3GPP TSG-RAN WG1 Meeting #110bis-e R1- 22xxxxx

E-meeting, October 10th-19th, 2022

Agenda Item: 9.10.2

Source: Moderator (Ericsson)

Title: Moderator Summary#1 – Study on XR Specific Capacity Improvements

Document for: Discussion, Decision

# 1 Introduction

This document provides a summary of the contributions submitted to RAN1#110bis-e under Agenda item 9.10.2 regarding the study of candidate enhancement techniques for XR capacity improvements, together with an overview and high level key questions to facilitate the discussions under the following email discussion assigned by Chair:

[110bis-e-R18-XR-02] Email discussion on XR capacity enhancement by October 19 – Sorour (Ericsson)

* Check points: October 14, October 19

Moderator presents the views on the candidate capacity enhancements techniques, based on the “common principle for assessment” that was agreed during the last meeting.

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| **Agreement:**   * For each candidate capacity enhancement technique for XR traffic, companies are encouraged to consider the following common principle for assessment of the candidate capacity enhancement technique:   + Identify the XR-specific issue(s) that the enhancement technique is addressing   + Identify the necessity of the enhancement technique to address the issues   + Identify whether/how the enhancements provide benefit/performance capacity gain.     - Consider at least feasibility, complexity, and system level performance evaluations in comparing the enhancement techniques. Power saving gains for a given enhancement technique can optionally be evaluated and considered in addition to these other aspects. * The baseline scheduling scheme when comparing the proposed capacity enhancements techniques is:   + Dynamic scheduling and/or   + Semi-persistent scheduling / Configured grant scheduling     - Note: Companies are encouraged to additionally use DG scheduling as the baseline scheduling scheme when showing the capacity performance gain   **Agreement:**   * To support a candidate capacity enhancement technique for XR traffic, capacity performance gain by the technique as compared to baseline should be shown.   + Capacity performance gain by the candidate technique as compared to baseline is a necessary condition to consider supporting the candidate technique.   **Agreement:**  Rel-17 evaluation methodology for XR capacity enhancement captured in TR 38.838 is used as the baseline evaluation methodology for XR capacity enhancement of Rel-18 SI on XR enhancements.  **For future meetings:**  Companies are **requested to follow** the following agreement and conclusion from RAN1#109-e. Check final FL summary for details.  **Agreement:**   * Rel-17 evaluation methodology for XR capacity enhancement captured in TR 38.838 is used as the baseline evaluation methodology for XR capacity enhancement of Rel-18 SI on XR enhancements.   **Conclusion:**  Companies are encouraged to use the capacity Excel sheet attached with TR 38.838 in [RP-213652](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_94e/Docs/RP-213652.zip)  for recording the simulation results that are provided in their contributions |

In the following sections, high level summary of companies’ preferences with respect to different enhancement areas are provided. The aim of the discussion is to assess the candidate enhancement techniques and provide valuable inputs for the technical report.

When feasible, few key questions are raised according to the agreed “assessment principle” that is summarized below.

**Summary of assessment principle:**

* **Q1: What are XR-specific issue(s) addressed by the enhancements?**
* **Q2: Whether the enhancement is necessary to address the issues(s)?**
* **Q3: Whether/how the enhancements benefit/performance capacity gain are provided?**
* **Note that capacity performance gain is necessary condition for supporting the enhancements**

# 2 SPS and CG enhancements

The followings are agreed/concluded previously:

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| **Agreement (RAN1#109-e)**  To study whether/how to support a candidate capacity enhancement technique for XR traffic based SPS/CG transmissions, companies are encouraged to consider the following studies:   * + - Study enhancements related to multiple PDSCHs SPStransmission occasions in a period     - Study enhancements related to multiple PUSCHs CG transmission occasions in a period     - Study enhancements related to dynamic adaptation of SPS/CG parameters/configurations     - Study enhancements related to non-integer periodicity for SPS/CG transmissions.     - Note: Other studies are not precluded, as well as the combination of the above studies. * Follow the *common principle for assessment of the candidate capacity enhancement technique*   **Conclusion (RAN1#110)**  There is no consensus in RAN1 on the benefits of enhancing SPS for the purpose of XR capacity enhancement |

The views regarding SPS/CG enhancements for serving XR traffic are summarized and discussed in the following sections.

## 2.1 Capacity performance evaluations for CG enhancements

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Companies with simulation results on CG enhancements (5):**

* **Ericsson, Huawei/HiSilicon, vivo, CATT, ZTE/Sanechips**
* **Supportive of CG enahncements:** 
  + **Yes (4): Huawei/HiSilicon, vivo, CATT, ZTE/Sanechips**
  + **No (1): Ericsson**

**High-level observations:**

* **Only 5 companies have provided simulation results among 24 companies with views on eCG.**
* **The issue for dynamic scheduling is SR delay and/or BSR delay, specialy for low PDB (10-15ms). Hence CG enhancements is discussed.**
* **Key observations:**
* **Ericsson:** 
  + Pre-scheduling DG provides higher capacity than DG, close to Genie. No need for eCG.
    - The assumptions for pre-scheding are considered based on XR wareness and/or learning based implementation.
  + Hybird CG-DG provides higher capacity than DG, close to Genie. No need for eCG.
    - CG resources are used to indicated incoming data and BSR. Non-empty BSR triggers DG.
* **Huawei/HiSilicon:**
  + Pre-scheduling DG improves DG performance (no delay due to SR/BSR).
    - The assumptions are considered ideal and not realistic. Hence, need for eCG.
* **Vivo:**
  + eCG (CG recycling) provides higher capacity than DG. Need for eCG.
* **ZTE/Sanechips**
  + eCG (adaptation/CG recycling) provides higher capacity than DG. Need for eCG.
* **CATT:**
  + XR specific CG resources followed by DG enables serving XR UL traffic during DRX off. Claimed benefits are power saving gain and serving XR traffic during DRX off. No capacity gain is provided.

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| **Company** | **Summary of Contributions inputs** |
| Ericsson | **Simulation cases:**   * **Genie scheduling based dynamic grant (Genie DG):** * The scheduling is based on dynamic grants where it is assumed BSR is available with zero delay at the scheduler when a new packet arrives in the UE buffer, to be used for indicating UL grants to the UE. This case is simulated to show the upper bound on capacity performance. See Figure **1**.     Figure 1: Illustration of Genie scheduling based dynamic grant (Genie DG) scheme   * **Dynamic grant (Normal DG):** * The scheduling is based on dynamic grants where it is assumed an SR is triggered upon arrival of a new video packet in the UE buffer. The network provides an initial grant of size 117 kbit as the minimum XR packet sizes used in simulation (See Note 1 below), upon receiving an SR. No knowledge of XR traffic periodicity is assumed. See Figure 2.   + Note 1: Given the traffic model specified in 38.838 [4], frame rate of 60 fps and data rate of 10 Mbit/s give approximate average packet size of 167 kbit. The minimum and maximum packet size is derived in such a manner that 99% of range of distribution centred around mean is covered, i.e., from mean minus three times standard deviation to mean plus three times standard deviation. This gives minimum packet size 117 kbit and maximum size 217 kbit.     Figure 2: Illustration of dynamic scheduling grant (Normal DG) scheme   * **Pre-scheduling dynamic grant (Pre-scheduling DG):** * The scheduling is based on dynamic grants where it is assumed that the network is provided with XR traffic periodicity. An initial grant to the UE when its traffic is expected is transmitted (implementation based learning) without using SR. The network provides an initial grant of size 117 kbit as the minimum XR packet sizes used in simulation. See Figure 3.       Figure 3: Illustration of Pre-scheduling dynamic grant (Pre-scheduling DG) scheme   * **Hybrid scheduling based configured and dynamic grant (Hybrid CG-DG):** * The scheduling is based on a combined use of configured and dynamic grants. SR resources are not used. Instead. CG resources are configured with minimum size in every UL slot in order to transmit BSR and small amount of data when new data arrives. Whenever XR packet arrives in a buffer, the UE uses the nearest possible CG occasion for BSR transmission and possibly small amount of data. The network can thus use the BSR to provide dynamic grants for the following data transmission. No knowledge of XR traffic periodicity is assumed. See Figure 4.     Figure 4: Illustration of Hybrid scheduling based configured and dynamic grant (Hybrid CG-DG)   * **Configured grant (Normal CG):** * The scheduling is based on configured grants where it is assumed that the network uses information on traffic periodicity, size statistics, TDD pattern, PDB, etc., to derive proper configurations for CG size and periodicity. The initial transmissions happen only on CG occasions, and retransmissions can occur on dynamic grant. See * We have simulated the performance curves for various CG configuration parameters as following and picked the best configuration for comparison with other schemes.   + PDB = 30 ms, CG with size / periodicity of (30 kbit / 2.5 ms), (60 kbit / 5 ms), and (90 kbit / 7.5 ms)     - The CG configuration with 5 ms periodicity and 60 kbit occasion size outperforms other CG configurations.   + PDB = 15 ms, CG with size / periodicity of (60 kbit / 2.5 ms) and (100 kbit / 2.5 ms)     - The CG configuration with 2.5 ms periodicity and 60 Kbit occasion size outperforms the other CG configuration.     Figure 5: Illustration of configured grant scheduling (Normal CG) scheme    Figure 6. Fraction of satisfied users, using the XR capacity KPI with target of 99% packet success rate, for Genie scheduling-based DG (upper bound), normal scheduling-based DG, pre-scheduling-based DG, normal CG and hybrid CG-DG for transmission of XR video in UL as percentage of number of satisfied users. Left: PDB = 15ms and Right: PDB = 30ms.  Table 1 Summary of simulation results for DG and CG scenarios   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | 30ms PDB | | 15ms PDB | | | Scenario | Capacity (#users) | Gain (comparing to Normal DG) | Capacity (#users) | Gain (comparing to Normal DG) | | Genie DG | 7.10 | 4.45% | 5.02 | 144% | | Normal DG | 6.80 | 0% | 2.06 | 0% | | Pre-scheduling DG | 6.86 | 0.9% | 4.85 | ~~121~~135% | | Normal CG | 6.35 | -6.48% | 2.75 | 33% | | Hybrid CG-DG | 6.97 | 2.56% | 4.97 | 142% |   Observation 3: Dynamicity of XR traffic with frequent/periodic occasions can be handled by existing specifications and gNB implementation.  Observation 4: Necessity of supporting new features to enable dynamic adaptation of CG transmission is not justified.  Proposal 4: Deprioritize studying the enhancements based on dynamic adaptations for CG based transmissions. |
| Huawei/HiSilicon | Figure 1. UL scheduling comparison (CG vs DG)  *Observation 1: The pros and cons of the above four cases are as shown in Table 1:*  *Table 1. Pros and Cons of DG and CG*   |  |  |  | | --- | --- | --- | | **Scheduling scheme** | **Pros** | **Cons** | | Case1: Legacy DG (first SR, then BSR with small grant, then UL data) | Not require prior information of XR traffic | Large delay due to SR/BSR report, thus causing capacity loss | | Case2: Legacy DG (first SR, then BSR with large grant, then remaining UL data) | No delay due to BSR report | Medium delay due to SR report, thus causing capacity loss especially when UL PDB is small | | Case3: Pre-scheduling DG (No SR, first BSR with large grant, then remaining UL data) | No delay due to SR/BSR report | Too ideal assumptions, may not be feasible in every real deployment.  E.g., it’s possible that gNB may not know accurate XR frame arrival/size information, UE may not be available to receive DCI in every slot (e.g., due to C-DRX, search space set, PDCCH skipping, etc.), etc. | | Case4: Configured Grant (CG) | No delay due to SR/BSR report | Need to handle variable frame size issue |     Figure 2. Capacity performance comparison between DG and CG  *Observation 2: Configured grant transmission can support more UEs compared with dynamic grant that requires SR/BSR report by reducing the transmission delay.*  *Observation 3: Pre-scheduling DG, which provides the upper bound of UL capacity in theory, has too ideal assumptions (e.g. gNB knows XR* *frame arrival/size information and UE* *are available to receive DCI in every slot), which may not be feasible in every real deployment. RAN1 needs to do comprehensive study which also considers more realistic assumptions.* |
| vivo | ***Observation 1: It is feasible to re-use legacy CG mechanism for conveying UL pose/control stream, as well as for BSR reporting for UL video traffic.***  ***Proposal 1: To convey BSR reports for UL video traffic, multiple CG configurations or non-integer CG periodicity can be considered to solve the non-integer XR traffic periodicity issue.***  For UL video stream, CG resources may also be configured to convey video packets for latency reduction, as well as DCI overhead reduction.    Figure 2. Example of CG resource recycling based on data volume  Table 1 System capacity performance for UL video stream in InH scenario   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Traffic model** | **Scheduling delay** | **Cases** | **Capacity (#UEs/cell)** | **Capacity gain** | | 10Mbps, 30ms PDB | 3ms | CG without resource recycling | 11.15 | - | | CG with resource recycling  (2.5ms recycling delay) | 11.79 | 5.74% | | CG with resource recycling  (0ms recycling delay) | 12.40 | 11.21% | | DG for all UEs | 13.71 | 22.96% | | 5ms | CG without resource recycling | 11.04 | - | | CG with resource recycling  (2.5ms recycling delay) | 11.60 | 5.07% | | CG with resource recycling  (0ms recycling delay) | 12.27 | 11.14% | | DG for all UEs | 13.60 | 23.19% | | 10Mbps, 10ms PDB | 3ms | CG without resource recycling | 7.17 | - | | CG with resource recycling  (2.5ms recycling delay) | 8.83 | 23.15% | | CG with resource recycling  (0ms recycling delay) | 9.38 | 30.82% | | DG for all UEs | 9.02 | 25.80% | | 5ms | CG without resource recycling | 4.60 | - | | CG with resource recycling  (2.5ms recycling delay) | 6.09 | 32.39% | | CG with resource recycling  (0ms recycling delay) | 6.78 | 47.39% | | DG for all UEs | 5.19 | 12.83% |  |  |  | | --- | --- | |  |  | | 1. 3ms scheduling delay for DG, 10Mbps video stream with 30ms PDB | 1. 3ms scheduling delay for DG, 10Mbps video stream with 10ms PDB | |  |  | | 1. 5ms scheduling delay for DG, 10Mbps video stream with 30ms PDB | 1. 5ms scheduling delay for DG, 10Mbps video stream with 10ms PDB |   ***Observation 2: In the case of 10Mbps@60fps with 10ms PDB, enhanced CG with resource recycling can achieve a system capacity close or even higher than that of DG scheduling.***  ***Proposal 2: Study CG PUSCH enhancements for UL video traffic, including the following:***   * ***Single CG configuration to align with UL XR burst periodicity, e.g., non-integer CG periodicity;*** * ***Single CG configuration with multiple transmission occasions within a CG period;*** * ***Recycling of unused CG resources within a CG period when configured CG resources within the CG period are more than required resources by the UL XR burst corresponding to the CG period, with potential assistant information exchanged between UE and gNB.*** |
| CATT | For the CG enhancement, the dynamic allocation of additional resource for XR data rate adaptation by dynamic grant could be included the at the CG occasion for the remaining packet data to be transmitted. The optimized configured grant is that the remaining packet data is scheduled by dynamic grant based on the UE reported by the BSR in the MAC subPDU at the CG MAC-PDU. If the BSR is reported by UE with the status “not empty”, UE would monitor the PDCCH in the subsequent slots for dynamic grant after XR packet transmission at the CG resource, in which the dynamic grant is used to schedule the remaining data of XR packet. In order for the same XR packet reception, the packets transmitted in CG and DG could be paired in the XR-specific CG configuration.    Figure 5: CG with additional resource allocation  Table 9: The evaluation results of the CG enhancement where the baseline is DG scheduling with UE always on   |  |  |  |  | | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | | **#satisfied UEs per cell** | **% of satisfied UEs** | **Capacity performance gain** | | DG scheduling with UE always on (Baseline) | 6 | 100.0% | - | | Single CG configuration | 0 | 0.0% | - | | CG enhancement | 5.9 | 98.3% | -1.7% |   **Observation 8: The capacity performance of the CG enhancement that** **additional resource requirement in a CG period is near to that of DG scheduling with UE always on and with the 1.7% capacity performance gap.**  **Proposal 9: The enhancement of Configured Grant UL transmission that additional resource requirement in a CG period should be considered as the enhanced scheme to support low latency and large data rate transmission of XR traffic.** |
| ZTE, Sanechips | * Simulation cases: Following case 1~ case 3 include the legacy CG, dynamic grant, and enhanced CG.   + Case 1: legacy CG   CG baseline假设  Figure 5 Legacy CG  In Figure 5, orthogonal CG configurations are configured among different UEs in one cell. Moreover, fixed MCS level and the number of layers are adopted.   * + Case 2: uplink dynamic grant   DG仿真假设   1. Agreed UL dynamic grant baseline (Case 2-1)   Argured DG 仿真假设   1. Another UL dynamic grant baseline (Case 2-2)   Figure 6 Dynamic grant with Tx delay (Note that DCI-x schedules PUSCH-x, while DCI-B schedules PUSCH only for BSR)  While in for XR use case, it seems challenging for gNB to predict the size of resources by the first UL grant. For simplification, we assume accurate size of resource for the first UL grant can be obtained with the ability of XR-awareness, while the allocated resource in the UL grant for a UE depends on the PF scheduler.   * + Case 3: CG enhancement   CG enhancement假设  Figure 7 multiple CG PUSCHs configuration with adaptive parameter adjustment  As shown in Figure 7, the assumptions are applied for multiple CG PUSCHs:   1. Overlapped resources can be configured among different multiple UEs 2. Unused resource is recycled. 3. Adaptive MCS level and the number of layers are applied.   Other evaluation assumptions have been listed in Appendix A.  Then the simulation results with different traffic models are shown below:   |  |  |  | | --- | --- | --- | |  |  |  | | (a) Traffic model 1: 20Mbps@60fps, 30ms PDB | (b) Traffic model 2: 20Mbps@60fps, 15ms PDB | (c) Traffic model 3: 20Mbps@60fps, 10ms PDB |   Figure 8 Capacity comparison among Case 1, Case 2 and Case 3 for 20Mbps@60fps traffic model with different PDB in Dense Urban scenario   |  |  | | --- | --- | |  |  | | 1. Traffic model 4: 10Mbps@60fps, 15ms | (b) Traffic model 5: 10Mbps@60fps, 10ms |   Figure 9 Capacity comparison among Case 1, Case 2 and Case 3 for 10Mbps@60fps traffic model with different PDB in Dense Urban scenario  For easier comparing these cases the above simulation results are summarized in Figure 10.   |  |  | | --- | --- | |  |  | | 1. 20Mbps@60fps | (b) 10Mbps@60fps |   Figure 10 Capacity summary of Figure 8 and Figure 9  Observation 7: CG enhancement is capable of bringing significant capacity gain compared to UL dynamic grant and legacy configured grant. Moreover, capacity gain increases when the required PDB decreases or the data rate increases. Analysis for capacity evaluation results **Resource occupation**   |  |  | | --- | --- | |  |  | | 1. Slot occupation | (b) Resource block occupation |   Figure 11 Resource occupation for Case 1(legacy CG), Case 2(DG) and Case 3(Multiple CG PUSCHs).  Observation 8: For multiple CG PUSCHs, the enhancements e.g., unused resource recycle and dynamic parameters adjustment are beneficial to achieve similar slots occupation with DG schemes from time domain resource occupation perspective.  Observation 9: For large packet size service, e.g. 20Mbps@60fps, in the uplink transmission, most frequency domain resource would be occupied for both CG and DG solutions.  **Transmission delay**  From transmission delay’s perspective, Case 2-1, case 2-2 considers the different transmission delay to simulate the procedure of SR-BSR-PUSCH transmission.   |  |  |  | | --- | --- | --- | |  |  |  | | (a) Traffic model 1: 20Mbps@60fps, 30ms | (b) Traffic model 2: 20Mbps@60fps, 15ms | (c) Traffic model 3: 20Mbps@60fps, 10ms |   Figure 12 Transmission delay comparison for Case 1&case 3, Case 2-1 and Case 2-2 in Traffic model 1~3 in Dense Urban scenario  Observation 10: For transmitting packets of 20Mbps@60fps traffic model in Dense Urban scenario, CG based solution has average [1.5] ms transmission delay considering UE is capable of transmitting data in the closest CG PUSCH. But DG based solution has average [3.0]~[6.0] ms transmission delay.  Proposal 1: Support to take multiple CG PUSCHs in a period as a candidate solution for XR service.  Proposal 2: For multiple CG PUSCHs, study and specify solutions of recycling unused CG PUSCH resources to improve resource usage efficiency.  Proposal 3: For multiple CG PUSCHs, study and specify solutions of dynamically adjusting CG parameters, including e.g., MCS level and the number of layers, to improve resource usage efficiency |

### 2.1.1 Initial Discussion

**Moderator’s suggestiosn for initial discussions:**

* **Q1:** Discuss your view on at least the practicality of assumptions for pre-scheduling, hybrid CG-DG and in comparison, with eCG (recycling/adaptation based)
* **Q2:** Discuss your view on eCG proposed by CATT, and whether it should be considered for this agenda item due to lack of capacity performance gain.
* **Q3:** Discuss your view on the necessity/benefit of eCG with considerations on simulation results**.**
* **Q4:** Discuss your view regarding the evaluation results and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TP.
* **Q5:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1: It is clear that DG always outperforms CG for capacity, especially for XR, with or without any CG enhancements; otherwise, the whole NR design is wrong. For latency, there is no issue in FR2 and possibly in FR1 in the NR bands having “sufficient” BW for XR that use 30 kHz. Pre-scheduling may be used as a complementary mechanism in FR1.  Q2: Almost all proposals can be analytically considered and that is preferable as it offers clarity. Regarding CATT’s proposal, if XR traffic arrives when the UE is not in Active Time, it is rather clear that the proposal can be beneficial. The question in our opinion is whether the scenario considered by CATT is a valid one and, if so, what is the point of having DRX.  Q3: No need for eCG – same reasons as for no need for eSPS.  Q4: Results not considering DG should not be captured. Results considering DG need to be discussed in detail for simulation assumptions and their overall relevance. We think that it would be beneficial to allocate some time for such discussions which may anyway be required in order to capture individual results in the TR. |
| **Futurewei** | Q1: PDCCH/DCI overhead is not the bottleneck for XR capacity as the number of UEs per cell is relatively small. DG should always provide better capacity than CG except when considering the latency introduced by SR/BSR. We are open to study CG related enhancement(s) when capacity improvement is shown.  Q2: In CATT simulation results, no performance gain over DG was able to show. And the gain over the baseline CG is due to additional DG. Therefore, we do not see the enhancement proposed it as one for capacity improvement.  Q3: We are open to study eCG if capacity gain over DG can be shown.  Q4: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| CATT | Q1: The pre-scheduling DG is similar to CATT’s proposed UL XR-PMW shown in Table 3 of R1-2208953 (also captured in section 3.5). The hybrid CG-DG is similar to CATT’s proposed eCG in Q2. We believe these two schemes are good techniques for XR system capacity enhancement  Q2: No system capacity gain of enhanced CG is due to the assumption of no SR delay of baseline dynamic scheduling with very dense SR resource configuration. We don’t have time to provide additional results of baseline dynamic scheduling with SR delay. CATT proposal of UL XR-PMW for dynamic scheduling (capatured in section 3.5) comparing with dynamic scheduling with 5 ms delay showed 33.3% system performance gain. We will provide additional results next time for comparing the baseline results with SR delay.  Q3: The study should include all evaluation results regarless gain or loss in system capacity in order to make conclusion of the study  Q4: All evaluation results should be captured. If there are questions on certain results, such as counter intuitive good performance results, such as UL capacity over 10 UEs, it should have notes to address the analysis and observation.  Q5: We like to clarify on vivo’s results of capacity over 10 users with/without resource recycling. Are the results based on MU-MIMO? |
| MTK | Q1: We tend to think hybrid CG-DG in current spec can already achieve good results. We also tend to agree with Samsung that by intuition DG should outperform CG for capacity. We can be open to discuss CG enhancement if RAN1 has common understanding that SR delay and BSR delay is inevitable and dominates PDB. (While this may be possible to be resolved by pre-scheduling as menionted by Samsung and tdoc from Ericsson)  Q2: The eCG proposed by CATT seems to suffer 1.7% capacity loss compared to DG. We can be open to consider it after CATT updated their results with SR delay in next meeting.  Q3: Currently we do not see the necessity due to lacke of demonstrated compacity gain.  Q4: We can capture results which considers DG in TR 38.835.  Q5: Whether SR delay and BSR delay is inevitable and dominates PDB. (While this may be possible to be resolved by pre-scheduling as menionted by Samsung and tdoc from Ericsson) |
| **ZTE, Sanechips** | Q1: For pre-scheduling DG, it is dependant of XR awareness information, which is too ideal. Moreover, which kind of information e.g., packet size statistics, actual packet arrival occasion can be obtained is unknown till SA’s conclusion.  Secondly, we need to further think that, i.e.,if the periodicity of UL grant of pre-scheduling DG was not aligned with the periodicity of packet arrival, there exists following problems:   * Transmission delay (e.g. the pre-granted resource is before the packet arrival) * Resource waste due to some periodic blank UL grant scheduling no data.   Besides, legacy BSR is conveyed in MAC CE transmitting in PUSCH with target BLER = 1%, implying BSR has a risk of transmission failure and cause extra transmission delay if SR is not transmitted in this case.  As to hybrid CG-DG, as CATT points out, in fact it is a kind of eCG.  Then, for CG, to be honest, if companies check the summaried results including ZTE,Huawei,CATT,vivo, it really doesn’t make sense to me to say that DG always outperforms CG for capacity.(DG compares with eCG).  Q2: Agree with CATT that more results can be provided to justify the benefit of eCG. Given collected result in this time, we think the benefit is from power saving metric. And it’s clear there is a trade-off between capacity and power saving.  Q3: According the simulation results, the drawback of dynamic grant baseline is SR-BSR/PUSCH procedure, which cause transmission delay. While **CG has natural advantage of reducing the scheduling/transmission delay.** In our view some CG enhancements have small specification impact, including e.g. multiple CG PUSCHs in a period, resource recycling etc. In additional, we also observed that eCG could bring capacity gain compared to pre-scheduling DG according with realistic simulation assumptions.  Q4: From our perspective, all enhancement techniques with reasonable evaluation results should be capture in TR 38.835, no matter they are high priority or low priority. Moreover, the reason for de-prioritizing the techniques should be stated in the document. |
| **LG** | **Q1:** DG always can be utilize suppliementally for CG. However, we think pre-scheduling is a kind of optimistic assumption. Based on current BSR, gNB may not acquire UE buffer information before traffic arrival. If gNB scheduling based on XR-awareness information, DG may not have significant benefit comparing to CG. Scheduling additional resource by dynamic UL grant is always possible even in current specification.  **Q2:** In existing system gNB can scheduling additional resource by UL grant or override configured CG resource as well. If CG resources need to be changed permernently, re-activation could be used. We don’t think proposed eCG has significant difference from those exisiting methodology.  **Q3:** Same as Q2.  **Q4:** Fine to capture.  **Q5:** In our view, main use case of CG is pose data traffic, which have static data size with short period. In this case, jitter handling would be the main issue to be solved. |
| **Panasonic** | Q1: We think the combination of CG and DG is a feasible approach for supporting XR traffics, considering the jitter of data arrivals.  Q2: The proposed technique could be further studied and considered.  Q3: We think there is no need for further CG enhancements. |
| **Google** | **Q1**:   * Pre-Scheduling: The pre-scheduling DG is relying on the gNB full awareness of the UL video frame arrival time and packet size to anticipate with a Pre-Scheduling. The awareness could be via signalling or via UE/gNB learning based implementation. These assumptions could be very difficult to agree at the moment with the lack of inputs from SA2/RAN2 on XR awareness. Also, the learning-based implementation is a very ideal assumption difficult to make at this stage. In terms of capacity enhancement, it shows less than 1% capacity enhancement compared to normal DG for the 30ms PDB required for the UL AR video traffic, which doesn’t justify this enhancement. * Hybrid CG-DG: UL pose and control information is a periodic traffic with no jitter and can use periodic CG configuration with no enhancement needed. The hybrid CG-DG can be useful for the UL AR video traffic. However, the PDB latency requirement for UL AR traffic is 30ms and the scheme seems to show less than 3% capacity gain compared to the normal DG, which is not enough to justify this enhancement. * eCG recycling/adaptation based: We think the use of multiple CG PUSCHS is beneficial and the use of adaptation and recycling techniques to improve this scheme is useful. The UE can request to cancel some occasions, add some occasions or to modify some occasions based on the arrival and the awareness of the UL traffic. However, the capacity gain is not very clear from ZTE’s results for the 30ms PDB requirement and vs. DG.   **Q2**: eCG as proposed by CATT where the CG is used and the remaining data is scheduled by DG and the UE switch to monitor PDCCH after sending a non-empty BSR. The capacity results dhow a degradation of 1.7% compared to DG. The enhancement can probably offer power saving gain compared to DG with continuous PDCCH monitoring but doesn’t seem to offer capacity gain  **Q3**: We are OK to study eCG if it offers capacity gain compared to DG.  **Q4**: Yes, we think the evaluation results should be captured as long as they use the agreed simulation assumptions. |
| **vivo** | Q1: In our opinion, pre-scheduling can be a feasible way for UL latency reduction, but realistic assumption should be made considering recycling of pre-allocated resources, resource efficiency, etc. Regarding the solution of hybrid CG-DG, it is a natural choice when CG resources are adopted to serve UL traffic. In summary, hybrid CG-DG, as well as DG, can be regarded as the baseline(s) to assess CG related enhancments, i.e. eCG.  Q2: Regarding the eCG solution proposed by CATT, since no capacity gain can be achieved compared to DG, we tend to not consider it for capacity enhancement.  Q5: Regarding CATT’s comment for clarification, in the simulation, SU-MIMO is assumed for evaluation of the performance of recycling of unused CG resources. |
| **Ericsson** | Q1:   * Hybrid CG-DG is based on existing specification. Hence no enhancement is needed and it is not an eCG.   + CATT proposal is similar to Hybrid CG-DG, BUT in CATT proposal, UE monitors PDCCH during DRX-OFF (spec impact). That is not the case for hybrid CG-DC (monitoring PDCCH during DRX-ON). * On Pre-scheduling and assumption of XR awarensse, we don’t think ideal/exact information is needed. A rough understand on XR packet sizes (which can be also obtained by learning imlementaiton is sufficient). What is important is to have an intital grant of reasonable size (not too small). Please see below when we simulated using initial grant as MIN/AVG/Max of XR traffic and obtaining similar results (in contribution, we showed only MIN)      * **ZTE:** On BSR comment on ZTE, it is unclear for us the reason. Consider URLLC where CG is used. If BLER was an issue, it should have been addressed fro URLLC. * **ZTE:** Ericsson also shows for low PDB, Baseline DG is not always better than CG (note that we used best case of CG for comparison). The issue is SR delay. That’s why we tried to show for XR traffic, we can address SR delay:   + Pre-scheduling is statistics of XR is available   + Hybird CG-DG (during DRX-ON) is no information is available. Please note we used in this case small CG resources in UL slots.   Q2: CATT proposal is suitable for power saving. No capacity gain is achieved.  Q3: We don’t think any eCG is needed. For the recycling schemes, if the additional information is considered in CG-UCI instead of multi-bit, then it is fine. Because this track is more consistent with current spec than changing SR to extend it to multi-bit. Etc.  Q4: We think at least the results showing meaningful capacity gain should be captured. |
| **Sony** | **Q1:** Pre-scheduling and hybrid CG-DG consume a lot of DL capacity (e.g., PDCCH) as well as DL power consumption. These issues have not been taken into account when companies provided simulation results for Pre-scheduling and hybrid CG-DG. For eCG, some eCG proposals do not impact on DL capacity and DL power consumption at all. In addition, eCG has a benefit of mitigating the scheduling delays.  **Q2:** All proposals should be on the table until Nov. Companies still have more time to provide more results.  **Q3:** The benefits of eCG are to mitigate the scheduling delays while providing performance similar or close to DG, as well as reduction of DL resource consumption (a plus sign).  **Q4:** We think we should have a fair treatment where all reasonable simulation results are captured in the TR provided that the baseline DG and CG are also simulated, and regardless of whether some are more favourable than others. |
| **InterDigital** | Q1: In our view, eCG is benefial for improving capacity and can be considered under enhancements related to adaptations of CG, e.g. for indicating any excess CG resources. We share similar understanding with ZTE that Hybrid CG-DG is a type of eCG, where DG resources can be requested when the allocated CG resources are insufficient, e.g. by including BSR when transmitting data with CG resources.  Regarding performance gains of CG over DG, from the evaluation results provided by some companies such as Huawei, vivo and ZTE, clearly the savings due to SR/BSR latency are useful for realizing capacity gains, particularly when considering PDB of 10ms for UL video.  Q2:We are open for discussing the benefits of eCG with more results as indicated by CATT under the capacity agenda, even though the gains may be in power savings.  Q3 - Q4:We think the latency reduction by avoiding SR/BSR are useful for realizing capacity gains for eCG compared to the legacy DG. We think the TR 38.835 should capture the evaluation results of any of the CG enhancement schemes that show gains over the baseline DG, including the conditions when eCG outperforms DG |
| **OPPO** | Q1: Although PDCCH overhead is not the bottleneck for XR, less detection of PDCCH can reduce the UE power consumption. Therefore, we think eCG can provide benefits for short latency and power saving.  Q2: We think CATT’s proposal is a hybrid CG-DG solution.  Q3: We are open to study eCG. |
| **Lenovo** | Pre-scheduling, at least if it is not single DCI scheduling multi-PUSCHs in cases that there is any jitter/inaccuracy w.r.t. XR traffic awareness may result in resource wastage.  Hybrid CG-DG may impact power saving (e.g., if DRX is configured) due to having CG resources in [many] slots. If gNB knows some traffic statistics or range of some XR paarmeters, the scheme may be more useful. |
| **Huawei/HiSilicon** | Q1: we think Ericsson’s “Hybrid CG-DG” seems to be legacy CG behavior, i.e.g, UE transmits on CG, and wait for dynamic scheduling if there is still remaining data, which is allowed by current spec. We are unclear about the “normal CG” in Ericsson’s simulation, it seems to be a new UE behavior.  In short, several companies’ simulation results prove that eCG can provide higher capacity compared with dynamic grant that requires SR/BSR by reducing the transmission delay. And re-allocate the unused PUSCH occasions to other UEs to avoid resource waste can improve capacity performance. Therefore, support eCG.  Q3: According to simulation results, eCG can provide higher capacity compared with dynamic grant that requires SR/BSR, especially in tighter PDB.  Q4: Simulation results of CG should be captured in TR. |
| **Nokia, NSB** | **Q1:** The simulation results provided by companies demonstrated that the scheduling delay caused by SR can significantly degrade the performance of XR users. Thus, solutions that minimizes the scheduling delay is of special importance.  From the simulation studies provided by companies, Pre-Scheduling DG and CG show the best results over conventional DG. As mentioned by HW, in case of pre-scheduling DG, UE may not be available to receive DCI in every slot (e.g., due to C-DRX, search space set, PDCCH skipping, etc.). Note that use of CG also comes with the advantage of avoiding failure due to UE PDCCH decoding failures as is the case for DG cases.  **Q2:** Therefore, CG is shown to be beneficial for XR use cases. During this meeting we need to agree whether the CG enhancements are necessary or not. Currently, two main problems were identified: (1) non-integer periodicity of video and (2) large video frame that can be conveyed over multiple slots.  Problem 1 need to be solved to help CG work properly when supporting XR.  Problem 2 can be solved by various means, e.g., by allocating multiple TBs per period, multiple CG configurations or by allocating extra resources with DG. We thus propose to concentrate on the proposed solutions and discuss the pros and cons o each of those and decide whether the enhancements are needed to support large video frame.  **Q4:** We also agree to capture the results and the observations related to CG following the assesment to TR 38.835. |
| **Qualcomm** | **Q1.** Some of the simulated schemes have ideal assumptions or assumptions with underlying standards impact. For example, the prescheduling scheme assume the gNB knows the packet distribution and arrival time. The simulations from Huawei show that CG is useful.  **Q2.** Considering that simulation results showed no performance gains then suggest to down prioritize. However, this is similar to one of our earlier proposals to have increased PDCCH monitoring around SPS/CG. The idea was to save power (and capacity wrt CG). Would be interesting to see PSG for this.  **Q3.** We think CG enhancements are useful for capacity and power savings  **Q4.** Agree that simulation results should be captured. |

## 2.2 Adaptation of CG parameters/configurations

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, companies have provided simulations results.

**Status of inputs in the contributions:**

* **Companies with view (16):** Huawei/HiSilicon\*, vivo\*, Nokia/NSB, IDC, QC, ZTE/Sanechips\*, Ericsson\*, CATT, ChinaTelecomm, OPPO, TCL, Sony, CMCC, Apple, Samsung, DCM
  + **Supportive (13)**: Huawei/HiSilicon\*, vivo\*, Nokia/NSB, IDC, QC, ZTE/Sanechips\*, ChinaTelecomm, OPPO, TCL, Sony, CMCC, Apple, DCM
  + **Not supportive (3):** Ericsson\*, CATT, Samsung
* **Companies with evalution results (4):** Huawei/HiSilicon\*, vivo\*, ZTE/Sanechips\*, Ericsson\*

**High-level observations:**

* **Only 4 companies have provided simulation results among 16 companies with views on eCG based on dynamic adaptation.**
* **Variety of adaptation schemes are proposed. Not clear how to relate the performance evaluation results to a specific proposed enhancement.**
* **High-level categorization of the proposals on dynamic adaptations of CG configuraitons**
  + **Group 1:** Dynamic indication of the unused CG PUSCH occasions by the UE to improve XR capacity performance
    - **Supported:** HW/HiSi\*, vivo\*, ZTE/Sanechips\*, Nokia/NSB, QC, IDC, China Telecom
    - **Not supported:** Ericsson\*, CATT, Samsung
  + **Group 2:** Dynamic indication to the UE to adjust CG parameters (e.g. MCS, number of symbols, number of PRBs, number of layers) to improve XR capacity performance
    - **Supported:** DCM, ZTE/Sanechips\*, TCL, CMCC
    - **Not supported:** Ericsson\*, CATT, Samsung
  + **Group 3:** Dynamic indication to the UE to modify PUSCH occasions (increase/descrease and/or advance/delay) to improve XR capacity performance
    - **Supported:** IDC, [QC]
    - **Not supported:** Ericsson\*, CATT, Samsung
  + **Group 4:** Dynamic indication from the UE for adjusted CG parameters (e.g. MCS, number of symbols, number of PRBs, number of layers) to improve XR capacity performance
    - **Supported:** Sony, Appple, QC, OPPO, [Lenovo]
    - **Not supported:** Ericsson\*, CATT, Samsung

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| **Company** | **Summary of Contributions inputs** |
| Futurewei | CG transmission for uplink has the advantage of without needing to wait for SR/BSR from the UE and hence can potentially reduce the overall latency of packet deliverable and improve capacity.  The proposed techniques are just trying to reduce the capacity loss of the SPS/CG transmissions. How much that can be done without changing the fundamentals of the SPS/CG mechanism is yet to be shown. Overall, it is hard to see it as a capacity improvement effort. The best it can achieve is to get closer (but still much less) to what dynamic scheduling can do and therefore far from solving the capacity issue we have for XR traffic.  ***Proposal 2: For enhancement for SPS/CG transmissions to improve XR capacity, focus study on enhancement for CG transmission for uplink.*** |
| Huawei/HiSilicon | *Observation 6: CG resource is semi-statically configured and cannot adapt to the varying size of XR frames,*   * *If the size of CG resource is larger than the actual frame size, radio resources may be wasted;* * *If the size of CG resource is not large enough to transmit the current frame, additional dynamic scheduling is needed, resulting in extra delay and reduced capacity.*     Figure 5. Illustration of indicating to gNB the unused PUSCH occasions within one CG period  In order to avoid the extra delay caused by additional dynamic scheduling, the CG resource within one CG period should be configured according to a relatively large size of XR frame. To avoid resource waste, mechanisms to allow re-allocate the unused CG resources within one CG period can be considered. When an UL XR video frame arrives, the UE can know the video frame size and thus the number of PUSCHs needed to transmit the video frame. If there are one or more unused PUSCHs, the UE can indicate the unused CG PUSCHs to the gNB via UCI or MAC CE in the first CG PUSCH occasion, as shown in Figure 5. A new type of UCI or MAC CE may be needed. Similar as CG-UCI, such UCI can be reported on the PUSCH. Then the gNB can re-allocate those unused CG PUSCH resources to other UEs.  ***Proposal 1: For multiple PUSCHs CG transmission occasions in a period, support indicating to the gNB the unused PUSCH occasions within one CG period, so that gNB can re-allocate the unused PUSCH occasions to other UEs to avoid resource waste.*** |
| Vivo | .    Figure 2. Example of CG resource recycling based on data volume  ***Proposal 2: Study CG PUSCH enhancements for UL video traffic, including the following:***   * ***Single CG configuration to align with UL XR burst periodicity, e.g., non-integer CG periodicity;*** * ***Single CG configuration with multiple transmission occasions within a CG period;*** * ***Recycling of unused CG resources within a CG period when configured CG resources within the CG period are more than required resources by the UL XR burst corresponding to the CG period, with potential assistant information exchanged between UE and gNB.*** |
| CATT | For the SPS/CG enhancement schemes, the following schemes were mostly proposed for improving the capacity performance and power saving gain.   * Enhancement scheme 1: Single SPS/CG configuration with multiple occasions[8][12] * Enhancement scheme 2: The SPS/CG configuration with adaptation parameters[8][11][12]   For the SPS PDSCH or configured grant type 2, if the PDCCH with the CRC scrambled by CS-RNTI and the PDCCH content indicates SPS activation or configured grant Type 2 activation, the configured downlink assignment or the configured uplink grant for this Serving Cell would be re-initialized. Thus, the Enhancement scheme 2, i.e. the SPS/CG configuration with adaptation parameters would not benefit for the XR-specific transmission.  Thus, we have the following observation:  **Observation 9:** **The SPS/CG parameter adapted adjustment has been supported via the DCI indicating the /Type2 CG activation as the existing specification in TS 38.321[4].**  Based on the above analysis, we give the following proposal.  **Proposal 11: According to the analysis, the Enhancement scheme 2, i.e.** **the SPS/CG configuration with adaptation parameters, could not efficient to improve the capacity of XR-specific traffic for not predict the packet size and packet arrival time and existing specification has supported.** |
| Nokia/NSB | Depending on the deployment scenario, it is also possible that UE informs gNB that part of the configured CG resources will not be used for XR frame delivery and can be used for other purposes or even for another UE. This could be more feasible, for example, in case of TDD.  ***Proposal 3:*** *RAN1 to study potential CG enhancements, for example, temporarily deactivating selected CG resources within one CG period.* |
| InterDigital | **Proposal 2:** Support dynamic adaptation (e.g. via DCI) to the number of PUSCHs per CG occasion  **Proposal 3:** Support UE sending an indication to gNB to request dynamic adaptation (e.g. increase/skip) the number of PUSCHs per CG occasion  **Proposal 4:** Study single DCI for dynamically adapting the number of PUSCHs for multiple CG occasions  **Proposal 5:** Support dynamic adaptation (e.g. via DCI) for time shifting the PUSCHs in a CG occasion (e.g. advancing or delaying) by an offset time value  **Proposal 6:** Study single DCI for dynamically time shifting the PUSCHs in multiple CG occasions |
| Qualcomm | In addition, for a single CG with multiple PUSCHs on a CG occasion (i.e., case 1 above), we can adapt to the variable number and sizes of packets per burst.  ***Proposal 4: For single CG with multiple PUSCHs on a CG occasion, consider studying methods to skip, modify, or add extra PUSCHs in an occasion.***    **Figure 2: Single CG with multiple PUSCHs on a CG occasion**  ***Proposal 5: For XR, consider studying methods to dynamically adapt the CG parameters to the traffic bursts.***    **Figure 4: CG dynamic adaptation**  ***Proposal 6: For XR, consider studying methods to jointly handle multiple CG configurations on the same or on different CCs using the same message***  For error-free demodulation in the UL, the UE must inform the network of which resources in the UL grant have been utilized or skipped. A UE may indicate the utilized or skipped resources through control signalling. The UCI-CG or a dedicated UCI may be used in this case. Alternatively, a lower MCS may be chosen by the UE to reduce the power consumption.  ***Observation 2: For proper demodulation in the UL, gNB is required to know which of the UL resources the UE has utilized or skipped or which MCS the UE utilized to transmit the TBS.***  ***Proposal 8: To increase capacity and reduce power consumption, study partial uplink transmission, and investigate necessary signalling to enable it***  ***Proposal 9: UCI indicating the resources utilized/skipped in the PUSCH or the MCS selected by the UE allows adaptation of the transport block size based on the UL XR traffic*** |
| ZTE, Sanechips | unused resource release  Figure 1 Unused resource release  Parameter Update  Figure 2 Parameter update for CG PUSCH  简化版上行资源分配  Figure 3 Procedure of uplink resource indication  As to periodicity misalignment, both semi-static indication and dynamic indication can adjust the location of transmission occasions in timeline as shown in Figure 4. In this way, the accumulated delay can be reduced to an acceptable range.  非整数周期对齐问题  Figure 4 Periodicity alignment illustration   1. For multiple CG PUSCHs, study and specify solutions of recycling unused CG PUSCH resources to improve resource usage efficiency. 2. For multiple CG PUSCHs, study and specify solutions of dynamically adjusting CG parameters, including e.g., MCS level and the number of layers, to improve resource usage efficiency. |
| Ericsson | Proposal 4: Deprioritize studying the enhancements based on dynamic adaptations for CG based transmissions. |
| China Telecom | **Figure 2 Variable Frame Size in CG Configuration**  ***Proposal 3 It is suggested to study the method of dynamically adjusting CG parameters. For example, UCI signal is sent to adjust the granted resource according to the flow.*** |
| OPPO | For CG PUSCH, UE can transmit CG-UCI to early terminate the CG transmission. Specifically, when multiple PUSCH transmission occasions are configured for one CG configuration, CG-UCI, transmitted in the early PUSCH transmission occasion(s) within a given period, can indicate the last configured PUSCH transmission occasion(s) within the given period is dropped. When gNB receives CG-UCI indicating early termination, the last configured PUSCH occasion(s) can be dynamically scheduled for other transmission to improve the system efficiency. Dynamic determination of MCS, TDRA or FDRA used to transmit CG PUSCH by UE should be further studied.   * Case 1: Among the occasions configured for CG PUSCH in a period, the last N≥1 occasion(s) could be released and each released occasion has to be released in full. * Case 2: Among the occasions configured for CG PUSCH in a period, the first occasion where any RB is released can have partial release, i.e., some of RBs in the occasion are released but some others are retained as needed; the later occasions after this first occasion, if any, are released in full. The first occasion where any RB is released cannot be the first occasion configured for CG PUSCH in a period. * Case 3: Same as Case 2, except that the first occasion where any RB is released can be the first occasion configured for CG PUSCH in a period.   Figure 3: 3 cases for early termination of CG transmission  Table 1 Comparison of legacy CG vs. CG with early termination   |  |  |  | | --- | --- | --- | |  | | Avg. number of consumed RBs  (per UE per packet) | | Legacy CG transmission | | 840.8 | | Early terminate the CG transmission | Case 1 | 679.1 | | Case 2 | 562.2 | | Case 3 | 560.5 |   ***Proposal 3: Early terminate the CG transmission should be further studied.*** |
| TCL | * **Changing resource allocation of CG**   When the resource allocation based on the mean or maximum packet size, a large number of RBs may be wasted if arrived packet size is smaller than the mean or maximum packet size. On the other hand, when the resource allocation based on the mean or minimum packet size, the resources of CG transmission occasion(s) are not enough if arrived packet size is larger than the mean or minimum packet size. Therefore, dynamic changing time and frequency resource allocation for CG configurations to match XR services should be considered.  ***Proposal 3: Dynamic changing resource allocation of CG configuration for XR can be considered.*** |
| Sony | The benefit of UE-based scheduling is to reduce latency, avoid the interferences, choose appropriate link adaptation parameters, and enable variable packet sizes, etc. Another benefit is that there may not be a good reason to configure multiple CG resources if a UE can schedule itself at any time with variable packet sizes based on CG occasions/periodicity. There could be different options of achieving the combination of CG and UE-based scheduling mode as follows:  **Option 1: CG-UCI.** Some control information can be piggy-backed/inserted on the CG PUSCH, like the legacy CG-UCI, to carry some scheduling information for this occasion and/or the future occasions:   * + UCI and CG PUSCH are encoded separately so that gNB can decode the UCI before decoding CG PUSCH.   + Each UE with XR data can be assigned a separate DMRS, for example if there are 12 UEs, each UE can have a unique DMRS.   + Overlapped resources are allowed to be configured among different UEs, except UCI resources for each UE.   **Option 2: Separate Control Region/resource.** Each UE is pre-allocated a separate “orthogonal” control region/resource (like PUCCH) that carries scheduling information for PUSCH from the UE within CG resource for this occasion and/or the future occasions. As in option 1, the gNB first decodes the control channel in order to know the control information for PUSCH. In addition, the control information could also tell to gNB whether CG resources (except the control region) are needed in the subsequent slots/occasions so that gNB can schedule the resources to other UEs. In this option, as the control region/resource is separate and orthogonal with other UEs, the UE can start its scheduling at any time within CG occasions, hence reducing the latency.  Proposal 7: Consider introducing a new mode of UE-based UL scheduling for XR traffic where a UE controls/decides its scheduling assignments within the pre-configured uplink resources (CG). |
| CMCC | **Scheme #1: SPS/CG parameters/configurations adaptation for one SPS/CG configuration**.  **Scheme #2: SPS/CG occasions skipping/release**.  **Proposal 2. SPS/CG parameters/configurations adaptation can be considered for XR service and the following alternatives can be further studied:**   * **Alt 1: The indication is carried in a simplified DCI with a small payload size;** * **Alt 2: The indication is carried in SPS PDSCH.** |
| Apple | A screen shot of a computer  Description automatically generated  Figure 5 Using CG-UCI to adapt the transport block size  **Proposal 3-2: study enhancement to CG-UCI to support indication of MCS and/or PRB adjustment for configured grant.** |
| Samsung | The conclusion from RAN1#110 identified absence of RAN1 consensus on possible benefits from introducing modifications to SPS PDSCH operation for the purpose of XR capacity enhancements. The same applies for modifications to CG PUSCH operation. Although CG PUSCH is attractive in reducing latency, it also requires predictable traffic, with fixed TB sizes, that can be served with a small bandwidth and does not require link adaptation. None of those conditions is fulfilled by XR traffic. Capacity would significantly decrease when a large bandwidth is reserved but there is no transmission (e.g. due to jitter) or when there is transmission requiring a smaller bandwidth (e.g. due to traffic variations), the majority of bandwidth cannot be reserved semi-statically for a single UE. Also, link adaptation is required for spectral efficiency. Any DCI-based signaling to adapt parameters of CG-PUSCH configurations is also meaningless as CRC is a large fixed overhead (and there may be additional padding to the DCI format size to preserve the “3+1” DCI format size budget). It is noted that for pose/control information (having a fixed and somewhat small TB size without jitter), Rel-17 CG PUSCH operation can apply. Further, there are no UE power savings gains from not receiving PDCCHs for scheduling PDSCHs but instead receiving multiple SPS PDSCHs over large bandwidth for high data rates and for multiple configurations when only one of those configurations may be valid at a time, or receiving PDCCH for adapting SPS PDSCH configurations, or operating XR without link adaptation and requiring longer times for each PDU set.  **Observation 2:** *In addition to SPS PDSCH, there is no need to further consider CG PUSCH modifications for XR.* |
| DCM | 图表  描述已自动生成  Fig 3: Example of SPS/CG time/frequency domain resource allocation adjustment  **Observation 2: Dynamic SPS/CG resource allocation adjustment may be helpful for handling variable packet size for XR.**  图示  描述已自动生成  Fig 4: Example of UE movement for XR service  图示  中度可信度描述已自动生成  Fig 5: Example of SPS/CG beam adjustment  **Observation 3: Dynamic update of SPS/CG MCS/TCI state/spatial relation information may be helpful for UE movement for XR.**  **Proposal 1: Study dynamic update of SPS/CG parameters for XR, e.g., periodicity, resource allocation, MCS, or TCI state/spatial relation.** |

### 2.2.1 Initial Discussion

**High level proposals based on input contributions:**

* **Proposal 2-2-1:** Dynamic indication of the unused CG PUSCH occasions by the UE to improve XR capacity performance is beneficial.
* **Proposal 2-2-2:** Dynamic indication to the UE to adjust CG parameters (e.g. MCS, number of symbols, number of PRBs, number of layers) to improve XR capacity performance is beneficial.
* **Proposal 2-2-3:** Dynamic indication to the UE to modify PUSCH occasions (increase/descrease and/or advance/delay) to improve XR capacity performance is beneficial.
* **Proposal 2-2-4:** Dynamic indication from the UE for adjusted CG parameters (e.g. MCS, number of symbols, number of PRBs, number of layers) to improve XR capacity performance is beneficial.

**Moderator’s suggestion for initial discussions:**

* **Q1:** Moderator recommends to down prioritize Proposal 2-2-3 and Proposal 2-2-4 due to lack of supporting capacity performance evaluation results by propoents.
  + What is your view on Moderator’s recommendation?
* **Q2:** What is your view on direction of Proposal 2-2-1 and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q3:** What is your view on direction of Proposal 2-2-2 and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q4:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q5:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1/Q2/Q3: We do not agree with further consideration for any of the proposals as there cannot be any benefit over DG, particularly for XR. For example, what is the benefit over DG for “Dynamic indication to the UE to adjust CG parameters (e.g. MCS, number of symbols, number of PRBs, number of layers)”? RAN1 may first discuss any benefits of few selected eCG proposals over DG.  A specification impact and how a proposal can be implementable/testable needs to be dscribed. For example, how will a UE determine that it needs fewer resources? Packet size is not enough for such determination and robustness of such UE estimation (e.g. to variations in link quality) need to be discussed for impact on capacity/QoS. How can a gNB trust various UEs to make decisions for spectrum allocation? How will the UE behavior be tested and what motivation does a UE have to not always indicate need for maximum resources? Given that a NW needs to plan for worst case, how many UEs can be supported with CGs based on maximum resources? How will link adaptation be performed differently from DG? There are several more aspects to be discussed for each individual eCG proposal.  Q4: Advantages over DG need to first be described/explained and agreed before capturing any results in TR 38.835. |
| **Futurewei** | Q1: WE are ok to down prioritize 2-2-3 and 2-2-4.  Q2: For 2-2-1, a few questions on the proposed scheme. For example, how often the dynamic indication needs to be sent and how fast it should be applied to obtain the potential benefit? What should be the criteria for the UE to send such indication?  Q3: For 2-2-2, a few questions on the proposed scheme. For example, how often the dynamic indication needs to be sent? What should be the criteria for the gNB to decide the adjustment? How is this better than directly using DG?  Q4: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: WE are ok to down prioritize 2-2-3 and 2-2-4.  Q2/Q3: We have question on how gNB sends the dynamic indication and how/when UE would receive the indication if there is no UL grant for retransmission.  Q4: All results should be captured. If there are questions on some results, they should have a note for clarification. |
| MTK | **Q1:** We are ok to down prioritize 2-2-3 and 2-2-4.  **Q2:** For Proposal 2-2-1, we think UE assistantce information (UAI) to indicate unused CG resource to NW may be useful for NW to more efficiently manage the scheduling resource. However, we this this is better to be discussed in RAN2 since UAI belongs to RAN2.  **Q3:** We do not see necessity/benefit for Proposal 2-2-2. If NW wants to dynamically adjust the MCS, number of symbols, …, NW can just use DG.  **Q4:** Results can be captured with description about advantages over DG to be described/explained. |
| **ZTE, Sanechips** | In our opinion, we should firstly focus on the necessity of CG enhancement, instead of down selecting the detailed techniques.  Q1: Disagree. We are open to study Proposal 2-2-3 and 2-2-4  Q2: Support Proposal 2-2-1  Q3: Support Proposal 2-2-2  Q4: From our perspective, all enhancement techniques with reasonable evaluation results should be capture in TR 38.835, no matter they are high priority or low priority. Moreover, the reason for de-prioritization should be clarified in brief, for the enhancement techniques with low priority.  Q5: We should firstly focus on the necessity of CG enhancement, instead of down selecting the detailed techniques |
| **LG** | **Q1:** We are fine to accept FL’s recommendation. One following question is whether 2-2-4 can be considered in SR/BSR enhancement if the indication of UE is formed as SR or BSR.  **Q2/Q3:** Same as 2.1.1, In existing system gNB can scheduling additional resource by UL grant or override configured CG resource as well. If CG resources need to be changed permernently, re-activation could be used. We don’t think proposed CG proposal has significant difference from those exisiting methodology.  **Q4:** With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. |
| **Panasonic** | Q1: We are fine with the recommendation.  Q2: The inidication for releasing the upcoming CG PUSCH requires knowing the exact time of data arrival, which is not feasible according to the agreement.  Q3: We do not see a need for dyanimic adjustment for CG resources, such as MCS.  Q5: We think the Proposal 2-2-3 could be further studied to align the CG PUSCH to XR traffic. |
| **Google** | **Q1**: We see benefit in Proposal 2-2-3 and Proposal 2-2-4 and we agree with ZTE. The listed proposals are detailed techniques for CG enhancement and we need first to agree whether CG enhancement is beneficial/needed and should be studied (like we did for SPS) and then decide about the detailed techniques to explore and ask for evaluation for each technique.  **Q2**: UE sends BSR information on the first CG PUSCH. Hence gNB can have the information of the data waiting for scheduling and can know which CG PUSCH occasions will be unused and can be re-used for other scheduling. Unless the UE is doing some discarding (e.g. close to expiry data) that the gNB is not aware of and the UE indicates that it can release some CG PUSCHs. Alternatively, the UE can provide further assistance information like amount of high and low priority data (e.g. based on the PDU set importance and PSDB) in the buffer and gNB can cancel/add resources based on that.  **Q3**: We Proposal 2-2-2 and think it is useful if the gNB get information about the priority of the data, the remaining delay, … For example, an enhanced BSR can signal such assistance information and based on that the gNB can adjust CG parameters.  **Q4**: Yes, we think the evaluation results should be captured as long as they use the agreed simulation assumptions. |
| **vivo** | Q1: WE are OK to down prioritize 2-2-3 and 2-2-4.  Q2: Based on our simulation results, we support Proposal 2-2-1.  Q3: In our opinion, CG (re-)activation in existing NR specification can achieve the target of adjusting CG parameters. Besides, how frequent to perform CG (re-)activation is up to gNB implementation. It is unclear to us what the enhancement is and how much additional capacity gain it can achieve compare to legacy mechanism. |
| **Ericsson** | Q1: Support to down prioritize 22.3/4.  Q2: If the indication is via CG-UCI, we could be OK to study further, since the container is already exists and spec impct is minimum. Having said that, we don’t see it improves capacity over DG, but in principle, providing assistance to gNB via CG-UCI can be useful.  Q3: Not supporting 2-2-2. As we showed, DG already provided best performance. No need to introduce adaptation in CG, when we can achieve the same goal with other means as we showed. |
| **Sony** | **Q1:** Disagree. We are open to study proposals 2-2-3 and 2-2-4. Companies still have more time to provide results.  **Q2:** Support Proposal 2-2-1  **Q3:** In our view proposal 2-2-2 is like CG Type 2 where network can modify the resource allocation of the CG resource. So it is not an enhancement.  **Q4:** Simulation Results should be captured in the TR 38.835 provided that the baseline DG and CG are also simulated. |
| **InterDigital** | **Q1:** We share same view with ZTE and Google; proposals 2-2-3 and 2-2-4 should not be down-prioritized at this stage, and should be considered as part of enhancements related to eCG.  **Q2:** Support proposal 2-2-1  **Q3:** Support proposal 2-2-2  **Q4:** We prefer capturing the evaluation results of the enhancement schemes related to adaptation of CG in the TR |
| **OPPO** | Q1: We are OK to down-prioritize Proposal 2-2-3 and 2-2-4.  Q2: We support Proposal 2-2-1 if multiple PUSCH transmission occasions in each period is supported. The unused CG PUSCH occasions can be indicated by CG-UCI transmitted in the first CG PUSCH in each period.  Q3: We are OK to down-prioritize Proposal 2-2-2, since it can be achcived by current DG overriding CG. |
| **Lenovo** | Schemes with simulation results should be prioritized. Proposal can be updated to include “if CG enhancement for XR is supported”. |
| **Huawei/HiSilicon** | Q1: we are ok to down prioritize 2-2-3 and 2-2-4.  Q2: For 2-2-1, we support. When an UL XR video frame arrives, the UE can know the video frame size and thus the number of PUSCH occasions needed to transmit the video frame. If there are one or more unused PUSCH occasions, the UE can indicate the unused CG PUSCH occasions to the gNB to avoid resource waste, which has capacity gain.  Q3: For 2-2-2, companies should clarify how often the dynamic indication needs to be sent? How is this better than directly using DG?  Q4: Results for Proposal 2-2-1 should be captured. |
| **Nokia, NSB** | Q1: We do not agree with proposal 2-2-4: UE can continue sending the CSI reports and gNB will be able to adjust the parameters via DCI if necessary. Not clear what is needed on top of already supported solution.  More clarification about Proposal 2-2-3 is needed to understand the motivation of the proposal.  Q2: We agree with proposal 2-2-1. However, we first need to decide on the solution to support large frame size in order to recommend this to WI.  Q3: We do not agree with proposal 2-2-2: The currect CG design allows to send DCI and modify the parameters if necessary. Not clear what is needed on top of already supported solution.  Q4: We support capturing the results of proposal 2-2-1 and related observations to TR 38.835. |
| **Qualcomm** | Q1: We are not ok with deprioritizing 2-2-4. We agree with Apple that this has potential capacity and power saving enhancements  Q2: for 2-2-1, this may be very useful in terms of freeing up CG resources that were previously reserved for a UE when not needed by that UE. This can be beneficial in terms with regards to the resource overhead as well as UL beam reservation for FR2, since freeing up that resource would un-reserve the beam in that direction and gNB can use some other beam for some other UE.  Q3: for 2-2-2, this may be useful for 1. reducing the need for additional DG resources if preconfigured CG is not enough for the data by allowing flexible CG resources, and 2. Avoid overbooking resources if data is less than the CG resource allocation.  Q4: We think companies evaluation results should be captured |

## 2.3 Multiple PUSCHs transmission occasions in a CG period

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, companies have provided simulations results.

**Status of inputs in the contributions:**

* **Companies with view (14):** CATT, vivo\*, Intel, IDC, QC, ZTE/Sanechips\*, Ericsson\*, China Telcom, OPPO, Lenovo, CMCC, LG, Google, Samsung, DCM
  + **Supportive of enhancements (11)**: vivo\*, Intel, IDC, QC, ZTE/Sanechips\*, China Telecom, Lenovo, CMCC, LG, Google, DCM
  + **Not supportive (3):** Ericsson\*, CATT, Samsung
* **Companies with evalution results (3):** vivo\*, ZTE/Sanechips\*, Ericsson\*

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| **Company** | **Summary of Contributions inputs** |
| CATT | For the SPS/CG enhancement schemes, the following schemes were mostly proposed for improving the capacity performance and power saving gain.   * Enhancement scheme 1: Single SPS/CG configuration with multiple occasions[8][12] * Enhancement scheme 2: The SPS/CG configuration with adaptation parameters[8][11][12]   For the Enhancement scheme 1, i.e. the single SPS/CG configuration with multiple occasions, it was proposed that increasing the occasions in per SPS/CG periodicities to adapt to the variable number and sizes of packets per burst [8] and the supported number of SPS/CG configurations is limited[12]. The existing multiple SPS/CG configurations cannot actually resolve the random jitter problem and it would need to reserve more resource for the larger packet size; otherwise, it can result in the additional delay for less reserved resource. However, the problems of the Enhancement scheme 1 are similar to that of the multiple SPS/CG configurations. gNB cannot predict the XR-specific packet arrival time and the exact packet size at the instance of packet arrival at least for DL XR transmission. The inappropriate resource reservation would result in the resource wasted and resource confliction among the UEs. Furthermore, when the XR-specific packet size is large, the power saving gain of reduced PDCCH detection would be limited compared with that of packet transmission.  **Proposal 10: According to the analysis, the Enhancement scheme 1, at least for the single SPS configuration with multiple occasions could not efficient to improve the capacity of XR-specific traffic for not predict the packet size and packet arrival time.** |
| vivo | ***Proposal 2: Study CG PUSCH enhancements for UL video traffic, including the following:***   * ***Single CG configuration to align with UL XR burst periodicity, e.g., non-integer CG periodicity;*** * ***Single CG configuration with multiple transmission occasions within a CG period;*** * ***Recycling of unused CG resources within a CG period when configured CG resources within the CG period are more than required resources by the UL XR burst corresponding to the CG period, with potential assistant information exchanged between UE and gNB.*** |
| Intel | On the other hand, CG PUSCH has the benefit over DG PUSCH in terms of saving scheduling delay. To this end, since XR packet (e.g., video) may require multiple PUSCHs for delivery, an enhancement to CG PUSCH can be considered where multiple PUSCH occasions per CG period or single DCI can activate multiple CG configurations, so that at least initial few PUSCHs corresponding to the XR packet can be delivered soon and subsequent PUSCHs can be dynamically scheduled, since gNB may have BSR information already available by then.  ***Proposal 2: RAN1 should investigate single CG configuration with multiple PUSCH occasions per CG period or single DCI based activation of multiple CG configurations.*** |
| InterDigital | **Proposal 1:** Support configuring multiple PUSCHs per CG occasion  **Proposal 8:** Support multiple active CG configurations (e.g. with different set of parameters) for handling multiple flows with different traffic patterns  **Proposal 9:** Support dynamic activation/deactivation of multiple CG configurations (e.g. with single DCI)  **Proposal 10:** Support UE sending an indication to gNB to request activation of multiple preconfigured CG configurations |
| Qualcomm | ***Proposal 1: For XR UL video data transmission, use a single activation DCI for the following cases based on the multi-PUSCH scheduling DCI***   * ***Case 1: activate a single CG with multiple PUSCHs on a CG occasion*** * ***Case 2: activate multiple CGs with one PUSCH on an occasion of each CG***     **Case 1**    **Case 2**  Figure 1: Multiple CG PUSCHs activated simultaneously  Similar to SSSG switching, this allows for adaptive adjustment of CG periodicity and adaptation of other scheduling information to better fit the channel and traffic conditions.  ***Proposal 2: Introduce the CG set switching mechanism to simultaneously activate one set of CGs and deactivate another set of CGs for adaptative CG configuration. Timer based switching can be introduced.***  In this case, the current NR design can be reused to indicate the set of CG by the HARQ process number field in the DCI. The time duration when the CGs are temporarily deactivated can be either configured by RRC or in the release DCI by repurposing the “PDCCH monitoring adaptation indication”.  ***Proposal 3: Introduce the CG set skipping mechanism to temporarily deactivate a set of CGs and reactivate it after a timer expires.*** |
| ZTE/Sanechips | 1. Support to take multiple CG PUSCHs in a period as a candidate solution for XR service. |
| Ericsson | In order to activate as a group, we see the following challenges:   * The network may need to spend signalling to allocate individual CG IDs, then configure a group ID mapping to group of individual CG IDs, in order to activate/update/reactivate CGs with required parameters. * It may increase both delay and PDCCH resource usage as control signalling will be spent, at first, perhaps creating individual CGs. * It may also need modification of DCI, or even additional of fields for group activation. This is not similar to group deactivation, where many of the fields are not useful, and thus used for validation or indicate group ID in the HARQ bitfield provided by *ConfiguredGrantConfigType2DeactivationStateList*. * To have all CGs belonging a group the same parameters, such as MCS, RV pattern, etc., then it does not make sense to create multiple CGs with same parameters. Instead, one could aim for devising multiple allocations with similar parameters within the single CG.   Therefore, we are not convinced with grouping of CG configurations with joint activation, as signalling and specification complexity is high. Based on the above discussion, we propose the following:  Proposal 6: Do not pursue enhancements based on joint activation to enable multiple CGs occasions in a period.  Although we are not convinced that CG enhancements are justified or necessary for improving XR traffic capacity performance, from the specification and complexity point of view, an extension of multi-PUSCH allocation framework to single CG seems to be the most reasonable approach, if justified to be needed.  Proposal 7: The enhancements based on multi-PUSCH allocation for a single CG can be considered to study if the corresponding capacity performance gains are provided and the specification effort is low. |
| China Telecom | We propose that UL CG is enhanced to adapt to the transmission characteristics of multi-stream and variable packet size of XR service. It supports simultaneous activation of multiple CG configurations. Multiple CG configurations that can be activated simultaneously are configured by high-level signaling, and DCI indicates the activation of multiple CG configurations.   * RRC signaling can be used for UE configuration ConfiguredGrantConfigType2ActivationStateList or ConfigActivationStateList indicates a set of CG configurations that can be activated simultaneously. For example, according to XR service requirements, it is configured to contain several CG configurations that can be simultaneously activated for XR service requirements. * DCI is used to indicate specific CG configurations activated simultaneously. It can be indicated as an entry of the simultaneously activated configurations list.   ***Proposal 1 Study the enhancement methods of UL CG. Support activation of multiple CG configurations.*** Multiple PDSCHs/PUSCHs CG transmission occasions in a period For XR, larger video frame data size may require multiple PUSCH transmissions per video frame cycle, so we can enhance CG to create multiple PUSCHs in the same CG. Two mechanisms can be used to achieve multiple PUSCH effects in the same cycle. One is multiple PUSCHs activated on the same CG occasion. The second is multiple CG activated by one DCI.    **Figure 1 Single DCI activates multiple CG configurations**  ***Proposal 2 Study an improved scheme for single DCI activating multiple different CG configurations. For example, multiple CG activated by the same DCI has different PUSCH capacities.*** |
| OPPO | ***Proposal 2: For CG transmission, the following*** ***solutions for XR-specific packet size adaptation should be further studied:***   * ***Alt.1: The CG configuration supports multiple PUSCH transmission occasions in each period.*** * ***Alt.2: A UE can have multiple CG configurations, one or more of which can be fast activated.*** |
| Lenovo | Further, in XR applications such as immersive online gaming and a smart helmet, latency-sensitive set of data collected from multiple cooperating sensors/devices (e.g. motion sensors, cameras, and audio devices) of a UE may need to be uploaded to an XR server within a certain time window for real-time rendering and/or virtual control of machines or other objects. Thus, CG enhancement such as joint activation of multiple CG configurations (potentially with different periodicities) for an indicated duration can address handling of multiple traffics of different QoS requirements in a quasi-synchronous manner with reduced DL and UL control singling overhead.  **Proposal 8: Study CG enhancements to address XR traffic variable packet size and quasi-synchronous communication of multiple flows. Enhancements may include:**   * **Enabling, within a CG period, a set of CG configurations having the same periodicity with CG resources of different size and transmitting only on CG resource(s) of one CG configuration within the set of CG configurations.** * **Joint activation of multiple CG configurations for an indicated duration to handle multiple traffics of different QoS requirements in a quasi-synchronous manner with reduced control signaling overhead**     **Figure 2: An example to realize the non-integer periodicity for CG.** |
| CMCC | Due to the large data sizes of XR traffic frames, one of the enhancements for SPS/CG is to support multiple PDSCH/PUSCH transmission occasions in an SPS/CG period. The detailed solutions include:  **Scheme #1: Multiple SPS/CG configurations and joint activation**.  **Scheme #2: Using multi-slot TDRA for an SPS/CG configuration.**  Regarding Scheme #1, multiple SPS/CG configurations are configured to UE, and then jointly activate one or more of the multiple SPS/CG configurations. However, up to 8 SPS/CG configurations are supported in the current specification, so configuring multiple SPS/CG configurations for UE to handle XR service may have a negative effect on the SPS/CG configurations associated with other types of services.  Regarding Scheme #2, this solution is similar to single DCI scheduling multiple TBs via configuring multiple SLIVs across slots in the TDRA table.  **Proposal 1. Multiple PDSCH/PUSCH transmission occasions can be supported in an SPS/CG period for one SPS/CG configuration.** |
| LG | **Proposal 3: At least for jitter handling with CG configuration, it is necessary to allocate multiple TOs in a periodicity with single CG configurations.**  Proposal 4: The single DCI scheduling multiple PDSCH/PUSCH can be re-used for SPS/CG activation DCI in order to allocate multiple TOs in a periodicity with single SPS/CG configurations if it is supported. |
| Google Inc | 1. ***Multiple PUSCH occasions in a CG period is useful for UL AR traffic.*** |
| Samsung | **Observation 2:** *In addition to SPS PDSCH, there is no need to further consider CG PUSCH modifications for XR.* |
| DCM | **Observation 4: It is possible that one PDSCH/PUSCH in one SPS/CG periodicity may be not enough to transmit one packet for XR. Using multiple SPS/CG configurations for one packet is not efficient.**  **Proposal 2: Study multiple SPS PDSCHs or CG PUSCHs in one SPS/CG periodicity for XR.** |

### 2.3.1 Initial Discussion

**High level proposals based on input contributions:**

**Proposal 2-3-1:**

* The following enhancement techniqure(s) is beneficial to improve XR capacity performance
  + Alt-1: single CG configuration with multiple PUSCH occasions per CG period
  + Alt-2: single DCI based activation of multiple CG configurations.

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 2-3-1 and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details/alternatives for the next round of the discussions.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Do not support.  Similar comments as for 2.2.1 apply for Q1 and Q2. |
| **Futurewei** | It is not clear to us how these multiple PUSCH occasions will be utilized by the UE and how it will perform better than DG. |
| **CATT** | We are not clear on the system capacity gain from proposal. |
| **MTK** | We are not clear on the system capacity gain for this proposal. |
| **ZTE, Sanechips** | Q1: Support Proposal 2-3-1. We are open to study both Alt-1 and Alt-2.  We should firstly focus on the necessity of CG enhancement, instead of down selecting the detailed techniques. |
| **LG** | **Q1: Support.** We think it could be useful to jitter handling and serving video traffic.  **Q2:** Same as before, fine to capture. |
| **Panasonic** | We think the mentioned enhancements could be beneficial and should be further studied. |
| **Google** | We support Proposal 2-3-1 and both alternatives can be studied. |
| **vivo** | We support Alt-1 of proposal 2-3-1.  For Alt-2, we think the motivation for Alt-2 is for signaling overhead reduction. Meanwhile the complexity involved in DCI format design should be considered. |
| **Ericsson** | Same view as Samsung, FW, others. Not support. |
| **Sony** | We think the enhancements as described in Proposal 2-3-1 can still be considered and further studied. |
| **InterDigital** | Support proposal 2-3-1 (both Alt-1 and Alt-2) |
| **OPPO** | As mentioned in 2.1.1, less detection of PDCCH can reduce the UE power consumption, so we support Alt-1 and open to Alt-2. |
| **Lenovo** | If CG enhancement is supported (e.g., gains shown w.r.t. a hybrid CG-DG), the alternatives are fine. |
| **Huawei/HiSilicon** | Q1: We support Alt-1. Results should be captured.  Alt-2 seems just saving DCI overhead, and does not bring capacity gain. |
| **Nokia, NSB** | We do not support Alt-2 since single activation will require a lot of DCI overhead as every CG configuration can have different PRBs, MCS, etc.  Alt-1 with the design similar to multi-PUSCH scheduling with single DCI seems more reasonable if we want to support multi TB per period to transmit video frame. |
| **Qualcomm** | We think it is useful, the first Alt-1 is useful when for single flow with larger burst size and the second Alt-2 is useful for multiple flow case. In order to take full advantage of these enhancements, a study of more dynamic PUSCH occasions parameters may be needed (e.g., cancelling un-used occasions, etc.) |

## 2.4 Non-integer periodicity for CG transmissions

The table below lists the proposals in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, companies have provided simulations results.

**Status of inputs in the contributions:**

* **Companies with view (20):** Huawei/HiSilicon\*, vivo\*, Nokia/NSB, IDC, QC, ZTE/Sanechips\*, Ericsson\*, China Telcom, OPPO, TCL, Sony, Lenovo, NEC, CMCC, Panasonic, LG, Apple, Google, Samsung, DCM
  + **Supportive of enhancements (17)**: vivo\*, Nokia/NSB, IDC, QC, ZTE/Sanechips\*, China Telcom, OPPO, TCL, Sony, Lenovo, NEC, CMCC, Panasonic, LG, Apple, Google, Samsung, DCM
  + **Not supportive (3):** Huawei/HiSilicon\*, Ericsson\*, Samsung
* **Companies with evalution results (4):** Huawei/HiSilicon\*, vivo\*, ZTE/Sanechips\*, Ericsson\*

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| **Company** | **Summary of Contributions inputs** |
| Huawei/HiSilicon | *Observation 4: For UL transmission, non-integer periodicity issue can be solved by configuring multiple CG configurations.*    **Figure 3. Multiple sets of CG configurations to match XR traffic** |
| vivo | ***Proposal 2: Study CG PUSCH enhancements for UL video traffic, including the following:***   * ***Single CG configuration to align with UL XR burst periodicity, e.g., non-integer CG periodicity;*** * ***Single CG configuration with multiple transmission occasions within a CG period;*** * ***Recycling of unused CG resources within a CG period when configured CG resources within the CG period are more than required resources by the UL XR burst corresponding to the CG period, with potential assistant information exchanged between UE and gNB.*** |
| Nokia/NSB | The CG is particularly useful for XR applications as per the currently agreed traffic models for pose/control and uplink video, no time-domain jitter is present.  For CG to be fully applicable for XR use cases, the periodicity at which the gNB can configure a UE with CG resources shall be in line with the XR traffic periodicity. ​  ***Proposal 1:*** *The options for configuration of the periodicity of CG resources shall match those of the uplink XR traffic models from 3GPP TR 38.838. Among others, this shall include a periodicity of every 16.6 ms (as required for 60 fps uplink video).*  Especially for the uplink video cases with 10Mbps, the XR frames are often so large that they have to be transmitted in multiple TTIs.  ***Proposal 2:*** *It should be possible to have CG configuration that includes an integer number of TTI transmissions per periodicity, e.g., in the range from 1 to 8.* |
| InterDigital | To address the timing misalignments, the UE can be configured with multiple offset time values that can be used for time shifting the resources with respect to their occasions. Based on the PDU set arrival, adaptations in terms of advancing/delaying the resources by any of the configured offset time values can be dynamically signaled to the UE. To minimize the overhead, especially when time shifting the resources for a large data burst, whether single DCI can be used for shifting the resources for multiple CG occasions should be discussed.  **Proposal 5:** Support dynamic adaptation (e.g. via DCI) for time shifting the PUSCHs in a CG occasion (e.g. advancing or delaying) by an offset time value  **Proposal 6:** Study single DCI for dynamically time shifting the PUSCHs in multiple CG occasions |
| Qualcomm | ***Observation 1: There is a time mismatch issue between periodic XR UL traffic and R16/17 CG configuration. This will lead to XR capacity loss due to the packet delay caused by the timing difference between CG resources and actual XR traffic.***  Chart, box and whisker chart  Description automatically generated  Figure 5 Mismatch between XR UL traffic (60fps) and R16/17 CG periodicity (16 slots or 17 slots)  ***Proposal 7: RAN1 should discuss a solution to address the time mismatch between R16/R17 CG configuration. The solution can be like those under consideration for a similar issue that exists for CDRX.*** |
| ZTE/Sanechips | As to periodicity misalignment, both semi-static indication and dynamic indication can adjust the location of transmission occasions in timeline as shown in Figure 4. In this way, the accumulated delay can be reduced to an acceptable range.  非整数周期对齐问题  Figure 4 Periodicity alignment illustration  Observation 6: For multiple CG PUSCHs, both semi-static indication and dynamic indication can be used to align the periodicity of XR packet arrival and periodicity of CG PUSCH. |
| Ericsson | The standard already supports multiple CG configurations that can be used to handle non-integer periodicites. For example, in case of 16.667 ms period, the period is 50/3 ms and therefore 3 CGs with period 100 slots on 30 kHz SCS could be used. However, CG can be beneficial if it is used as a complement to DG but relying solely on CG to serve XR service is not a preferred solution. Figure 6 shows that good performance is obtained when CG is used to carry BSR and potentially smaller amount of data.  Observation 5: Introduction of new CG periodicities to match the periodicity between XR video traffic and CG configuration seems to be unnecessary  Based on the above discussion, we propose the following:  Proposal 5: Deprioritize studying the enhancements for matching the periodicity of CG resource allocations to XR traffic periodicity. |
| China Telecom | **Figure 3 Using multiple CG configurations to solve non-integer periodic problems**  ***Proposal 4 In order to solve the problem of non-integer period, configuring multiple CG solutions should be the benchmark of other methods.***  To solve the non-integer period problem of XR traffic, the following two methods can be used to enhance CG:  The first method is to set multiple periodic values in the CG configuration, which can effectively avoid delay accumulation. As shown in Figure 4, the number of transmission frames per second of XR traffic is 60fps, if the CG configuration periodicity is 17ms, it will lead to delay accumulation. Consider configuring two CG periodicities in one CG configuration and the two periodicities are applied in a semi-static pattern. This method can ensure that the two are realigned after each interval of time.    **Figure 4 Configure a CG periodicity pattern with two periodicities**  The second method is to periodically adjust the configuration and align the cycle to ensure that the delay is not too large. For example, a delay alignment mechanism can be set up to send an alignment signal CG-UCI every other period of time, so that the current signal slot and traffic arrival time are aligned to avoid delay accumulation. The difficulty of this method is to select the appropriate timing of the alignment signal CG-UCI. It ensures that the delay is within the acceptable range and does not generate a lot of additional resource consumption due to CG-UCI.  ***Proposal 5 To solve the non-integer period problem, we recommend specifying the following two schemes:***  ***1. Establishment of two distinct periodic values***  ***2. Introduction of periodicity realignment mechanisms*** |
| OPPO | Figure 1: Example of CG PUSCH occasions calculated for a 60fps period  .    Figure 2: Example of configured CG PUSCH pattern for a 60fps period  ***Proposal 1: The following solutions to resolve the periodicity mismatch issue should be further studied:***   * ***Option 1: Introduce non-integer values for CG periodicity and add ceiling operation in CG occasion calculation formula.*** * ***Option 2: Introduce the periodic CG pattern in which multiple non-consecutive sets of PUSCH occasions can be configured in one*** ***period.*** |
| TCL | * **Transmission pattern of CG within an integer periodicity**   ***Observation 2：There is a gap between XR periodic DL traffic and CG configuration.***    Figure 1. Mismatch between DL traffic with 30 fps and CG/SPS with 32ms  ***Proposal 1: A fixed transmission pattern of CG within an integer periodicity for XR can be considered.*** |
| Sony | Chart  Description automatically generated  Figure 1: Mismatch of SPS allocation pattern and XR traffic pattern  Observation 1: Depending on the XR traffic pattern, there can be a mismatch of periods between NR SPS/CG configuration and XR traffic.  Observation 2: The search space size for PDCCH transmission can be relatively small. Hence, it would be beneficial to reduce the PDCCH transmission which can also increase the overall XR capacity.  Proposal 1: SPS enhancement can still be considered for XR capacity enhancements as the search space size for PDCCH transmission can be relatively small.  Proposal 2: Consider Dynamic SPS/CG configuration to dynamically adjust the transmission in order to accommodate the XR traffic pattern.    Figure 2: A schematic/illustration of pseudo periodic CG  Proposal 3: Pseudo-periodic SPS/CG configuration can be considered for XR traffic with non-integer period. |
| Lenovo | **Figure 2: An example to realize the non-integer periodicity for CG.**  **Proposal 9:** **Enhancements related to non-integer periodicity for CG transmissions could include configure multiple small periodicities for one CG configuration to compose a longer periodicity cycle.** |
| NEC | **Proposal 4:**   * *Study enhancement for the mismatch between the periodicity of CG configuration and the XR packet arrival time.*   **Proposal 5:**   * *Specify XR specific configured grant offset parameter such as kOffsetSymbols in Search Space Set configuration.*   **Proposal 6:**   * *‘cg-nrofSlots’ may be reused to transmit different transport blocks if PUSCH repetition type is not set.*   **Proposal 7:**   * *Specify a higher layer parameter of ‘frame per second’ for the frame rate of XR traffic.* |
| CMCC | **Scheme #1: Configure an SPS/CG periodicity set or pattern that contains multiple SPS/CG periodicities and apply this pattern cyclically in the time domain**. For example, an SPS/CG periodicity pattern of {16ms, 17ms, 17ms} can be used to align with XR traffic with a 60fps frame rate.  **Scheme #2: Non-integer SPS/CG periodicity**.  **Scheme #3: Periodically adjust the SPS/CG periodicity by using a dynamic indication**.  Regarding Scheme #2, a new rational SPS/CG periodicity will be added for each non-integer XR traffic periodicity and ceiling operations in SPS/CG occasion calculation formula should be added, which would result in more specification changes and more complex implementation.  Regarding Scheme #3, the dynamic indication will cause an extra dynamic signaling overhead.  Based on the above analysis, it is suggested to further study the configuration of the SPS/CG periodicity set or pattern in Scheme #1.  **Proposal 4. Configure an SPS/CG periodicity set or pattern that contains multiple SPS/CG periodicities and apply this pattern cyclically in the time domain.** |
| Panasonic | **Proposal 1: CG should efficiently handle the non-integer periodicity transmissions, including the video stream frame periodicities like 16.66667, 11.11111, and 8.33333 ms.**  The non-integer periodicities could be supported in a semi-static manner (e.g., through RRC configurations) or/and dynamic manners (e.g., through a DCI). Here we discuss some methods to handle non-integer periodicities.  **Approach 1: Rounding the non-integer transmission instances**    Figure 1. Matching non-integer periodicities to radio resources.  **Approach 2: Enabling/disabling the non-integer periodicity instances**    Figure 2. using a virtual cycle linked to a CG configuration.  **Approach 3: Alternating periodicities**  Chart, histogram  Description automatically generated  Figure 3. Supporting alternating periodicities.  **Approach 4: DCI to reconfigure group of CG configurations**  .    Figure 2. A DCI with group-based CG reconfigurations.  **Comparison of the approaches**  Table 1. Approaches to efficiently handle the non-integer periodicity transmissions   |  |  |  | | --- | --- | --- | | Approach | Pros | Cons | | 1. Rounding the non-integer transmission instances | - Only semi-static configurations. | - the accurate alignment of non-integer periodicity is required. | | 2.Enabling/disabling the non-integer periodicity instances | - Only semi-static configurations.  - Which resources are used after the adjustment of the periodicity can be configured separately. | - More complex compared with approach 1.  - the accurate alignment of non-integer periodicity is required. | | 3. Alternating periodicities | - Only semi-static configurations.  - the alignment of non-integer periodicity is on the order of alternating periodicity. | - Depending on the combination of alternative periodicities, it may not fully be aligned with the target non-integer periodicity. This can be corrected by DCI based scheme. | | 4. DCI to reconfigure Group of CG | - The adjustment of the periodicity other than caused by the fractional periodicity are possible like the accumulation of UE-gNB frequency error, the adjustment caused by the autonomous TA adjustment and so on. | - A DCI is required to adjust the periodicity.  - The handling of miss/false detection of DCI. |   **Proposal 2: The combination between DCI based (approach 4) and alternating periodicities (approach 3) should be taken.** |
| LG | Proposal 6: Support non-integer periodicities by modified equation determining SPS/CG occasions.   * FFS: How to add non-integer periodicities to current periodicity parameter. |
| Apple | Chart, timeline  Description automatically generated  Figure 4 Multiple data streams with periodical traffic arrivals and time-varying packet size  **Proposal 3-1: introduce the support of non-integer periodicity for SPS configurations/Configured grant configurations.** |
| Google Inc | 1. ***CG periodicities require enhancement to align with UL AR traffic periodicities*** |
| Samsung | **Observation 2:** *In addition to SPS PDSCH, there is no need to further consider CG PUSCH modifications for XR.* |
| DCM | 图示  描述已自动生成  Fig 1: Example of mismatch of SPS/CG periodicity and XR traffic  图表, 箱线图  描述已自动生成  Fig 2: Example of SPS periodicity adjustment  **Observation 1: Dynamic SPS/CG periodicity adjustment may be helpful for handling mismatch of XR traffic arrival and SPS/CG periodicity.**  Another example of parameter adjustment is resource allocation of SPS/CG. For some XR services, e.g. AR UL traffic model with multiple streams, payload size in different time instances may be different. For such case, time and/or frequency resource allocation adjustment can be helpful.  图表  描述已自动生成  Fig 3: Example of SPS/CG time/frequency domain resource allocation adjustment  **Observation 2: Dynamic SPS/CG resource allocation adjustment may be helpful for handling variable packet size for XR.**  **Proposal 1: Study dynamic update of SPS/CG parameters for XR, e.g., periodicity, resource allocation, MCS, or TCI state/spatial relation.** |

### 2.4.1 Initial Discussion

**High level proposals based on input contributions:**

**Proposal 2-4-1:**

* Enhancements related to match the periodicity for CG transmissions with non-interger periodicity of XR traffic is beneficial to improve XR capacity performance.

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 2-4-1 and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details/alternatives for the next round of the discussions.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **Samsung** | Do not support.  Similar comments as for 2.2.1 apply for Q1 and Q2. |
| **Futurewei** | This is also discussed under power saving agenda item. Though it may have power saving benefit, we do not see it as capacity improvement scheme. |
| **CATT** | We don’t see the benefit in capacity enhancement |
| **MTK** | We tend to agree with Futurewei. We do not see clear benefit in capacity enhancement. |
| **ZTE, Sanechips** | Q1: Suppport Proposal 2-4-1. |
| **LG** | **Q1:** Support. Non-interger periodicity has clear benefit to serve periodic traffic by avoiding redundant resource allocation with reducing latency. Based on the contributions, the flexibility of periodicity can be obtain by only few minor specification changes.  **Q2**: Same as before, fine to capture the proposal. |
| **Panasonic** | We think the relevant enhancement could bring power saving gain but not much capacity gain. |
| **Google** | We support the Proposal. |
| **vivo** | We think non-integer periodicity for CG needs to be considered. |
| **Ericsson** | Q1: Not support.  We showed with our simulations that non-interger periodicity is not an issue. |
| **Sony** | Q1: Suppport Proposal 2-4-1. The quasi-periodicity of XR transmissions can also be reflected in layer 1 operation (e.g., enhancements of CG). |
| **InterDigital** | We support proposal 2-4-1 |
| **OPPO** | Support Proposal 2-4-1. We think eCG can provide benefits for short latency and power saving. |
| **Lenovo** | Ok |
| **Huawei/HiSilicon** | Non-integer periodicity issue can be solved by configuring multiple CG configurations. No need for more enhancements. |
| **Nokia, NSB** | Simulation results have shown the benefits from CG. It is therefore important to identify the necessary enhancements to support XR with CG. Non-integer periodicity is already considered as an issue for C-DRX in Power saving domain. This enhancement is also necessary for CG and should be considered. The solution can be the same as for non-integer periodicity in C-DRX. We support Proposal 2-4-1. |
| **Qualcomm** | We support non-integer periodicity for CG to match with XR traffic |

## 2.5 Other enhancements

The table below lists the proposals in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, companies have provided simulations results.

**Status of inputs in the contributions:**

* **Topic 1: SPS enhancements:**
* **Supporting SPS enhancements (5): CATT\*, ZTE/Sanechips\*, IDC, Sony, China Telcomm**
* **Not supporting SPS enhancements (4): Futurewei, Huawei/HiSilicon, Ericsson, Samsung**
* **Topic 2: PDCCH monitoring occasions during DRX-OFF:**
* **Supported: TCL, CATT\*, Panasonic**
* **Topic 3: XR multiple flows differentiation with CG transmission**
* **Supported: Intel\*, Sony**

|  |  |
| --- | --- |
| **Company** | **Summary of Contributions inputs** |
| Futurewei | ***Observation 1: PDCCH/DCI overhead is not the bottleneck for XR system capacity improvement.***  ***Observation 2: For XR capacity improvement, the necessity of an enhancement technique lies in its effectiveness to handle XR traffic with stringent requirements on data rate, delay, and reliability to achieve higher capacity.***  ***Proposal 1: For XR capacity improvement, the focus of the study should be on dynamic scheduling schemes.***  SPS/CG transmissions are designed to reduce PDCCH/DCI transmission/monitoring and hence possibly to reduce power consumption. At the same time, due to reduced scheduling opportunity, less flexible resource allocation and link adaptation, lack of MU-MIMO capability, etc., it is expected that SPS transmission will result in significantly lower capacity even for full buffer or FTP traffics. For XR traffic with stringent data-rate/latency/reliability requirements, the degradation of system capacity can be even more severe compared to dynamic scheduling. Note that with the limited number of users per cell for XR traffic, PDCCH overhead is not an issue at all. CG transmission for uplink has the advantage of without needing to wait for SR/BSR from the UE and hence can potentially reduce the overall latency of packet deliverable and improve capacity.  The proposed techniques are just trying to reduce the capacity loss of the SPS/CG transmissions. How much that can be done without changing the fundamentals of the SPS/CG mechanism is yet to be shown. Overall, it is hard to see it as a capacity improvement effort. The best it can achieve is to get closer (but still much less) to what dynamic scheduling can do and therefore far from solving the capacity issue we have for XR traffic.  For the reasons listed above, the following conclusion was reached during last RAN1 meeting:  **Conclusion**  There is no consensus in RAN1 on the benefits of enhancing SPS for the purpose of XR capacity enhancement  Furthermore, for the same reasons, we also do not see the benefits of capacity performance of single DCI scheduling multi-PDSCHs/PUSCHs.  Based on the above analysis, we propose the following:  ***Proposal 2: For enhancement for SPS/CG transmissions to improve XR capacity, focus study on enhancement for CG transmission for uplink.*** |
| Huawei/HiSilicon | **DL scheduling (SPS vs DG)**  *Observation 7: For XR DL transmission, the benefits of using SPS is not clear compared with dynamic scheduling.* |
| CATT | **Observation 5: The two alternatives of SPS enhancement as following can both improve the capacity of XR traffic based on the SPS configuration:**   * **Alt 1: The additional resource allocation is indicated by L1 signalling and/or MAC layer information for improving the capacity of XR-specific traffic.** * **Alt 2: The pre-configured monitoring window is bundled with the SPS PDSCH occasion for improving the capacity of XR-specific traffic.**   However, from the flexibility perspective, the Alt 2 of SPS enhancement that the pre-configured PDCCH monitoring window bundled with the SPS reserved resource occasion has the advantage of minimizing the overhead and flexible in improving the resources for the variable XR-packet sizes and interarrival time caused by network delay jitter.    Figure 4: SPS with additional resource allocation  Table 7: The evaluation results of the SPS enhancement where the baseline is DG scheduling with C-DRX(16,12,4)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | Power saving | | **#satisfied UEs per cell** | **% of satisfied UEs** | **Capacity performance gain** | **PSG** | | DG scheduling with C-DRX(16,12,4) (Baseline) | 10.9 | 90.97% | - | - | | Multiple SPS configurations | 0 | 0% | - | - | | SPS enhancement | 10.8 | 90% | -0.9% | 9.9% | | SPS enhancement with Go-To-Sleep | 10.6 | 88.3% | -2.7% | 38.1% |   Thus, we have the following observation:  **Observation 6: The SPS enhancement scheme can obtain the capacity performance of 10.8 UEs per cell and 9.9%~38.1% power saving gain compared to that of DG scheduling with C-DRX(16,12,4), additionally the multiple SPS configurations hardly provide UE the XR-specific service.**  Table 8: The evaluation results of the SPS enhancement where the baseline is DG scheduling with UE always on   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | Power saving | | **#satisfied UEs per cell** | **% of satisfied UEs** | **Capacity performance gain** | **PSG** | | DG scheduling with UE always on | 11.5 | 95.83% | - | - | | SPS enhancement | 10.8 | 90% | -6.1% | 12.6% | | SPS enhancement with Go-To-Sleep | 10.6 | 88.3% | -7.8% | 39.9% |   Thus, we have the following observation:  **Observation 7: The capacity performance of the SPS enhancement in our contribution is near to that of DG scheduling with UE always on and with the 6.1%~7.8% capacity performance gap, while it can obtain the obvious power saving gain, i.e. 12.6%~39.9%, than that of baseline scheme.**  Based on the description and the evaluation results, we give the following proposal.  **Proposal 8: The Alt 2 of SPS enhancement that the pre-configured PDCCH monitoring window bundled with the reserved SPS resource for PDSCH would be provide the resource to meet the QoS requirement of XR-specific traffic.** |
| Intel | Handling multiple flows and CG enhancements  In the capacity evaluation of UL AR [2], significant performance degradation was observed for two stream traffic (pose/control + video) compared to single stream traffic (video) despite the small packet size of pose/control traffic. In Figure 3, it is shown that the capacity decreases from 7.8 to 3.4 for SU-MIMO and from 10.5 to 4.6 for MU-MIMO. This is because the scheduler is not being aware of which stream each packet belongs to and schedules using first in, first out approach. Therefore, it is possible that pose/control packets with more stringent delay requirement fails to be delivered within its PDB due to the long wait time in the buffer while the large video packet is served.    Figure 3. Capacity comparison between UL AR 10Mbps video with and without pose/control  ***Observation 1: For UL AR two stream traffic, the capacity decreases significantly if the scheduler does not differentiate between the streams and schedules the packets using first in, first out approach.*** |
| InterDigital | **Proposal 8:** Support multiple active CG configurations (e.g. with different set of parameters) for handling multiple flows with different traffic patterns  **Proposal 11:** Support UE requesting dynamic adaptation to SPS parameters (e.g. number of PDSCHs per occasion) for receiving DL traffic |
| ZTE, Sanechips | Observation 11: Given the advantages of reducing overhead of downlink control signaling and transmission latency, SPS mechanism can be considered for XR traffic.  Proposal 4: Suggest to capture SPS enhancement techniques as well as their evaluation results proposed by companies into TR38.835. Potential XR-specific SPS enhancement Towards to the all the issues of transmitting XR service by SPS transmission mentioned above, the solution is similar to potential CG enhancement:   * Parameters, such as MCS level and the number of layers, are adjusted for each packet transmission to increase capacity performance by resource efficiency enhancement. * Non-integer periodicity alignment is used to eliminate the accumulation of delay so that the delay is controlled within the acceptable range. * Unused resource release is used to release the redundant resources and UE is capable of skipping the redundant resources instead of blindly detecting each resource.  Evaluation results and analysis for SPS enhancement  |  |  | | --- | --- | |  |  | | (a) Downlink Traffic model 6: 45Mbps@60fps, 10ms | (b) Downlink Traffic model 7:  60Mbps@60fps, 10ms |   Figure 13 Capacity performance comparison for Case 1 and Case 2 for Traffic Model 6 and Traffic Model 7 in Indoor HotSpot scenario  Observation 12: When considering the traffic model of 45Mbps@60fps, 10ms or 60Mbps@60fps, 10ms in Indoor Hotspot, SPS enhancement techniques, including e.g., unused resource release and dynamic parameter adjustment are capable of supporting considerable amount of UEs compared with legacy SPS transmission scheme.  Table 3 Power consumption comparison for Case 1 and Case 2 for Traffic Model 6 and Traffic Model 7 in Indoor HotSpot scenario   |  |  |  |  | | --- | --- | --- | --- | | **Traffic model No.** | **Case** | **Capacity** | **Power consumption** | | Traffic Model 6:  45Mbps@60fps, 10ms | Case 1: Legacy SPS | 0 | 195.43 | | Case 2: MSPS | 4 | 52.88 | | Traffic Model 7:  60Mbps@60fps, 10ms | Case 1: Legacy SPS | 0 | 195.37 | | Case 2: MSPS | 2.4 | 61.06 |   功耗降低的增益  Figure 14 Power consumption reduction  Observation 13: SPS enhancement techniques, including e.g., unused resource release, are capable of reducing power consumption by reducing the blind detection of PDSCH compared with legacy SPS transmission scheme. |
| Ericsson | ***Conclusion (RAN1#110):***  *There is no consensus in RAN1 on the benefits of enhancing SPS for the purpose of XR capacity enhancement* **Due to the Conclusion in RAN1#110 reported above, we focus our analysis on CG enhancements.** |
| China Telecom | HARQ-ACK and CBG enhancements for SPS In XR service, we consider introducing a CBG-based SPS configuration scheme. The downlink SPS is enhanced to adapt to the characteristics of high transmission rate of XR service.  UE receives the signaling sent by the base station, and the signaling carries the SPS code block configuration information. The configuration information is used for UE to receive downlink SPS PDSCH based on CBG. The configuration can be used for all/part/single SPS transmission configuration. For example, CBG-based SPS transmissions can adopt the same or different transmission configurations due to different service transmission and priorities.  ***Proposal 6 Support CBG-based SPS transmission with multiple TBs.*** |
| TCL | * **Additional PDCCH monitoring occasion**   As agreed in Rel-17 RAN1 meeting, a truncated Gaussian distribution is used to model the jitter of DL and UL video stream for XR services. The range of jitter is agreed to be [-4, 4]ms (baseline) and [-5, 5]ms (optional). This means the XR packets may arrive at gNB or UE within a time window of 8ms or 10ms length, and the exact arrival time is not known in advance. When the XR traffic is arrived before CG transmission occasion, UE can transmit a PUSCH on the following TO. However, when the XR traffic is arrived after CG transmission occasion, UE need to postpone the PUSCH transmission to the next CG periodicity. As a result, latency maybe over budget. One potential way to solve this problem is to use multiple CG configurations for XR services, however, low resource efficiency will be caused due to much resources need to be reserved in this way. To improve the resource efficiency, additional PDCCH monitoring occasions can be considered for XR during the range of jitter.  ***Proposal 2: Additional PDCCH monitor occasions can be considered for XR during the range window of jitter.*** |
| Sony | The legacy downlink control information (DCI) for SPS/CG is scrambled by CS-RNTI. The DCI is used for the indication of SPS/CG type II activation and release. The associated SPS/CG can only support periodic traffic with fixed packet size. Moreover, only one CS-RNTI is supported in the legacy NR. XR service could contain multiple UL and DL streams/flows (pairs) with variable packet size. To cover the indication of SPS/CG operations for each stream/flow (pair), multi-TB SPS/CG and dynamic update of SPS/CG configurations was proposed [6]. However, considering one more case when both DL I-stream and P-stream need same SPS periodicity, one way to solve this issue is to configure two SPS with different SPS id but same periodicity, this will waste SPS configuration since the max number of SPS is limited to 8 by radio resource control (RRC). Alternatively, another method is to use same SPS id and different resource allocation for different streams. But in this case, UE needs to know which stream the DCI indicates. Noticing this, in this section, we would like to propose a scheme with multi CS-RNTIs configuration as a complement to solve the issue.  An example of the multi CS-RNTIs scheme is illustrated in Figure 3, with the assumption of AR scenario with two DL (I-stream and P-stream) and three UL streams (I-stream, P-stream and pose/control stream). Firstly, two CS-RNTIs associated with different stream (pairs) will be configured and sent by RRC signalling, e.g. CS-RNTI1 will indicate the operations of SPS/CG for I-stream pair (green) and CS-RNTI2 for P-stream pair (purple). The third periodic UL stream (yellow) can be served by CG type I without CS-RNTI. Through this configuration and scheduling procedure, the operations of SPS/CG for four streams with two I-steam and P-stream pair can be dynamically and flexibly indicated.    Figure 3:Multi CS-RNTIs configuration for multi streams in XR.  Proposal 4: Multi CS-RNTIs configuration for multi flows in XR can be considered.  Proposal 5: A new SPS type configuration that is similar to CG type I configuration can be considered to support multi-flows in XR. |
| Panasonic | Simultaneous CG and DG configurations If the DRX is configured for the power saving purpose, the UE will not monitor the PDCCH during the DRX OFF state. Hence, a scheduling DCI cannot be delivered fast. To enable the UE to monitor PDCCH after the CG transmissions, The UE will continue monitoring the PDCCH occasions for a defined period of time if it performs the CG transmissions. This is similar to support *drx-RetransmissionTimerUL* after CG transmission.  **Proposal 3: The UE continues monitoring PD~~S~~CCH occasions for a defined period of time after performing the CG transmission. It is similar to support *drx-RetransmissionTimerUL* after CG transmission.**    Figure 3. CG resources configured for an UL video stream. |
| Samsung | **Observation 2:** *In addition to SPS PDSCH, there is no need to further consider CG PUSCH modifications for XR.*  RAN1 considered that a UE provides pose/control information every 4 msec and SA4 seems to consider even faster updates every 1 msec. The above are not possible for typical TDD UL-DL configurations at 15 kHz and may also not be possible at 30 kHz for the faster rates. In Rel-17, latency reduction for HARQ-ACK information is supported through PUCCH cell switching for UEs supporting (and configured with) inter-band UL CA. This can also reduce latency for a UE to provide a positive SR and get scheduled. Although considered several times in the past, a similar mechanism is not supported for the PUSCH mainly because a MAC entity for a given HARQ process will need to be shared by multiple cells in order to support retransmissions on any of the multiple cells. However, pose/control information is UCI similar to CSI report providing information for subsequent scheduling, and there is no need for HARQ retransmissions of outdated pose/control information and Rel-17 PUCCH cell switching (semi-static) is directly applicable.  **Proposal 2: Support CG-PUSCH cell switching for pose/control information (no HARQ retransmissions).** |

### 2.5.1 Initial Discussion

**High level proposals based on input contributions:**

**Topic 1: SPS enhancements:**

* The proposed enhancements suggest configuring PDCCH monitoring occasions after SPS PDSCH transmission occasions. The performance evaluation results by CATT show power saving gain, but no capacity gain. The performance evaluation results by ZTE show gain as compared to legacy SPS, and not DG. Other enhancemnts such as support of CBG for SPS and Type-1 activation are suggested.
* Few companies have expressed concerns on support of any SPS enhancementsfor XR capacity improvements emphasizing that the DCI overhead is not a bottle-neck for XR capacity.
* **Moderator’s recommendation for Topic 1:**
  + **Per conclusion in RAN1#110, SPS enhancements for XR capacity improvements is down prioritized.**

**Topic 2: PDCCH monitoring occasion during DRX OFF**

* CATT has provided simulation results for the proposed enhancements for both DL and UL (see section 2-1), showing power saving gain, but no capacity gain.
* **Moderator’s recommendation for Topic 2:**
  + **Configuration of PDCCH monitoring occasions during DRX-off for XR capacity improvements is down prioritized**

**Topic 3: XR multiple flows differentiation with CG transmission**

* **Moderator’s recommendation for Topic 3:**
  + **Companies feedback regarding this topic is needed.**

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on **Moderator’s recommendation for Topic 1**?
* **Q2:** What is your view on **Moderator’s recommendation for Topic 2**?
* **Q3:** Discuss your view regarding the proposed enhancements in **for Topic 3**
* **Q4:** Discuss your view regarding the proposed enhancements/recommendations and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q5:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **Samsung** | Q1: Agree with moderator – RAN1 already concluded.  Q2: Agree with moderator. Given the almost certainly short DRX cycle for XR, if proposal 2 was to apply, what would be the meaning of having DRX?  Q3: No need for the proposed enhancements – CG is even less appropriate for multiple flows as that is another dimension for the dynamic nature of XR.  Q4: RAN1 discussion/conclusion for simulation assumptions and feasibility and for the benefits over DG is first needed. |
| **Futurewei** | Q1: Agree that this is already concluded.  Q2: Agree with moderator  Q3: With multiple flows, it is even more difficult to see the capacity benefit of CG over DG.  Q4: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: We are OK with the proposal deprioritize SPS.  Q2: We don’t agree with the proposal.  PDCCH monitoring at DRX OFF is the enhancement of dynamic scheduling to support XR and other traffic in the same time. The PDCCH monitoring at DRX OFF is one technique of C-DRX enhancement to align the PDCCH monitoring cycle with the XR traffic cycle.  Q3: The trunking efficiency is reduced for XR multiple flow differentiation with CG. We need performance results to justify the proposed techniques.  Q4: All results should be captured in the TR |
| **MTK** | Q1: Agree with moderator – RAN1 already concluded.  Q2: Tend to agree with moderator. To us this is more like a power enhancement scheme. Besides, RAN2 is desining semi-static DRX periodicity enhancement to match XR traffic, so the XR traffic aligning with CDRX (PDCCH monitoring) may not still be an issue  Q3: We do not see evident capacity gain for the proposed enhancements  Q4: Discuss your view regarding the proposed enhancements/recommendations and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.  Q5: We are ok to capture the results if the comparison baseline is DG |
| **ZTE, Sanechips** | Q1: Agree with Moderator’s recommendation for Topic 1. But we think the evaluations on SPS enhancement can be captured in TR38.835 as illustrated in Q4.  Q3: We are open to study CG enhancement on multiple streams model. However, due to limited time unit, RAN1 has not yet had any conclusions for CG enhancement for single stream model. We suggest to focus on the discussion on 2.1~2.4. Moreover, the XR multiple streams differentiation is more likely for XR-awareness transmission, which is in charged by RAN2. We can wait for RAN2’s conclusions on XR-awareness transmission |
| **LG** | **Q1, Q2:** Agree with moderator’s assement.  **Q3:** multi-flow is XR use case clearly, but the issue is hard to be identified since it highly depends on what kind enhancement would be done in this AI. We don’t think it is necessary to down-prioritize at this stage. It would be better to keep this for future discussion.  **Q4:** Same as before. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Panasonic** | Q1: We are fine with the proposal.  Q2:We are fine with the proposal.  Q3: We are fine with the proposal. Flow differentiation is required to meet different QoS. |
| **Google** | **Q1, Q2**: We agree with the moderator’s recommendation.  **Q3**: UL pose and control information is a periodic traffic with no jitter and can use CG configuration with no enhancement needed. UL AR video would need a different CG with some enhancement to handle the varying packet sizes and the jitter. |
| **vivo** | Q1: Support moderator’s recommendation.  Q2: Support moderator’s recommendation.  Q3: Currently multi-CG configurations be used to address multi-flow case. What will be enhanced and the spec impact need more clarifications. |
| **Ericsson** | Q1: Agree w Moderator  Q2: Agree with Moderator. To CATT, the fact that there is no capacity gain, it is clear this proposal does not belong to capacity gain agenda. It should be discussed in power saving.  Q3: Agree with others. Moreover, such differentiation is more RAN2 topic than RAN1. |
| **Sony** | The conclusion made in RAN1#110 did not explicitly mention to down-prioritize SPS enhancements. The discussion and evaluation related to SPS enhancement can still be captured in the TR. |
| **InterDigital** | Q1 and Q2:Agree with Moderator’s recommendation  Q3:Ok for studying CG enhancements for supporting multiple flows. We think configuring different CG configurations with different periodicties that are aligned with the periodicities of different UL flows (e.g. pose, video) are beneficial for improving capacity. |
| **OPPO** | Q1/Q2: Agree with moderator.  Q3: Multiple flows differentiation with CG transmission can be solved if the followings are supported:   * Single CG configuration with multiple PUSCH occasions per CG period; * Dynamic indication of the unused CG PUSCH occasions. |
| **Lenovo** | Q1&Q2: agree with Moderator  Q2: can conclude  Q3: maybe RAN2 can discuss this first |
| **Huawei/HiSilicon** | Q1: Agree with moderator – RAN1 already concluded.  Q2/3: Agree with moderator. |
| **Nokia, NSB** | We support Moderator’s recommendation for Topic 1&2.  As per Topic 3, more justification is need to see the benefits from the enhacnements and already existing possibility to activate multiple CGs per different flow if needed. |
| **Qualcomm** | Agree on views. |

# 3 Dynamic scheduling/grant enhancements

The followings are agreed/concluded previously:

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| **Agreement (RAN1#109-e):**  To study whether/how to support a candidate capacity enhancement technique for XR traffic based dynamic scheduling/grant transmissions, companies are encouraged to consider the following studies:   * + - Study enhancements related to extending capability of single DCI scheduling multi-PDSCHs/PUSCHs for FR2-2 to FR1/FR2.     - Note: whether and how to discuss enhancements may depend on the outcome of Rel-17 B52.6G UE feature discussion     - Study enhancements related to HARQ-ACK and/or CBG transmissions for single DCI scheduling one or multi PDSCH(s).     - Study enhancements related to allowing different configurations per PDSCH/PUSCH     - Study enhancement related to scheduling request and/or BSR with the focus on L1 enhancements.     - Note: Other studies are not precluded as well as the combination of the above studies. * Follow the *common principle for assessment of the candidate capacity enhancement technique.*   **Agreement (RAN1#110):**  RAN1 to make decision on the following in RAN1#110bis-e   * Support single DCI scheduling multi-PDSCHs/PUSCHs which is currently supported for FR2-2 to other SCS in FR1/FR2.   **Agreement (RAN1#110):**  Whether/how to enhance BSR to improve capacity performance of XR traffic is within RAN2 scope and is not handled by RAN1.   * Note that companies should indicate if and what BSR enhancement is assumed in their RAN1 proposals on CG and DG enhancements. * RAN1 can evaluate BSR enhancement to improve capacity performance. |

The views regarding DG enhancements for serving XR traffic are summarized and discussed in the following sections.

## 3.1 Extension of multi-slot PxSCHs from FR2-2 to FR1/FR2

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (15):** Futurewei, Huawei/HiSilicon, CATT, vivo\*, Intel\*, MTK, Nokia/NSB, IDC, QC, ZTE/Sanechips\*, Ericsson, CMCC, Panasonic, LG, [Samsung]
  + **Supportive of enhancements (10)**: vivo\*, Intel\*, Nokia/NSB, IDC, QC, Ericsson, CMCC, Panasonic, LG, Samsung
* **Not supportive (5):** Futurewei, Huawei/HiSilicon, CATT, MTK, ZTE/Sanechips\*
* **Companies with evaluation results (3):** vivo\*, Intel\*, ZTE/Sanechips\*

**High-level observations:**

* The Proponents’ main reason is that due to large XR packet sizes, it is reasonable to use a single DCI to schedule the XR TBs in multiple slots. The performance maybe improved by supporting the flexibility.
* The opponents’ main reason is that the PDCCH overhead is not a bottleneck for XR capacity. Hence, supporting multi-slot PxSCHs is not beneficial.
* 3 companies, vivo, ZTE/Sanechips and Intel have provided simulation results.
  + Vivo shows capacity gain when PDCCH overhead is used by data, however ZTE does not show any gain.

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| **Company** | **Summary of Contributions inputs** |
| Futurewei | Reasons: As the number of users per cell is relatively small for XR traffic, PDCCH/DCI overhead is not the bottleneck for system capacity. Instead of improving capacity, single DCI scheduling multi-PDSCH/PUSCH losses some flexibility of scheduling in terms of resource allocation, link adaptation, MU-MIMO pairing, etc. and may in fact decrease capacity.  ***Proposal 3: Deprioritize the study of enhancements related to extending capability of single DCI scheduling multi-PDSCHs/PUSCHs for FR2-2 to FR1/2.*** |
| Huawei/HiSilicon | If several PDSCHs/PUSCHs scheduled by one DCI use the same MCS to transmit, it may decrease the XR capacity. Moreover, according to R17 XR evaluation, the bottleneck of XR capacity lies in the data channel rather than the control channel. Using multiple DCIs to schedule multiple PDSCHs/ PUSCHs may be more flexible and better for XR capacity.  ***Observation 10: Single DCI scheduling multi-PDSCHs/PUSCHs may decrease the XR capacity.***  ***Proposal 3: RAN1 does not pursue enhancements related to single DCI scheduling multi-PUSCH/PDSCHs in XR SI.*** |
| CATT | **Proposal 7: The single DCI scheduling multi-PDSCHs/PUSCHs in FR1/FR2 would not be considered in XR capacity enhancement, since the PDCCH monitoring per slot is not be the challenge for UE capability and the drawbacks of this scheme is not ignored.** |
| vivo | Multi-PXSCH scheduling  * **Case 1**: Single-PDSCH scheduling, and X symbol(s) are always reserved for PDCCH transmission in each slot. * **Case 2**: Multi-PDSCH scheduling, and X symbol(s) are always reserved for PDCCH transmission in each slot. * **Case 3**: Multi-PDSCH scheduling, where unoccupied CORESET in a slot can be re-used for PDSCH transmission. * X symbol(s) are reserved for PDCCH transmission in a slot, if in the slot at least one scheduling DCI is transmitted based on single-PDSCH scheduling and/or multi-PDSCH scheduling. X = 0.5 means that the CORESET occupies one OFDM symbol and 1/2 of the carrier bandwidth, while for X = 1 or X = 2, the CORESET occupies X OFDM symbol(s) and the full carrier bandwidth. * No symbol is reserved for PDCCH transmission in a slot, if in the slot no scheduling DCI is transmitted, i.e., the X symbol(s) reserved for PDCCH transmission in the slot are re-used for PDSCH transmission.   Table 2 Comparison of capacity performance between single-PDSCH scheduling and multi-PDSCH scheduling   |  |  |  |  | | --- | --- | --- | --- | | **X** | **Cases** | **Capacity (#UEs/cell)** | **Capacity gain** | | 0.5 | Case 1 | 10.25 | - | | Case 2 | 9.68 | -5.56% | | Case 3 | 10.10 | -1.14% | | 1 | Case 1 | 9.80 | - | | Case 2 | 8.81 | -10.10% | | Case 3 | 10.37 | 5.82% | | 2 | Case 1 | 8.16 | - | | Case 2 | 7.25 | -11.15% | | Case 3 | 9.58 | 17.40% |   Meanwhile, the comparison of capacity performance between single-PDSCH scheduling and multi-PDSCH scheduling is also shown in Figure 4.    Figure 4. Comparison of capacity performance between single-PDSCH scheduling and multi-PDSCH scheduling  *Observation 4: Compared to single-PDSCH scheduling, multi-PDSCH scheduling can achieve capacity gain in case that during multi-PDSCH transmission 1 or 2 symbols of PDCCH resources may be saved and the unused PDCCH resources can be allocated for PDSCH transmissions.*  *Observation 5: If dynamic PDCCH resource sharing with PDSCH can be supported, it is beneficial to adopt multi-PDSCH scheduling for resource allocation of XR traffic, especially for video traffic.*  *Observation 6: Up to Rel-17 NR, multi-PUSCH scheduling has been supported for all SCSs and for FR1/FR2-1/FR2-2.*  ***Proposal 3: Support single DCI scheduling multi-PDSCHs which is currently supported for FR2-2 to other SCS in FR1/FR2-1.*** |
| Intel | In one example, DCI can explicitly provide the number of consecutive PDSCH allocations, where the first PDSCH allocation follows the TDRA in the DCI, and the remaining PDSCH allocations have the same length, starting symbol and PDSCH mapping type, and are appended in the following slots. On the other hand, different configurations per PDSCH can also be considered such as separate MCS selection, which can be useful when scheduling packets from multiple flows. Single slot scheduling may provide higher capacity gain than multi-slot PDSCH/PUSCH scheduling if channel is dynamically varying and frequent channel states feedbacks are available. If channel is slowly varying and/or frequent channel updates are not available, multi-slot scheduling may result in comparable performance with single slot scheduling.    Figure 1. Average number of TBs per packet for DL AR, CG    Figure 2. Average number of TBs per packet for UL AR  ***Proposal 1: Since a given XR DL or UL packet may require multiple PDSCH or PUSCHs to complete delivery of packet transmission, RAN1 can investigate single DCI based multiple PDSCHs and/or PUSCHs scheduling to reduce DCI overhead and provide gNB with scheduling flexibility and options.***   * ***Multiple PUSCH/PDSCH scheduling solution adopted for B52.5GHz can be a starting point.*** |
| MediaTek | ***Proposal 4: Since control overhead is not the bottle neck for XR capacity according to R17 study, we suggest to deprioritize enhancement for "one DCI to schedule multiple-slot PDSCH/PUSCH" with similar reason as SPS enhancement.*** |
| Nokia/NSB | Current multi-PxSCH scheduling with single DCI is supported for the following SCSs:  - For multi-PUSCH/PDSCH scheduling: SCSs 120 kHz, 480 kHz, 960 kHz  - For multi-PUSCH scheduling: SCSs 15 kHz, 30 kHz and 60 kHz are also supported in FR1.  In case there is consensus in RAN1 to extend the capability of supporting single DCI scheduling multi-PxSCHs for XR, it is worth to investigate further any essential gaps considering fulfilling the QoS requirements at least PDB and reliability of XR TBs. For example, multiple TBs over multi-PxSCHs corresponding to the same XR frame are actually transmitted in different TTIs which leads to different available time window for transmission of different TBs.  ***Proposal 5****: Extend the capability of multi-PDSCH scheduling to lower SCS and frequency range in order to better serve XR use cases in various deployments.* |
| InterDigital | For minimizing the scheduling latency and overhead when transmitting PDU sets with different payload sizes in one or multiple TBs, it can be beneficial for allocating multiple PUSCHs with a single DCI. Similar savings in overhead can be expected in DL when scheduling multiple PDSCH with single DCI.  **Proposal 12:** Support single DCI scheduling multiple PxSCH for FR1 and FR2-1 |
| Qualcomm | ***Observation 5: Multi-PDSCH/PUSCH scheduling DCI is suitable for XR video data transmission for jitter handling, scheduling of large and variable size of video frame data and UE power saving by PDCCH monitoring reduction.***    Figure 12: multi-PDSCH scheduling DCI with jitter handling and PDCCH skipping  ***Proposal 11: To support more efficient scheduling of XR video data, the single DCI scheduling multiple independent PDSCHs feature can be extended to FR1 and FR2-1.*** |
| ZTE/Sanechips | Observation 14: In the assumption that the PDCCH resource are saved in all PDSCHs except the first PDSCH, single DCI scheduling multi-PDSCHs provides marginal capacity performance gain, i.e around 3% performance gain [2].   |  |  | | --- | --- | |  |  | | 1. Scenario: Urban Macro | (b) Scenario: Indoor Hotspot |   Figure 15 Capacity performance comparison between single DCI scheduling multiple PDSCHs and single DCI scheduling single PDSCH in 30Mbps@60fps, 10ms in Urban Macro/ Indoor HotSpot scenario  Observation 15: Compared to one DCI scheduling one PDSCH, capacity performance of one DCI scheduling multiple PDSCHs degrades, due to limited PDCCH overhead saving as well as inflexible resource assignment, i.e., fixed MCS and FDRA assignment across multiple PDSCHs.  Observation 16: In the assumption that the PDCCH resource are seldom saved in all PDSCHs due to random UE data arrival, single DCI scheduling multi-PDSCHs is not beneficial to the improvement of system capacity and even worse than that of single DCI scheduling single PDSCH.  Observation 17: Considering mixed initial transmission and re-transmission in single DCI scheduling multi-PDSCH is supported in current specification, it has a negative impact on capacity performance due to inflexible resource assignment, i.e., fixed MCS and FDRA assignment for each PDSCH.  Proposal 5: De-prioritize the study of enhancements related to extending capability of single DCI scheduling multi-PDSCHs for FR2-2 to FR1/FR2 for XR, since it has no benefit to improve capacity performance. |
| Ericsson | Observation 6: For serving varying and large-sized XR application packets, single DCI (PDCCH) scheduling multiple PxSCHs can be an alternative to single DCI (PDCCH) scheduling single PxSCH.  Proposal 8: RAN1 to support the extension of operation of dynamic multi-PDSCH scheduling to FR1 and lower SCS (e.g., 30 kHz). |
| CMCC | **Proposal 5. Different configurations per PDSCH/PUSCH in a single DCI grant, e.g., MCS, frequency resources can be considered for the extension of single DCI scheduling multi-PDSCHs/PUSCHs in FR2-2 to FR1/FR2.** |
| Panasonic | The XR traffic data could be large and require a number of PDSCH/PUSCH allocations for each frame. To reduce the signaling overhead for DCI transmission over PDCCH and achieve a better power consumption for the UE, a DCI with multiple PDSCH/PUSCH scheduling could be considered. The functionality was specified already for FR2-2 in Rel.17. We currently think the same design can be applicable to FR1 and FR2-1.  **Proposal 4: A DCI scheduling multi-PDSCH/PUSCH specified for FR2 should be considered for other frequency range.** |
| LG | If PDCCH overhead is not an issue, there wouldn’t be performance benefit to support single DCI scheduling multi-PDSCHs/PUSCHs for XR capacity improvement. Since the single DCI scheduling multi-PDSCHs/PUSCHs could only save the number of DCI with less flexibility as trade-off. Nevertheless, less number of DCI could help changing services faster, and multi-PUSCHs can be utilized for CG enhancement in order to support multiple CG occasion in a period. Thus, it would be beneficial to support single DCI scheduling multi-PDSCHs/PUSCHs for XR if specification impact can be minimized.  Proposal 7: It is beneficial to re-use the UE capability of single DCI scheduling multi-PDSCHs/PUSCHs for XR capacity improvement.   * It is necessary to wait the outcome of Rel-17 B52.6G UE feature discussion. |
| Samsung | Another issue that remains pending from RAN1#110 is the support of multi-slot PXSCH scheduling in FR1/FR2. Although the reasons for introducing multi-slot PXSCH scheduling in FR2-2 (PDCCH limitations and short slot duration) do not apply in FR1/FR2, PDCCH capacity/overhead is not an issue for XR, and scheduling restrictions associated with multi-slot PXSCH scheduling are undesirable for XR, it may be argued that multi-slot PXSCH scheduling can also apply to FR1/FR2 subject to UE capability. |

### 3.1.1 Initial Discussion

**High level proposals based on input contributions:**

**Proposal 3-1-1:**

* **Support single DCI scheduling multi-PDSCHs which is currently supported for FR2-2 to other SCS in FR1/FR2-1*.***

**Moderator’s suggestion for initial discussions:**

* **Q1:** Provide your analysis to understand the difference between ZTE/Sanechips and vivo simulation results.
* What is your view on direction of Proposal 3-1-1 and the necessity/benefit of the proposed enhancements?
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1: DCI rates (~1 Kbps) are several (4-5) orders of magnitude less than data rates (10s Mbps) for XR. That removes from consideration any PDCCH/DCI enhancements for the purpose of capacity. Therefore, based on simple analytical considerations, there is no need to spend time discussing specific simulation assumptions/accuracy of evaluations for Q1.  Q2: We prefer to have the option to apply “as is” the multi-PXSCH scheduling from FR2-2 to FR1/FR2 and to postpone for now a decision to include/exclude (can still be concluded at this meeting). Whether anything needs to be captured in the TR can be discussed later. |
| **Futurewei** | Q1: Agree with Samsung’s analysis. No need to consider further Proposal 3-1-1.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: We don’t see the benefit of Proposal 3-1-1. The results of performance gain from contributions are way too optimistic even with 2 symbols of PDCCH used for PDSCH in single DCI scheduled multiple PDSCH. The loss of link adaptation gain and inflexible of retransmission among PDSCH HARQ by single DCI scheduling multiple PDSCH would limit the performance.  Q2: All results should be captured. Some over-optimistic results should have note and observation for clarification. |
| **MTK** | Q1: We don’t see clear benefit for Proposal 3-1-1. The results from vivo which assumes “PDCCH overhead is used by data” is not really practical from our perspective. The results from ZTE seems more reasonable to us.  Q2: The results can be captured if the evaluation assumption is clearly explained in the TR. |
| **ZTE, Sanechips** | Q1: In fact we have similar observation as vivo in the contributions: the capacity performance of 1 DCI scheduling multiple PDSCHs is highly correlated with the PDCCH overhead assumptions. If ideal assumption for PDCCH overhead saving is considered, considerable capacity gain of 1 DCI scheduling multiple PDSCHs can be obtained, while if realistic assumption for PDCCH overhead saving are considered, marginal capacity gain or no capacity gain of 1 DCI scheduling multiple PDSCHs is obtained.  And in our contribution, the two different assumption for PDCCH overhead saving are considered:   * Realistic assumption in R1-2209198: Considering multiple UEs are waiting for scheduling in one slot, PDCCH overheads cannot be saved in the PDSCH except the first PDSCH, where there are PDCCH monitoring occasions for other UEs. * Ideal assumption in R1-2207062: the PDSCHs except the first PDSCHs can re-use the PDCCH overhead to transmit data.   The results for these two assumptions are summarized as follow:   |  |  |  |  | | --- | --- | --- | --- | | **Assumption** | **Techniques** | **Capacity** | **Capacity gain** | | Realistic assumption | 1 DCI scheduling one PDSCH | 9.1 | - | | 1 DCI scheduling multiple PDSCHs | 9.4 | -13.18% | | Ideal assumption | 1 DCI scheduling one PDSCH | 9.1 | - | | 1 DCI scheduling multiple PDSCHs | 7.9 | 3.29% |   We also find that **Ericsson, vivo and ZTE/Sanechips** has provided some negative capacity performance of 1 DCI scheduling multiple PDSCHs compared to 1 DCI scheduling 1 PDSCH in some cases. As a result, basically the observation of negative capacity performance of 1 DCI scheduling multiple PDSCHs in the cases is reasonable.  Q2: Disagreed. |
| **LG** | **Q1:** We share similar view to Samsung, as long as the PDCCH/DCI overhead is not an issue for XR services.  Regarding evaluation results, based on the current specification, the symbols for PDCCH can be utilized as PDSCH resource by gNB’s scheduling. If it is considered in evaluation, the result should be better than other evaluation not considering that.  **Q2:** Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | **Q1**: We support for Proposal 3-1-1. Single DCI scheduling multiple PDSCHs/PUSCHs can have capacity gain thanks to the PDCCH overhead reduction that can be re-used for PDSCHs/PUSCHs scheduling as shown in vivo results. Also, the scheme comes with minimum specification effort as it will be extended from Fr2-2, hence our support for Proposal 3-1-1 |
| **vivo** | Q1: Thanks for ZTE’s clarification.  Indeed some ideal assumptions are adopted for our simulation. We would like to further clarify our evaluation results that we did not consider any other PDCCH that may occupy the CORESET(s) than scheduling DCI, e.g. broadcast PDCCH. With the existence of such PDCCH other than scheduling DCI, the reserved X(1 or 2) symbol(s) may not be fully utilized for PDSCH scheduling if not used for scheduling DCI. Therefore the potential performance gain by multi-PDSCH scheduling shown in the evaluation can be viewed as the upper bound.  Q2: We think the proposed enhancements with evaluation results, especially those showing potential performance gain, can be captured in the TR. Necessary clarification if any can be included. Whether and how to draw observation and conclusion based on the captured techiques and evaluation results can be discussed separately. |
| **Ericsson** | Q1: We are OK to enable support of multi-PxSCH “as it is”, tha tis without enhancements to FR1/FR2-1. The capacity gain, if any, is limited for any enhancement and we should be consistent in our decisions. |
| **InterDigital** | Q1: We think the extension of single DCI scheduling multiple-PDSCH is useful for addressing issues related to transmission of large PDU sets, where any savings from PDCCH overhead reduction that can be used for data can result in capacity improvement. In this regard we support proposal 3-1-1. |
| **OPPO** | Q1: Agree with other companies. No need to further enhance the multi-PxSCH scheduling. |
| **Lenovo** | Similar to SPS, PDCCH is not the bottleneck in XR scenario, and such extension is not likely needed. In general, wondering if entire 1 or 2 symbol PDCCH (full BW) overhead assumption is a bit conservative? |
| **Huawei/HiSilicon** | Q1: disagree with Proposal 3-1-1.  Single DCI scheduling multiple PXSCHs has been studied in Rel-17 B52.6GHz with the benefit of control signaling overhead saving. Multiple PDSCHs scheduled by single DCI have the same MCS and frequency domain allocation indication, which may decrease the XR capacity due to the variable channel condition. In addition, inflexible retransmission may cause extra delay which would also limit the capacity. Moreover, according to R17 XR evaluation, the bottleneck of XR capacity lies in the data channel rather than the control channel. Therefore, this topic can be down-prioritized.  Q2: This topic can be down-prioritized. |
| **Nokia, NSB** | Q1: the difference is coming from vivo’s assumption of giving the resources for PDCCH to PDSCH if the former is not used.  We support Proposal 3-1-1. It helps reduce the DCI overhead and is considered advantages for transmission of larger XR payloads that does not fit into a single TTI. We support having captured single-DCI multi-PDSCH scheduling options for FR1 in the TR.  Moreover, when sparse PDCCH monitoring is configured to save power, multi-PxSCH scheduling can greatly affect the capacity since the scheduling delay is significantly reduced.  Q2: We agree to capture observations and results to TR 38.835. |
| **Qualcomm** | Q1: We think that the capacity gains from vivo are useful. They are showing that Case 3 is useful for capacity as unoccupied coreset can be used for PDSCH. Something that can already be supported.  We support the proposal 3-1-1. We think it is useful for XR burst transmission and reduces the overhead of DCI scheduling.  Q2: We think companies effort should be respected. |

## 3.2 Enhancements of CBG and/or HARQ-ACK feedback

**Status of inputs in the contributions:**

* **Companies with view (11):** vivo\*, QC, ZTE/Sanechips, Lenovo, Rakuten, Nokia/NSB, Samsung, LG, InterDigital, Google, Apple
* **Companies with evaluation results (1):** vivo\*

**High-level observations:**

* **Proposed enhancement for early/Multiple HARQ-ACK feedback reporting for multi-slot PDSCHs scheduling**
  + Vivo\*, QC, ZTE/Sanechips, Lenovo, Rakuten
* **CBG support for multi-slot PDSCH scheduling (when supported)**
  + Support: Nokia/NSB, Samsung
  + Not support: LG
* **Proposed enhancement for CBG based HARQ-ACK feedback reporting**
  + Alt-1: CBG overhead reduction, e.g., Per CBG HARQ-ACK feedback for erroneous TBs
    - Nokia/NSB, Lenovo
  + Alt-2: Mapping TB related XR information to corresponding CBG
    - Lenovo
  + Alt-3: Flexibility in number of CBGs per TB
    - InterDigital, Google
  + Alt-4: CBG based transmission to support QoS enhancement at lower layers.
    - Apple

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| **Company** | **Summary of Contributions inputs** |
| vivo | For example, multiple PUCCHs may be considered where HARQ-ACK for the earlier PDSCH(s) can be reported earlier than the later PDSCH(s) scheduled by the same DCI, to reduce latency of HARQ-ACK feedback. This provides timelier feedback for gNB scheduler.    Figure 5. Multiple PUCCHs for multi-PDSCH scheduling    Figure 6. Comparison of capacity performance for multi-PDSCH scheduling with and without earlier HARQ-ACK feedback  *Proposal 4: Study feasibility and potential benefit of earlier HARQ-ACK feedback for a sub-set of PDSCHs scheduled by a single DCI.* |
| Nokia/NSB | Current multi-PxSCH scheduling with single DCI does not support CBG-based transmission which limits the applicability of multi-PxSCH scheduling for XR use cases with very large payloads. We thus propose to study and consider the CBG-based transmission to be supported by multi-PxSCH scheduling with single DCI.  ***Proposal 6:*** *Consider CBG-based transmission to be supported by multi-PxSCH scheduling with single DCI.*  One of the changes compared to the legacy CBG-based single-PDSCH scheduling is the increase in the HARQ feedback overhead. For instance, if a total number of N PDSCH transmissions are co-scheduled and each contain M CBGs, the total number of HARQ ACK/NACK feedback is of size of M\*N. When M = 8 and N = 8, the total HARQ ACK/NACK feedback can be signifant.  ***Observation 2:*** *Size of HARQ feedback increases as in CBG-based multi-PDSCH transmissions.*  One way to limit this additional overhead is to use some compression techniques to reduce the number of feedback bits. For instance, one possible approach is to consider to send the per CBG HARQ ACK/NACK feedback for the TBs that are in error.  ***Proposal******7****: Consider the per CBG HARQ ACK/NACK feedback for the TBs that are in error to reduce the size of the HARQ feedback in case of CBG-based multi-PDSCH scheduling schemes are specified.* |
| InterDigital | When transmitting different types of video frames (e.g. I-frame, P/B-frames), the corresponding PDU sets may consist of variable payload sizes at each periodic occasion. In this scenario, using a fixed number of CBGs per TB in each period, regardless of the TB size, may increase overhead. For saving the overhead during feedback, it can be beneficial to use a different number of CBGs based on the TB sizes.  **Proposal 15:** Support configuring in UE different number of CBGs associated with different TB sizes  **Proposal 16:** Support dynamic adaptation (e.g. via DCI) to the number of CBGs per TB  For XR traffic consisting of multiple PDU sets which may be transmitted via multiple-PxSCH, the size of each TB in the multi-PxSCH need not be the same.  In this case, using the same number of CBGs per TB when performing multi-PxSCH scheduling may be inefficient.  **Proposal 17:** Support CBG enhancements with different number of CBGs for the different TBs in multi-PxSCH scheduling |
| Qualcomm | ***Proposal 14: For XR, consider studying enhancements for single DCI scheduling multi-PDSCH/PUSCH grants including:***   * ***Allowing for different configurations per PDSCH/PUSCH in a single DCI grant*** * ***Allowing the gNB to change the behavior of one or more of the already granted PDSCHs/PUSCHs after the granting DCI*** * ***Allowing for multiple HARQ-ACKs each for a subset of the multiple PDSCHs***     **Figure 13: Enhanced single-DCI multi-PDSCH**    **Figure 14: Multiple HARQ-ACKs** |
| ZTE, Sanechips | If HARQ-ACK can be reported in multiple slots according to corresponding groups of the scheduled downlink transmissions. Accordingly, delay of HARQ-ACK for a group of PDSCHs can be reduced. In other words, to improve the capacity of DL transmission, partial DL transmission can be re-transmitted earlier if it is not detected correctly by the UE.  Observation 18: It is beneficial that HARQ-ACK feedback for multiple groups of the scheduled downlink transmissions can be reported in multiple slots.  Expect single DCI scheduling multiple PDSCHs, TB over multiple slots can be also considered. TBoMS for PUSCH has been studied and specified in Coverage work item in Release 17. The technique can be also extended to PDSCH to realize the purpose of one DCI scheduling a large packet size.  Therefore, CBG technique can be considered together with the TBoMS to reduce the packet that needs to be re-transmitted. One simple method of CBG division is treat the data in one slot as a CBG, as shown in Figure 16.    Figure 16 CBG based TBoMS  To this end, CBG-based PDSCH transmission in multiple slots can be considered, if single DCI scheduling multiple PDSCHs is supported in RAN1.  Observation 20: Compared with single DCI scheduling multiple PDSCH for FR2-2, TBoMS functionality can be introduced and extended to PDSCH which can reduce the HARQ process number. |
| Lenovo | The packet size of I-frames/I-slices is large, so there would be more TBs (e.g., over multiple slots) scheduled by a single DCI. In this case, UE transmits the HARQ-ACK after the last TB will cause large delay to the first several scheduled TBs, so how to decrease the latency should be studied. For example, multiple TBs could be divided into multiple TB groups and the HARQ-ACK for one TB group could be transmitted timely after that TB group, accordingly, the K1 value and PUCCH resource for each TB group should be decided.  **Proposal 3: Study latency reduction for HARQ-ACK transmission for multi-PD(U)SCH scheduling.**  Another solution to the delayed HARQ-ACK issue (for both single DCI multi-TB scheduling, and multiple single DCIs scheduling couple of TBs each) could be to send any NACK of the first few TBs in a resource that is earlier than a resource used for multiplexing all HARQ-ACK of the multiple TBs. Such a scheme can help gNB schedule the retransmissions in time and avoid PDB expiration. To avoid any ambiguity between gNB and UE, the HARQ-ACK of all TBs (including the ones that have been NACK’d in an earlier PUC(S)CH) are multiplexed in the later PUC(S)CH.  **Proposal 4: Investigate HARQ-NACK prioritization benefits to avoid PDB expiration.**  Given the bursty, quasi-periodic XR traffic characteristic, one of the challenges of XR traffic at L1 is the necessity to quickly retransmit and resolve any erroneously received TBs by a receiver. As errors may affect only part of the CBs of a TB, it is thus of interest to reduce the retransmission overhead to the CB payloads affected only. To this end, the CBG feature of NR may be used. However, the mapping of XR traffic logical channels to a TB, subsequent CBs and enclosing CBGs may benefit from application awareness to map and align video slices to CBGs. Beyond such slice-level awareness, slice importance awareness may be relevant to L1 for FEC with unequal error protection, providing lower coding rates for highly important slices and higher coding rates for lower importance slices. Leveraging the XR application awareness at L1/L2 may thus provide two-fold gains, on one hand reducing the overhead of retransmissions via CBGs, and on the other hand offering proportional error protection to importance of XR information carried by the CBGs.  **Proposal 10: Investigate leveraging XR application awareness (e.g., video slice and stream awareness, video slice importance) to map video slices to TB CBGs for optimized transmissions and retransmissions of XR traffic.**  **Proposal 11: Investigate signaling overhead reduction for CBG-based HARQ-ACK feedback per TB for XR traffic.**  **Proposal 12: Investigate signaling overhead reduction for CBGTI when both CBG-based feedback and multi-PDSCH/PUSCH scheduling are configured simultaneously for a UE.** |
| LG | Once the single DCI scheduling multi-PDSCHs/PUSCHs is supported for XR, gNB would be able to control PDSCH/PUSCH resource size according to XR traffic pattern, like I/P video frame. Considering PDB for XR services, it was proposed to report HARQ-ACK in the middle of multiple PDSCH receptions scheduled by single DCI. However, if DCI overhead is not an issue, it would be sufficient to send two DCI scheduling multi-PDSCHs, in order to have two of HARQ-ACK timings.  Proposal 8: It is not necessary to investigate enhanced HARQ-ACK timing for single DCI scheduling multi-PDSCHs. |
| Apple | On the same CC, simultaneous reception of overlapping unicast PDSCHs is not supported; and simultaneous transmissions of overlapping PUSCHs is not supported. With either dynamic grant PDSCH/PUSCH or configured grant PDSCH/PUSCH tailored for different traffic flows, then it is possible multiplexing packets from multiple data flows on the same MAC PDU/PxSCH. As those packets may have different QoS requirements, e.g. packet 1 is latency sensitive, packet 2 is not. If the first transmission of the MAC PDU over PxSCH is not successful, it may happen at the occasion when retransmission can take place, the latency bound of the packet 1 has been exceeded. In that case, performing retransmission for the packet 1 is a waste of resource. Whether and how to use code block group-based transmission to handle that can be study.  **Proposal 3-3: Study whether code block group based transmission can be used to support QoS enhancement at lower layers.** |
| Rakuten Symphony | Another enhancement for multi-slot scheduling is to support multiple HARQ feedback occasions so that faster HARQ feedback can be sent within the packet delay budget.  **Proposal 3: Consider supporting multiple HARQ occasions for multi-slot scheduling.** |
| Google Inc | Figure 1 shows an example of the legacy design of single DCI scheduling multiple PDSCHs as specified in Rel-17 for FR2-2. The HARQ-ACK feedback for all the PDSCHs is transmitted k1 slots after the end of the last PDSCH of the group of PDSCHs scheduled by the single DCI. This is fine for traffic with standard latency and reliability requirements. But for the XR traffic, getting the HARQ-ACK feedback as soon as possible is crucial to schedule the retransmissions before the expiry of the small XR and cloud gaming packet delay budget.  Figure 2 shows an example of single DCI scheduling multiple PDSCHs. PUCCH resources for HARQ-ACK feedbacks are respectively configured for PDSCHs with different or same K1 values that apply to each PDSCH.    Figure 1: Legacy Single DCI scheduling multiple PDSCHs    Figure 2: K1 per PDSCH for the single DCI scheduling multiple PDSCHs   1. ***Introduce enhancement to the single DCI scheduling multi-PDSCHs scheduling scheme to address the HARQ-ACK feedback latency.***   The number of CBGs per TB could be L1 signalled for better flexibility as shown in Figure 4. Therefore, a new DCI bit-field could be used to signal the number of CBGs per TB. The CBG transmission scheme could also be enabled/disabled dynamically. For example, the CBG transmission scheme can be enabled per traffic flow (e.g. enabled for video traffic and disabled for audio traffic) or enabled depending on the TB size.   1. ***The number of CBGs per TB could be L1 signalled for better flexibility for the XR traffic.*** |
| Samsung | **Observation 3:** *If multi-slot PXSCH scheduling is to be considered for XR, changes to DCI formats and impact to DCI format size matching, support of CBG-based retransmissions, and approximate XR capacity gains should be first concluded.* |

### Initial Discussion

**High level proposals based on input contributions:**

* **Proposal 3-2-1:** **Early/Multiple HARQ-ACK feedback reporting for multi-slot PDSCHs scheduling is beneficial to improve XR capacity performance.**
* **Proposal 3-2-2:** **CBG support for multi-slot PDSCH scheduling (when supported) is beneficial to improve XR capacity performance.**
* **Proposal 3-2-3:** **Enhancement for CBG based HARQ-ACK feedback reporting) is beneficial to improve XR capacity performance. Examples of enhancements are listed below.**
  + Alt-1: CBG overhead reduction, e.g Per CBG HARQ-ACK feedback for erroneous TBs
  + Alt-2: Mapping TB related XR information to corresponding CBG
  + Alt-3: Flexibility in number of CBGs per TB
  + Alt-4: CBG based transmission to support QoS enhancement at lower layers.

**Moderator’s suggestion for initial discussions:**

* **Q1:** Moderator recommends prioritizing Proposal 3-2-1 and Proposal 3-2-2 for discussions due to availability of simulation results and/or more supporting companies.
  + What is your view on Moderator’s recommendation?
* **Q2:** What is your view on direction of Proposal 3-2-1, Proposal 3-2-2 and Proposal 3-2-3, and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q3:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q4:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1-Q3: Suggest to first conclude on the support of multi-PXSCH. If concluded, OK to focus on the more fundamental aspects captured in Q1 as they were also discussed in R17 for B52. |
| **Futurewei** | Q1-Q2: we do not see the need or potential to have multi-PXSCH for XR capacity improvement.  Q3: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1-Q2: We need to see the performance gain before we further discuss the proposed schemes.  Q3: All results should be captured with note for clarification. |
| **MTK** | Q1-Q2: (Same as Samsung) Suggest to first conclude on the support of multi-PXSCH. If concluded, OK to focus on the more fundamental aspects captured in Q1 as they were also discussed in R17 for B52.  Q3: We are ok to capture the results if the comparison baseline is DG. |
| **LG** | It should be discussed after 3.1.1  Q3: Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | We see benefits in the listed proposals but we are aligned with Samsung to first conclude on the support of multi-PDSCHs/PUSCHs scheduling before diving into the details. |
| **vivo** | Q1: For Proposal 3-2-1, if there is conclusion in section 3.1.1, further study on the feasibility and potential benefit of earlier HARQ-ACK feedback can be considered.  Q2: For proposal 3-2-2 and 3-2-3, the benefit needs to be justified by evaluation. Regarding Proposal 3-2-2, it should be noted that there are a lot of issues for enhancements related to CBG based re-transmission and HARQ-ACK reporting, in conjuction with multi-PDSCH scheduling. Besides, most of these issues were discussed extensively during Rel-16 NR-U and Rel-17 B52.6GHz with the conclusion of not supporting. |
| **Ericsson** | Q1: OK with prioritization suggestion. Then agree with Samsung that we need to focus on support of multi-slot PDSCH (since main use case scenarions are FR1/FR2-2).  Q2: We are OK to support 3-2-2 if there is strong majority. Please see our simulation results in section 4.3 shows similar performance between TB based and CBG based. So, the capacity gain is not clear to us.  Regarding other proposals, we don’t see the need. For example for 3-2-1, if there is TDD pattern, it can use both single-slot and multi-slot PDSCH scheduling, to enable early feedback. (for example for n=0,..,2 multi-slot, for slot n=4,.. multi/single slot)   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | D  n=0 | D  n=1 | D  n=2 | U  n=3 | D  n=4 | D  n=5 | D  n=6 | U  n=7 | |
| **InterDigital** | Q1 - Q2:We do not see the need for prioritizing proposals 3-2-1 and 3-2-2 related to multi-slot PDSCH scheduling. We think proposal 3-2-3 on the enhancements for CBG based HARQ-ACK should also be the focus of the study/discussion, as these enhancements apply even for the baseline single PDSCH scheduling. |
| **OPPO** | Q1/Q2: We think there is no need to further enhance the multi-PXSCH scheduling. |
| **Lenovo** | The schemes with simulation results should be prioritized. |
| **Huawei/HiSilicon** | Q1-Q3: Suggest to first conclude on the support of multi-PXSCH. Then, performance gain should be given before we further discuss the topic. |
| **Nokia, NSB** | We support proposals 3-2-1, 3-2-2, 3-2-3 as CBG-based transmission has proven to be useful for XR use cases with transmission of large payloads. This should be supported also for single-DCI multi-PDSCH scheduling options. Having Early/Multiple HARQ-ACK feedback reporting for multi-slot PDSCHs scheduling is beneficial to HARQ loop latencies, and a consequence, help the overall improve XR capacity performance. |
| **Qualcomm** | We think that enhancements for multi-PXSCH are useful. Therefore, we are supporting of multi-HARQ ACK, dynamic indication of change of configuration and adaptive configuration. |

## 3.3 Enhancements of parameters/configurations of multi-slot PDSCHs

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (8):** vivo\*, InterDigital\*, QC, TCL, Ericsson, Sony, Rakuten, CMCC
* **Companies with evaluation results (2):** vivo\*, InterDigital\*

**High-level observations:**

* **Applying different parameters (e.g., MCS, FDRA, TDRA, number of PxSCHs) for multi-PxSCHs scheduled by a single DCI**
  + Support: Vivo\*, InterDigital\*, QC, TCL, Ericsson, Sony, Rakuten
* **PDCCH skipping indication in the single DCI scheduling multi-PDSCHs allows for PDCCH skipping after decoding of the multi-PDSCHs**
  + Support: QC
* **For single DCI scheduling multi-PDSCHs/PUSCHs, support of dynamic change between single TB transmission per PDSCH/PUSCH and TB repetition on multiple PDSCHs/PUSCHs**
  + Support: CMCC
* ..

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| **Company** | **Summary of Contributions inputs** |
| vivo | Enhanced FDRA  In addition, FDRA related indications can be enhanced to better match resource allocation with channel status, as well as pending data for initial transmission and/or re-transmission. For example, the restriction that a single FDRA indication in a scheduling DCI is applied commonly to each PXSCH scheduled by the scheduling DCI may be relaxed, so that more than one FDRA indication can be contained in the scheduling DCI, each of which is applied to one or more scheduled PXSCH.    Figure 7. Comparison of capacity performance for multi-PDSCH scheduling with and without FDRA enhancement  *Proposal 5: Study flexible FDRA related indications for multi-PXSCH scheduling, e.g. more than one FDRA indication can be contained in a scheduling DCI.* |
| InterDigital | Simulation Results  The baseline schemes used in the evaluations are:   * DG with PF scheduling   + Single PDCCH schedules 1 PDSCH   + Overhead: 2 PDCCH symbols per PDSCH   The enhancement resource allocation schemes evaluated in the simulations are:   * DG with FIFO   + gNB prioritizes UEs based on the packet arrival time in UEs buffer. * DG with resource sharing   + gNB ensures that all packets (and hence UEs) are allocated equal number of resources at every scheduling time instance. This guarantees all UEs have some resources. * DG with multi-PDSCHs/PUSCHs   + Single PDCCH schedules up to 4 PDSCHs/PUSCHs   + Overhead: 4 PDCCH symbols for 4 PDSCHs/PUSCHS   + For this scheme, we assume full flexibility in terms of resource (RB allocation) as well as MCS for each of the 4 PDSCHs/PUSCHs. Effectively, this makes it a best case/genie approach.  Downlink   **Figure 1:** FR1 DL CG results for Indoor Hotspot scenario at data rate of 30 Mbps    **Figure 2:** FR1 DL AR results for Indoor Hotspot scenario at data rate of 30 Mbps    **Figure 3:** FR1 DL AR results for Indoor Hotspot scenario at data rate of 45 Mbps Uplink Chart, bar chart  Description automatically generatedChart, bar chart  Description automatically generated  **Figure 4:** FR1 UL AR 10 Mbps for Indoor Hotspot scenario  Chart, bar chart  Description automatically generatedChart, bar chart  Description automatically generated  **Figure 5:** FR1 UL AR two streams for Indoor Hotspot scenario Downlink   **Figure 6:** FR1 DL CG results for Dense Urban scenario at data rate of 30 Mbps    **Figure 7:** FR1 DL AR results for Dense Urban scenario at data rate of 30 Mbps    **Figure 8:** FR1 DL AR results for Dense Urban scenario at data rate of 45 Mbps Uplink   **Figure 9:** FR1 UL AR 10 Mbps for Dense Urban scenario    **Figure 10:** FR1 UL AR two streams for Dense Urban scenario  **Observation 6:** The DG with resource sharing scheduling scheme lowers the probability of bottlenecks in the system by also taking into account the PDB requirements, resulting in improved system capacity, especially at higher loads.  **Observation 7:** The DG with multi-PDSCH scheduling scheme gives the overall best capacity performance due to maximum adaptation/alignment with XR traffic pattern (e.g. large payload sizes, different PDU arrival rates)  **Observation 8:** UL capacity of multi-stream traffic is typically less than that of single-stream traffic when using PF and FIFO based scheduling approaches.  **Observation 9:** Resource sharing based scheduling approach (e.g. allocation of RBs to all UEs in cell) enables UL capacity achieved with multi-stream traffic to be similar with that of single stream traffic. Additionally, this approach significantly outperforms PF and FIFO based scheduling approaches for multi-stream traffic. |
| Qualcomm | ***Observation 6: If data of a XR video frame is scheduled by the same DCI, the number of schedulable PDSCHs may need to be increased beyond 8.***  Increasing the maximum number of schedulable PDSCHs does not necessarily increase the DCI field size for the Time Domain Resource Assignment (TDRA) field because the actual resource allocation information is provided by the TDRA table.  ***Proposal 12:*** ***When more than 8 PDSCHs are scheduled by the same DCI, the RV field can be removed from the scheduling DCI to avoid the increase of DCI size.***  PDCCH skipping after decoding of the multi-PDSCHs provides power saving gains and capacity gains since it allows the UE to skip PDCCH monitoring after reception of the PDSCHs.  ***Proposal 13: PDCCH skipping indication in the single DCI scheduling multi-PDSCHs allows for PDCCH skipping after decoding of the multi-PDSCHs***  XR traffic may be such that it has jitter and/or non-integer cycles and different number and lengths of packets per burst. The current single DCI multi-PDSCH/PUSCH design may be restrictive for XR. Consider the following cases:   * Case 1: an XR traffic burst consists of packets of different sizes   + With the current NR design, since the sizes of the PDSCHs should be the same, a DCI would grant multiple PDSCHs dimensioned over the maximum packet size à causes resource waste * Case 2: at the time of the granting DCI, the gNB may know some of the traffic patterns (or some time into the future) but may not know the rest (or cannot predict so far into the future). To mitigate this issue:   + The gNB may grant a fewer number of PDSCH/PUSCH à causes more DCIs to be sent + more delays   + The gNB may over-grant resources to account for un-expected resources à causes resource waste and un-necessary UL beam reservation   ***Observation 7: The existing single DCI scheduling multi-PDSCH/PUSCH framework can cause resource waste, additional delays, or more control signalling.***  To mitigate these issues, the following enhancements can be made:   * Enhancement 1: allow for different configurations per PDSCH/PUSCH in a single DCI grant, e.g., different MCS, FDRA, etc. * Enhancement 2: resource efficient single DCI Multi-PDSCH/PUSCH (examples in Figure 9)   + After the single DCI grant, the gNB may change the behavior of one or more of the already granted PDSCHs/PUSCHs, e.g.:   + Skipping or activating resource   + Change TCI state/spatial relation   + Change MCS, FDRA, TDRA, #RBs, etc…   + Change from new TB to repetition   + The behavior change can be:   + Explicitly signaled: WUS (wake-up-signal), PDCCH (DCI), MAC-CE (using DG or CG), piggy-back DCI, SR, PUCCH, or RRC   + Implicit: e.g.: cancel pre-granted DL PDSCH after a HARQ-ACK * Enhancement 3: the current support for single DCI scheduling multiple PDSCHs is such that a single HARQ-ACK is sent for all the PDSCHs after all PDSCHs are decoded. For XR, this may add to the delays and hence may affect the PDB/capacity. Enhancements to send multiple HARQ-ACKs each for a subset of the PDSCHs may help reduce the latency (Figure 10).   The following proposal can be made:  ***Proposal 14: For XR, consider studying enhancements for single DCI scheduling multi-PDSCH/PUSCH grants including:***   * ***Allowing for different configurations per PDSCH/PUSCH in a single DCI grant*** * ***Allowing the gNB to change the behavior of one or more of the already granted PDSCHs/PUSCHs after the granting DCI*** * ***Allowing for multiple HARQ-ACKs each for a subset of the multiple PDSCHs***     **Figure 13: Enhanced single-DCI multi-PDSCH** |
| Ericsson | As regards to specific enhancements, we believe that the simulation results provided in [5] highlight that such enhancements should focus on increasing the flexibility in resource allocation of the existing multi-PxSCH scheduling framework. Indeed, enabling a more flexible allocation of MCS and bandwidth across the PxSCHs scheduled by the same PDCCH fits well with XR traffic and leads to performance similar to normal DG. The gains over standard multi-PxSCH scheduling depend on how efficiently such flexibility is included in the existing framework (e.g., in terms of additional control signalling), an aspect to address in the next SI/WI phases.  Proposal 9: Consider study of enhancements for dynamic multi-PxSCH scheduling to enable a flexible allocation of MCS and frequency for the PxSCHs scheduled by the same DCI (PDCCH) with reduced control signalling overhead. |
| TCL | In Rel-17 52.6GHz WI, multi-PDSCHs and multi-PUSCHs scheduling by a single DCI were studied. The intention is to reduce the UE blind decoding complexity for PDCCH in the larger SCS scenario. This feature can also be considered to address the issues of large and varying packet size for XR. It is beneficial to reduce UE blind decoding complexity and improve the scheduling latency. In addition, as discussed in section 2, XR services may include multiple data streams and the multiple streams may have different traffic characteristics, requirements and priorities. For a single DCI scheduling multiple PDSCHs or PUSCHs, a shared MCS cannot be suitable for different characteristics (e.g. reliability) for multiple flows, as a result, a single DCI scheduling multiple PDSCHs or PUSCHs with different MCS could be also considered.  ***Proposal 5: A single DCI scheduling multi-PDSCHs and multi-PUSCHs with different MCS for XR can be considered.*** |
| Sony | In the current NR system, the transmission with multiple PDSCHs can be used to alleviate to aforementioned issues. A unit of video transmission can be transmitted with a single DCI for multiple PDSCHs. However, we need to consider high reliability for the multiple PDSCH transmissions scheduled by a single DCI. A failure in one of the PDSCHs may increase the latency. It may result in the packet reception exceeding the packet delay budget (PDB). As part of the dynamic grant enhancement, the multiple PDSCH transmission for XR application shall consider reliability aspects by taking into account the radio condition after the first part of PDSCH(s). The reliability can be improved, for example, by scheduling different modulation coding scheme (MCS), time/frequency diversity in the multiple PDSCHs.  Proposal 8: Multiple PDSCHs transmission with single DCI shall consider reliability aspects by taking into account the radio condition after the first part of PDSCH(s), such as scheduling with different MCS, time/frequency diversity in the multiple PDSCHs transmission. |
| CMCC | **Proposal 5. Different configurations per PDSCH/PUSCH in a single DCI grant, e.g., MCS, frequency resources can be considered for the extension of single DCI scheduling multi-PDSCHs/PUSCHs in FR2-2 to FR1/FR2.**  **Proposal 6. For single DCI scheduling multi-PDSCHs/PUSCHs, dynamic change between single TB transmission per PDSCH/PUSCH and TB repetition on multiple PDSCHs/PUSCHs can be supported.** |
| Rakuten Symphony | One shortcoming of the currently supported multi-slot mechanisms is that the same resource allocation is used over the scheduled slots, and this resource allocation may not be very efficient under certain channel conditions for XR traffic due to the inherent variability of the traffic pattern. So, enhancements to enable variable resource allocation in multi-slot scheduling can be considered for capacity improvement.  **Proposal 2: Consider XR-specific enhancements for dynamic multi-slot scheduling.** |

### 3.3.1 Initial Discussion

**High level proposals based on input contributions:**

* **Proposal 3-3-1:** **Applying different parameters (e.g.,** **MCS, FDRA, TDRA, number of PxSCHs) for multi-PxSCHs scheduled by a single DCI is beneficial to improve XR capacity performance.**
* **Proposal 3-3-2:** **PDCCH skipping indication in the single DCI scheduling multi-PDSCHs allows for PDCCH skipping after decoding of the multi-PDSCHs that is beneficial to improve XR capacity performance.**
* **Proposal 3-3-3:** **For single DCI scheduling multi-PDSCHs/PUSCHs, support of dynamic change between single TB transmission per PDSCH/PUSCH and TB repetition on multiple PDSCHs/PUSCHs, is beneficial to improve XR capacity performance.**

**Moderator’s suggestion for initial discussions:**

* **Q1:** Moderator recommends prioritizing Proposal 3-3-1 for discussions due to availability of simulation results and/or more supporting companies.
  + What is your view on Moderator’s recommendation?
* **Q2:** What is your view on direction of Proposal 3-3-1, Proposal 3-3-2 and Proposal 3-3-3, and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q3:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q4:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1: Do not support proposal 3-3-1. For any further consideration of 3-3-1, proponents should describe the DCI format design together with DCI overhead savings considering possible DCI size matching in order to maintain the “3+1” DCI size budget (and preferably, in conjunction with other Rel-18 WIs that are directly applicable for XR such as multi-cell scheduling using a single DCI).  Q1-Q3: Similar comment as for CBG enhancements in 3.2.1 – first need to conclude on whether to support multi-slot PXSCH scheduling. |
| **Futurewei** | Q1-Q2: we do not see the need or potential to have multi-PXSCH for XR capacity improvement.  Q3: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1/Q2: We don’t see the benefit of proposed scheme.  Q3: all results should be captured with note. |
| **MTK** | Q1: We do not see clear benefit for Proposal 3-3-1. If NW wants to dynamically change MCS, FDRA, TDRA, …, why not NW just use single PxSCH scheduling?  Q2: We do not see clear benefit for Proposal 3-3-1/3-3-3. If NW wants to dynamically change the paramteters…, why not NW just use single PxSCH scheduling?  Q3: We agree with Samsung -- first need to conclude on whether to support multi-slot PXSCH scheduling. If the results are to be captured, the comparison baseline should be reasonable chosen and explained in the TR. |
| **LG** | It should be discussed after 3.1.1  Q3: Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | Same as discussion in 3.2, we see benefits in the listed proposals but we need to first conclude on the support of multi-PDSCHs/PUSCHs scheduling before diving into the details. |
| **vivo** | Q1: If multi-PDSCH scheduling is considered for XR, the proposed enhancement in proposal 3-3-1 can be considered, since they can provide more flexibility of scheduling for multi-PDSCH transmission. Besides, capacity gain can be achieved based on our simulation results.  Q2: For proposal 3-3-2, it seems the proposed enhancement is addressing power saving rather than capacity improvement. Maybe it is more proper to discuss whether it is beneficial or not for power saving in agenda 9.10.1. Regarding Proposal 3-3-3, from our perspective, there is no need for considering repetition due to that coverage issue is not the focus of this agenda. |
| **Ericsson** | Q1: OK to prioritized.  Q2:   * On 3-3-1, as proponet, we are supportive. But, as mentioned earlier, we are OK to enable support of multi-PxSCH “as it is”, that is without enhancements to FR1/FR2-1. The capacity gain, if any, is limited for any enhancement and we should be consistent in our decisions. Therefore, we stay neutral regarding this enhancement. * On 3-3-2: We don’t support. No capacity gain is shown, and intuitively, it seems to be more a power saving feature than capacity improvement, * On 3-3-3: We don’t support. NW can already switch using single slot on multi-slot DCI. Repetition is also can be dynamically indicated. It is not clear to use the gain that the proposed enhancement offers. |
| **InterDigital** | Support proposal 3-3-1 and Moderator’s recommendation. Using flexible parameters for the different PxSCHs results in better alignment with the XR traffic and matches with the flexibility of DG minus the high PDCCH overhead. |
| **OPPO** | Q1/Q2: We think there is no need to further enhance the multi-PxSCH scheduling. |
| **Lenovo** | The proposals need to be updated to clearly indicate whether they are needed for the extension from FR2-2 to FR1/FR2.  Proposal 3-3-2 may not much needed for FR2-2?  Proposal 3-3-3 if only applicable to FR2-2, assuming channel conditions do not change much across TBs, may not be needed. |
| **Huawei/HiSilicon** | Q1-Q3: Suggest to first conclude on the support of multi-PXSCH. Then, performance gain should be given before we further discuss the topic. |
| **Nokia, NSB** | The enhancement in Proposal 3-3-1 needs to be further studied to see whether the gains from flexible parameters can motivate the considerable DCI overhead.  Proposal 3-3-2 seems more for power saving not fo capacity thus the motivation to further study is not clear.  Enhancements in Proposal 3-3-3 are mainly seen important for the uplink where repetition may sometimes be needed due to potential uplink coverage challenges. |
| **Qualcomm** | Similar to our reasoning above for the previous two questions. We think enhancements for multi-PXSCHs are useful. |

## SR and/or BSR enhancements

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (9):** **Huawei/HiSilicon\*, Vivo\*, CATT\*, ZTE\*, TCL, Apple, Ericsson, LG, InterDigitial**
* **Companies with evaluation results (4):** **Huawei/HiSilicon\*, Vivo\*, CATT\*, ZTE\***

**High-level observations:**

* Study enhanced BSR mechanisms for capacity improvement of XR traffic.
  + Support: Vivo\*, CATT\*, ZTE\*, Ericsson, LG, InterDigital
* **Study multi-bits SR for XR traffic for capacity improvement of XR traffic.**
  + **Support:** Huawei/HiSilicon\*, Apple, TCL. LG
  + **Not Support:** Ericsson

On multi-bits enhancements, additional discussion is needed regarding the concerns raised by opponents.

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| **Company** | **Summary of Contributions inputs** |
| Huawei/HiSilicon | Enhancement to enable accurate UL delay-aware scheduling   * Case 1 (C1: Proportional Fair scheduling): we assume gNB uses PF scheduling, i.e., the scheduling priority of each user is calculated as the ratio of the instantaneous data rate over the historical data rate. The gNB does not consider delay during scheduling. * Case 2 (C2: Delay-aware, gNB is not aware of the exact data arrival time): we assume gNB is not aware of the exact UL data arrival time, and can only apply SR or BSR reception time for delay-aware scheduling. * Case 3 (C3: Delay-aware, gNB is aware of the exact data arrival time): we assume gNB is aware of the exact data arrival time, and uses the exact data arrival time for delay-aware scheduling.   ***Observation 9:*** ***As shown in Table 2, the network capacity of the UL AR video stream can be improved by applying delay aware scheduling. If gNB is aware of the exact data arrival time, the capacity can be largely increased.***   |  |  |  |  | | --- | --- | --- | --- | | ***Scheduling scheme*** | ***Case 1***  ***(Proportional Fair)*** | ***Case 2***  ***(Delay-aware, gNB is not aware of the exact data arrival time)*** | ***Case 3***  ***(Delay-aware, gNB is aware of the exact data arrival time)*** | | ***Average number of supported users per cell*** | ***3.0*** | ***3.2*** | ***3.8*** | | ***Capacity improvement over Case 1*** | ***-*** | ***6.7%*** | ***26.67%*** |   *Table 2. Capacity of the UL AR video stream with 10Mbps in FR1 Dense Urban MU-MIMO*  ***Proposal 2: To enable accurate UL delay-aware scheduling, support UE indicating to the network the data arrival time or the remaining delivery time of UL XR traffic via multi-bits SR.***    Figure 7. Capacity results of the AR UL video stream with/without knowing the exact data arrival time |
| CATT | The XR-dedicated PDCCH monitoring window for UL .The SR resource is configured periodically for UE to request the dynamic resource allocation of UL transmission based on robust traffic arrival. Since SR resources are the overhead of UL radio resource, the periodicity of SR resource would not be too short. The additional delay caused by SR transmitted at the configured SR resource would be introduced for UL dynamic scheduling, which can degrade the system capacity of UL XR transmission. During the XR-dedicated PDCCH monitoring window, UE is configured to monitor PDCCH within the window at each cycle with periodicity based on the XR packet generation. The BSR scheme could be enhanced to have XR-specific triggering mechanism of BSR report to minimize the scheduling delay. The XR-specific BSR report triggering mechanism is that the BSR report will be trigger at the 1st PUSCH of each XR packet at each cycle to inform gNB the remaining packet size to be transmitted after the 1st PUSCH transmission of the XR traffic. When gNB receive the BSR, gNB would schedule UE the UL PUSCH transmission until the completion of XR packet delivery in this cycle.  Table 3: The evaluation result comparison between XR-PMW for UL  and UL dynamic scheduling with SR/BSR delay (5ms)   |  |  |  | | --- | --- | --- | |  | Capacity | | | #satisfied UEs per cell / % of satisfied UEs | Capacity gain | | DG scheduling with 5ms SR/BSR delay and UE always on (baseline) | 5.4 / 90.0% | - | | XR-PMW (16.67, 8) for UL with the BSR enhancement | 7.2 / 90.0% | 33.3% |   **Proposal 4: The BSR enhancement that UE sends the BSR report at the 1st PUSCH of each XR packet periodicity should be considered for the UL dynamic scheduling enhancement scheme for improving the capacity of XR-specific traffic.** |
| vivo | Enhancements related to UL buffer status For XR UL traffic, to facilitate more flexible and efficient UL scheduling to improve UL capacity performance, BSR mechanism can be enhanced from the following aspects:   * **Finer granularities and more detailed information reporting.** For example, in a BSR report, queuing delay or remaining PDB for each pending packet or each set of packets can be additionally included, to assist the gNB for more efficient UL scheduling. * **New triggering mechanisms for reporting.** For example, if a new packet or a new set of packets belonging to a logical channel / QoS flow/stream satisfying pre-defined requirement(s) arrives at L2 buffer(s), or, the amount of data of the logical channel / QoS flow/stream pending for transmission exceeds a pre-defined threshold, a BSR can be triggered. As a result, faster BSR reporting can be achieved based on buffer status change, which can further facilitate more timely UL scheduling.   *Observation 3: It is beneficial to study enhanced BSR mechanism for XR traffic to facilitate timelier and matched UL scheduling.* |
| InterDigital | Another approach that can be considered for multi-PUSCH scheduling can be based on the dynamic information on the traffic pattern provided by the UE to gNB. For example, the UE may be aware of the traffic pattern associated with the PDU set (e.g. number of PDUs of PDU set, expected arrival time of PDUs) based on markings in some of the first PDUs of the PDU set (e.g., PDU header). Such info can be provided to the gNB in an enhanced BSR associated with PDU set. The gNB can then indicate in DCI different parameters including a recurring DG allocation pattern that is aligned with the timings when the PDUs of PDU sets are expected to arrive and be ready for UL transmission.  **Proposal 14:** Support UE providing traffic pattern info associated with PDU sets (e.g. in enhanced BSR) when requesting for DG |
| ZTE, Sanechips | |  |  | | --- | --- | |  |  | | (a)10Mbps@60fps traffic model distribution | (b)20Mbps@60fps traffic model distribution |   Figure 17 Distribution of UL AR video traffic model and BS level table.   1. For both 10Mbps@60fps traffic model and 20Mbps@60fps traffic model, more than a half proportion of packet sizes are overestimated if existing BSR tables are used.   The capacity performance between precise BSR and legacy BSR is depicted as follows:   |  | | --- | |  |   Figure 18 Capacity comparison between precise BSR and current legacy BSR.  In Figure 18, for 10Mbps@60fps, capacity performances are increased from [9.5] with legacy BSR indication to [10.9] @90% satisfied UE percentage with precise BSR indication by about [14.47%], while for 20Mbps@60fps, capacity performances are increased from [3.4] with legacy BSR indication to [5.1] @90% satisfied UE percentage with precise BSR indication by about [50.00%] using MU-MIMO in UL FR1 dense urban scenario.   1. In uplink transmission, overestimated packet sizes may cause capacity performance loss. Therefore, uplink transmission with precise BSR indication can bring capacity performance gain. 2. Suggest to capture the evaluation results of BSR enhancement provided by companies in RAN1 into TR 38.835. |
| Ericsson | Assuming that application awareness provides traffic properties to RAN, the gNB can predict traffic arrival and packet size at certain accuracy and can proactively provide grants of appropriate size to UE (see our discussion on pre-scheduling based dynamic grant in Section 2.2). Therefore, by using proper scheduling, the impact of SR on the performance would be minor, in particular for serving XR traffic due to its characteristics. Similar observations can be derived by assuming to use Hybrid CG-DG (see again discussion on the scheduling schemes in Section 2.2). Also in this case, the need for SRs is effectively minimized, since the availability of a CG in the next UL slot would enable to directly send an updated BSR to the network, thus skipping the SR.  If the intention of the proposed enhancements for SR is to provide information about traffic type (video or pose) for which SR is triggered, such that this information can be combined with knowledge of traffic properties derived from application awareness to benefit the scheduler, it is still unclear if any enhancement is needed. Such goals can be achieved by means of the current specifications via proper association of logical channels and SR configurations.  Based on above we can conclude that SR enhancements are not needed at physical layer.   1. Deprioritize studying SR enhancements at physical layer to improve capacity performance of XR traffic.   Regarding potential enhancements for BSR, we have previously shown the benefits of the enhancements that can contribute to more efficient scheduling of UL XR traffic to improve capacity [8][9]. However, the needed BSR enhancements are within RAN2 expertise as we discussed in [8][9].  Observation 8: Finer BSR granularity improves the capacity performance for XR traffic, and it is within the RAN2 scope.  Observation 9: Including additional delay information in BSR can increase system capacity.  Therefore, to properly utilizing the time in RAN1 and RAN2, we propose the following:  Proposal 11: The BSR enhancements to improve capacity performance of XR traffic are not handled by RAN1. |
| TCL | To solve the issue, one straightforward way is to drop/adjust one or several step(s) of DG scheduling mechanism, e.g. SR or BSR or both SR+BSR. However, when both SR+BSR are dropped, a configured grant resource will be needed, however, this is not an efficient resource utilized way for PUSCH transmission, especially for XR services with large and vary packet size. As a result, to drop/adjust SR or BSR procedure for PUSCH dynamic scheduling can be considered. One potential way is to combine the CG and dynamic grant for the uplink video traffic transmission, a CG configuration is configured for the BSR transmission with the periodicity based on the video frame rate, and then followed dynamic grant can be used to schedule a uplink video traffic transmission, denote as CG-based DG. Another potential way is introducing multiple bits information SR, a SR can carry several bits information for BSR size indication, and gNB can scheduling a uplink video traffic transmission right after a triggered positive SR, denote as SR-based DG.  ***Proposal 7: Both CG-based dynamic grant and multiple bits information SR-based dynamic grant for XR UL traffic transmission can be studied.*** |
| Sony | In our view, dynamic scheduling may be well-suited for DL scheduling, but for UL scheduling there will be significant delays as UE should initially provide an indication of the availability of the data (e.g., via SR) to the gNB, and then waits from the gNB to schedule with a limited data as gNB does not know how much data is available in the UE’s buffer, and subsequently the UE includes BSR in the PUSCH and waits to be scheduled for larger data based on latest BSR information.  Observation 4: Enhancement of single DCI to schedule multi-PDSCH/PUSCH may be well-suited for DL scheduling, but for UL scheduling there will be significant delays as UE should initially provide an indication of availability of the data (e.g., via SR) to the gNB. |
| LG | In case of uplink, SR may be transmitted for requesting dynamic scheduling. Considering stringent requirement of XR service, any kind of SR enhancement can be considered. SR enhancement would be dependent whether it is possible for UE and gNB to exchange higher layer information including XR-specific traffic characteristic (a.k.a., XR-awareness).  Proposal 9: For XR-specific capacity improvement, enhancement on SR/BSR can be considered.  If PDB information can be considered in the MAC layer, it would be beneficial to indicate required PDB in scheduling request. For example, 2-bit SR can be considered for PDB indication. Then, UE can request UL resource which meets PDB requirement for certain logical channel. Or, UE can report least PDB of data in UE buffer via BSR information.  Proposal 10: If scheduling techniques for XR-awareness information is supported, PDB information can be reported via SR/BSR for XR-specific capacity improvement |
| Apple | Figure 6 Buffer size levels (TS 38.321)  One table for buffer size levels from TS 38.321 is copied above. It can be seen SR provides quite little information about buffer size compared with BSR. Since XR traffic has some special characteristics:   * For audio stream/data stream, as it is almost of constant-bit rate, a single bit SR is sufficient * For pose/control stream, as it is of constant-bit rate, a single bit SR is sufficient. * For Video streams, the packet size follows a distribution (e.g., truncated Gaussian). As the range does not go from 10 bytes to 150000 bytes, only meaningfully distinctive values can be associated with the code states of SR. That in general motivates to consider multiple bits for a single SR. In one example, two bits for SR can be considered. Then 4 code states can be associated with different buffered data size.   **Proposal 3-4: study multiple bit SR design for buffer size reporting. The code states for a SR reporting can be associated different data sizes.** |

### 3.4.1 Initial Discussion

**High level proposals based on input contributions:**

* Proposal 3-4-1: It is beneficial to study enhanced BSR mechanisms for capacity improvement of XR traffic.
  + Support: Vivo\*, CATT\*, ZTE\*, Ericsson, LG, InterDigital
* Proposal 3-4-2: It is beneficial to study multi-bits SR mechanisms for capacity improvement of XR traffic.
  + **Support:** Huawei/HiSilicon\*, Apple, TCL. LG
  + **Not Support:** Ericsson

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 3-4-1 and Proposal 3-4-2, and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
  + **Moderator recommends endorsing** Proposal 3-4-1.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1-Q2: Suggest to leave conclusions to RAN2 – this is outside the RAN1 role/expertise. RAN2 is aware of the topics, they were discussed in the previous RAN2 meeting, and there are RAN2 Tdocs with relevant proposals for this meeting. |
| **Futurewei** | Q1: BSR enhancement should be discussed in RAN2. About multi-bits SR (proposal 3-4-2), it can be beneficial to indicate from the UE to the gNB the UL traffic information in a timely manner via multi-bits SR.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: The performance results with BSR enhancement had been shown. The final BSR enhancement would be determined by RAN2  Q2: Multi-bit BSR would be decided by RAN2 |
| **MTK** | Q1-Q2: (Same view as Samsung) Suggest to leave conclusions to RAN2 – this is outside the RAN1 role/expertise. RAN2 is aware of the topics, they were discussed in the previous RAN2 meeting, and there are RAN2 Tdocs with relevant proposals for this meeting. |
| **ZTE, Sanechips** | Support Proposal 3-4-1 and Proposal 3-4-2. |
| **LG** | Q1: the necessity seems clear since most of proposals assumes gNB knows UE traffic characteristic. SR can support responsive indication from UE side, with simplified information. BSR would have larger information size to indicate detailed traffic property for further scheduling. We think both can be kept in RAN1 and proposal 3-4-2 may need to be discussed in RAN2 first.  Q2: Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | We also suggest to leave this topic to RAN2 |
| **vivo** | **Q1:** BSR enhancement can be recommended for XR capacity improvement and the detailed designed can be handled by RAN2.  With enhanced BSR report, we don’t see the need for multi-bits SR. |
| **Ericsson** | Q1: Support, but also OK with other companies’ suggestions that record the results. But we also would like to record our concerns, as explained in contribution on multi-bit SR that we are not supportive.  Q2: We support 3-4-1 and do not support 3-4-2. |
| **Sony** | Q1-Q2: We support 3-4-1. But, this topic should be lead by RAN2. RAN1 provides comments if there are any requests from RAN2. |
| **InterDigital** | Support Proposal 3-4-1 and moderator’s recommendation. The details/design of enhanced BSR can be handled by RAN2 |
| **OPPO** | Q1: BSR should be discussed in RAN2. We are open to proposal 3-4-2 if performance gain is shown by multi-bits SR. |
| **Lenovo** | BSR enhancements should be discussed in RAN2. We don’t see the need for SR enhancements, e.g. multi-bit SR. The concept of multi-bit SR was already discussed in the beginning of Rel-15. However instead of introducing a multi-bit SR it was concluded to introduce different SR configurations. The current NR scheme, i.e. mapping of LCHs to SR configurations, allows UE to indicate some traffic related information to gNB with a single-bit SR. |
| Huawei/HiSilicon | Q1:  For Proposal 3-4-1, although BSR enhancement is RAN2’s impact, RAN1 can evaluate BSR enhancement to show the capacity gain.  For Proposal 3-4-2, SR enhancement can be considered since SR has RAN1’s impact. And according to our simulation results, it is beneficial to study multi-bits SR mechanisms for capacity improvement of XR traffic.  Q2: The proposed SR/BSR enhancements should be captured in TR 38.835. Our simulation results show that UE indicating the gNB of the data arrival time can improve the XR capacity. |
| Nokia, NSB | Q1: We agree that BSR enhancements are beneficial for XR use cases. Details of BSR enhancements shall be directed to RAN2. RAN1 shall focus on RAN1 part and prioritize it given the limited time left for this SI.  We do not support Proposal 3-4-2. The numerical results of Pre-Scheduling DG and CG already showed the capacity close to Genie (when gNB aware about the precise traffic arrival and packet size). Therefore, the challenges coming from changing the SR design are not justified. |
| Qualcomm | Ok to consider BSR enhancements; we think BSR enhancements should be discussed in RAN2. Same comment for SR enhancements. Note that in the past RAN1 meeting the following agreement was made:  Agreement: Whether/how to enhance BSR to improve capacity performance of XR traffic is within RAN2 scope and is not handled by RAN1.  Note that companies should indicate if and what BSR enhancement is assumed in their RAN1 proposals on CG and DG enhancements.  RAN1 can evaluate BSR enhancement to improve capacity performance |

## Other enhancements

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Selection of few additional proposed enhancements:**

* **Introduce XR-dedicated PDCCH monitoring window (XR-PMW) for DL/UL that is monitored irrespective of DRX ON/OFF**
  + Support: CATT\* (with simulation results)
* **Introduce XR-specific *playoutDelayForMediaStartup* for XR awareness scheduling**
  + Support: CATT\* (with simulation results)
* **Proposal 7: Study if PHR should be further enhanced based on XR traffic arrival periodicity or UL pose periodicity.**
  + Support: Lenovo
* ***Study mechanism of packet dropping based on the PDB requirement, in order to avoid resource waste due to the out-of-date packets.***
  + Support: NEC
* ***Proposal 2: Under CA with different TDD patterns, data retransmission can take place on the carrier different from its initial transmission.***
  + Support: MediTek
* **Proposal 3: Consider mechanisms to satisfy the PDB in the sub-6 GHz NR (TDD) bands such as enabling HARQ retransmission of a TB on a different cell than the cell of the initial TB transmission.**
  + Support: Samsung
* …..

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| **Company** | **Summary of Contributions inputs** |
| CATT | The XR-dedicated PDCCH monitoring window for the C-DRX enhancement **Proposal 1：The dynamic scheduling enhancement for XR traffic should not impact the PDCCH monitoring and resource allocation of other traffic, such as robust traffic arrival of eMBB used by the UE in the same time in achieving UE power saving.** The XR-dedicated PDCCH monitoring window for DL   Figure 1: The XR-specific PDCCH monitoring window (XR-PMW) scheme  Table 1: The evaluation result comparison between the XR-PMW with MU-MIMO and the Baseline scheme 1 (UE always on with SU-MIMO)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | Power saving | | #satisfied UEs per cell | % of satisfied UEs | Capacity enhancement Gain | Power Saving Gain (PSG) | | DG scheduling and UE always on (SU-MIMO) (Baseline scheme 1) | 5.8 | 96.7% | 0.0% | - | | XR-PMW scheme 1:  XR-PMW (16,12) | 10.8 | 90.00% | 86.2% | 7.62% | | XR-PMW scheme 2:  XR-PMW (16,12) with go-to-sleep | 10.8 | 90.00% | 86.2% | 20.90% | | XR-PMW scheme 3:  XR-PMW (16,12)  with PDCCH skipping and go-to-sleep | 10.7 | 89.17% | 84.5% | 26.68% |   Thus, we have the following observation:  **Observation 1: The XR-PMW based on MU-MIMO with coordinated monitoring window among co-scheduled UEs could obtain the 84.5%~86.2% capacity gain than that of the UE always on for DG scheduling based on SU-MIMO and obtain 20.9%~26.68% PSG compared to that of the UE always on for DG scheduling.**  Table 2: The performance comparison between baseline scheme 2 (SU-MIMO) (C-DRX (16, 12, 4)) and  XR-PMW with PDCCH skipping and go-to-sleep using MU-MIMO   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | Power saving | | #satisfied UEs per cell | % of satisfied UEs | Capacity enhancement Gain | Power Saving Gain (PSG) | | DG scheduling with C-DRX(16,12,4) (SU-MIMO)  (Baseline scheme 2) | 3.7 | 92.5% | - | - | | XR-PMW scheme 1:  XR-PMW with (16,12) | 10.8 | 90.00% | 192% | 3.81% | | XR-PMW scheme 2:  XR-PMW with go-to-sleep | 10.8 | 90.00% | 192% | 17.64% | | XR-PMW scheme 3:  XR-PMW  with PDCCH skipping and go-to-sleep | 10.7 | 89.17% | 189% | 23.66% |   Thus, we have the following observation:  **Observation 2: The XR-PMW based on MU-MIMO with coordinate monitoring window of co-scheduled UEs with go-to-sleep and XR-PMW based on MU-MIMO with PDCCH skipping and go-to-sleep can obtain 189%~192% capacity gain and 17.64% and 23.66% PSG than the C-DRX with (16, 12, 4) using SU-MIMO, respectively.**  **Proposal 2: The XR-dedicated PDCCH Monitoring Window should be considered as the dynamic scheduling enhancement scheme for improving the capacity and power saving performance of XR-specific traffic and not impact the other traffic.**  **Proposal 3: The measurement of the average transmission delay and jitter should be standardized to optimize the configure PDCCH monitoring window size of XR-PMW scheme and to improve system capacity and the power saving performance.** The XR-dedicated PDCCH monitoring window for UL Table 3: The evaluation result comparison between XR-PMW for UL  and UL dynamic scheduling with SR/BSR delay (5ms)   |  |  |  | | --- | --- | --- | |  | Capacity | | | #satisfied UEs per cell / % of satisfied UEs | Capacity gain | | DG scheduling with 5ms SR/BSR delay and UE always on (baseline) | 5.4 / 90.0% | - | | XR-PMW (16.67, 8) for UL with the BSR enhancement | 7.2 / 90.0% | 33.3% |   **Proposal 4: The BSR enhancement that UE sends the BSR report at the 1st PUSCH of each XR packet periodicity should be considered for the UL dynamic scheduling enhancement scheme for improving the capacity of XR-specific traffic.** The XR-specific *playoutDelayForMediaStartup* for the gNB scheduling awareness **Proposal 5: The gNB could also feed back the measurement results of the average transmission delay and jitter to UE** **to improve the XR capacity performance.**    Figure 2: The gNB scheduling awareness XR-specific *playoutDelayForMediaStartup* from UE  The simple descriptions of the power saving schemes are listed as follows.   * XR-specific *playoutDelayForMediaStartup* scheme with go-to-sleep: UE is configured with C-DRX (16, 8, 4). UE transforms to sleep state once the all PDSCH of frame is received successfully and all ACKs for PDSCH are reported. The 3 frames playout delay is used for relaxing the packet delay requirements in the scheduler. * XR-specific *playoutDelayForMediaStartup* scheme with PDCCH skipping and go-to-sleep: UE is configured with C-DRX (16, 8, 4). UE performs PDCCH skipping when On Duration starts until UE starts receiving PDSCH. UE transforms to sleep state once the all PDSCH of frame is received successfully and all ACKs for PDSCH are reported. The 3 frames playout delay is obtained by the gNB scheduler for relaxing the packet delay requirements.   Table 4: The evaluation results of the gNB scheduling awareness schemes  with XR-specific *playoutDelayForMediaStartup* where the baseline is DG scheduling with C-DRX (16,12,4) for the MU-MIMO   |  |  |  |  | | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | | #satisfied UEs per cell | % of satisfied UEs | Capacity performance gain | | DG scheduling with C-DRX(16,12,4) (Baseline) | 10.9 | 90.97% | - | | XR-specific *playoutDelayForMediaStartup* scheme  (2 frames playout delay) | 16 | 95% | 46.8% | | XR-specific *playoutDelayForMediaStartup* scheme  (3 frames playout delay) | 20 | 92% | 83.5% | | XR-specific *playoutDelayForMediaStartup* scheme  (4 frames playout delay) | 20 | 91% | 83.5% |   Table 5: The evaluation results of the gNB scheduling awareness schemes  with XR-specific *playoutDelayForMediaStartup* where the baseline is DG scheduling with UE always on for the SU-MIMO   |  |  |  |  | | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | | #satisfied UEs per cell | % of satisfied UEs | Capacity performance gain | | DG scheduling with UE always on (Baseline) | 5.8 | 96.7% | - | | XR-specific *playoutDelayForMediaStartup* scheme  (3 frames playout delay) | 7.3 | 91.3% | 25.86% | | XR-specific *playoutDelayForMediaStartup* scheme  (4 frames playout delay) | 11.8 | 98.3% | 103.45% | | XR-specific *playoutDelayForMediaStartup* scheme  (mixed playout delay {3, 4}) | 11.3 | 94.4% | 94.83% |   Thus, we have the following observation:  **Observation 3: The XR-specific *playoutDelayForMediaStartup* scheme could obtain the obvious capacity performance gain from 46.8% to 83.7% for the 2 frames to 4 frames playout delay based on MU-MIMO, while 25.86% to 103.45% capacity gain for 3 frames to 4 frames playout delay based on SU-MIMO, compared with DG scheduling with C-DRX with (16, 12, 4).**  Table 6: The evaluation results of the gNB scheduling awareness schemes  with XR-specific *playoutDelayForMediaStartup* where the baseline is DG scheduling with UE always on (MU-MIMO)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Evaluation Schemes | Capacity | | | Power saving | | #satisfied UEs per cell | % of satisfied UEs | Capacity performance gain | PSG | | DG scheduling with UE always on (Baseline) | 11.5 | 95.83% | - | - | | XR-specific *playoutDelayForMediaStartup* scheme with go-to-sleep  (3 frames playout delay) | 20 | 94.17% | 67% | 26.43%\* | | XR-specific *playoutDelayForMediaStartup* scheme with PDCCH skipping and go-to-sleep  (3 frames playout delay) | 20 | 93.3% | 67% | 28.51%\* | | \*Note: The power saving gain is based on the same capacity as that of the baseline scheme (DG scheduling with UE always on). | | | | |   Thus, we have the following observation:  **Observation 4: The XR-specific *playoutDelayForMediaStartup* scheme under the 3 frames playout delay can obtain 67% capacity performance gain and the 26.43%~ 28.51% power saving gain compared with UE always on.**  Based on the description and the evaluation results, we have the following proposal.  **Proposal 6: The XR-specific *playoutDelayForMediaStartup* scheme should be considered as the dynamic scheduling enhancement scheme for its significant capacity gain and obvious power saving gain.** |
| Lenovo | **PHR** If gNB receives upfront some power headroom information from the UE, the network can provide efficient UL scheduling and consequently shorten the transmission time of the UE, which will ultimately also lead to increased system capacity. To ensure a timely PHR, an UL DCI can trigger a PHR, e.g., when a first TB of an PDU set is scheduled.  **Proposal 6: Study techniques providing timely PHR, e.g., UL DCI triggering a PHR.**  To better match the PHR timers with the XR traffic arrival times, and hence provide a more accurate PHR, new timer values can be proposed for instance, derived based on the XR traffic arrival periodicity or UL pose periodicity.  **Proposal 7: Study if PHR should be further enhanced based on XR traffic arrival periodicity or UL pose periodicity.** |
| NEC | From an E2E perspective, an Application Data Unit (ADU) may be divided into multiple IP packets and then delivered to gNB or UE. Considering the large size of XR traffic packet, multiple transmission occasions may be needed to deliver the entire ADU. Apparently, only if all the transmissions are transmitted successfully within the PDB requirement, the ADU can be declared transmitted successfully. However, in some cases, gNB or UE may be not able to transmit all the transmissions before the PDB deadline. Then, transmitting the remaining out-of-date packets may be meaningless but lead to resource waste. Therefore, it is beneficial to support packet dropping based on the PDB requirement.  **Proposal 3:**   * *Study mechanism of packet dropping based on the PDB requirement, in order to avoid resource waste due to the out-of-date packets.* |
| MTK | Enhancement of Cross Carrier HARQ Retransmission  For outdoor wide area deployment, TDD patterns favoring UL-heavy or DL-heavy traffic are very common and widely deployed, which leads to extra PDCCH alignment delay when retransmission happens.    ***Observation 5: For outdoor wide area deployment, TDD patterns favoring UL-heavy or DL-heavy traffic are very common and widely deployed, which leads to extra PDCCH alignment delay when retransmission happens.***    ***Proposal 2: Under CA with different TDD patterns, data retransmission can take place on the carrier different from its initial transmission. This can be realized by either***   * ***Designing common HARQ processes pool per cell group or in addition to the HARQ process pools defined per CC, or*** * ***Establishing a mapping between the HARQ process for the initial transmission on a specific CC and the HARQ process for the retransmission on another CC*** |
| Samsung | **Proposal 3: Consider mechanisms to satisfy the PDB in the sub-6 GHz NR (TDD) bands such as enabling HARQ retransmission of a TB on a different cell than the cell of the initial TB transmission.** |

### Initial Discussion

**High level proposals based on input contributions:**

* **Proposal 3-5-1: Introduce XR-dedicated PDCCH monitoring window (XR-PMW) for DL/UL that is monitored irrespective of DRX ON/OFF**
  + Support: CATT\* (with simulation results)
* **Proposal 3-5-2: Introduce XR-specific *playoutDelayForMediaStartup* for XR awareness scheduling**
  + Support: CATT\* (with simulation results)
* **Proposal 3-5-3: Study if PHR should be further enhanced based on XR traffic arrival periodicity or UL pose periodicity.**
  + Support: Lenovo
* **Proposal 3-5-4: Study mechanism of packet dropping based on the PDB requirement, in order to avoid resource waste due to the out-of-date packets.**
  + Support: NEC
* **Proposal 3-5-5: Under CA with different TDD patterns, data retransmission can take place on the carrier different from its initial transmission.**
  + Support: MediTek
* **Proposal 3-5-6: Consider mechanisms to satisfy the PDB in the sub-6 GHz NR (TDD) bands such as enabling HARQ retransmission of a TB on a different cell than the cell of the initial TB transmission.**
  + Support: Samsung
* …..

**Moderator’s comments:**

* **Moderator recommends prioritizing Proposal 3-5-1 and Proposal 3-5-2, due to availability of simulation results.**
  + **Proponent (CATT) is kindly requested to provide clarifications regarding following comments:**
    - **Proposal 3-5-1:** SU-MIMO is used as baseline, but MU-MIMO is used for enhancement schemes. It is not clear if the capacity gain due to MU-MIMO. CATT RAN1#109-e R1-2206385 shows with MU-MIMO as baseline, there is no capacity gain for enhancements but power saving gain.
    - **Proposal 3-5-2:** The proposed enhancements seem to be higher layers. Is the RAN1 design part related to Proposal 5 in the contribution?

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 3-5-1 to Proposal 3-5-6, and the necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
  + **Moderator recommends prioritizing Proposal 3-5-1 and Proposal 3-5-2.**
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1-Q3: A general comment is that simulation results should not be the only criterion to consider proposals particularly as, even for proposals with simulation results from more than one company, there has been no discussion/agreement/calibration on simulation assumptions for a particular scheme nor on its relevance.  Many proposals do not require new simulations. For example, it should be clear that it is beneficial for capacity that a gNB has an up-to-date CSI report in order to schedule a UE when the UE enters Active Time and that CSI report should not be provided ~5 msec later. That was OK for eMBB, it is not OK for XR. Similar with beam management, particularly given that FR2 would be a main deployment scenario for XR given the BW availability (and unavailability in FR1) – it is not possible for a UE to enter Active Time with a poor beam. Asking for simulation results for the above is proactically equivalent to saying that CSI reporting or beam management are unnecessary.  Some of the proposals, e.g. 3-5-2/3-5-4, fall under RAN2’s expertise.  Proposals 3-5-5 and 3-5-6 are probably the same proposal and aim for a structural mechanism for latency reduction – no simulation results are needed – any tradeoffs can be fully determined by analysis. |
| **Futurewei** | Q1: 3-5-2 / 3-5-4 seems to be RAN2 issue and without RAN1 impact. For 3-5-3  It is yet to see how and how much 3-5-3 can improve XR capacity. Are 3-5-5 and 3-5-6 similar proposals? There is potential benefit of cross-carrier/cell HARQ to reduce latency and hence improve capacity. About 3-5-1, similar question as the moderator. In addition, we do not see how the proposed scheme can do better than DG.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | **Q1:** For 3-5-1, the XR-PMW scheme has the benefit of gNB pairing in the optimization of the MU-MIMO performance comparing to normal MU-MIMO scheme. We showed about similar performance of XR-PMW with MU-MIMO comparing to dynamic grant with MU-MIMO. However, we followed RAN1 agreements using SU-MIMO as the baseline.  For 3-5-2, the XR-specific playoutDelayForMediaStartup for XR awareness scheduling is the de-jitter techniques at gNB scheduler. The gNB obtains the playoutDelayFor MediaStartup from UE XR application layer via RRC. However, the de-jitter techniques of gNB scheduler is for physical layer to measure the delay jitter at the gNB and dynamic adapt the gNB scheduling algorithm based on the measured delay jitter to optimize link adaptation gain. RAN1 impacts of the proposed scheme is to collect the statistic of XR packet arrival in delay and delay jitter along with UE’s CSI feedback for scheduler to optimize the system performance with the system performance gain from 25.8% - 103.6%.  **Q2:** The system performance gain is the strong evidence and the results should be captured in the TR. The results and system performance gain had been clearly analyzed in the contribution. Companies are welcomed to verify the results. |
| **MTK** | Q1:   * 3-5-2 /3-5-4 seems to be RAN2 issue and without RAN1 impact. * It is yet to see how and how much 3-5-3 can improve XR capacity. * About 3-5-5 and 3-5-6, there is potential benefit of cross-carrier/cell HARQ to reduce latency and hence improve capacity, and we urge companies to take a look. * About 3-5-1, we think the table 1 from CATT can use 16.67 ms CDRX period as baseline, similar to table 3 from CATT; at the same time, it would be more certain about the capacity gain if more than one companies can provide input/evaluation.   Q2: We think results can be captured with evaluation assumption clear explained in the TR. |
| **LG** | **Q1:** 3-5-1/2/3 seems releated to RAN2. 3-5-4 are related to SR/BSR enhancement. For 3-5-5/6, we see an amount of specification impact comparing expected benefits.  **Q2:** Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | 3-5-2 and 3-5-4 are RAN2 topics.  3-5-5 and 3-5-6 are very similar and have the potential to improve latency and reliability by giving more flexibility for HARQ retransmissions in TDD mode. |
| **vivo** | Q1: Proposal 3-5-2 and 3-5-4 are related to XR-awareness which is handled by RAN2.  It seems proposal 3-5-1 is addressing power issue rather than capacity. Maybe it needs more clarifications. To ensure the capacity, sufficient long on duration needs to be configured for DRX, e.g., to cover the jitter range. It is not clear that how the proposed enhancement in proposal 3-5-1 benefit for capacity improvement.  For proposal 3-5-3, 3-5-5 and 3-5-6, the performance gain on XR capacity needs to be clarified by evaluation results, according to the agreements. |
| **Ericsson** | Q1:   * Proposal 3-5-1: Consideirng CATT clairfcaiton, we see the enhancement as a power saving feature, and not capacity gain. Hence, for this agenda, we are not supportive of the proposal. * Proposal 3-5-2: Considering CATt clarification, the RAN1 related procedures is about CSI measurement. So, the question is whether this part (CSI measurement) should be handled differently? We are fine to capture this feature in TR as a scheme that shows how XR awareness is used (higher layer aspects). But it seems there is no RAN1 impact. Feedback from CATT is appreciated.   Q2:   * Proposal 3-5-3: Similar to FW, it is not clear to us the necessity and benefit of the feature. So, we cant support this proposal. * Proposal 3-5-4: We agree with others that the impact is on higher layers. What RAN1 can do is to study performance evaluation results (like other schemes, for example CATT). Due to lack of performance evaluation, the need to disucs sin RAN1 is not clear. * Proposal 3-5-5/3-5-6: We agree with others that these two proposals can be merged. Our view is that although technically, this feature would be beneficial, we think it has considerable impact on RAN2, as well as current implementations, also at NW side. That’s why we are hesitant at this stage. |
| **Nokia, NSB** | We do not support Proposal 3-5-1 to 3-5-6. Proposals 3-5-3 to 3-5-6 does not have simulation results and justification that the enhancements are needed.  Proposal 3-5-1 shows worse results if we compare MU-MIMO without and MU-MIMO with enhancements.  Proposal 3-5-2 does not seem to have a RAN1 impact. |
| **Qualcomm** | Agree with other companies that 3-5-2 / 3-5-3/ 3-5-4 may be better discussed in RAN2. In regards to 3-5-5 and 3-5-6 it would be good if the supporting companies can provide simulation results that prove benefit. All proposals should be treated similarly when it comes to their consideration with or without simulation results. |

# 4 Other capacity enhancements

The followings are agreed/concluded previously:

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| **Agreement:**  The following lists the candidate enhancements techniques for link adaptation to improve XR capacity that are proposed by companies RAN1#109-e.   * At least the proponents are encouraged to justify the corresponding capacity benefits for XR traffic for considering potential study of these candidate enhancements techniques.   + Delta MCS   + Soft HARQ-ACK feedback   + Cooperative MIMO scheme via precoding technique - bi-directional training   + Enhanced link adaptation for CBG-based transmission   + CSI report enhancements to address the different BLER requirements of different XR flows * Follow the *common principle for assessment of the candidate capacity enhancement technique.*   **Agreement:**  The following lists the candidate enhancements techniques based on measurement-gap link to improve XR capacity that are proposed by companies RAN1#109-e.   * At least the proponents are encouraged to justify the corresponding capacity benefits for XR traffic for considering potential study of these candidate enhancements techniques.   + Dynamic L1 based MG activation/deactivation.   + Reuse current R16/R17 RRM relaxation condition to allow scheduling in MG to transform the R16/R17 RRM power saving gain into capacity gain. * Follow the *common principle for assessment of the candidate capacity enhancement technique.*   **Agreement:**  The following lists the candidate enhancements techniques to improve XR capacity that are proposed by companies RAN1#109-e.   * At least the proponents are encouraged to justify the corresponding capacity benefits for XR traffic for considering potential study of these candidate enhancements techniques.   + Inter-UE/intra-UE multiplexing techniques, including e.g. finer granularity preemption indication * Follow the *common principle for assessment of the candidate capacity enhancement technique.*   **Agreement:**   * Deprioritize the study of CQI report for different BLER and/or different XR traffic to improve XR capacity performance.   **Agreement:**   * Deprioritize the study of intra/inter UE prioritization/multiplexing enhancements to improve XR capacity performance. |

The views regarding these enhancements for serving XR traffic are summarized and discussed in the following sections.

## 4.1 Delta MCS and Soft HARQ-ACK feedback

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (8):** Qualcomm\*, Apple, Nokia/NSB, MediaTek, Futurewei, Ericsson, Samsung, LG
  + **Supportive ([3])**: Qualcomm\*, Apple, [Nokia/NSB]
  + **Not supportive (5):** MediaTek, Futurewei, Ericsson, Samsung, LG
* **Capacity performance results (2):** Futurewei, Qualcomm

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| **Company** | **Summary of Contributions inputs** |
| Futurewei | Some of these proposals, for example Delta MCS, soft HARQ-ACK feedback, and CSI report enhancements, have been discussed in Rel-17 CSI enhancement for URLLC and no consensus was reached on their benefit for URLLC traffic. Applying these proposals to XR traffic, issues discussed during Rel-17 are still to be addressed, such as:   * The lack of capability to deal with CSI state variation caused by bursty interference and/or change of subband/beam/spatial layers between the time when report/feedback is measured and the time when data packet is transmitted, * The uncertainty on deriving report/feedback as it also depends on whether soft-combining between initial transmission and retransmission should be considered, * Potential mis-alignment between assumed BLER target at UE and actual operating BLER target, * Potential impact on UE processing timeline, and * Potential impact of additional UL overhead and related feedback channel reliability.   .  ***Proposal 4: For enhancement for link adaptation to improve XR capacity, avoid repeating discussions on CSI enhancement schemes that have been discussed in Rel-17 CSI enhancement for URLLC.***  **Delta MCS/soft HARQ-ACK feedback scheme description and simulation assumption provided. Shows no capacity gain.**    **Figure 1: Capacity Results with soft HARQ-ACK**   * ***Observation 3: Delta MCS/soft HARQ-ACK feedback scheme does not show performance gain for XR traffic.*** * ***Proposal 6: Down prioritize the Delta MCS/soft HARQ-ACK feedback topic.*** |
| MediTek | ***Observation 6: The soft-ACK reporting enhancement using delta-CQI/MCS was discussed in Rel-16/17 URLLC. Some concerns were brought up including***   * ***How to decide the soft value?*** * ***UE power consumption due to the unneeded 99% of delta-CQI/MCS reports computation*** * ***Impact to the latency and reliability due to the increase in the HARQ codebook size***   ***Proposal 3: The concerns brought up in Rel-16/17 URLLC should be addressed when discussing potential Rel-18 XR capacity enhancement based on soft-ACK reporting enhancement using delta-CQI/MCS.*** |
| Nokia/NSB | Another method to improve the HARQ operation is to replace the Boolean ACK/NACK feedback with multi-bit feedback that expresses the decoder state information (DSI). The DSI conveys information on “how close” the receiver was at being able to correctly decode a failed HARQ transmission. DSI-rich HARQ feedback allows more accurate redundancy version matching of the retransmission. As an example, for the log maximum a-posteriori (LogMAP) receivers (decoder), the output LLRs (Log Likelihood ratios) can be used as an estimate of the DSI. Such options of HARQ enhancements were earlier studied for NR Rel-15 and Rel-16, but without being standardized, while instead the CBG-based HARQ enhancement got standardized (that also introduces multi-bit HARQ feedback in the form of per CBG ACK/NACK). For further studying soft HARQ feedback schemes with quantized feedback of DSI/LLRs, we therefore recommend that the CBG-based HARQ retransmissions is taken as the baseline reference. This is particularly relevant for XR use cases where the TB size is typically rather large, and hence CBG-based HARQ is attractive.  ***Proposal 11:*** *The baseline for comparing the potential performance benefits of soft HARQ feedback schemes (e.g. with quantized DSI/LLR feedback) shall be CBG-based HARQ as this one is attractive for XR cases with large TB sizes.* |
| Qualcomm | The soft HARQ-ACK feedback uses SINR measurements done on each TB and link curves obtained from link level simulations. Then the information the UE feeds back to the gNodeB is an estimation of how far the experienced SINR is from the SINR that would allow a reliable decoding of the TB. Based on this feedback, the scheduler may decide to schedule more than one retransmission without waiting for another HARQ round trip.  **Simulation Assumptions**  HARQ round trip delay depends on UE and gNodeB processing delays, as well as TDD configuration. Here are our assumptions:   * TDD configuration: DDDSU * UE processing delay: Capability 1 * gNodeB processing delay (from HARQ feedback to retransmission) = 4, 6 or 8 slots * When this processing delay is set to K, that means a NACK received in slot n will trigger a retransmission in the downlink slot after slot (n + K) in the TDD configuration   Other simulation assumptions follow the baseline as suggested by TR 38.838 [3]. We show XR capacity results for Dense Urban and Indoor Hotspot scenarios. The traffic consists of 60Mbps, 60Hz video with 10ms PDB, over downlink only.  **Simulation Results**  Figure 6 to Figure 11 show the ratio of satisfied UEs (based on ≥ 99% packet completion rate) as a function of the number of UEs in the cell for the dense urban and indoor hotspot scenarios respectively. Results are presented for soft HARQ-ACK as well as baseline HARQ-ACK for 4, 6, and 8 slots gNodeB processing delay. (Simulation results summary is provided in the Appendix section).    Figure 6: Capacity comparison between soft HARQ-ACK and baseline HARQ-ACK for 4, 6, and 8 slots NACK to retransmission delay, Dense Urban, 60Mbps, 60fps DL stream, 10ms PDB  Table 1 FR1, Dense Urban, VR/AR 60Mbps, 60fps DL stream   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **TDD format** | **SU/MU-MIMO** | **Transmission scheme** | **gNodeB delay1 (slots)** | **HARQ-Ack feedback** | **Capacity (UEs/cell)** | **C1=floor (Capacity)** | **% of satisfied UEs when #UEs/cell =C1** | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Soft | 4.6 | 4 | 94.50% | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Baseline | 0 | 0 | N.A. | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Soft | 2.8 | 2 | 92.90% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Baseline | 0 | 0 | N.A. | | DDDSU | MU-MIMO | reciprocity-based precoding | 8 | Soft | 2 | 2 | 90.10% | | DDDSU | MU-MIMO | reciprocity-based precoding | 8 | Baseline | 0 | 0 | N.A. | | Notes: Random traffic arrival offset among UEs, PDB: 10ms 1: NACK to retransmission delay | | | | | | | |     Figure 7: Capacity comparison between soft HARQ-ACK and baseline HARQ-ACK for 4, 6, and 8 slots NACK to retransmission delay, Indoor Hotspot, 60Mbps, 60fps DL stream, 10ms PDB  Table 2 FR1, Indoor Hotspot, VR/AR 60Mbps, 60fps DL stream   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **TDD format** | **SU/MU-MIMO** | **Transmission scheme** | **gNodeB delay1 (slots)** | **HARQ-Ack feedback** | **Capacity (UEs/cell)** | **C1=floor (Capacity)** | **% of satisfied UEs when #UEs/cell =C1** | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Soft | 2.93 | 2 | 97.70% | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Baseline | 0 | 0 | N.A. | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Soft | 2.1 | 2 | 91.25% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Baseline | 0 | 0 | N.A. | | DDDSU | MU-MIMO | reciprocity-based precoding | 8 | Soft | 1.17 | 1 | 91.25% | | DDDSU | MU-MIMO | reciprocity-based precoding | 8 | Baseline | 0 | 0 | N.A. | | Notes: Random traffic arrival offset among UEs, PDB: 10ms 1: NACK to retransmission delay | | | | | | | |     Figure 8: Capacity comparison between soft HARQ-ACK and baseline HARQ-ACK for 4 and 6 slots NACK to retransmission delay, Dense Urban, 45Mbps, 60fps DL stream, 10ms PDB  Table 3: FR1, Dense Urban, VR/AR 45Mbps, 60fps DL stream   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **TDD format** | **SU/MU-MIMO** | **Transmission scheme** | **gNodeB delay1 (slots)** | **HARQ-Ack feedback** | **Capacity (UEs/cell)** | **C1=floor (Capacity)** | **% of satisfied UEs when #UEs/cell =C1** | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Soft | 7.46 | 7 | 92.3% | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Baseline | 6.64 | 6 | 92.1% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Soft | 5.55 | 5 | 92.4% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Baseline | 0 | 0 | - | | Notes: Random traffic arrival offset among UEs, PDB: 10ms 1: NACK to retransmission delay | | | | | | | |     Figure 9: Capacity comparison between soft HARQ-ACK and baseline HARQ-ACK for 4 and 6 slots NACK to retransmission delay, Indoor Hotspot, 45Mbps, 60fps DL stream, 10ms PDB  Table 4: FR1, Indoor Hotspot, VR/AR 45Mbps, 60fps DL stream   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **TDD format** | **SU/MU-MIMO** | **Transmission scheme** | **gNodeB delay1 (slots)** | **HARQ-Ack feedback** | **Capacity (UEs/cell)** | **C1=floor (Capacity)** | **% of satisfied UEs when #UEs/cell =C1** | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Soft | 5.4 | 5 | 92.3% | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Baseline | 4.5 | 4 | 93.1% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Soft | 4.1 | 4 | 91.0% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Baseline | 0 | 0 | - | | Notes: Random traffic arrival offset among UEs, PDB: 10ms 1: NACK to retransmission delay | | | | | | | |     Figure 10: Capacity comparison between soft HARQ-ACK and baseline HARQ-ACK for 4 and 6 slots NACK to retransmission delay, Dense Urban, 30Mbps, 60fps DL stream, 10ms PDB  Table 5: FR1, Dense Urban, VR/AR 30Mbps, 60fps DL stream   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **TDD format** | **SU/MU-MIMO** | **Transmission scheme** | **gNodeB delay1 (slots)** | **HARQ-Ack feedback** | **Capacity (UEs/cell)** | **C1=floor (Capacity)** | **% of satisfied UEs when #UEs/cell =C1** | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Soft | 11.9 | 11 | 94.1% | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Baseline | 11.3 | 11 | 91.3% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Soft | 10.4 | 10 | 92.0% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Baseline | 0 | 0 | - | | Notes: Random traffic arrival offset among UEs, PDB: 10ms 1: NACK to retransmission delay | | | | | | | |     Figure 11: Capacity comparison between soft HARQ-ACK and baseline HARQ-ACK for 4 and 6 slots NACK to retransmission delay, Indoor Hotspot, 30Mbps, 60fps DL stream, 10ms PDB  Table 6: FR1, Indoor Hotspot, VR/AR 30Mbps, 60fps DL stream   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **TDD format** | **SU/MU-MIMO** | **Transmission scheme** | **gNodeB delay1 (slots)** | **HARQ-Ack feedback** | **Capacity (UEs/cell)** | **C1=floor (Capacity)** | **% of satisfied UEs when #UEs/cell =C1** | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Soft | 8.96 | 8 | 95.0% | | DDDSU | MU-MIMO | reciprocity-based precoding | 4 | Baseline | 8.5 | 8 | 92.9% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Soft | 7.8 | 7 | 93.5% | | DDDSU | MU-MIMO | reciprocity-based precoding | 6 | Baseline | 0 | 0 | - | | Notes: Random traffic arrival offset among UEs, PDB: 10ms 1: NACK to retransmission delay | | | | | | | |   These figures show the benefit brought by soft HARQ-ACK feedback. A significant increase in XR capacity is observed in these conditions for the soft HARQ-ACK based approach as compared to the baseline HARQ-ACK scheme.  The gain of soft HARQ-ACK relative to baseline HARQ-ACK increases when the HARQ round trip delay increases (which is modeled here by increasing gNodeB processing delay).  ***Observation 3: Soft HARQ-ACK is observed to provide a significant gain in XR capacity over baseline HARQ-ACK.***  ***Observation 4: The gain of soft HARQ-ACK relative to baseline HARQ-ACK increases when the HARQ round trip delay increases.***  Based on the observations and discussions, we have the following proposal.  ***Proposal 10: Support soft HARQ-ACK for capacity enhancement of XR capacity.*** |
| Ericsson | Both Delta MCS and Soft HARQ-ACK feedback were intensively discussed in Rel-17 where it was very difficult for companies to agree. We believe the main difficulty is that both measures are relative, and that UE has no knowledge of what target BLER the gNB aimed for which means that a reference point (BLER) is needed. Since companies did not manage to agree on a new reference point and the details of these schemes in Rel-17, we believe there is no hope that this will change in Rel-18. We, therefore, propose:   1. Deprioritize further study of Delta MCS and Soft HARQ feedback. |
| Apple | As some traffic stream of XR service can have a stringent latency requirement, the 2nd transmission is the only opportunity for the gNB to provide more coded bits to the UE, so they can be combined with previously received coded bits (LLRs) for successful decoding. As such, if a UE does not decode PDSCH successfully for the first transmission or for a retransmission when the latency bound is in danger of being exceeded, the more relevant information for the UE to provide is not merely the fact the UE fails to decode the transport block, rather how much more redundancy is needed from the gNB to allow the UE to decode the transport block in the next attempt, which can be the only chance for the UE to receive the transport block within the latency bound. From that, it is reasonable to allow the UE to indicate how much redundancy is needed further for the UE to decode the transport block. Also the UE can consider the current status of the soft buffer in its feedback to the gNB. In Rel-17 eIIoT/URLLC, a number of soft NACK/soft ACK schemes have been proposed; some of them target 10^-6 BLER which is not the typically required for XR. Nevertheless, we feel CSI enhancements can be important for achieving low latency & decent system capacity, and some of them may lead to suitable solution for XR.  **Proposal 3-5: Study soft HARQ-ACK feedback according to PDSCH reception to support low latency traffic efficiently.** |
| Samsung | Another issue that remains pending from RAN1#110 is about CSI reporting using “soft-ACK” or “delta-MCS” as considered in Rel-17 URLLC where discussion focused on “delta-MCS” without conclusion. The determination of a “delta-MCS” value is based on UE implementation (e.g. using estimated SINR, LLR values, LDPC decoder iterations, etc.). Therefore, due to the UE proprietary determination, testing of the feature is difficult. Main additional shortcomings are that delta-MCS is primarily useful for TB retransmissions, thereby failing to offer a benefit ~90%-99% of the time, and that the channel, the interference, the bandwidth, and the target BLER for a TB retransmission need to be identical as for the previous transmission of the TB in order for a “delta-MCS” report to be meaningful. Such requirements are not generally realistic. Also, unlike sporadic URLLC traffic, XR traffic is largely predictable within a time period (including the jitter), and performing link adaptation based on CSI reports is robust and compatible with existing UE/network implementations.  **Observation 4:** *There is no need to further consider “soft-ACK” or “delta-MCS” reporting for XR.* |

### 4.1.1 Initial Discussion

**High level proposals based on input contributions:**

* **Proposal 4-1-1: Support of soft HARQ-ACK for capacity enhancement of XR capacity.**

**Moderator’s observation:**

* The proponent (QC) has provided extensive simulation results, showing large capacity gain.
* The opponent, Futurewei has also provided evaluation results showing capacity loss.
  + Discussion is needed to understand the reason for difference.
* Other companies than Apple/QC are not supportive of this enhancement.
* The proposal can be discussed to address the comments and issues for the initial round of discussions.

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 4-1-1, necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1-Q3: That is another case where simulation results from proponents show (large) gains while it is already known from Rel-17 that such gains are questionable (if any), the requirements to achieve them are unrealistic, and the schemes are not testable as everything is up to UE implementation. |
| **Futurewei** | Q1: Our simulation follows strictly the agreed assumption baseline and we explained in our contribution why no gain is observed. Therefore, we do not see the benefit of the proposal and still have the similar questions since R17 discussion.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: Both capacity gain and lose had been shown. We need to understand how the gain is obtained before we could further discuss this proposal.  Q2: All results should be captured. |
| **MTK** | Q1: Tend to agree with Samsung. To our understanding this discussion also happens in R17 URLLC and it seems hard to achieve consensus.  Q2: We think results can be captured with evaluation assumption clearly explained in the TR, e.g., how the soft values are derived. |
| **ZTE, Sanechips** | Support Proposal 4-4-1. |
| **LG** | **Q1: Not support.** It is already known that the performance gains are totally UE implementation specific, and as Futurewei mentioned, the requirement is also quite high. It is hard to say that the feature would be benefial for the sysyem in the practical situation.  **Q2:** Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | We don’t support Proposal 4-4-1. This proposal has been discussed an exhausted in Rel-17 URLLC with no convergence. |
| **vivo** | Q1: The proposed enhancement in proposal 4-1-1 has been discussed in R17 URLLC session. The main concern is the impact on UE complexity and processing time. It seems the situation is not changed much since then. So we suggest proposal 4-1-1 is deprioritized for XR capacity.  Q2: We think the proposed enhancements with evaluation results, especially those showing potential performance gain, can be captured in the TR. Necessary clarification if any can be included. Whether and how to draw observation and conclusion based on the captured techiques and evaluation results can be discussed separately. |
| **Ericsson** | Q1: We believe the main difficulty in Rel-17 (that still exists), is that both measures are relative, and that UE has no knowledge of what target BLER the gNB aimed for which means that a reference point (BLER) is needed. Since companies did not manage to agree on a new reference point and the details of these schemes in Rel-17, we believe there is no hope that this will change in Rel-18. Also considering FW’s feedback, we think we should down-prioritze this topic. |
| **Nokia, NSB** | We suggest having enhancements in Proposal 4-1-1 compared against CBG-based HARQ transmission cases. We are also fine to deprioritize Proposal 4-1-1 in Rel-18. |
| **Qualcomm** | Q1: our evaluations have followed the agreed evaluation methodologies. We also explained in our contribution text why the proposed solution has capacity gain for the latency stringent XR traffic.  Q2: yes, evaluation results should be captured in TR 38.835 if they follow evaluation methodologies. |

## 4.2 Cooperative MIMO scheme via precoding technique

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (2):** Futurewei\*, Ericsson
  + **Supportive**: Futurewei\*
  + **Not supportive:** Ericsson (in XR, OK in MIMO)
* **Capacity performance results (1):** Futurewei\*

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| **Company** | **Summary of Contributions inputs** |
| Futurewei | **Enhancement Scheme in System Simulation**  Graphical user interface, text, chat or text message  Description automatically generated with medium confidence  **Figure 2 CQI Filtering**  The CQI filtering scheme is used in all the results presented in this paper. Combining with the relatively slow OLLA adjustment, the MCS assigned is less sensitive to the instantaneous CQI feedback that is heavily based on interferences caused by bursts of data packets scheduled for users in all the sectors.  ***Observation 4: The CQI filtering scheme can help both the baseline zero-forcing transmission scheme and the transmission scheme based on cooperative MIMO. The IIR filtering of the CQI enable smoother and more conservative MCS assignment, which lead to generally better performance for XR traffic.***  **Cooperative MIMO for TDD with downlink interference probing via SRS**  Cooperative MIMO (e.g., CoMP in LTE) has not been found successful yet in practice.  To resolve these issues and obtain the promised gain from the massive number of antennas, a new approach is proposed here. Instead of trying to obtain channel state information of interfering links and then determine precodings jointly at a centralized entity, SRS is enhanced to directly reflect DL interference spatial information (utilizing UL-DL reciprocity). Each gNB measures the corresponding SRS resources to obtain such information and adjusts its precoding to achieve interference coordination/avoidance.  To summarize, DL Interference Probing from UL is possible if the network controls the UEs to transmit SRS in a way that best reflects prospective DL interference.    **Figure 4:** TDD DL SE performance enhancement via interference probing and mitigation. To convey spatial information about the interference (both intra-cell and inter-cell) to the network, flexible A-SRS triggering based on prescheduling may be used.  The above approach is effective to suppress both inter-cell and intra-cell interference. This approach also has the following advantages:   * Distributed across gNBs (or TRPs) in the network, with low computational complexity for each gNB * No or little channel information exchange among gNBs * Can adapt to inter-cell interference, including unknown interference from non-cooperative gNBs or outside of the network (e.g., from other service providers, small cells, etc.) * No need to estimate element-wise channel, reducing the complexity and overhead.   One specific way to implement is called bi-directional training (BiT);    **Capacity Results with BiT precoding:**  ***Table 6 & 7 for more results.***  ***Observation 5: TDD ZF performance can be significantly improved by flexible A-SRS triggering with dynamically indicated partial frequency sounding.***  ***Proposal 8: Support cooperative MIMO via DL interference probing based on SRS enhancements to improve XR system capacity for TDD.***  ***Observation 6: DU scenario experiences higher gains than Uma scenario with the BiT precoding relative to Zero-Forcing precoding, due to the shorter inter-cell distance, in which interference is more dominating than noise.***  ***Proposal 9: Include the text proposal for the cooperative MIMO scheme in the SI TR.*** |
| Ericsson | We understand the technique *Cooperative MIMO scheme via precoding technique - bi-directional training* as a general MIMO technique that is not specifically related to XR. Our understanding of the technique is that this is already possible to perform by implementation using current specification at least to some extent. It is strongly preferred that the potential enhancements in sounding flexibility suggested by the proponent are treated under Rel-18 NR MIMO evolution for downlink and uplink.   1. Potential continuation of study of Cooperative MIMO scheme via precoding technique - bi-directional training is performed under Rel-18 SI NR MIMO evolution for downlink and uplink. |

### 4.2.1 Initial discussion

**High level proposals based on input contributions:**

* **Proposal 4-2-1: *Cooperative MIMO via DL interference probing based on SRS enhancements to improve XR system capacity for TDD* is beneficial.**

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 4-2-1, necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1-Q3: It is not realistic to consider the proposal in XR. |
| **Futurewei** | Q1: we’ve provided extensive simulation results, analysis, and description of the proposal. Significant benefits of XR capacity gain are shown. The scheme should be considered for XR capacity improvement.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: The synchronization of data, the transmission state, and HARQ among TRPs is the most challenged issue in the proposed scheme. The proposed scheme coud be used for any traffic data and not limited to XR.  Q2: All results should be captured. |
| **MTK** | Q1: The capacity gain seems good but only reported by one company and not sure whether it is specific to XR. We would be open to consider this enhancement if majority of companies think so.  Q2: The results can be captured with evaluation assumptions clearly explained in the TR. |
| **LG** | We think it can be considered as an issue of general MIMO discussion. We don’t think this issue is not XR specific issue. |
| **Google** | This propsal is not addressing an XR pseicifc limitation and it s generic to any type of data. Not sure if it should be discussed under XR AI. |
| **vivo** | Q1: The proposed enhancement in proposal 4-2-1 should be discussed in MIMO session. Besides, Proposal 4-2-1 is not addressing an XR specific issue based on our understanding.  Q2: See the reply in section 4.1.1. |
| **Ericsson** | Q1. We are fine to report this results in TR. Indeed high capacity gain is shown.  As we mentioned previously, our concern is more on logistics if this enhancement is to be treated in XR WI where needs the expertise in MIMO. |
| **InterDigital** | Same view as Google. We no not see how this enhancement is best suited for addressing only XR-specific issues. |
| **Nokia, NSB** | Defer MIMO enhancements to the dedicated 3GPP MIMO item. |

## 4.3 Enhanced CQI based on CBG or DMRS

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (4):** Nokia/NSB\*, Ericsson\*, Futurewei
  + **Supportive eCQI based CBG (1)**: Nokia/NSB
    - **Not supportive (3):** Futurewei, Ericsson
  + **Supportive eCQI based DMRS (1)**: Ericsson\* (new simulation results)
* **Capacity performance results (1):** Nokia/NSB\*, Ericsson\*

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| **Company** | **Summary of Contributions inputs** |
| Futurewei | Regarding enhanced link adaptation for CBG-based transmission, since 4-bit full sub-band CQI has been adopted in Rel-17, where the frequency domain granularity of sub-band CQI can better match the required frequency resource for CBG-based transmission, it is hard to see the benefit the enhanced link adaptation for CBG-based transmission can bring compared to 4-bit full sub-band CQI. On the other hand, in Section 3.2, we show that using IIR filtering of CQI at the gNB can improve the system capacity without specifying new link adaptation enhancements.  ***Proposal 5: For link adaptation for XR, reuse the 4-bit full sub-band CQI together with implementation-based CQI filtering.*** |
| Nokia/NSB | Enhanced CQI feedback for CBG-based transmissions  *Given the large payloads for XR cases, CBG-based transmissions are therefore attractive as a mean to have resource efficient transmissions, and hence helps improve the overall capacity.* However, in order to fully gain from CBG-based transmissions, we need to have efficient link adaptation. Our proposal is therefore to enhance CQI (eCQI) so guides the gNB on the maximum MCS scheme it can use while ensuring that only a certain maximum subset of CBGs will need retransmission with a controllable probability. E.g. have an eCQI scheme that guides the gNB to use a MCS index such that at most 4 CBGs (out of 8 CBGs) will require retransmission with P=0.1 probability (10%). This is clearly different from current CQI designs that only offers the possibility to select the MCS corresponding to a certain TB block error probability (BLEP), without controlling the CBG error probability and hence how many CBGs of a TB are in error  . At RAN1#110 it was commented that the CBG error probability could be derived directly from the TB BLER via a simple equation as e.g. presented in R1-2205917. However, this is only true if we assume that the errors on CBG’s are independently identically distributed (i.i.d.) which is not the case in reality. Figure 1 is a snapshot of the CB and CBG SINR experienced by one UE in an indoor hotspot scenario. As can be seen, the assumption of similar CB and consecutively similar CBG SINR values does not hold. Therefore, assuming that the error probabilities are identical is not accurate.   |  |  | | --- | --- | | (a) CB SINR values in one TB | (b) CBG SINR values in the same TB |   *Figure 1. The experienced CB and CBG SINR values for one example TB of a UE at 30Mbps in an Indoor Hotspot deployment in FR1 scenario.*  Secondly, it was discussed that sub-band based CQI could also be used as mean to gain more insight on the CBG error probability. However, as CBGs are not localized in frequency such that a CBG is mapped to only one or few subbands, it is hard to estimate and control the CBG error probability of PDSCH transmission from the sub-band legacy CQI schemes. This leads us to the following observations  ***Observation 3:*** *The legacy CQI scheme with a recommended MCS to obtain a certain TB BLER, offers no direct mean for the gNB to control the CBG error probability for PDSCH transmissions. Only under certain conditions of i.i.d. CBG errors is this feasible, which is usually not the case.*  ***Observation 4:*** *As the name indicates, sub-band based CQI offers the channel quality per sub-based. However, as the CBG mapping to PHY is not strictly localized in frequency, there is no one-to-one mapping of the sub-band per sub-band to the CBG error probability.*  A general overview of the eCQI scheme can be summarized as the following: The UE performs measurements on the CSI reference resources to determine the received post-detection SINR (this is the same as done for the current legacy CQI schemes). Based on these measurements, the UE estimates the effective SINR for the M-different CBGs. The UE thereafter determines the highest MCS that it can support, while at most N out of the M CBGs are in error with probability P. This may be implemented in the UE for example having a table with CBG error rate vs effective SINR for the different MCS’s (just as current UE implementations has a table with effective TB error rate vs effective SINR). The reporting of the eCQI can be in the form of an eCQI index that points to a new eCQI table that enumerates the supported modulation scheme, effective code rate, and overall efficiency that it recommends the gNB to use for its PDSCH transmissions.  ***Proposal 8:*** *An enhanced CQI (eCQI) shall be further considered, where the UE measures on the CSI reference resources to determine the highest supported MCS, while at most N out of M CBGs are in error with probability P. The reporting of the eCQI is in form of an index to an eCQI table. Other options for eCQI schemes to gain the most for CBG-based XR transmissions are not excluded.*  ***Proposal 9:*** *Note that the proposed eCQI does not include any changes to the CSI-RS transmission, the specification changes are mainly limited to 3GPP TS 388.214 clause 5.2.2.1 as follows:*   * *The UE shall derive for each CQI value reported in uplink slot n the highest CQI index which satisfies the following condition: A single PDSCH transport block with a combination of modulation scheme, target code rate and transport block size corresponding to the CQI index, and occupying a group of downlink physical resource blocks termed the CSI reference resource with M code block groups, could be received with an error probability of at most N failed code block groups not exceeding:*   ***Proposal 10:*** *Signaling of the eCQI configuration parameters M, N, P may be included in CSI-ReportConfig and sent via RRC signaling (needs to be further discussed with RAN2).*  To quantify the benefits of the improved link adaptation for CBG-based transmissions from the eCQI, we have run a series of XR system-level simulations in line with the agreed assumptions (3GPP TR 38.838 [2]).   |  |  | | --- | --- | | (a) AR/VR in FR1 at 30Mbps with X=99% | (b) CG in FR1 at 30Mbps with X=99% |   *Figure 2. DL Capacity evaluation of the different link adaptation schemes (with/without eCQI) for CG traffic (Video) and AR/VR (Video) at 30Mbps in Indoor Hotspot deployment in FR1 with X=99% of frames received within PDB and cells evenly loaded. The lower bound on the percentage of satisfied user is Y=90% (dashed line).*   |  |  | | --- | --- | | (a) AR/VR in FR1 at 45Mbps with X=99% | (b) CG in FR1 at 45Mbps with X=99% |   *Figure 3. DL Capacity evaluation of the different link adaptation schemes (with/without eCQI) for CG traffic (Video) and AR/VR (Video) at 45Mbps in Indoor Hotspot deployment in FR1 with X=99% of frames received within PDB and cells evenly loaded. The lower bound on the percentage of satisfied user is Y=90% (dashed line).*  Two different algorithms are compared: legacy link adaptation with TB-based transmission and legacy CQI reporting and enhanced link adaptation with CBG-based transmission and enhanced CQI reporting with two parameter set versions. The CQI mechanism in the legacy algorithm is set to fix the BLER of the first transmission to 10% for the TBs. On the other hand, enhanced CQI is working with a fixed CBG error probability to have at most N/M =25% N/M =50% (blue curve in Figures 2 and 3) failed CBGs. As can be seen from the figure, the number of satisfied users has been increased in both CG and AR/VR use cases for both data rates. Moreover, the gain is still achieved for the stricter PDB of 10 ms for the AR/VR applications. We can also observe that for these simulation scenarios, the best N/M ratio is around 50% where the MCS selection is done in a way that in the worst-case scenarios at most half of the CBGs in one TB transmission will be successfully decoded. It is worth noting that the results presented in [4], the case with a rank adaptation mechanism with a maximum rank of 2 were presented that showed an improved XR capacity for the eCQI method. *The main reason for eCQI gain is due to the ability of the eCQI method to tolerate a certain probability of CBG failure, P, that can be compensated (via retransmission) with very small resource consumption. On the other hand, this tolerance allows the possibility of choosing much higher MCS indices compared to legacy CQI method, leading to much better resource efficiency outcome.* |
| Ericsson | **Methods for re-transmission LA:**  When gNB performs LA for a re-transmission, the TBS cannot be changed, but time- and/or frequency-domain allocation and modulation can be adopted. In our simulations, as a baseline we assume re-transmission LA to be without time-domain adaption, i.e., slot-based transmission, while frequency-domain allocation and a modulation are selected by gNB such that predicted BLEP (Block-Error Probability) is lower than a target BLEP. This is similar to LA for initial transmission, where the only difference is that the TBS is not fixed for the initial transmission. Since LA has no knowledge about the reception quality for previous PDSCH transmissions, other than that they failed or not, for baseline schemes LA assumes that only the upcoming PDSCH will contribute to a potential correct decoding.  When DMRS-based CSI (we denote it as DMRS-CQI) is available, the LA has knowledge of the reception quality of previous PDSCH transmissions which enables LA to estimate how each transmission contribute to the total decoding result. The DMRS-CQI reports can also be used as a better prediction of the quality that can be expected for the upcoming PDSCH transmission. Here, we can make a simple assumption that the SINR for the upcoming PDSCH transmission is either the mean SINR deduced from the DMRS-CQI values or the SINR deduced from the last legacy CSI report depending on which of them is smallest. We emphasize here that LA for initial transmission is performed in the same way as for baseline LA although a DMRS-CQI report may be a better prediction of the SINR for an initial PDSCH than a legacy CSI report. In simulations, the DMRS-CQI value reported is with respect to same CQI table used for legacy CSI reporting.  We compare the DMRS-CQI scheme with two baseline schemes:   * TB-based transmission (denoted as “TB-tx”) * CBG-based transmission (denoted as “CBG-tx”), where CBG (Codeblock group) HARQ-ACK is enabled, and UE is configured with 8 CBGs.   **Relation between CBG and TB error probability:**  For CBG-based transmission scheme, CBGs for which a HARQ NACK was received are only re-transmitted. In simulations, we assume all CB (Code blocks) to have same error probability. That is, we assume that NR’s interleaved VRB-to-PRB mapping can perfectly average out the SINR for all CBs. With this assumption, it can be further assumed that the number of CBG errors to be binomially distributed with parameters ), where is the CBG error probability and is the number of CBGs. The TB error probability then equals . Furthermore, if LA would like to target a defined CBG error rate, it can choose a suitable TB error target. Since we can assume the number of in-correct CBGs to be a binomially distributed random variable with parameters ), then the probability that at most of the CBGs are erroneous equals:  .  If LA targets at most 25% of CBGs to be in error, then will fulfil this target with a 99.9% probability when . In terms of TB error probability this corresponds to 22% error probability. In simulations, LA will however only use BLER target in terms of TB error probability.  **Simulation results with different TB BLER target:**  Figure 7 and Figure 8 shows simulation results in Indoor Hotspot (InH) and Urban macro (Uma) scenario, respectively, with the different LA schemes: TB-based (“TB-tx”), CBG-based with CBG HARQ-ACK (“CBG-tx”) and TB-based with DMRS-CQI reporting (“TB-tx, DMRS-CQI”) for different BLER target settings. All schemes simulated with outer loop (OL) or without outer loop (no OL). *“noOL” means that 10% TB target BLER for inner-loop LA and disabled outer-loop, “OL 10%” means 10% TB target BLER for inner- and outer-loop and “OL 22%” means 22% TB target BLER for inner- and outer-loop.* Detailed simulation parameters are collected in Table 1 (UMa) and Table 2 (InH) in the Appendix. For UMa scenario, reciprocity-based precoding is used while codebook-based pre-coding is used for InH. For both scenarios, proportional-fair scheduling is used.    Figure 7: Indoor Hotspot (InH) DL capacity evaluation for LA schemes for AR/VR (left figure) and CG (right figure).    Figure 8: Urban macro (UMa) DL capacity evaluation for LA schemes for AR/VR (left figure) and CG (right figure).  **Small gain with CBG-based re-transmission compared to TB-based, but significant gain with DMRS-based CQI:**  Based on the simulation results in Figure 7 and Figure 8 we can make the following observations.  Observation: For the InH and UMa scenarios, CBG-based re-transmissions yield only a small capacity improvement compared to TB-based re-transmissions.  Observation: Downlink XR capacity depends heavily on the target BLER in link adaptation. For the InH and UMa scenarios, significantly higher capacity is possible than achievable using an OL with 10% target BLER.  Observation: For comparable BLER targets in link adaption, DMRS-based CQI give a significant downlink XR capacity improvement compared to a baseline TB- or CBG-based scheme in the InH and UMa scenarios.  Observation: For CBG-based re-transmission with 8 CBGs, the reporting overhead increase is 7 bits per PDSCH compared to TB-based re-transmission while for DMRS-based CQI the reporting overhead increase is 4 bits per PDSCH.  The reason why CBG-based re-transmissions only give a small capacity improvement compared to TB-based is due to that error curves versus SINR are “knee-like”. Only a small change in SINR can change BLEP from close to 1 to 1e-5. This further has the consequence that for almost all transmissions either all CBGs are successfully decoded or none of the CBGs could be correctly decoded. In fact, for less than 3% for InH (6% for Uma) of the transmissions, the number of in-correctly decoded CBGs is different from 0 and . This means that the occasions where CBG-based re-transmission can reduce the resource consumption compared to TB-based re-transmission are rather rare for the InH and UMa scenarios.  **Higher CBG BLER target does not help CBG-based scheme, but even bigger gain with DMRS-based CQI for 15 ms PDB;**  It may be argued that a 3% CBG error probability target is too low for CBG-based re-transmissions to benefit from not having to re-transmit correct CBG. With , the expected value for the binomially distributed random variable with parameters equals if . If instead , then the expected number of in-correct CBGs equals 25% of the number of CBGs, which maybe could be a better target. With and the TB error probability equals , For InH scenario we have simulated the cases TB-based (“TB-tx”), CBG-based with CBG HARQ-ACK (“CBG-tx”) and TB-based with DMRS-CQI reporting (“TB-tx, DMRS-CQI”) where both inner- and outer-loop LA target 90% TB error probability. Since the case “OL 10%” yield worst performance in Figure 7, we re-placed it in Figure 9 with “OL 90%” where both inner- and outer-loop LA target 90% TB error probability.    Figure 9: Indoor Hotspot (InH) DL capacity evaluation for LA schemes for AR/VR (left figure) and CG (right figure), where the LA scheme “OL 10%” is replaced with “OL 90%”.  **Only a few UEs reach the target BLER for InH scenario**  It should be emphasized that for the “OL 90%” LA schemes, although OL attempts to push MCS selection towards 90% BLER, only a small fraction of the UEs reach such high BLER. In fact, only 10% of the UEs come close to 90% and only for the highest load points. At 10 UEs/cell, the BLER for the average UE is below ~50%. This is shown in Figure 10 below.    Figure 10: Transport block HARQ BLER for 10%-tile (solid), mean (dashed) and 90%-tile (dot-dashed) for Indoor Hotspot scenario.  Based on the simulation results in Figure 9 and Figure 10 we can make the following observations:  Observation: For the InH scenario, CBG-based re-transmissions only yield a small capacity improvement compared to TB-based re-transmissions also for 90% TB BLER target.  Observation: 90% TB BLER target only reached by a few UEs at highest load points for InH scenario.  Observation: For 15 ms PDB, the capacity obtained with DMRS-based CQI can be further improved using 90% TB error probability target.  Based on our simulation results and observations we propose:  Proposal: Deprioritize further study of CSI enhancements specific to CBG-based (re-)transmission.  Proposal: R18 supports DMRS-based CSI reporting. |

### 4.3.1 Initial discussion

**High level proposals based on input contributions:**

* **Proposal 4-3-1: Enhanced CQI based on CBG transmission improves the link adaptation and is beneficial for improving XR capacity performance.**

* **Proposal 4-3-2: DMRS based CQI improves the link adaptation and is beneficial for improving XR capacity performance.**

**Moderator’s observation:**

* eCQI based CBG:
  + Both Nokia and Ericsosn have provided extensive analysis and evaluations on eCQI based CBG where have different views. Futurewei as well provided views on this enhancements.
  + Moderator recommends companies review the input contributions and discuss.
* eCQI based DMRS:
  + Ericsson has provided extensive analysis and simulation results for this enhancements. It seems the analysis and evaluations jointly covers the eCQI based CBG.
  + Moderator recommends companies review the input contributions and discuss.

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on direction of Proposal 4-3-1 and Proposal 4-3-2, necessity/benefit of the proposed enhancements? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

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| **Company** | **Comment** |
| **Samsung** | Q1-Q3: DMRS-based CQI has been considered under MIMO over many releases (going back to LTE) and was not agreed. There are several reasons for that and it is not realistic to re-consider under XR. For CBG-based CQI, unless different CBGs correspond to different QoS flows, TB-based CQI is fundamentally preferable. If different CBGs correspond to different QoS, the DCI format design needs to be discussed together with any benefit over using separate DCIs for separate QoS flows. In our opinion, no further consideration is justified for either proposal. |
| **Futurewei** | Q1: These proposals were discussed in previous releases extensively. It is preferred not to re-discuss again.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: We should not re-open the issue dropped in MIMO session.  Q2: All results should be captured. |
| **MTK** | Q1: The capacity gain seems good but only reported by one company. We would be open to consider this enhancement if majority of companies think so.  Q2: The results can be captured with evaluation assumptions clearly explained in the TR. |
| **ZTE, Sanechips** | We are open to the Proposal 4-3-1 and Proposal 4-3-2 |
| **LG** | **Q1:** We share views from Samsung and Futurewei. We also think gNB can consider CBG even with existing CQI.  **Q2:** Same as others. With repect to companies’ effort, we are fine to capture proposals when the performance has been shown or can be clearly expected. We think the same principle can be applied for all of the proposal. |
| **Google** | With the large UL/DL video packets in XR, the use of CBG is very important to improve the system capacity.  Also, enhancements to the CBG mechanisms are needed. CBG-based CQI reporting could be further studied. |
| **vivo** | Q1: We think proposal 4-3-1 and 4-3-2 should be deprioritized for XR capacity study.  For proposal 4-3-1, the benefit of CBG based transmission with CBG based CQI reporting compared to TB based retransmission with legacy subband CQI reporting (at most 4 bits) is not clear, while it may burden UE with more complexity and computation.  For proposal 4-3-2, it is showed that with 90% target BLER where there will be high probability for retransmission, DMRS-based CSI reporting with HARQ-ACK (if not impact the latency) may be useful. However, if target BLER is typically set as 10%, then there will be no more than 10% retransmission. UE needs to measure CSI based on DMRS with high probability. When considering the increased latency to generate CQI based on DMRS, the beneifit will be vanished due to the short PDB of XR traffic. Meanwhile, this also causes increased UE power consumption.  Q2: Same reply as section 4.1.1 |
| **Ericsson** | Q1: We are not supportive of 4-3-1. As proponets, we are supportive of 4-3-2.  Based on the input contribution (Nokia), we would like to provide few feedbacks:   * Regarding eCQI based CBG, it is important to see as baseline the performance of legacy CBG (only TB based is provided). * We would like to know the assumption on target BLER and OL. * In Nokia’s contribution when SINR distribution for CBG and TB are shown (Figure 1), the difference in SINR for the CB difference is (6-7 dB), but for CBG is **maximum 1 dB** as Nokia shows. To us, this means that some CBs in the CBG has good quality while other has worse. So even if VRBs is not used (not clear for us if it is used in Nokia’s result) it will be rather lucky that frequency selective interference happen such that CBs that suffer all belongs to same CBGs while other CBs in other CBGs succeed. * We explained in our contribution that the reason why CBG-based re-transmissions only give a small capacity improvement compared to TB-based is due to that error curves versus SINR are “knee-like”. Only a small change in SINR can change BLEP from close to 1 to 1e-5.   + This further has the consequence that for almost all transmissions either all CBGs are successfully decoded or none of the CBGs could be correctly decoded. In fact, for less than 3% for InH (6% for Uma) of the transmissions, the number of in-correctly decoded CBGs is different from 0 and .   + This means that the occasions where CBG-based re-transmission can reduce the resource consumption compared to TB-based re-transmission are rather rare for the InH and UMa scenarios. |
| **InterDigital** | We are open for discussing Proposal 4-3-1 |
| **Nokia, NSB** | Q1: We support Proposal 4-3-1 as we have shown capacity improvements while using CBG-based transmission with an enhanced CQI scheme compared to TB-based and legacy CQI scheme. We have also introduced the specification impact of the enhanced CQI scheme (mainly on 3GPP TS 38.214 clause 5.2.2.1). We believe that it is necessary to update the current CQI determination mechanism to fit better with CBG based transmission. Specifically, for the XR use cases, most of the times full bandwidth is allocated for one UE and due to large channel fading variation among the code blocks, there is a need for an enhancement that takes this variations and unequal CB (and CBG) error probabilities into account. From the Ericsson tdoc, it seems that i.i.d. errors of CBGs are assumed (?), while our sim results show that CBG errors actually vary within one TB.  Regarding Proposal 4-3-2, our understanding is that the DMRS based CQI can only happen when there is a PDSCH transmission. This would result in a periodicity of 16.7 ms for a typical XR UE which could lead to outdated channel measurement data.  Q2: Yes, we support capturing the results and related observations to TR 38.835. |
| **Qualcomm** | Similar to other companies views prefer not to reconsider. |

## 4.4 Enhancements based Measurement gap

The table below lists short descriptions, and the proposals and observations in the contributions submitted in this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions.

**Status of inputs in the contributions:**

* **Companies with view (5):** Qualcomm, Nokia/NSB\*, MediaTek\*, Futurewei, Ericsson
  + **Supportive ([4])**: Qualcomm, Nokia/NSB\*, MediaTek\*
  + **Not supportive (1):** Futurewei, Ericsson
* **Capacity performance results (2):** Nokia/NSB\*, MediaTek\*

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| **Company** | **Summary of Contributions inputs** |
| Futurewei | We are open to study this proposal if capacity gain can be shown for typical scenarios/configurations. However, it is unlikely that UE will be configured with measurement gap and provide seamless XR service simultaneously, because usually at this moment, inter-frequency measurement has higher priority. Furthermore, since the scenarios will be different from the scenarios agreed so far, new baseline and assumptions/scenarios need to be defined before investigating the proposals. In addition, the room of improvements is expected to be limited, one of the reasons being that the UE may handle XR traffic with a PDB of 10-15ms, which is much longer than the duration of measurement gap. Besides, measurement-gap enhancement also needs RAN4 involvement. It is unclear whether RAN4 has the capacity to handle this topic given their already very busy schedule.  Based on the above analysis, we propose the following:  ***Proposal 7: For*** ***enhancement for measurement-gap, down prioritize this topic and reuse existing schemes as much as possible. New baseline and assumptions/scenarios need to be defined before investigating the proposals.*** |
| MediaTek | Figure 3: Capacity – max user number with (90% User @ “99% frame Tx done < 10ms”)  ***Observation 1: In 5G NR system, measurement gaps (MG) are configured to allow UE to do inter-frequency neighbour cell measurement and the corresponding RF tuning for RRM purposes (e.g. mobility, load balancing, CA set-up). MG is a feature specific to mobile network, which is different from WiFi. In measurement gap, NW cannot schedule UE to transmit/receive data.***   * ***System level simulation in Figure 3 shows that***    + ***XR DL Capacity falls from 10 (no MG) to less than 2 (MGRP=80, MGL=6) and less than 1 (MGRP=40, MGL=6), if all UEs are configured with MG***   + ***XR DL Capacity falls from 10 (no MG) to 6 (MGRP=80, MGL=6) and less than 2 (MGRP=40, MGL=6), if only the 20% cell-edge UEs are configured with MG***     - ***The capacity loss is much more than 20%***   ***Observation 2: It should be exploited to enhance measurement gap for XR with orchestrated gNB/UE coordination, say more dynamic MG activation/deactivation or MG setting (including duration and period) change***   * ***current spec only allows RRC reconfiguration to change the MG settings or enable/disable MG.***   ***Proposal 1: Support a more dynamic DCI/MAC-CE based MG activation/deactivation or MG setting (including duration and period) change for XR capacity enhancement.***  At the same time, from NW side, the Rel-16/Rel-17 defined RRM relaxation criteria, and the link condition can be used to determine how to do the MG activation/deactivation.  ***Observation 3: From NW side, the Rel-16/Rel-17 defined RRM relaxation criteria***   * + ***lowMobilityEvaluation or not-at-cell-edge criteria defined in 5G NR Rel-16***   + ***stationary or not-at-cell-edge criteria defined in 5G NR Rel-17***   ***and the link condition can be used to determine how to do the MG activation/deactivation.***  :    Figure 4: Capacity – max user number with (90% User @ “99% frame Tx done < 10ms”) with MG enhancement (Case 1 & Case 2)  ***Observation 4: Assuming NW can dynamically change the MG period using some link condition criteria (Case 1 and Case 2 described below), SLS results (mobility simulation is based on 30km/h UE speed and FR1 with 200m ISD) in Figure 4 show that***   * **The XR capacity increases from 2 to 6 under Case 1** * **The XR capacity increases from 2 to 8 under Case 2**   **where**   * **Case 1: The MG period is adapted to be 2 times when PCell RSRP is 2dB better than the best neighbor cell and 4 times when PCell RSRP is 4dB better than the best neighbour cell**   + **Performance impact (handover fail rate): 2.08% 🡪 2.81%** * **Case 2: The MG period is adapted to be 4 times when PCell RSRP is 2dB better than the best neighbor cell and 8 times when PCell RSRP is 4dB better than the best neighbour cell**   + **Performance impact (handover fail rate): 2.08% 🡪 4.37%** |
| Nokia/NSB | Scheduling restrictions due to RRM measurements  UE based scheduling restrictions avoidance  UEs performing RRM measurements does not come for free, as there are cases where this imposes scheduling restrictions. Either due to potential measurement gaps for inter-frequency RRM measurements, of alike restrictions for FR2 intra-frequency RRM measurements as is discussed in greater details in this section.  From that figure it is visible that the SMTC windows with scheduling restrictions often collides with time periods where the gNB would have preferred to schedule the XR transmission. This will impact the experienced XR QoE, as well as negatively impacting the obtained network XR capacity.    ***Figure 4. Sketch of timing of SMTC windows with scheduling restrictions as well as arrival of XR frames.***  We have conducted simulations without any scheduling restrictions (as companies also report in TR 38.838) and simulations with scheduling restrictions every 20 ms time period for an SMTC window of 5 ms.  ***Observation 5****: Scheduling XR users with 60 fps according to the agreed QoS constraints in 3GPP TR 38.838 is seriously challenged for FR2 if subject to scheduling restrictions with SMTC windows of 5 ms every 20 ms time-period. System-level performance results confirm that this severely impacts network XR capacity.*   |  |  | | --- | --- | | (a) CG in FR2 at 30Mbps with X=99% | (b) AR/VR in FR2 at 30Mbps with X=99% |   ***Figure 5. Percentage of satisfied XR users obtained from system-level simulations for DU at FR2 with 30 Mbps and PDBs of 10ms and 15 ms, with/without scheduling restrictions during SMTC windows of 5 ms for every 20 ms time period.***  The current NR specs also allow the network to configure the UE with a search threshold (*s-MeasureConfig*) for a UE in connected mode to enable reduction of the intra-frequency measurement effort. 3GPP TS 38.331 defines:   * ***s-MeasureConfig:*** Threshold for NR SpCell RSRP measurement controlling when the UE is required to perform measurements on non-serving cells. Choice of *ssb-RSRP* corresponds to cell RSRP based on SS/PBCH block and choice of *csi-RSRP* corresponds to cell RSRP of CSI-RS   If the network has configured the *s-MeasureConfig* threshold allowing the UE not to perform measurements on non-serving cells, including the intra-frequency neighbor cells, there may be unused scheduling opportunities in those cases where the UE is not performing intra-frequency measurements, but the network is not aware of this, and hence obeys the defined scheduling restrictions.  ***Proposal 12:*** *For UEs that are configured with s-MeasureConfig, additional UE-to-gNB signaling shall be introduced to make the gNB scheduler aware of when scheduling restrictions apply. The solution may include signaling when the UE starts and stops making intra-freq measurements as per the s-MeasureConfig.*  As UE evaluated the *s-MeasureConfig* against its L3 filtered serving cell measurement, the proposed UE-2-gNB signaling does not necessary need to be very fast, and hence higher-layer signaling could be considered depending on RAN2 views as follows:  ***Proposal 13:*** *The UE-to-gNB signaling to make the gNB scheduler aware of when s-MeasureConfig induced scheduling restrictions apply could be realized with higher-layer signaling such MAC CE or RRC signaling. RAN2 shall be asked for further guidance.*  Network based scheduling restrictions avoidance due to inter-freq meas. gaps  Whether a measurement is non-gap-assisted or gap-assisted depends on the capability of the UE, the active BWP of the UE and the current operating frequency. For SSB based inter-frequency measurement, if the measurement gaps are required by the UE, a measurement gap configuration will be provided according to the information. Otherwise, a measurement gap configuration is always provided in the following cases: (i) if the UE only supports per-UE measurement gaps, (ii) if the UE supports per-FR measurement gaps and any of the serving cells are in the same frequency range of the measurement object. During inter-frequency measurement gaps, the UE is not schedulable.  ***Observation 6:*** *UEs that are configured with gap-assisted inter-frequency measurements are not schedulable during such gaps, and hence will impact the XR performance negatively as also reported in Section 6.1.*  ***Observation 7:*** *Inter-frequency measurement gaps are configured more seldomly for UEs as compared to intra-frequency RRM measurements (SMTC windows), and hence the problems associated with intra-freq RRM measurements (i.e. scheduling restrictions) shall be addressed first as discussed in Section 6.1.*  ***Proposal 14:*** *For UEs configured with inter-frequency measurement gaps, solutions where the gNB can signal the UE to skip a measurement gap (to avoid scheduling restrictions) shall be captured in the TR. The gNB-2-UE signaling for this may be realized via a compact DCI format to have fast signaling.*  As in case of inter-frequency, also the SMTC induced scheduling restrictions in intra-frequency at FR2, discussed in Section 6.1, we also propose to consider the scheme where the gNB can configure a UE to prioritize decoding of potentially critical PDCCH/PDSCH transmissions from its serving cell, even if colliding with SMTC windows where the UE may perform RSRP measurements.  ***Proposal 15:*** *FR2 solutions for the gNB to instruct the UE to prioritize PDCCH/PDSCH decoding during a sub-set of SMTC windows shall be captured in the TR such that XR payloads can be scheduled timely without unnecessary scheduling restrictions.*  ***Proposal 16:*** *The gNB could use RRC signaling to instruct the UE with a time pattern where it always will have to prioritize PDCCH/PDSCG decoding even if colliding an SMTC window. RAN1 should ask RAN2’s opinion on this.*  Secondly, as proposed above for inter-frequency measurement gaps, we should consider a dynamic solution also for FR-2 scheduling restrictions, where the gNB, shortly before (say up to few milliseconds) an SMTC, should be able to signal the UE to prioritize PDCCH/PDSCH decoding during this particular SMTC window. We refer to this as the on-demand solution as it is sent on-demand to prioritize scheduling for a single SMTC window.  ***Proposal 17:*** *Fast on-demand signaling from the gNB to UE to instruct it to prioritize PDCCH/PDSCH decoding during the next SMTC window shall be supported by means of PDCCH signaling.*  For cases proposed above where UE prioritize PDCCH/PDSCH decoding during a SMTC window or measurement gap, and hence is skipping one L1 RRM measurement, it shall therefore be defined how this is handled at the interface to the L3 filter. For such cases we simply propose adopt a simple solution, where the latest L1 RRM measurement is forwarded to the L3 filter, if the anticipated L1 RRM measurement is skipped due to prioritization of PDCCH/PDSCH decoding in an SMTC window. This would essentially mean that no spec changes are needed for the L3 RRM filtering mechanism in the RRC specifications.  ***Proposal 18:*** *If a L1 RRM measurement in a measurement gap or SMTC window is skipped due to prioritization of PDCCH/PDSCH, the latest L1 RRM measurement is forwarded to the L3 filter at RRC.* |
| Qualcomm | **Issue: XR Traffic Interruption by MG**  ***Observation 8: In R15/16/17 MG operation, all configured MGs are always activated with a higher priority than PDSCH and PUSCH except Msg2/3/4/A/B, which may cause a frequent XR traffic interruption and highly degrade the user experience.***  Diagram  Description automatically generated  Figure 15 XR DL traffic interrupted by measurement gaps  ***Observation 9: When CDRX is configured with MG, UE may enter the inactivity state during MG, and the remained packets should be buffered and delivered when the next DRX on-duration cycle starts.***  Diagram  Description automatically generated with low confidence  Figure 16 DRX inactivity state during measurement gaps due to DRX inactivity timer expiration  A picture containing timeline  Description automatically generated  Figure 17 DRX inactivity state during measurement gaps due to DRX on-duration timer expiration  As stated above, the MG can cause a frequent and significant increasing of packet delay in XR and CG applications, so it should be handled carefully along with CDRX operation. We believe that this MG problem can be resolved by handling the priority of data packets or dynamically activating/deactivating the MG occasions from gNB. Therefore, MG enhancement needs to be discussed in R18.  ***Proposal 15: For XR traffic, MG should be enhanced by handling the priority of data packets or dynamically activating/deactivating the MG occasions from gNB.*** |
| Ericsson | First, we would like to pay attention to the fact that the measurement procedures to be done by UE are defined in 38.133 which is handled by RAN4. So, any possible change or potential enhancement of RAN4 specification should be coordinated with RAN4 group.  Secondly, the measurement gap is not necessary to be configured and its usage strongly depends on scenario. For example, if UE is supposed to measure only NR cells in FR1 with central frequency aligned with serving cell and having same SCS and BWP, UE can do measurements without gaps. This is the case if we refer to system simulation parameters for FR1 defined in 38.838 in Annex A.1 and A.4 - measurement gaps are not required in that scenario. Having said that, RAN1 should agree on whether MG are needed or not for most probable use cases. If MG are needed, enhancements may have to be discussed in RAN2 and RAN4 as well.   1. To study potential improvements in XR capacity based on measurement gaps, the scenarios where a measurement gap is needed should be considered for the study and RAN2 and RAN4 involvements in the study should be accommodated. |

### 4.4.1 Initial discussion

**High level proposals based on input contributions:**

* **Proposal 4-4-1: Support enhancements on RRM to relax scheduling restcition during MG**
  + **Proposal (Nokia):** The UE-to-gNB signaling to make the gNB scheduler aware of when s-MeasureConfig induced scheduling restrictions apply could be realized with higher-layer signaling such MAC CE or RRC signaling. RAN2 shall be asked for further guidance.
  + **Proposal (Nokia):** For UEs configured with inter-frequency measurement gaps, solutions where the gNB can signal the UE to skip a measurement gap (to avoid scheduling restrictions) shall be captured in the TR. The gNB-2-UE signaling for this may be realized via a compact DCI format to have fast signaling
  + **Proposal (MTK):** Support a more dynamic DCI/MAC-CE based MG activation/deactivation or MG setting (including duration and period) change for XR capacity enhancement**.**
  + **Proposal (QC):** MG should be enhanced by handling the priority of data packets or dynamically activating/deactivating the MG occasions from gNB.

**Moderator’s observation and suggestions for discussions:**

* Enhancements of scheduling restriction due to RRM is proposed by Nokia/NSB and MTK and Qualcomm.The proponents provided extensive analysis and performance evaluation results.
* Two companies (Futurewei and Ericsson) have raised concern on the applicability of scenarios and impact on other WGs.
* Moderator suggests using the initial discuss to address the concern raised by opponents.

**Moderator’s suggestion for initial discussions:**

* **Q1:** What is your view on necessity/benefit of the proposed enhancements under **Proposal 4-4-1** for **scheduling restrictions based on RRM**? Please note that based on your feedbacks, the proposals can be updated with more details for the next round of the discussions.
* **Q2:** Discuss your view regarding the proposed enhancements and whether they should be captured in TR 38.835. If yes, feel free to provide suggestions on corresponding TPs.
* **Q3:** Discuss any clarification/correction/comment/question helping the discussion and needed decisions.

**Note: For discussions, please ensure the information provided in companies contributions are taken into account.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **Samsung** | Q1-Q2: We are supportive to discuss the applicable scenarios. Once that is concluded, it should be clear whether the proposal for scheduling restrictions based on RRM (or probably the reverse – i.e. skip RRM) is beneficial to support. |
| **Futurewei** | Q1: it is intuitively understandable that with measurement gap the system performance degrades for any traffic including XR traffic and reusing some of the resource configured for MG can potentially bring back some of the performance loss. Note that dynamic indication may not always work for example when the XR data arrives during the MG. In addition, questions like the proper configuration of the MG, applicable scenarios, and the impact to RRM measurement need to be answered and RAN2 and RAN4 may need to get involved.  Q2: In general, we think companies’ effort should be respected and captured when evaluations were performed according to the agreed simulation assumptions and the agreed common principles. It is better to have a consistent manner on whether/how to capture results with proper observation and conclusion than discussing each individual proposal/result separately. |
| **CATT** | Q1: This is more implementation issue than standard issue since the measurement gap and the XR resource allocations are controlled by the gNB.  Q2: All results should be capatured. |
| **MTK** | Q1: The simulation results from MTK/Nokia show evident capacity gain with MG/SMTC scheduling enhancement. QC also provides very nicely drawn figure to explain the issue. To us, this issue is worthy of an enhancement in the WI phase, since **this issue is XR-specific**, and the **capacity gain is evident**. As 5G NR is a mobile network, MG is always necessary under some mobility scenarios. Moreover, Nokia mentions SMTC scheduling restriction due to beam management which would also have strong impact on capacity for FR2. **If we want to support XR with mobile user or FR2 user, an enhancement to scheduling availability for MG/SMTC seems helpful.**   * As for RAN2/RAN4 involvement, if RAN1 agrees on direction, it can be further discussed in RAN plenary when devising the WI description.   Q2: The restuls can be captured with evaluation assumptions clear explained in the TR. |
| **ZTE, Sanechips** | We are open to Proposal 4-4-1. |
| **LG** | **Q1:** Fine to discuss in general. However, the trade-off should be identified and need to be answered by other WGs. For example, a contribution proposed that the trade-off is hand-over failure. Cosidering those performance degradation, RAN2 should be involded at least. Otherwise, it would be necessary to leave the issue to RAN2. |
| **vivo** | Q1: We support to study the enhancements on RRM to relax scheduling restcition during MG. In our opinion, it is beneficial for both network capacity performance and UE power saving by dynamically skipping MG of UE.  Q2: We think the proposed enhancements with evaluation results, especially those showing potential performance gain, can be captured in the TR. Necessary clarification if any can be included. Whether and how to draw observation and conclusion based on the captured techiques and evaluation results can be discussed separately. |
| **Ericsson** | Q1: In this case, showing capacity gain when one can use 6ms for scheduling is evident.  However, as we mentione din our contributions, we have two main concerns: the applicability of the scenarios, and impact on other WGs.  We appreciate if propoents provide feedback. |
| **Lenovo** | It can be discussed how often such events/measurement occur in typical situations, and whether XR data transmission is important or e.g., inter-frequency measurement (e.g., for cell-edge UEs) also whether communication is restricted in all symbols or e.g., just within SSB symbols and 1 symbol before and after consecutive SSB symbols. RAN4 should be involved. |
| **Nokia, NSB** | We support Proposal 4-4-1. The benefit of having such enhancements is presented in our tdoc with performance results. Support that such enhancements are captured in the TR.  We propose to modify the proposal to capture FR2 related restrictions:   * **Proposal 4-4-1: Support enhancements on RRM to relax scheduling restcition for intra-frequency RRM without MGs and for inter-frequency RRM with MGs**   Q2: Yes, we support capturing the results and related observations to TR 38.835 |
| **Qualcomm** | We are supportive of studying this. |

# 5 Others

Few enhancement topics were down-prioritized last meeting; however, companies proposed those enhancements at this meeting.

* SPS enhancements
* Intra-UE/Inter-UE prioritization.

Moderator have not treated those proposals. If proponents have concern, please use this section to share your view.

### Initial discussions

Please share your views on the proposals that you prefer to be discussed. Please also use this section to share your view on any issue that needs to be discussed.

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| Company | Comments |
| **ZTE, Sanechips** | **We prefer to discuss section 2.1.1 and section 3.1.1 firstly, which are the critical issues and have the widest interests and evaluation results. And of course it is the right way to provide some proposals for section 2.1.1 after collection of views of the 1st round.** |
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# Conclusion

TBD

# References

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| --- | --- | --- | --- |
| 1 | [**R1-2208377**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208377.zip) | XR Capacity Evaluation and Enhancements | FUTUREWEI |
| 2 | [**R1-2208402**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208402.zip) | Discussion on capacity enhancements for XR | Ericsson |
| 3 | [**R1-2208421**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208421.zip) | Discussion on XR-specific capacity enhancements techniques | Huawei, HiSilicon |
| 4 | [**R1-2208661**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208661.zip) | Discussion on XR specific capacity enhancements | vivo |
| 5 | [**R1-2208782**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208782.zip) | Discussion on XR specific capacity enhancement for NR | China Telecom |
| 6 | [**R1-2208863**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208863.zip) | Discussion on XR specific capacity enhancements techniques | OPPO |
| 7 | [**R1-2208953**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208953.zip) | NR enhancement for XR capacity improvement | CATT |
| 8 | [**R1-2209000**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209000.zip) | XR-specific capacity enhancements techniques | TCL Communication Ltd. |
| 9 | [**R1-2209070**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209070.zip) | Discussion on XR specific capacity enhancement techniques | Intel Corporation |
| 10 | [**R1-2209113**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209113.zip) | Considerations on XR-specific capacity enhancements | Sony |
| 11 | [**R1-2209129**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209129.zip) | XR-specific Capacity Enhancement Techniques | Lenovo |
| 12 | [**R1-2209156**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209156.zip) | Discussion on XR-specific capacity enhancements | NEC |
| 13 | [**R1-2209198**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209198.zip) | XR specific capacity enhancements | ZTE, Sanechips |
| 14 | [**R1-2209355**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209355.zip) | Discussion on XR-specific capacity enhancements techniques | CMCC |
| 15 | [**R1-2209388**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209388.zip) | Discussion on XR capacity enhancement techniques | Panasonic |
| 16 | [**R1-2209457**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209457.zip) | Discussion on XR-specific capacity enhancement techniques | LG Electronics |
| 17 | [**R1-2209518**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209518.zip) | On XR specific capacity improvement enhancements | MediaTek Inc. |
| 18 | [**R1-2209536**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209536.zip) | XR-specific capacity enhancements | Nokia, Nokia Shanghai Bell |
| 19 | [**R1-2209598**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209598.zip) | XR-specific capacity enhancements techniques | Apple |
| 20 | [**R1-2209620**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209620.zip) | Discussion on XR-specific capacity improvements | Rakuten Symphony |
| 21 | [**R1-2209642**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209642.zip) | On XR-specific capacity enhancements techniques | Google Inc. |
| 22 | [**R1-2209658**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209658.zip) | Discussion on XR-specific capacity enhancements techniques | InterDigital, Inc. |
| 23 | [**R1-2209749**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209749.zip) | Considerations on Capacity Improvements for XR | Samsung |
| 24 | [**R1-2209920**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209920.zip) | Discussion on XR specific capacity improvement enhancements | NTT DOCOMO, INC. |
| 25 | [**R1-2210003**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210003.zip) | Capacity enhancement techniques for XR | Qualcomm Incorporated |