 flexibility within the same priority should be retained. |
| Apple | Support the conclusion. |
| vivo | Support the conclusion |
| Qualcomm | Support the proposed conclusion. |
| CATT | We would prefer to go one step further to support overlapping DG PUSCH and CG PUSCH with same priority even if Rel-15 timeline does not satisfy. We understand that UE complexity issue was raised if Rel-15 timeline is not satisfied, but we would like to understand the concern better. In Rel-16, we support a LP PUSCH to be pre-empted by a HP channel and a HP PUSCH to pre-empt a LP channel w/o satisfied Rel-15 timeline, we would like to understand the difference in terms of UE implementation. In addition, for overlapping PUSCHs with different L1 priorities, depending on the discussion in eCG AI, it may or may not be supported. If it is supported, the Rel-15 timeline may or may not be met. We would like to understand the difference in terms of UE implementation for these cases as well. |
| HW/HiSi | We do not agree with the proposed conclusion.  Also for DG vs CG, the later grant should be prioritized. Re-using the Rel-15 rules is not desirable for the following reasons:   * Using a dynamic grant is in general more spectrum efficient than a configured grant. The configured grant, on the other hand, achieves lower latency. When possible, it can be expected that the gNB applies a DG to schedule a first UL transmission. If the UE then has to send another UL transmission with higher LCH priority, it should use the CG. Otherwise, the incurred latency of the new transmission would become too long. Therefore, the CG should be prioritized if it comes later than the DG. * Also, if the Rel-15 rule is re-used, then probably also the DG/CG case where the CG has a higher priority would need to be re-considered. But I assume that this is not desired by anyone. When the CG has higher PHY priority, the MAC PDU should be generated and sent to PHY. If a new rule for this case is supported by everyone, why not using the new rule for the same PHY priority as well? * If MAC has PDUs for two grants to assemble (DG and CG) with the same PHY priority and the CG has higher LCH priority, then MAC should generate the PDU for the CG and send it to PHY. But if PHY always prioritizes the DG, it would contradict to this. Re-using the Rel-15 rule for PHY would basically deny the grant prioritization procedure in the MAC layer. This is not reasonable in our understanding, especially when considering that UE grant multiplexing is a RAN2 led topic. |
| CMCC | we slightly prefer to support later grant override earlier grant with some restrictions, i.e. only if no UCI multiplexing proposed by CATT |
| Samsung | Agree. |
| ZTE | Support the conclusion |
| Sony | We do not agree with the proposal. We share same view as Huawei that CG is useful for low latency transmissions and so it is likely to be used for URLLC to overwrite a DG-PUSCH. Also Rel-15 does not have a high or low L1 priority. As far as the specs is concerned if L1 priority is not configured, it is regarded as low priority. So perhaps we can do the following:   * **For CG and DG that are High L1 priroity, the later PUSCH overrides the earlier PUSCH.**   This will then conform to Rel-15 rule but still allows the UE to use (High L1 priority) CG to carry a high LCH priority packet that overrides an earlier (High L1 priority) DG-PUSCH. |
| FUTUREWEI | In rel-15 had hoped for better handling of DG vs CG, where CG could be prioritized in some cases. We should support improved handling in rel-16 as best we can, with whatever restrictions, etc are needed. This would require modification to the conclusion. |
| InterDigital | Support the conclusion. |
| Intel | Support the conclusion. |

For the collision between two CG PUSCHs, it has been discussed how to utilize multiple configured grants in enhanced CG AI. Based on the previous agreement, one purpose of multiple configured grants is to enhance reliability and reduce latency by overlapped configuration with PUSCH repetitions.

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| Agreements:   * Multiple active configured grant configurations for a given BWP of a serving cell should be supported at least for different services/traffic types and/or for enhancing reliability and reducing latency   + FFS details   + Note: it is understood that the above may be related to RAN2-led work on intra-UE multiplexing |

In this sense, it seems clear it is allowed to configure/schedule overlapped two configured grant PUSCHs. However, it is still necessary to discuss how-to. Based on the current MAC specification, MAC is already choosing one grant among overlapped configured grant according to LCH-based priorities. If priorities are equal, it is up to UE implementation how UE chooses one grant between two configured uplink grants.

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| **In 38.321, Section 5.4.1:**  NOTE 6: If there is overlapping PUSCH duration of at least two configured uplink grants whose priorities are equal, the prioritized uplink grant is determined by UE implementation. |

Though this is only when the MAC entity is configured with lch-basedPrioritization, there is no reason to have different UE behavior when the MAC entity is not configured with lch-basedPrioritization. At least for this discussion, I would like to suggest to have common background assumption as below

**Proposed Conclusion**:

* **RAN1’s understanding is that the prioritized uplink grant is determined by UE implementation when the MAC entity is configured with lch-basedPrioritization, if there is overlapping PUSCH duration of at least two configured uplink grants whose priorities are equal.**
* **RAN1’s understanding is that the prioritized uplink grant is determined by UE implementation when the MAC entity is not configured with lch-basedPrioritization, if there is overlapping PUSCH duration of at least two configured uplink grants.**

Companies are encouraged to provide your preference or editorial correction if any on above proposal.

**Comment:**

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| Company | Comment if any |
| Nokia, NSB | We agree with the intention to treat this the same, but then it seems in the second bullet the ‘whose priority is equal’ is missing!?   * **RAN1’s understanding is that the prioritized uplink grant is determined by UE implementation when the MAC entity is not configured with lch-basedPrioritization, if there is overlapping PUSCH duration of at least two configured uplink grants whose priorities are equal.**   If this is added – we support! |
| Apple | We support the proposed conclusion from FL. |
| vivo | We support the intention here. But for the second bullet, we think it is better to be clarified or confirmed by RAN2 for “when the MAC entity is not configured with *lch-basedPrioritization*”. |
| Qualcomm | There is no need to have an explicit conclusion here as it makes some assumptions on how MAC should work. We only need to let RAN2 know whether RAN1 prefers option 1 or option 2 of the LS. |
| CATT | We assume priorities in the first bullet refer to LCH priority.   * **RAN1’s understanding is that the prioritized uplink grant is determined by UE implementation when the MAC entity is configured with lch-basedPrioritization, if there is overlapping PUSCH duration of at least two configured uplink grants whose logical channel priorities are equal.**   In general, we share the similar view with Qualcomm that we do not discuss this in RAN1. Our understanding is that for both cases, MAC would not deliver multiple MAC PDUs to PHY. |
| HW/HiSI | We do not agree with the proposed conclusion.  The agreement shown above is for the case “when the MAC entity is configured with lch-basedPrioritization”. In our view it applies when there is the same LCH priority level for both transmissions. Then, of course, it should be left for UE implementation. This agreement has in our view no relevance for the situation that is discussed in this LS reply.  The case we are discussing for this LS, is that the MAC layer has already decided that the later grant has the higher LCH priority and should be transmitted. Otherwise it would not send it to PHY.  There are 16 levels of LCH priorities but only two PHY priorities. A UE can support multiple services. In order to support multiple services efficiently in the UE, RAN1 should follow the desired handling from RAN2 and ensure that the later grant can be transmitted. |
| CMCC | Support the proposed conclusion and fine with Nokia’s update. |
| Samsung | We share same view with Qualcomm. We don’t need to have RAN1 conclusion for that since it is not asked by RAN2 in LS. This email thread should address LS issue only. |
| ZTE | Partially support the proposed conclusion. We could agree “**the prioritized uplink grant is determined by UE implementation**” but one sentence of “Two grants have different MAC priority, UE follow MAC prioritization.” in FL’s email needs clarification, if UE follows MAC prioritization (I guess it is LCH priority), what is the detail behavior to following MAC prioritization? Maybe it is not UE implementation issue. |
| Sony | Share same view with CATT & QC. This is a MAC procedures and it should be up to RAN2 to decide if it is up to UE implementation and so we do not need to conclude this in RAN1 and not need for LS reply. |
| InterDigital | Agree with Qualcomm. This is for RAN2 to decide. |

If above two are concluded, we can discuss on following two options in the LS.

1. RAN2 changes MAC specification to accommodate current PHY ehavior. With this option, MAC will avoid providing second MAC PDU with the same L1 priority to PHY, meaning that PHY would transmit the packet with lower LCH priority data.
2. RAN1 changes PHY specification to accommodate current MAC ehavior of prioritizing the second MAC PDU provided from MAC.

Following are collected companies’ preference on those options.

* Option 1
  + Support(8): ZTE[1,21], Ericsson[3], Samsung[8], LG[10], MTK[12], Qualcomm[16,20], vivo[17,22 ], Nokia[19,24](no change RAN1 spec.), Apple, InterDigital, Intel
* Option 2
  + Support(4): CATT[5,23] (only if no UCI multiplexing), Huawei[17], Sony[13] (for UE supporting or configured with L1 priority), oppo[25]

Main discussion point would be a feasibility of the cancellation via second MAC PDU. Here is companies’ view on the feasibility

* The reason of infeasibility of option 1
* The reason of infeasibility of option 2
  + Timeline won’t be guaranteed
  + A moment when MAC PDU is delivered cannot be specified
  + It needs to redesign entire UCI multiplexing/prioritization behavior at the very late CR phase.
    - Especially, it may potentially produce the unintended dropping of a high-priority HARQ multiplexed onto the deprioritized PUSCH.
  + It will lead to unnecessary increase in gNB complexity, DL control load, reduced DL & UL system efficiency, and reduced inter-UE CG PUSCH multiplexing capabilities

Since RAN2 asked RAN1 to provide feedback on **“which option is more feasible/appropriate”**, I would like to suggest to discuss which options is feasible or not, it would be a pre-condition to choose one of options, especially option 2 (Since option 1 has RAN2 impact and RAN2 proposed this). If someone think both are not feasible and has a solution not one of listed options, it is also appreciated to provide that.

**Q1: Which option is more feasible in the perspective of RAN1.**

Companies are encouraged to provide view on the feasibility. For a proponent of option 2, please also provide opinion on the listed reasons of infeasibility of option 2 above. If collected preference is wrongly captured, please let us know.

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| Company | Comment, if any |
| Nokia, NSB | Option 1 is overall more feasible, as the negative side-effects (such as HARQ-Ack dropping, need for re-tx) as discussed in our contribution [R1-2003583](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_101-e/Docs/R1-2003583.zip) need to be considered as well – not just the latency of a single UL-SCH packet. |
| Apple | 1. It is too late to entertain the possibility of changing physical layer specification to align with the MAC behavior, 2) also as pointed by companies such as Nokia, the negative side effects with Option 2 are quite severe; so we support Option 1. |
| Vivo | Based on our analysis in [R1-2003347](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_101\Docs\R1-2003347.zip), there are two interpretations in 38.214 for handling the DG vs. CG with the same priority.   * Interpretation 1: for DG and CG with same priority i.e., both CG and DG are high priority or both CG and DG are low priority, Rel.15 rule applies, DG is prioritized over CG and CG may not starts the transmission. In such case, CG MAC PDU shall not be generated in MAC. * Interpretation 2: for UE reports the capability of intra-UE prioritization, CG may or may not start Tx. If earlier CG starts Tx, later DG can cancel the CG under the timeline restriction *M*. In such case, PHY layer can support two MAC PDUs are delivered from MAC, but the DG is always prioritized over CG.   If interpretation 2 is adopted, PHY layer handling is aligned with the MAC layer handling if the second MAC PDU is the DG and first MAC PDU is CG. While it is not aligned if second MAC PDU is the CG and first MAC PDU is DG. We would like to understand which interpretation is for Rel.16 UE behaviour.  For CG vs. CG, we have not discussed, it is possible to align with the MAC layer handling, the timeline to cancel the first MAC PDU can be left to UE implementation.  We think it is better to first check which case PHY layer handling is not aligned with MAC layer handling, then what is the options. |
| Qualcomm | We support Option 1; under Option 1, MAC will generate a single PDU, and no change in the RAN1 specification is needed. It should also be noted that as in a realistic case, the UE is aware of the data in the buffer, and the case of data just-arrived is unrealistic, performance will not be compromised. |
| CATT | We support option 2.  Regarding the issues mentioned for option 2, our views are as follows.   * + Timeline won’t be guaranteed   It is related to the first proposed conclusion. As we commented, we do not think the timeline needs to be guaranteed, which is similar as overlapping UL channels with different L1 priorities.   * + A moment when MAC PDU is delivered cannot be specified   We think at least the order of MAC PDU arrival is clear.   * + It needs to redesign entire UCI multiplexing/prioritization behavior at the very late CR phase.     - Especially, it may potentially produce the unintended dropping of a high-priority HARQ multiplexed onto the deprioritized PUSCH.   We have considered the issue and proposed a compromise solution to avoid UCI dropping, i.e. the second PDU is only prioritized if there is no UCI multiplexed on the first PUSCH.   * + It will lead to unnecessary increase in gNB complexity, DL control load, reduced DL & UL system efficiency, and reduced inter-UE CG PUSCH multiplexing capabilities   For gNB complexity, we do not see much difference from PUSCHs with different priorities. We are not clear why option 2 leads to increased DL control load, reduced DL&UL system efficiency and reduced inter-UE CG PUSCH multiplexing capabilities. |
| HW/HiSi | We support Option 2, it is more desirable from the performance point of view and it is feasible for implementation.  To address the concerns mentioned above by the FL:   * For the time-line, the same rules has for LP vs HP can be re-used. * For the case when UCI is included in the first transmission, it could be further discussed whether to skip cancelling the first transmission in this case. It should be a rather rare situation that three uplink transmissions are scheduled so tight in time that UCI is multiplexed into a first PUSCH which then is cancelled again because of a second PUSCH with higher LCH priority. Another option would be to move the UCI into the later PUSCH. * Regarding the increased gNB complexity. We do not see a significant increase of the gNB complexity. For the case that the gNB does not know whether the DG is dropped by a CG or the UL grant is missed. This would firstly only be true when the DG transmission has not started yet. But even then, the gNB can always schedule a retransmission with RV0, and then the UE would use this RV regardless if the UE had missed the UL grant, or it is dropped. About the concern that the gNB needs to detect another PUSCH during an ongoing PUSCH. This does exist already for LP vs HP. If a later CG 1 with higher L1 priority overlaps with another CG 2/DG or lower L1 priority, then the gNB also needs to detect the CG of higher L1 priority during the reception of the CG 2/DG |
| CMCC | We slightly prefer the compromised solution proposed by CATT. |
| Samsung | Support option 1. Option 1 is more feasible in the perspective of RAN1 since option 1 does not have any impact on RAN1. We also share views from companies supporting option 1. Although this is discussion for replying LS, we should consider carefully impact of RAN1 at very late stage of Rel-16 CR. Only essential corrections should be considered in perspective of RAN1. We think that option 2 would be seen as optimization. |
| ZTE | Option1. The pros of prioritizing the second MAC PDU is to accelerate the PUSCH with higher LCH priority, but the cons is delaying the PUSCH with lower LCH priority to a later time even the PUSCH comes firstly. Actually the prioritizing of the second MAC PDU with higher LCH priority seems likely the optimization but not essential issue to be solved. So the PHY standard work is not preferred for this, and option1 is the better choice. UE is not expected the MAC layer provides second MAC PDU with the same L1 priority to PHY. |
| Sony | Option 2. RAN2 already stated that they could not conclude to use Option 1 within RAN2 and we do not see why Option 2 is not feasible. Firstly, we proposed that Option 2 is used only for case where both CG & DG PUSCHs have High L1 priority so that we still conform to Rel-15 for Low L1 priority PUSCH:   * In terms of timeline, we share Huawei’s view that if this can be done between Low L1 Priority PUSCH & High L1 Priority PUSCH, it isn’t clear why it is an issue for a High L1 Priority PUSCH and another High L1 Priority PUSCH. * In terms of UCI multiplexing on an earlier DG-PUSCH, it should be noted that there are 16 priority levels at the Logical level. Here, the MAC decided that the later CG-PUSCH has higher priority than the earlier DG-PUSCH and so the same treatment should be used between a low L1 priority DG-PUSCH with a high L1 priority CG-PUSCH. Also, it should be more important to send the CG-PUSCH with higher logical priority than HARQ-ACK feedback for PDSCH because:   + A URLLC PDSCH would very likely be received (with BLER of 10-5 to 10-6)   + If gNB did not receive the HARQ-ACK bits, it will retransmit the PDSCH anyway.   *Hence dropping the UCI would not lead to the UE failing its PDSCH URLLC latency. However, dropping the CG-PUSCH would mean the UE fails to meet the URLLC latency*.   * It isn’t clear where there is any gNB mire complexity than a Low L1 Priority DG-PUSCH vs High L1 Priority CG-PUSCH. |
| FUTUREWEI | We should take the RAN2 work and request seriously and try for Option 2, rather than just pick the option with less work for us. It may be that some restrictions are needed, such as for the UCI issue mentioned by Nokia. From the responses gNB should be feasible. |
| InterDigital | We support Option 1. |
| Intel | We support Option 1. Even if we would like to support the flexibility offered by Option 2, there does not seem an easy way to capture “order or MAC PDU arrival at PHY” in RAN1 specs without running into layer violation issues. |

# Open issues to be discussed

For section 3, it is recommended for companies to take into account the issues carefully and to come back with sufficiently specific options/preference/suggestions to the next meeting so that we can complete RAN1 works on the relevant functionalities with respect to specification.

# Final outcome from [101-e-NR-L1enh-URLLC-IIoTenh-04]

# References

1. R1-2003323, Remaining issues on SPS enhancements, ZTE
2. R1-2003393, Other issues for URLLC, vivo
3. R1-2003445, Remaining Issue of Other Enhancements for NR URLLC/IIoT, Ericsson
4. R1-2003582, Maintenance of Rel-16 URLLC/IIoT SPS enhancements, Nokia, Nokia Shanghai Bell
5. R1-2003625, Remaining issues on IIoT, CATT
6. R1-2003710, Remaining issues on DL SPS enhancement for URLLC, NEC
7. R1-2003741, Corrections for DL SPS and intra-UE prioritization involving CG PUSCH, Intel Corporation
8. R1-2003869, Remaining issues for Others, Samsung
9. R1-2003982, Remaining issues on enhanced DL SPS for IIoT, Spreadtrum Communications
10. R1-2004034, Remaining issues of other aspects for URLLC/IIOT, LG Electronics
11. R1-2004120, DL SPS enhancement, OPPO
12. R1-2004125, Remaining issues on intra-UE prioritization for URLLC, MediaTek Inc.
13. R1-2004184, Discussion on RAN2 LS on Intra-UE Prioritization, Sony
14. R1-2004227, Remaining Issues in eURLLC/IIoT, Apple
15. R1-2004394, Remaining issues for SPS enhancement for Rel-16 URLLC, NTT DOCOMO, INC
16. R1-2004461, Remaining issues on uplink collision handling and SPS for URLLC, Qualcomm Incorporated
17. R1-2004611, Corrections on other aspects for URLLC/IIOT enhancements, Huawei, HiSilicon
18. R1-2003347, Discussion on Intra-UE Prioritization, vivo
19. R1-2003583, Discussion on RAN2 LS on Intra-UE Prioritization, Nokia, Nokia Shanghai Bell
20. R1-2004433, Discussion on Intra-UE prioritization, Qualcomm Incorporated
21. R1-2003345, Draft reply LS on Intra-UE Prioritization, ZTE
22. R1-2003348, Draft reply LS on Intra-UE Prioritization, vivo
23. R1-2003584, [Draft] Reply LS on Intra-UE Prioritization, Nokia
24. R1-2003589, Draft LS reply on Intra-UE Prioritization, CATT
25. R1-2004124, [Draft] Rely LS on Intra UE prioritization, OPPO