3GPP TSG-RAN WG1 Meeting #110 R1- 2207821

Toulouse, France, August 22nd – 26th, 2022

Agenda Item: 9.11.2

Source: Moderator (Ericsson)

Title: Moderator Summary#2 – Study on XR Specific Capacity Improvements

Document for: Discussion, Decision

# 1 Introduction

This document provides a summary of the contributions submitted to RAN1#110 under Agenda item 9.11.2 regarding the study of candidate enhancement techniques for XR capacity improvements, together with an overview and high level key questions to facilitate the initial discussions.

The following tabke, shows an overview of the discussed topics in the contributions. We observe that:

* the most discussed topics are SPS/CG and dynamic scheudling enhancments.
* limited number of contributions provide capacity performance evaluations
* no convergence in views in any study area

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Candidate enhancement technique | #  Companies with views | #  Supportive companies | #  Non-supportive companies | #  Companies with evaluation |
| A | SPS and CG enhancements | 27 | 20 (SPS) - 22 (CG) | 7(SPS) – 5(CG) | 6 |
| A1 | Multiple PDSCHs occasions per SPS period | 24 | 17 | 8 |  |
| A2 | Multiple PUSCHs occasions per CG period | 23 | 16 | 7 |  |
| A3 | Dynamic adaptation of SPS/CG | 23 | 16 | 7 |  |
| A4 | Non-integer periodicity of SPS/CG | 22 | 16 | 6 |  |
| B | Dynamic scheduling/grant enhancements | 20 | 18 | 2 | 7 |
| B1-1 | Extension of multi-slot PxSCHs scheduling from FR2-2 to FR1/FR2 | 8 | 6 | 2 | 3 |
| B1-2 | HARQ-ACK/CBG enh. for multi-slot PDSCHs scheduling | 11 | 9 | 2 | 3 |
| B1-3 | Enhanced flexibility of multi-slot PxSCHs scheduling | 14 | 10 | 4 | 5 |
| B2 | SR and/or BSR enhancement | 11 | 8 (BSR)-3 (SR) | 1(BSR)-2(SR) | 6 |
| C1 | Delta MCS/Soft HARQ-ACK feedback | 8 | 3 | 5 | 1 |
| C2 | Cooperative MIMO via precoding | 3 | 1 | 2 | 1 |
| C3 | Enhanced CQI based CBG | 4 | 1 | 3 | 1 |
| C4 | CQI report for different BLER and XR flows | 4 | 2 | 2 | 0 |
| C5 | Measurement gap enhancements | 5 | 2 | 3 | 2 |
| C6 | Intra/Inter-UE multiplexing enhancements | 5 | 2 | 3 | 0 |

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

|  |
| --- |
| **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. |

In the following sections, high level summary of companies’ preferences with respect to different enhancement areas are provided. 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 ccapacity performance gain is necessary condition for supporting the enhancements**

The aim is to improve the common understanding and identify the best direction that helps assessment of the candidate enhancement techniques and provide valuable input for the technical report.

This document is a revision of R1-2207820.

# 2 SPS and CG enhancements

The following agreement was made in RAN1#109-e.

|  |
| --- |
| **Agreement**  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* |

The views regarding SPS/CG enhancements for serving XR traffic as summarized below:

**Status of inputs in the contributions:**

* **Companies with view (27):** Futurewei, TCL, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Sony, Nokia/NSB, OPPO, CATT, NEC, Lenovo, Intel, China Telecom, Samsung, CMCC, ETRI, Google, LG, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, Rakuten, Apple, DCM
  + **Supportive of enhancing SPS (20):** TCL, Sony, Nokia/NSB, OPPO, CATT, NEC, Lenovo, Intel, China Telecom, CMCC, ETRI, Google, LG, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, Apple, DCM
  + **Not supportive of enhancing SPS (7):** Futurewei, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Samsung, Rakuten
  + **Supportive of enhancing CG (22):** TCL, Huawei/HiSilicon, vivo Sony, Nokia/NSB, OPPO, CATT, NEC, Lenovo, Intel, China Telecom, CMCC, ETRI, Google, LG, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, Apple, DCM
  + **Not supportive of enhancing CG (5):** Futurewei, Ericsson, Spreadtrum, Samsung, Rakuten
* **Capacity performance results (6): Available (Ericsson, vivo, CATT, ZTE/Sanechips, InterDigital, DCM)**

## 2.0 General discussion on SPS/CG enhancements

**Moderator’s observation and suggestion for initial discussion:**

Similar to the last meeting, this study area is the most popular and controversial study area. As the status shows, there is no convergence on the views. Most importantly, most of the inputs are not supported by capacity performance evaluations results.

In relation to the assessment principle, companies’ views can be summarized as the following:

**Q1: What are XR-specific issue(s) addressed by the enhancements?**

Companies supportive of SPS/CG enhancements consider mainly the following as issues:

* Control (DCI) overhead, large and variable size packets, jitter of packet arrival time, non-integer periodicity, scheduling delay in UL due to SR

**Q2: Whether the enhancement is necessary to address the issues(s)?**

Companies supportive of enhanced SPS/CG, find the enhancements necessary for at least the following reasons:

* CG/SPS is suitable for XR traffic being quasi-periodic
* DCI overhead is addressed by CG/SPS
* CG/SPS flexibility is improved by proposed enhancements
* CG reduces delay in uplink
* Enhanced CG/SPS reduces UE power consumptions
* …

Companies non-supportive of enhanced SPS/CG, find the enhancements are not necessary for at least the following reasons:

* CG/SPS is suitable for small size packets with predictable size and periodic arrival without jitter
* DCI overhead is not a source for improving XR capacity to be addressed by CG/SPS (referenced e.g., to Rel-17 SI)
* Dynamic scheduling provides flexibility and is superior to (enhanced) CG/SPS.
* eSPS increases UE power consumption due to blind detection
* With XR awareness and enhanced BSR, dynamic scheduling works best for XR.
* Pre-scheduling/pro-active scheduling avoid the SR delay with XR awareness and enhanced BSR.
* …

**Q3: Whether/how the enhancements benefit/performance capacity gain are provided?**

Few companies have provided capacity performance evaluation results:

* E///, vivo, CATT, ZTE/Sanechips, InterDigital, DCM

Regarding baseline:

* All companies assumed dynamic scheduling (DG) as baseline where the capacity performance of legacy CG/SPS based schemes are additionally provided.

Moderator observed that among these companies, assumptions on at least baseline dynamic scheduling differs. For example:

* Some companies assume that actual data transmission is initiated after transmission of SR and BSR. Therefore, dynamic scheduling experiences the delay due to SR and initial BSR.
* Some companies assume that actual data transmission is initiated after transmission of SR, together with BSR. Therefore, dynamic scheduling experiences delay due to SR.

**Therefore, it is important to discuss the simulation assumptions together with results to conduct a proper assessment**.

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

**It is recommended to conduct a discussion based on the key questions above discuss.**

### 2.0.0 Intital Discussion

The key questions above were discussed during the first offline session.

Companies provided the following additional views:

* On the DCI overhead and relation to study in Rel-17, views were different. In support of the enhancements, companies expressed that only/mostly DG was studied and there was no conclusion stating the CG/SPS was not useful. It was also discussed by the opponents of the enhancements that the studied showed DCI overhead it not a bottleneck.
* In support of the enhancements, the view was expressed that when XR traffic arrives outside DRX active time (e.g due to jitter) where the UE does not monitor PDCCH and hence, traffic cant be served by DG based schemes. Even at the presence of XR awareness.
* Long term variations can be handled by SPS/CG based transmissions, and short term variations by DG based transmissions.
* In support of CG enhanacement, it was stated that LCH for CG mapping is more straightforward as compared to DG on relation to BSR.
* Regarding assessment of the proposed techniques:
  + On power saving Always on/C-DRX as baseline: it was proposed to consider both Always on and power saving on (c-DRX) as baseline and consider both power saving and capacity gain. Other companies disagreed and stated that power saving gain should be addressed speparately (under power saving agenda). In this study, the focus should be on capacity enhancements. Moderator also commented that this aspect was discussed last meeting and it was agreed that capacity performance gain is a necessity. Other aspects can be also studied including power saving aspects to provide more complete assessment. However, it should be understood that it was not agreed as part of baseline.
  + On MU-MIMO as baseline, a company had a view that MU-MIMO should be considered as baseline. Simialry to previous topic, the view was not shared by other companies.
* Separate CG and SPS w.r.t enhancements:
  + It was emphaisez to decouple CG and SPS regarding enhancements since there are companies that are in favor of CG enhancements, but not SPS enhancements.

**Moderator’s comment:**

It is clear that views are split regarding Q1 and Q2, and even on evalautions. Moderator recommends for the follow-up discussion, focus the discussion on performance evaluation results provided by companies. There are two mainobservations:

* For simulation results, companies have used DG as the baseline as it was encouraged based on the agreement last meeting.
* For uplink, the assumption on delay is different, that impacts the baseline (to include SR delay meaning that the UL grant for data arrives after SR where UE includes both BSR and data, or to include both SR+BSR delay meaning that the UL grant for data arrives after BSR). Since the amount of perdormance gain depends on the performance by baseline scheme, for eventual comparison and assessment it is important to clarify this aspects

Therefore, moderator recommends the following discussion points:

#### Proposal 2-0-1:

When DG is used as the baseline scheme to study CG enhancements to improve XR capacity performance, for the performance evaluation scheduling, there are two assumptions regarding the UL grant after SR is triggered as Alt 1 and Al 2 (listed below). Discuss to use a common assumption.

* Alt 1: After SR is triggered, both BSR and UL data are transmitted using the UL grant after SR.
* Alt 2: After SR is triggered, only BSR is transmissited using the UL grant after SR.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| ZTE (comment onR1-2207820) | We can align with basic assumption that DG endures SR and BSR delay according to legacy specifications. And enhanced scheduler can be considered to reduce the delay caused by SR in terms of awareness of periodic traffic.  As to section 2 in the summary, I noted there’s no other proposal for “the most polular and controversial issues”, we think it makes more sense to move forward on treating the key issues as you highlighted. |
| MTK | We think Alt 2 is more reasonable. |
| LG | Even if SR resource can be linked with logical channel of each data flow, it is difficult to assume that buffer status can be correctly estimated by gNB. We think Alt. 2 is safer assumption, especially when SR enhancement is not considered. |
| Qualcomm | We believe Alt 1 is a better choice since it has the lowest delay for DG UL (i.e., the best existing single grant UL DG solution in terms of delay) and having this would add a good benchmark for any feature. |

Summary of performance evaluation results related to SPS/CG enhancements

|  |
| --- |
| **Ericsson** |
| * **Genie scheduling based dynamic (Genie DG):**   + The scheduling is based on dynamic grants where it is assumed accurate BSR with zero delay is available at the scheduler to be used for indicating proper UL grant to the UE. This case is considered to show the upper bound. * **Normal scheduling-based dynamic grant (Normal DG):**   + The scheduling is based on dynamic grants where it is assumed an SR is triggered upon arrival of a new ADU in the UE buffer. A UL resource is granted then to the UE and the follow up UL grants are updated based on corresponding BSR. This case is considered as baseline. * **Pre-scheduling based dynamic grant (Pre-scheduling DG):**   + An initial grant for a TBS with e.g., minimum size of ADU of 100 kbits, is scheduled and periodically (every 5ms here) is updated assuming the XR periodicity and arrivals related information is known according to XR awareness (i.e., without relying on SR). * **Normal scheduling based configured grant (Normal CG):**   + Configured grant with 60 kbits TBS every 5 ms, or 100 kbits TBS every 2.5 ms for 30 ms and 15ms PDB, respectively, are used. To ensure the CG scheme is simulated with bigger sized and more frequent occasions for 15 ms PDB requirement.   Chart  Description automatically generated  Figure 1. Fraction of satisfied users, using the XR capacity KPI with target of 99% packet success rate for  Table 2 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 | 4.41% | 5.02 | 96% | | Normal DG | 6.80 | 0% | 2.56 | 0% | | Pre-scheduling DG | 6.80 | 0% | 4.50 | 76% | | Normal CG | 6.35 | -6.62% | 1.61 | -39% | |
| **Vivo** |
| In the simulation, the conditions for switching to dynamic scheduling are assumed as following:   * The reserved SPS resources are determined based on the mean packet size. If the allocated SPS resources are not enough to accommodate all data of a packet, dynamic scheduling will be performed to schedule the remaining data of the packet. * When a packet arrives at a gNB, if there is no corresponding SPS resource within 4ms after the packet arrival time, the gNB will immediately carry out dynamic scheduling to ensure UE experience and the unused SPS resources before the arrival time of a next packet will also be released for dynamic scheduling. For example, in the case of SCS=30KHz where 8 slots are equal to 4ms, if the packet arrives at the gNB in slot n and no SPS resource is available in the following 8 slots (i.e., from slot n to slot n+7), the gNB will allocate resources for the packet via dynamic scheduling from slot n based on available resources. * SPS is only used for new transmission, retransmission will be scheduled by dynamic scheduling.  |  |  | | --- | --- | |  |  | | (a) System Capacity | (b) SPS PDSCH proportion |   Figure 1. Comparison of capacity performance between dynamic scheduling and SPS  In Figure 2, two cases are evaluated, where UL pose/control packets are conveyed by CG and DG PUSCH, respectively. The simulation assumptions are summarized in Appendix A. For CG PUSCH transmission, a periodicity of 5ms is assumed to better align with the assumed TDD pattern. For DG PUSCH transmission, a BSR delay of 5ms is assumed, where the modelling of BSR delay is described in Appendix B.  Figure 2. System capacity for pose/control stream of UL AR/VR/CG (FR1, Indoor Hotspot scenario) |
| **CATT** |
| Table 3: 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 / #UEs per cell** | **% of satisfied UEs** | **Capacity performance gain** | **PSG** | | DG scheduling with C-DRX(16,12,4) (Baseline) | 10.9 /12 | 90.97% | 0.0% | 0.0% | | Multiple SPS configurations | 0 /12 | 0% | - | 46.1% | | SPS enhancement | 10.8 / 12 | 90% | -0.9% | 9.9% | | SPS enhancement with Go-To-Sleep | 10.6 / 12 | 88.3% | -2.7% | 38.1% |   Table 4: 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% | 0.0% | 0.0% | | SPS enhancement | 10.8 | 90% | -6.1% | 12.6% | | SPS enhancement with Go-To-Sleep | 10.6 | 88.3% | -7.8% | 39.9% |   Table 5: 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% | 0.0% | | Single CG configuration | 0 | - | - | | CG enhancement | 5.9 | 98.3% | -1.7% | |
| **ZTE/Sanechips** |
| **Evaluation results for CG enhancement**  * + Case 1: legacy CG configuration   CG baseline假设  Figure 5 Legacy CG configuration example  In Figure 5, orthogonal CG configurations are configured among different UEs in one cell. Moreover, no adaptive parameter adjustment is introduced, implying fixed MCS level and the number of layers are adopted and the unused resource release is not used in CG configurations.   * + Case 2: uplink dynamic grant   DG仿真假设  Figure 6 Dynamic grant with Tx delay consideration  In Figure 6, we assume that each packet would encounter the SR-BSR-PUSCH procedure. Wherein, Delay1 is the gap between packet arrival and SR reporting, which is relevant to TDD pattern. And Delay2 is the gap between SR reporting and BSR signaling, which is also relevant to TDD pattern. Last but not least, Delay3 is the gap between BSR signaling and PUSCH, which is relevant to TDD pattern and the gNB scheduling capability.  In our simulation, the delay introduced by SR-BSR-PUSCH procedure is 5ms, and 7.5ms considering the data arrival time and TDD pattern. It implies that UE will undergo 5ms or 7.5ms Tx delay. Moreover, if we further consider the scheduling delay from gNB’s side, the transmission delay is likely to increase, resulting in a greater descend in capacity performance.   * + Case 3: multiple CG PUSCHs configuration with adaptive parameter adjustment (labeled ‘MCG’ in figure)   CG enhancement假设  Figure 7 multiple CG PUSCHs configuration with adaptive parameter adjustment example  According to Figure 7, the applied enhancements include:   1. Overlapped resources are supported to be configured among different UEs 2. Quick deactivation among multiple CG PUSCHs to release the unused resource. 3. Update signaling is used for updating the parameters such as MCS level and the number of layers per CG PUSCHs group. 4. Indoor HotSpot  |  |  | | --- | --- | |  |  | | 1. Traffic Model 1 | (b) Traffic Model 3 |   Figure 8 Capacity performance comparison for Case 1, Case 2 and Case 3 for Traffic Model 1 and Traffic Model 3 in Indoor HotSpot Scenario |
| **IntelDigital** |
| The baseline schemes used in the evaluations are:   * DG with PF scheduling   + Single PDCCH schedules 1 PDSCH   + Overhead: 2 PDCCH symbols per PDSCH * SPS   + Configured with 1 PDSCH per SPS occasion   + Periodicity: 10ms   The enhancement resource allocation schemes evaluated in the simulations are:   * Enhanced SPS   + Configured with 2 PDSCHs per SPS occasion   + Periodicity: 10ms * 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   + Single PDCCH schedules up to 4 PDSCHs   + Overhead: 4 PDCCH symbols for 4 PDSCHs   Chart, bar chart  Description automatically generated  **Figure 4:** FR1 DL CG results for Dense Urban scenario at data rate of 30 Mbp |
| **NTT DOCOMO** |
| Four schemes are evaluated for comparison:   * Baseline dynamic PUSCH scheduling (Baseline DG) * Baseline configured grant PUSCH (Baseline CG) * Enhanced CG scheme #1 with MCS update: MCS index for the CG configuration can be updated after a certain time duration (e.g. every 0.1ms) * Enhanced CG scheme #2 with MCS update + CG periodicity update + TDRA/FDRA update: CG periodicity can be adjusted to better align with the CG occasion and XR traffic arrival; MCS can be updated after a certain time duration (e.g. every 0.1ms) to adapt to the channel condition; TDRA/FDRA can be updated to adapt to the varying packet size (e.g. I-frame or P-frame)   Table 2: XR capability performance   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | Baseline DG | Baseline CG | Enhanced CG scheme #1 | Enhanced CG scheme #2 | | XR capacity | 1 | 1.49 | 2.45 | 2.69 |   According to the simulation results in Table 2, we have following observations.   1. Baseline CG outperforms baseline DG with about 49% gain. The reason comes from two aspects. On one hand, latency can be largely reduced for CG than DG. For DG case, when UE needs to transmit UL data, UE needs to wait for “UL” slot to send SR, then wait for DL slot for UL grant DCI reception, then wait for UL slot to transmit PUSCH. The latency would be large for a TDD pattern with DDDSU. While for the case of CG PUSCH, SR and UL grant DCI are not needed. On the other hand, eMBB users in the system have larger impact for dynamic scheduling case, since they need to compete for resources (e.g. about 90% resource occupied by XR users, 10% resource occupied by eMBB users). For configured grant case, 90% resources are configured/reserved for XR users, and remaining 10% resources for eMBB users. 2. Enhanced CG scheme #1 with MCS update outperforms baseline CG scheme with 64.42% gain. This is because MCS parameter update can provide more timely MCS scheme for the varying channel condition. 3. Enhanced CG scheme #2 with MCS update + CG periodicity update + TDRA/FDRA update outperforms enhanced CG scheme #1 with only MCS update with 9.8% gain. Update of CG periodicity and TDRA/FDRA can further improve XR capacity performance. |

|  |  |
| --- | --- |
| **Company** | **Proposal and Observations** |
| Nokia/NSB | **Proposal 1**: For making SPS applicable for XR use cases, the following candidate enhancements may be further studied for enhanced SPS (eSPS): (i) include broader set of periodicities that match XR fps settings, (ii) support for more than one transport block transmission per SPS periodicity, and (iii) options for dynamic change of an existing SPS configuration. Other SPS enhancements may also be considered.  **Proposal 2**: Potential eSPS standardization shall be justified by performance gains as compared to dynamic scheduling, considering KPIs such as XR capacity benefits, savings in DCI signaling overhead and potential UE power savings. Reporting of other KPIs is not excluded.  **Proposal 3**: For making CG applicable for XR use cases, the following candidate enhancements may be further studied for enhanced CG (eCG): (i) include broader set of periodicities that match XR fps settings, (ii) support for more than one transport block transmission per CG periodicity, and (iii) options for dynamic change of an existing CG configuration. Other CG enhancements may also be considered.  **Proposal 4**: Potential eCG standardization shall be justified by performance gains as compared to dynamic scheduling, considering KPIs such as XR capacity benefits, savings in DCI signaling overhead and potential UE power savings. Reporting of other KPIs is not excluded. |
| 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.   **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.  **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.  **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.  **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].  **Proposal 5**: 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.  **Proposal 6**: 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.  **Proposal 7**: According to the analysis, the Enhancement scheme 1, i.e. the single SPS/CG 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.  **Proposal 8**: 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. |
| Ericsson | **Observation 1** DG is a suitable transmission scheme to deal with varying and large-sized application packets and possible jitter for DL video and UL scene XR traffic.  **Observation 2** CG is a suitable transmission scheme for predictable and fixed small-sized UL traffic, e.g., pose/control and BSRs triggered by UL scene XR traffic.  **Observation 3** Dynamicity of XR traffic with frequent/periodic occasions can be handled by existing gNB implementation using pre-scheduling based on dynamic allocation.  **Observation 4** The capacity performance of dynamic pre-scheduling with XR-awareness is the highest and the closest to the achievable bound.  **Observation 5** Necessity of supporting new features to enable dynamic adaptation of CG/SPS transmission is not justified.  **Observation 6** Usage of CG/SPS based transmission for XR video traffic is not motivated, and consequently, any potential enhancement to match the periodicity between XR video traffic and CG/SPS configurations seems to be unnecessary  **Proposal 1** To assess the necessity and benefits of the candidate enhancement techniques for improving capacity of XR video traffic, prioritize DG based enhancement techniques for XR video traffic.  **Proposal 2** To assess the necessity of the candidate CG/SPS enhancement techniques for improving capacity of XR video traffic, the CG/SPS based transmissions for XR video traffic should be compared to DG based transmissions for XR video traffic.  **Proposal 3** The necessity and benefit of the candidate enhancement techniques of DG and CG/SPS schemes for XR services should be assessed under the assumption of XR-awareness at RAN.  **Proposal 4** Deprioritize studying the enhancements based on dynamic adaptations for SPS/CG based transmissions.  **Proposal 5** Deprioritize studying the enhancements for matching the periodicity of CG/SPS resource allocations to XR traffic periodicity.  **Proposal 6** Do not pursue enhancements based on joint activation to enable multiple CGs/SPSs occasions in a period.  **Proposal 7** The enhancements based on multi-PxSCH allocation for a single CG/SPS can be considered to study if the corresponding capacity performance gains are provided and the specification effort is low. |
| Qualcomm | **Observation 1**: There is a time mismatch issue between periodic XR UL/DL traffic and R16/17 CG/SPS configuration. This will lead to XR capacity loss due to the packet delay caused by the timing difference between CG/SPS resources and actual XR traffic.  **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 1**: For XR UL/DL video data transmission, use a single activation DCI for the following cases based on the multi-PUSCH/PDSCH scheduling DCI   * Case 1: activate a single CG/SPS with multiple PUSCHs/PDSCHs on a CG/SPS occasion * Case 2: activate multiple CGs/SPSs with one PUSCH/PDSCH on an occasion of each CG/SPS   **Proposal 2**: Introduce the CG/SPS set switching mechanism to simultaneously activate one set of CGs/SPSs and deactivate another set of CGs/SPSs for adaptative CG/SPS configuration. Timer based switching can be introduced.  **Proposal 3**: Introduce the CG/SPS set skipping mechanism to temporarily deactivate a set of CGs/SPSs and reactivate it after a timer expires.  **Proposal 4**: For single SPS/CG with multiple PDSCHs/PUSCHs on a SPS/CG occasion, consider studying methods to skip, modify, or add extra PDSCHs/PUSCHs in an occasion.  **Proposal 5**: For XR, consider studying enhancement methods for combined SPS/CG and DG operation:   * Implicitly increased PDCCH/SR opportunities before and/or after the SPS/CG occasions * Implicitly increased PDCCH/SR opportunities in cancelled cycles of SPS/CG occasions * SPS/DG piggy-back control information to assist with possible future dynamic grants   **Proposal 6**: For XR, consider studying methods to dynamically adapt the SPS and CG parameters to the traffic bursts.  **Proposal 7**: For XR, consider studying methods to jointly handle multiple CG/SPS configurations on the same or on different CCs using the same message  **Proposal 8**: RAN1 should discuss a solution to address the time mismatch between R16/R17 CG/SPS configuration. The solution can be like those under consideration for a similar issue that exists for CDRX. |
| Futurewei | **Proposal 1**: For XR capacity improvement, the focus of the study should be on dynamic scheduling schemes.  **Proposal 2**: For enhancement for SPS/CG transmissions to improve XR capacity, focus study on enhancement for CG transmission for uplink. |
| ZTE/Sanechips | **Observation 1:** Given the advantage of reducing transmission latency, CG mechanism should be considered to be applied in XR traffic transmission.  **Observation 2:** Current CG mechanism is suitable for Pose/Control transmissions.  **Observation 3:** Multiple CG PUSCHs configuration with CG parameters adjustment, and releasing unused resources, can address the problem of low resource efficiency.  **Observation 4:** Multiple CG PUSCHs configuration with dynamic resource indication, can be considered to address the problem of inter-UE resource collision.  **Observation 5:** Non-integer periodicity alignment can be considered to address the problem of misalignment between non-integer periodicity of XR packet arrival and periodicity of CG PUSCH.  **Observation 6:** When considering the traffic model of 20Mbps@60fps or 10Mbps@60fps with 10ms PDB in Indoor HotSpot, the transmission scheme of multiple CG PUSCHs configuration with adaptive parameter adjustment is capable of supporting considerable amount of UEs compared to legacy CG transmission scheme or DG transmission scheme with Tx delay consideration.  **Observation 7:** When considering the traffic model of 20Mbps@60fps, 30ms in Dense Urban, multiple CG PUSCHs configuration with adaptive parameter adjustment transmission scheme is capable of supporting considerable amount of UEs compared with legacy CG transmission scheme, which is capable of bringing about 11%~14% capacity gain compared to DG transmission scheme with Tx delay consideration.  **Observation 8:** When considering the traffic model of 20Mbps@60fps, 10ms in Dense Urban, multiple CG PUSCHs configuration with adaptive parameter adjustment transmission scheme is capable of supporting considerable amount of UEs compared to legacy CG transmission scheme and DG transmission scheme with Tx delay consideration.  **Observation 9:** When considering the traffic model of 10Mbps@60fps, 10ms in Dense Urban, multiple CG PUSCHs configuration with adaptive parameter adjustment transmission scheme is capable of supporting considerable amount of UEs compared to legacy CG transmission scheme and DG transmission scheme with Tx delay consideration.  **Observation 10:** Multiple CG PUSCHs configuration with adaptive parameter adjustment can achieve similar slots occupation with DG schemes from time domain resource occupation perspective.  **Observation 11:** For large packet size service transmitting in the uplink transmission, most frequency domain resource would be occupied for both enhanced CG and DG solutions.  **Observation 12:** Configured grant transmission is capable of reducing the transmission delay compared with dynamic grant.  **Observation 13:** Multiple CG PUSCHs configuration transmission with adaptive parameter adjustment is capable of reducing the the number of error packets.  **Observation 14:** Given the advantages of reducing overhead of downlink control signaling and transmission latency, SPS mechanism can be considered and applied in XR traffic.  **Observation 15:** When considering the traffic model of 45Mbps@60fps, 10ms or 60Mbps@60fps, 10ms in Indoor Hotspot, multiple SPS PDSCHs configuration with adaptive parameter adjustment transmission scheme is capable of supporting considerable amount of UEs compared to legacy CG transmission scheme.  **Proposal 1:** Compared with legacy CG transmission scheme, CG enhancement technique, including e.g., multiple CG PUSCHs configuration with adaptive parameter adjustment, can be considered to improve capacity for XR service.  **Proposal 2:** Compared with DG transmission scheme, CG enhancement technique, including e.g., multiple CG PUSCHs configuration with adaptive parameter adjustment, can be considered to improve capacity for XR service.  **Proposal 3**: Compared with legacy SPS transmission scheme, SPS enhancement techniques, including e.g., multiple SPS PDSCHs configuration with adaptive parameter adjustment, can be considered to improve capacity for XR service.  **Proposal 4:** Compared to legacy SPS transmission, SPS enhancement technique, including e.g., multiple SPS PDSCHs configuration with adaptive parameter adjustment, can be considered to reduce power consumption for XR service. |
| InterDigital | **Observation 1**: Achieving high system capacity in UL and DL when supporting XR traffic in different deployment scenarios (e.g. InH, DU) is extremely challenging  **Observation 2**: PDU sets generated at each periodic occasion can consist of variable number of PDUs or payload sizes per PDU set. Multiple PDU sets may be transmitted in a data burst  **Observation 3**: Due to data processing and congestion in network the PDU set transmissions in DL are impacted by intra-PDU set jitter and inter-PDU set jitter  **Observation 4**: Due to application processing and handling of different types of video frame the presence of inter-PDU set jitter in UL is non-negligible  **Observation 6**: SPS reduces the scheduling overhead when compared to dynamic scheduling/DG. However, without any enhancements, the stringent requirements for XR traffic (high data rate: 30/45 Mbps, low latency: 10/15 Mbps) result in low overall system capacity for SPS.  **Observation 7**: Enhanced SPS (e.g. multiple PDSCHs per occasion) achieves an improvement in overall capacity compared to baseline SPS, making the transmission scheme more adapted to XR traffic pattern.  **Proposal 1**: Support configuring multiple PDSCHs/PUSCHs per SPS/CG occasion  **Proposal 2**: Support adaptation (e.g. via DCI) for increasing/decreasing the number of PDSCHs/PUSCHs per SPS/CG occasion  **Proposal 3**: Support UE requesting adaptation to the number of PUSCHs per CG occasion  **Proposal 4**: Study single DCI for dynamically adapting the number of PDSCHs/PUSCHs for multiple SPS/CG occasions  **Proposal 5**: Support adaptation (e.g. via DCI) for time shifting the resources in a SPS/CG occasion (e.g. advancing or delaying) by an offset time value  **Proposal 6**: Study single DCI for dynamically time shifting the resources for multiple SPS/CG occasions  **Proposal 7**: Study mechanism for triggering DG request (e.g. SR) when the UE is with configured CG resources based on certain conditions (e.g. when CG resources are unable to accommodate changes to XR traffic pattern)  **Proposal 8**: Support UE requesting dynamic adaptation to SPS parameters (e.g. number of PDSCHs per occasion) for receiving DL traffic  **Proposal 9**: Support multiple active CG configurations (e.g. with different set of parameters) for handling multiple flows with different traffic patterns  **Proposal 10**: Support dynamic activation/deactivation of multiple CG configurations (e.g. with single DCI)  **Proposal 11**: Support UE requesting dynamic activation of multiple preconfigured CG configurations |
| Sony | **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**: SPS enhancements are required to support XR services with the benefit to improve the capacity and minimize unnecessary UE power consumption.  **Proposal 1**: Consider Dynamic SPS/CG configuration to dynamically adjust the transmission in order to accommodate the XR traffic pattern.  **Proposal 2**: Pseudo-periodic SPS/CG configuration can be considered for XR traffic with non-integer period.  **Proposal 4**: A new SPS type configuration that is similar to CG type I configuration can be considered to support multi-flows in XR.  **Proposal 5**: Consider the UE to monitor a subset of configured SPS in a group of configured SPS to handle the jitter of XR traffic. |
| vivo | **Observation 1**: System capacity of dynamic scheduling is much larger than that of SPS.  **Observation 2**: It is beneficial to re-use legacy CG mechanism for conveying UL pose/control stream, as well as for BSR reporting for UL video traffic.  **Proposal 1**: SPS enhancement for XR should be de-prioritized in Rel-18 XR SI.  **Proposal 2**: 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.  **Proposal 3**: Study potential CG PUSCH enhancements for UL video traffic, e.g., non-integer CG periodicity, multiple transmission occasions within a CG period, and recycling of unused CG resources. |
| Huawei/HiSilicon | **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.  **Observation 1**: For XR DL transmission, the benefits of using SPS is not clear compared with dynamic scheduling.  **Observation 2**: For XR UL transmission, Configured Grant (CG) is beneficial because latency can be reduced due to no SR/BSR procedure.  **Observation 3**: For XR UL traffic, both CG and dynamic grant can be considered.  **Observation 4**: Regarding the XR traffic non-integer periodicity issue,   * For DL transmission, it can be solved by dynamic scheduling * For UL transmission, it can be solved by configuring multiple CG configurations   **Observation 5**: For DL transmission, jitter issue can be solved by dynamic scheduling.  **Observation 6**: There is no jitter issue for uplink in most cases.  **Observation 7**: The size of XR frames/slices varies in a wide range which does not suite scheduling based on a fixed radio resource size.  **Observation 8**: 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. |
| Lenovo | **Proposal 7**: Study SPS/CG enhancements to address XR traffic variable packet size and arrival time and quasi-synchronous communication of multiple flows. Enhancements may include:   * Enabling, within a SPS/CG period, multiple SPS/CG configurations having the same periodicity with SPS resources of different size and starting time * Joint activation of multiple SPS/CG configurations for an indicated duration to handle multiple traffics of different QoS requirements in a quasi-synchronous manner with reduced control signaling overhead   **Proposal 8**: Enhancements related to non-integer periodicity for SPS/CG transmissions could include configure multiple small periodicities for one SPS configuration to compose a longer periodicity cycle.  **Proposal 11**: Investigate CBG-based transmission for SPS PDSCH for XR. |
| Samsung | **Proposal 1**: Do not further consider SPS PDSCH/CG PUSCH enhancements for XR.  **Proposal 8**: A UE can be provided CG PUSCH configurations and activation of transmission based on some of the CG PUSCH configurations can be indicated by the network.  **Observation 1**: SPS PDSCH/CG PUSCH enhancements are not relevant to increasing XR capacity and schemes relying on multiple configurations, or on DCI-based adaptation of configurations, are detrimental to UE/network operation.  **Observation 2**: A network can maximize DL capacity gains for XR using traffic-aware scheduling and Rel-17 mechanisms. |
| Google | **Proposal 1**: Enhancement to SPS/CG should be justified for XR scheduling and should be evaluated against dynamic grant (DG) scheduling which should be considered as baseline.  **Proposal 2**: Support alignment between the SPS/CG periodicites and the XR traffic.  **Proposal 3**: Support Multiple PDSCH/PUSCH transmissions per SPS/CG cycle for XR service.  **Proposal 4**: Use DMRS scrambling to identify PDSCH transmissions in the different PDSCH occasions in the SPS cycle.  **Proposal 5**: Study the dynamic adaptation of the SPS parameters for the scheduling of DL XR traffic while considering the increased control overhead.  **Proposal 6**: Study the impact of the UE missing the reception of the dynamic adaptation of the SPS parameters for the scheduling of DL XR traffic.  **Proposal 7**: Study the support of joint activation of multiple CG configurations with a single DCI for UL AR traffic. |
| Intel | **Observation 1**: Due to jitter, XR packet arrival may not align with ON duration if C-DRX is configured. In such cases, SPS PDSCH occasions outside DRX active time can be leveraged for XR packet delivery.  **Observation 2**: Although SPS PDSCH may not outperform DG PDSCH in terms of capacity performance, but SPS enhancements for support of XR traffic can still be useful for the network when use of DG PDSCH may not be possible, such as when XR packet arrives outside DRX active time.  **Observation 3**: 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.  **Proposal 1**: RAN1 should investigate SPS configuration with multiple PDSCH occasions per period or single DCI based activation of multiple SPS PDSCH configurations.  **Proposal 4**: RAN1 should investigate single CG configuration with multiple PUSCH occasions per period or single DCI based activation of multiple CG configurations.  **Proposal 3**: For multi-stream traffic such as the two-stream traffic in UL, mix of CG (for pose/control) and DG (video) based transmission can be considered. Further discussion is needed whether any enhancements with respect to Rel-16 and 17 CG/DG prioritization and handling are needed. |
| TCL | **Observation 1**: XR services have the following characteristics.   * The non-integer periodicity * Jitter of packet arrival time * Lower latency * Large and varying packet size * Multiple flows   **Observation 2**：There is a gap between XR periodic DL traffic and CG/SPS configuration.  **Proposal 1**: Pre-defined a fixed transmission pattern of SPS/CG within an integer periodicity for XR can be considered.  **Proposal 2**: Additional PDCCH monitor occasions can be considered for XR during the range of jitter.  **Proposal 3**: Dynamic changing resource allocation of SPS and CG for XR can be considered. |
| LG | **Proposal 5**: At least for jitter handling with SPS/CG configuration, it is necessary to allocate multiple TOs in a periodicity with single SPS/CG configurations.  **Proposal 6**: 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.  **Proposal 7**: It can be considered to activate/release multiple SPS/CG and/or other semi-static configuration with least number of DCIs.  **Proposal 8**: It can be considered to define UE behaviour on interaction between SPS/CG configurations, in order to improve overall UE capacity.  **Proposal 9** : Support non-integer periodicities by modified equation determining SPS/CG occasions.   * FFS: How to add non-integer periodicities to current periodicity parameter. |
| China Telecom | **Proposal 1** Study the enhancement methods of DL SPS and UL CG. Support activation of multiple SPS or CG configurations.  **Proposal 2** Study an improved scheme for single DCI activating multiple different SPS/CG configurations. For example, multiple SPS/CG activated by the same DCI has different PUSCH capacities.  **Proposal 3** It is suggested to study the method of dynamically adjusting SPS and CG parameters. For example, UCI signal is sent to adjust the granted resource according to the flow.  **Proposal 4** In order to solve the problem of non-integer period, configuring multiple SPS/CG solutions should be the benchmark of other methods.  **Proposal 5** To solve the non-integer period problem, we recommend the following two schemes for further study:  **1.** Establishment of two distinct periodic values  **2.** Introduction of periodicity realignment mechanisms |
| Apple | **Proposal 3**-3: introduce the support of non-integer periodicity for SPS configurations/Configured grant configurations.  **Proposal 3**-4: study enhancement to CG-UCI to support indication of MCS and/or PRB adjustment. |
| CMCC | **Proposal 1**. 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 small payload size;  Alt 2: The indication is carried in SPS PDSCH.  **Proposal 2**. Multiple periodicities configuration for one SPS configuration can be considered for XR service, which the multiple periodicities are used in a round. |
| OPPO | **Proposal 2**: The following solutions to resolve the periodicity mismatch issue should be further studied:   * Option 1: Introduce non-integer values for CG/SPS periodicity and add ceiling operation in CG/SPS occasion calculation formula. * Option 2: Introduce the periodic CG/SPS pattern in which multiple non-consecutive PUSCH/PDSCH occasions can be configured in one period.   **Proposal 3**: SPS HARQ-ACK enhancement to reduce the HARQ-ACK overhead for jitter should be further studied.  **Proposal 4**: For SPS or configured grant transmission, the following solutions to adapt XR-specific packet size requirements should be further studied:   * Alt.1: Allocate multiple PDSCH/PUSCH transmission occasions in each period. * Alt.2: Multiple CG/SPS configurations are configured to UE, fast activate one or more of the multiple CG/SPS configurations.   **Proposal 5**: Adaptive resource allocation (i.e. MCS, TDRA or FDRA) for SPS transmission should be further studied.  **Proposal 6**: Early terminate the CG transmission should be further studied. |
| FGI | **Observations** regarding dynamic adaptation of SPS/CG parameters/configurations:   * In the current specifications, once a SPS/Type-2 CG configuration is activated, the NW cannot update the parameters configured by RRC, e.g., mcs-Table and periodicity, until the NW reconfigures the SPS/Type- 2CG configuration. This may limit the flexibility to use SPS/CG to deliver XR services. * In the current specifications, once a Type-1 CG configuration is configured, the NW cannot update all parameters, e.g., mcs-Table, periodicity, TDRA, FDRA and K1, of the Type-1 CG configuration until the NW reconfigures the Type-1 CG configuration. This may limit the flexibility to use Type-1 CG to deliver XR services.   **Proposals** regarding multiple PDSCHs SPS transmission occasions in a period:   * RAN1 to study using RRC (and DCI) to configure multiple SPS PDSCH transmission occasions in a period of an SPS configuration. * RAN1 to study how to avoid resource waste when multiple SPS PDSCH transmission occasions are configured in a period of an SPS configuration.   **Proposals** regarding multiple PUSCHs CG transmission occasions in a period:   * RAN1 to study using RRC (and DCI) to configure multiple CG PUSCH transmission occasions in a period of a CG configuration. * RAN1 to study how to avoid waste of resources when multiple CG PUSCH transmission occasions are configured in a period of a CG configuration.   **Proposals** regarding dynamic adaptation of SPS/CG parameters/configurations:   * RAN1 to study which parameters should be dynamically adapted for an SPS/a CG configuration. * RAN1 to study when/how parameters should be dynamically adapted for an SPS/a CG configuration, e.g., when a/some event(s) or criterion/criteria is/are satisfied. |
| NEC | **Proposal 1**: Study multi-PDSCH/PUSCH occasions per SPS/CG period for XR traffic with large and varying packet size and the mechanism to alleviate the jitter effect.  **Proposal 2**: Study CBG based retransmission for SPS PDSCH for XR traffic with large packet size.  **Proposal 3**: Study enhancement for the mismatch between the periodicity of SPS/CG configuration and the XR packet arrival time.  **Proposal 4**: Specify XR specific configured grant offset parameter such as kOffsetSymbols in Search Space Set configuration.  **Proposal 5**: ‘cg-nrofSlots’ may be reused to transmit different transport blocks if PUSCH repetition type is not set. |
| NTT DOCOMO | **Observation 1**: Dynamic SPS/CG periodicity adjustment may be helpful for handling mismatch of XR traffic arrival and SPS/CG periodicity.  **Observation 2**: Dynamic SPS/CG resource allocation adjustment may be helpful for handling variable packet size for XR.  **Observation 3**: Dynamic update of SPS/CG MCS/TCI state/spatial relation information may be helpful for UE movement for XR.  **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 1**: Study dynamic update of SPS/CG parameters for XR, e.g., periodicity, resource allocation, MCS, or TCI state/spatial relation.  **Proposal 2**: Study multiple SPS PDSCHs or CG PUSCHs in one SPS/CG periodicity for XR.  **Observation 5**: Dynamic update of CG parameters (e.g. MCS, periodicity, TDRA/FDRA) can improve XR capacity. |
| ETRI | **Proposal 1**: To efficiently serve XR traffics having non-integer periodicities, study allowing non-uniform SPS/CG periodicities for a single SPS/CG configuration.  **Proposal 2**: To efficiently handle XR traffic size and arrival timing uncertainty, study dynamic adaptation of SPS/CG resources/parameters, e.g., for SPS case a DCI dynamically indicating SPS resources/parameters.  **Proposal 3**: Study how to improve the HARQ operation for SPS transmissions outside the DRX active time. |
| Spreadtrum comm. | **Observation 1**. For UL pose/control traffic, CG-PUSCH can work well.  **Observation 2**. For the XR DL video traffic, dynamic scheduling is more proper comparing SPS PDSCH.  **Proposal 1**. For the XR DL video traffic, we do not recommend to enhance SPS PDSCH. |
| CEWiT | **Proposal 1**: Study solutions to support multi-PDSCH transmission using SPS.  **Proposal 2**: Study enhancements to support dynamic adaptation of SPS parameters.  **Proposal 3**: Study enhancements to support transmission of traffic with non-integer periodicity using SPS. |
| Rakuten | **Proposal 1**: Dynamic scheduling is prioritized for XR capacity improvements. |

## Multiple PDSCH transmission occasions in a SPS period

**Status of inputs in the contributions:**

* **Companies with view (24):** Futurewei, TCL, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Sony, Nokia/NSB, OPPO, CATT, NEC, Lenovo, Intel, China Telecom, Samsung, Google, LG, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, Rakuten, DCM
  + **Supporitve (17)**: TCL, Sony, Nokia/NSB, OPPO, NEC, Lenovo, Intel, China Telecom, Google, LG, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, DCM
  + **Not supportive (8):** Futurewei, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Samsung, Rakuten, CATT

**Moderator’s suggestion for discussion:**

Despite the large support for the enhancements, the capacity performance evaluation results to support the enhancements are few or absent. Regardless, Moderator suggests that it is more constructive if the initial discussions are focused on the key questions discussed in section 2.1, rather than the details of proposed enhancements.

### Place holder for discussion

TBD

## Multiple PUSCHs transmission occasions in a CG period

**Status of inputs in the contributions:**

* **Companies with view (23):** Futurewei, TCL, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Sony, Nokia/NSB, OPPO, CATT, NEC, Lenovo, Intel, China Telecom, Samsung, Google, LG, ZTE/Sanechips, FGI, Qualcomm, InterDigital, Rakuten, DCM
  + **Supportive (16)**: TCL, vivo, Sony, Nokia/NSB, OPPO, NEC, Lenovo, Intel, China Telecom, Google, LG, ZTE/Sanechips, FGI, Qualcomm, InterDigital, DCM
  + **Not supportive (7): [**Futurewei], Huawei/HiSilicon, Ericsson, Spreadtrum, Samsung, Rakuten, CATT

**Moderator’s suggestion for discussion:**

Despite the large support for the enhancements, the capacity performance evaluation results to support the enhancements are few or absent. Regardless, Moderator suggests that it is more constructive if the initial discussions are focused on the key questions discussed in section 2.1, rather than the details of proposed enhancements.

### Place holder for discussion this meeting

TBD

## Dynamic adaptation of SPS/CG parameters/configurations

**Status of inputs in the contributions:**

* **Companies with view (23):** Futurewei, TCL, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Sony, Nokia/NSB, OPPO, CATT, China Telecom, Samsung, CMCC, ETRI, Google, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, Rakuten, Apple, DCM
  + **Supportive (16)**: TCL, Sony, Nokia/NSB, OPPO, CATT, China Telecom, CMCC, ETRI, Google, ZTE/Sanechips, CEWiT, FGI, Qualcomm, InterDigital, Apple, DCM
  + **Not supportive (7):** Futurewei, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Samsung, Rakuten

**Moderator’s suggestion for discussion:**

Despite the large support for the enhancements, the capacity performance evaluation results to support the enhancements are few or absent. Regardless, Moderator suggests that it is more constructive if the initial discussions are focused on the key questions discussed in section 2.1, rather than the details of proposed enhancements.

### Place holder for discussion this meeting

TBD

## Non-integer periodicity for SPS/CG transmissions

**Status of inputs in the contributions:**

* **Companies with view (22):** Futurewei, TCL, Huawei/HiSilicon, Ericsson, Spreadtrum, vivo, Sony, Nokia/NSB, OPPO, NEC, Leveno, China Telecom, Samsung, CMCC, ETRI, Google, LG, CEWiT, Qualcomm, InterDigital, Rakuten, Apple
  + **Supportive (16)**: TCL, vivo, Sony, Nokia/NSB, OPPO, NEC, Leveno, China Telecom, CMCC, ETRI, Google, LG, CEWiT, Qualcomm, InterDigital, Apple
  + **Not supportive (6):** Futurewei, Huawei/HiSilicon, Ericsson, Spreadtrum, Samsung, Rakuten

**Moderator’s suggestion for discussion:**

Despite the large support for the enhancements, the capacity performance evaluation results to support the enhancements are few or absent. Regardless, Moderator suggests that it is more constructive if the initial discussions are focused on the key questions discussed in section 2.1, rather than the details of proposed enhancements.

### Place holder for discussion this meeting

TBD

# 3 Dynamic scheduling/grant enhancements

The following agreement was made in RAN1#109-e.

|  |
| --- |
| **Agreement:**  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.* |

Companies’ view described in the respective contributions regarding this agreement are summarized in this section for different candidate enhancements area, and followed up with few key questions, suggested for discussion.

## 3.1 Enhancements of multi-slot PxSCHs scheduling

An area for candidate enhancement techniques is multi-slot scheduling based on single DCI. Please note that this area is further categorized into 3 sub-areas based on the inputs. 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):** Qualcomm, Ericsson, Intel, LG, Spreadtrum, CMCC, CATT, Futurewei, vivo, Nokia/NSB, NEC, Lenovo, Samsung, Rakuten, Apple, TCL, Sony, Intel, ZTE/Sanechips, InterDigital
  + **Supportive/OK to study (18)**: Qualcomm, Ericsson, Intel, LG, Spreadtrum, CMCC, vivo, Nokia/NSB, NEC, Lenovo, Samsung, Rakuten, Apple, TCL, Sony, Intel, ZTE/Sanechips, InterDigital
  + **Not supportive (2):** Futurewei,CATT
* **Capacity performance results (7):** Available (Ericsson, vivo, Nokia/NSB, Intel, InterDigital, CATT, ZTE/Sanechips)

**Moderator’s observation and suggestion for discussion:**

Many companies find usage of multi-slot scheduling for serving XR traffic beneficial. The main claimed reasons are benefit of dynamic scheduling, as well as large packet sizes that requires transmission of multiple TBs for sending an XR packet. In this way, at least the DCI overhead is reduced, or the DCI overhead is used for data and hence the capacity can be improved.

However, the main criticism by opponents is that the DCI overhead is not a bottleneck for capacity to start with. Single-slot dynamic scheduling would provide the maximum flexibility and can results in the highest capacity. Therefore, why to spend efforts on supporting features where the same goal can be achieved by existing that existing features?

Some proponents refer to DCI overhead reduction as the motivation.

Some proponents refer to using resources for DCI for data to improve the capacity.

The proponents state that the best flexibility can be achieved by single-slot scheduling. Therefore, they suggest enhancing flexibility to maximize the capacity.

Regarding simulation results, the proponents have provided simulation results to support the claimed capacity performance improvements. However, the opponents also provided simulation results claiming that there are other contributors to capacity increase that are worth to investigate, rather DCI overhead reduction.

It seems it is important to discuss the fundamental question:

* **Key question:** **Why support/enhancements of multi-slot PxSCHs scheduling is necessary to improve the capacity performance of XR traffic, especially as compared to single-slot PxSCH scheduling? How the capacity performance gain can be assessed to be beneficial?**

### 3.1.1 Extension from FR2-2 to FR1/FR2

This section provides a summary of view on extending capability of single DCI scheduling multi-PDSCHs/PUSCHs for FR2-2 to FR1/FR2. 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 (8):** Qualcomm, Ericsson, Intel, LG, Spreadtrum, CMCC, CATT, Futurewei
  + **Supportive (6)**: Qualcomm, Ericsson, Intel, LG (wait for Rel-17 outcome), Spreadtrum, CMCC
  + **Not supportive (2):** CATT, Futurewei
* **Capacity performance results (3):** Available (Ericsson, Intel, CATT)

**Moderator’s observation and suggestion for discussion:**

Many companies considered extension of multi-slot PxSCH scheduling in FR2-2 to FR1/FR2 is beneficial for serving XR traffic. However, for the reason discussed in previous section, there is a concern for this extension. From Moderator perspective, discussion is needed how to manage the logistic to handle this topic.

* **Key question: How to organize/progress the discussion due to the following dependency?**
  + Dependency on the Rel-17 UE features discussion
    - If Rel-17 UE feature decides to support this extension, no further in XR SI is needed.
    - If the discussion in Rel-17 UE feature is pending, discussion is needed in XR SI to whether wait or conclude on this topic (support or not).
    - If the discussion in Rel-17 UE feature is concluded not to support, discussion is needed in XR SI to conclude on this topic (support or not).
  + Dependency of other enhancements for multi-slot scheduling (HARQ-ACK and/or CBG based and flexibility) on this topic
    - **Note that the Moderator tries to structure these discussions with starting the condition of support of this feature for the progress.**

|  |  |
| --- | --- |
| **Company** | **Proposal and Observations** |
| Qualcomm | **Proposal 12**: 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. |
| Ericsson | **Observation 7** Dynamic scheduling based on single DCI scheduling multiple PxSCHs is a natural choice to serve XR traffic due to corresponding varying and large-sized application packets.  **Proposal 9** Extend operation of dynamic scheduling of multi-PDSCH to FR1 and lower SCS (e.g., 30 kHz) for XR. The work on this aspect must consider the outcomes from the UE feature discussions in Rel-17 B52.6G. |
| Intel | **Proposal 2**: 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.   * Multiple PUSCH/PDSCH scheduling solution adopted for B52.5GHz can be a starting point. |
| LG | **Proposal 1**: 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. |
| Spreadtrum | **Proposal 2**. Support to extend single DCI scheduling multi-PDSCHs/PUSCHs to other SCS in FR1/FR2-1. |
| CMCC | **Proposal 3**. The following enhancements can be considered for extension of single DCI scheduling multi-PDSCHs/PUSCHs in FR2-2 to FR1/FR2:   * Per PDSCH/PUSCH different configurations, e.g., MCS, frequency resources |
| CATT | **Proposal 4**: 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. |

#### 3.1.1.0 Initial discussion

Moderator recommends to focus the discussion on the following:

##### Proposal 3-1-1:

* Decide by RAN1#110-bs whether extending the support of single DCI scheduling multi-PDSCHs/PUSCHs from FR2-2 to FR1/FR2 is beneficial to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | This proposal seems to be agreed in online session. |
| LG | Support the proposal.  We are supportive to extend usage of single DCI scheduling multi-PxSCH to FR1/FR2 since it efficiently alleviate DCI overhead and companies’ concerns on supporting XR with dynamic scheduling. However, if control overhead is not a bottleneck and it is common understanding, we don’t see any reason to further enhance the single DCI scheduling multi-PxSCH for XR.  It is true that single DCI scheduling multi-PxSCH only has benefit of signaling overhead reduction, comparing dynamic scheduling. As a trade-off, it has less scheduling flexibility and could cause redundant scheduling. In addition, if DCI overhead is not an issue, the multi-PUxCH scheduling could be emulated by activating and releasing SPS/CG and it would be more efficient if XR traffic is periodic or prolonged more than 10 ms. |
| Qualcomm | Yes, this may be the same as the one agreed in online session. One comment though. The single DCI multi-PDSCH/PUSCH in Rel17 was agreed for FR2-2 (regardless of SCS), hence we recommend this rewording for accuracy. : “… from FR2-2 to FR1/FR2-1 …” |

### 3.1.2 HARQ-ACK feedback and/or CBG based enhancements

This section provides a summary of view for HARQ-ACK feedback and/or CBG based enhancements. 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 (10):** vivo, NEC, Lenovo, Samsung, LG, Qualcomm, Rakuten, Apple, CATT, Futurewei
  + **Supportive (8)** vivo, NEC, Lenovo, Samsung, LG, Qualcomm, Rakuten, Apple
  + **Not supportive (2):** CATT, Futurewei
* **Capacity performance results (2):** Available (vivo, CATT)
* **Proposed enhancement for HARQ-ACK feedback reporting:**
  + **Early/Multiple HARQ-ACK feedback reporting**
    - Vivo, Samsung, Rakuten, Lenovo, [LG]
* **Proposed enhancement for CBG based HARQ-ACK feedback reporting**
  + **CBG support for multi-slot PDSCH scheduling**
    - Samsung, Lenovo, Apple, NEC
    - **Mapping TB related XR information to corresponding CBG**
      * Lenovo

**Moderator’s observation and suggestion for discussion:**

Assuming multi-slot PDSCH by single DCI would be supported, companies discussed the enhancements for HARQ-ACK feedback and/or support and potentially enhancements of CBG based HARQ-ACK feedback transmission.

Moderator understanding of the proposals is that there are basically two main tracks:

* First track focuses on HARQ-ACK enhancements and providing earlier HARQ-ACK feedback reporting. This enhancement is motived for XR due to delay budget and large packets being scheduled. The earlier the information about the status of transmission is provided, is claimed to assist the scheduler to take necessary actions, such as dropping, if needed.
* Second track focuses on support of CBG based transmission and/or potential enhancements. Companies find the support of CBG very reasonable for XR traffic due to large packet sizes and delay requirements. A company even expressed the view that without support of CBG, the support of multi-slot scheduling is meaningless. Some companies further suggest enhancing CBG framework specifically customized for XR customized to obtain additional information that in turn would help XR performance specifically. The detailed description of these proposals is available in the corresponding contributions.

From Moderator perspective, it would be beneficial to discuss at least around the following key questions:

* **Key question (primary): If multi-slot PDSCHs scheduled by single DCI is supported, is it necessary and beneficial to support any of the following:**
  + **Early/Multiple HARQ-ACK feedback reporting?**
  + **CBG for multi-slot PDSCH scheduling?**
* **Key question (secondary): If multi-slot PDSCHs scheduled by single DCI and CBG based transmission are supported, is it necessary and beneficial from XR capacity perspective to support the proposed enhancements (listed below):**
  + - **Mapping TB related XR information to corresponding CBG**

|  |  |
| --- | --- |
| **Company** | **Proposal and Observations** |
| Qualcomm | **Proposal 15**: For XR, consider studying enhancements for single DCI 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 |
| vivo | **Proposal 5**: Study potential enhancements for multi-PXSCH scheduling, e.g. earlier HARQ-ACK feedback for a sub-set of PDSCHs scheduled by a single DCI. |
| Lenovo | **Proposal 2**: Study latency reduction for HARQ-ACK transmission for multi-PD(U)SCH scheduling.  **Proposal 3**: Investigate HARQ-NACK prioritization benefits to avoid PDB expiration.  **Proposal 9**: 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.  **Observation**: The XR PDU set/packet importance value can help the RAN skip retransmissions of non-important PDU sets.  **Proposal 10**: Investigate signaling overhead reduction for CBG-based HARQ-ACK feedback 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. |
| Samsung | **Proposal 2**: If multi-slot PDSCH scheduling is supported for XR, support multiple HARQ-ACK reporting occasions.  **Proposal 3**: If multi-slot PDSCH scheduling is supported for XR, support CBG-based HARQ-ACK reporting. |
| LG | **Proposal 2**: It is necessary to investigate enhanced HARQ-ACK timing for single DCI scheduling multi-PDSCHs/PUSCHs. |
| Apple | **Proposal 3**-6: Study whether code block group based transmission can be used to support QoS enhancement at lower layers. |
| NEC | **Proposal 7**: Study enhancement for CBG based transmission for multi-slot PDSCHs scheduling by single DCI. |
| Rakuten | **Proposal 3**: Consider supporting multiple HARQ occasions for multi-slot scheduling. |

#### 3.1.2.0 Initial discussion

Moderator recommends to focus the discussion on the following:

##### Proposal 3-1-2-1:

* If the support of multi-slot PDSCH scheduling for FR2-2 (Rel-17 feature) is extended to FR1/FR2, study of enhancement based on multiple HARQ-ACK reporting occasions for PDSCHs scheduling by a single DCI to improve XR capacity enhancements.

##### Proposal 3-1-2-2:

* If the support of multi-slot PDSCH scheduling for FR2-2 (Rel-17 feature) is extended to FR1/FR2, study the enhancement based on CBG based HARQ-ACK for PDSCHs scheduling by a single DCI to improve XR capacity enhancements.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | These proposals can be discussed after decision for Proposal 3-1-1. |
| LG | In general, we think the discussion on enhancement should be after the determination on the existence of enhancement target. We prefer to discuss those further enhancement in the next meeting together.  at least we would like to have similar sentence to proposal 3-1-1, as like following: Proposal 3-1-2-1:  * If the support of multi-slot PDSCH scheduling for FR2-2 (Rel-17 feature) is extended to FR1/FR2, study the necessity of enhancement based on multiple HARQ-ACK reporting occasions for PDSCHs scheduling by a single DCI to improve XR capacity enhancements.  Proposal 3-1-2-2: If the support of multi-slot PDSCH scheduling for FR2-2 (Rel-17 feature) is extended to FR1/FR2, study the necessity of the enhancement based on CBG based HARQ-ACK for PDSCHs scheduling by a single DCI to improve XR capacity enhancements |
| Qualcomm | It may be better not to tie these proposals to the extension to FR1/FR2-1. These can be also applicable to FR2-2. So we are not in favour of agreeing the above 2 proposals and would like to keep them open for study regardless of the FR (especially multiple HARQ-ACK reporting occasions for PDSCHs scheduling by a single DCI) |

### 3.1.3 Flexibility on transmission parameters/configurations

This section provides a summary of views for supporting more flexible transmission based on multi-slot PxSCHs scheduled by single DCI. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, some companies have provided simulations results.

**Status of inputs in the contributions:**

* **Companies with view (14):** Futurewei, TCL, Ericsson, Sony, Nokia/NSB, NEC, Lenovo, Intel, Samsung, CMCC, ZTE/Sanechips, Qualcomm, InterDigital, CATT
  + **Supportive (10)**: TCL, Ericsson, Sony, Nokia/NSB, NEC, Lenovo, Intel, CMCC, Qualcomm, InterDigital
  + **Not supportive/Needs study (4):** CATT, Futurewei, Samsung, ZTE/Sanechips
* **Capacity performance results (5):** Available (Ericsson, CATT, ZTE/Sanechips, Intel, InterDigital)

**Moderator’s observation and suggestion for discussion:**

There are diverge views regarding the proposed enhancements. A group of companies are not convinced that support of multi-slot PxSCHs is necessary as discussed in section 3.1. In addition, another group of companies are not convinced with introducing additional flexibility.

The proponents coming from the view that multi-slot scheduling is a proper choice to serve XR traffic, reason that by additional flexibility the capacity can be further improved.

Regarding simulation results, the proponents have provided simulation results to support the claimed capacity performance improvements. However, the opponents also provided simulation results claiming that there are other contributors to capacity increase that are worth to investigate, rather DCI overhead reduction.

Regarding how/what to provide more flexibility, as shown from the proposals, views are quite diverge.

Therefore, before discussing the details, it is important to discuss around the fundamental question below by considering the detailed justifications and performance evaluations results available in respective contribution:

* **Key question:** **Why support/enhancements of flexibility for multi-slot PxSCHs scheduling if supported, is necessary to improve the capacity performance of XR traffic? How the capacity performance gain can be assessed to be beneficial?**

|  |  |
| --- | --- |
| **Company** | **Proposal and Observations** |
| Nokia/NSB | **Proposal 5**: Study if additional information is needed to allocate number of slots for multi-PDSCH/PUSCH scheduling to transmit an XR payload (e.g., no information is needed, minimum size of the packet, exact size of the packet, etc.)  **Proposal 6**: Consider a periodicity parameter to multi-PDSCH/PUSCH scheduling with single DCI, where periodicity parameter indicates how many slots (or symbols) are left between allocations associated with different HARQ processes. |
| Ericsson | **Observation 7** Dynamic scheduling based on single DCI scheduling multiple PxSCHs is a natural choice to serve XR traffic due to corresponding varying and large-sized application packets.  **Observation 8** Single DCI scheduling multiple PxSCHs lacks the flexibility of single DCI scheduling single PxSCH,  **Proposal 8** Consider studying candidate enhancement techniques for single DCI scheduling multiple PxSCHs to explore potential capacity performance gains when used for serving XR traffic.  **Proposal 10** Consider study of enhancements for multi-PxSCHs dynamic scheduling to enable flexibility for MCS values and frequency allocation for the TBs scheduled by the same DCI with reduced control signalling overhead. |
| Qualcomm | **Observation 7**: The existing single DCI multi-PDSCH/PUSCH framework can cause resource waste, additional delays, or more control signalling.  **Proposal 13**: 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.  **Proposal 14**: PDCCH skipping indication in the single DCI scheduling multi-PDSCHs allows for PDCCH skipping after decoding of the multi-PDSCHs  **Proposal 15**: For XR, consider studying enhancements for single DCI 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 |
| Futurewei | **Observation 3**: For enhancement for dynamic scheduling/grant transmissions to improve XR capacity, the proposed techniques related to single DCI scheduling multi-PDSCH/PUSCH are trying to reduce PDCCH/DCI overhead, which is not the bottleneck for XR system capacity. The space for improvement for proposed techniques related to SR/BSR is very limited. |
| ZTE/Sanechips | **Proposal 5:** Further evaluate and justify the performance of single DCI scheduling multi-PxSCHs for XR scenarios.  Observation 19: The flexibility of bit field as SLIV, RV, etc in DCI format 0-1/ DCI format 1-1 per PDSCH/PUSCH may be not necessary. But for frequency domain perspective, finer frequency granularity deserves further discussion. |
| InterDigital | **Observation 9**: 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)  **Proposal 13**: Support DG enhancement for single DCI indicating multiple DG allocations (e.g. multiple PUSCHs, timing pattern for recurring DG allocations) |
| Sony | **Observation 3**: 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.  **Proposal 8**: Multiple PDSCHs transmission 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. |
| Lenovo | **Proposal 4**: Study if multi-PD(U)SCH scheduling should be further enhanced based on application awareness. |
| Samsung | **Observation 3**: If the multi-slot PDSCHs or PUSCHs provide same type of video frames and have same priority, there is no benefit from indicating different MCS or different TDRA/FDRA. |
| CATT | **Proposal 4**: 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. |
| Intel | **Proposal 2**: 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.   * Multiple PUSCH/PDSCH scheduling solution adopted for B52.5GHz can be a starting point. |
| TCL | **Proposal 5**: A single DCI scheduling multi-PDSCHs and multi-PUSCHs with different MCS for XR can be considered.  **Proposal 6**: TB processing over multiple slots with no limit number of CBs and transmission layers can be considered for XR. |
| CMCC | **Proposal 3**. The following enhancements can be considered for extension of single DCI scheduling multi-PDSCHs/PUSCHs in FR2-2 to FR1/FR2:   * Per PDSCH/PUSCH different configurations, e.g., MCS, frequency resources * Reduce the number of maximum 8 scheduled PDSCHs/PUSCHs per DCI and maximum 32 HARQ processes.   **Proposal 4**. 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. |
| NEC | **Proposal 8**: Study enhancement for repetition transmission for multi-slot PDSCHs scheduling by single DCI. |

#### 3.1.3.0 Initial discussion

Moderator recommends to focus the discussion on the following:

##### Proposal 3-1-3-1:

* If the support of multi-slot PDSCH/PUSCH scheduling for FR2-2 (Rel-17 feature) is extended to FR1/FR2, study enhancements of multi-slot PDSCH/PUSCH scheduling.
* Study enhancements of multi-slot PUSCHs scheduled by a single DCI (Rel-16 feature).

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | These proposals can be discussed after decision for Proposal 3-1-1. |
| LG | We have similar view to MediaTek. The proposal can be discussed after the decision on multi-slot scheduling. |
| Qualcomm | Similar to our comment for 3.1.2. It may be better not to tie this proposal to the extension to FR1/FR2-1. This can be also applicable to FR2-2. So we are not in favour of agreeing the above proposal and would like to keep it open for study regardless of the FR. |

## 3.3 SR and/or BSR enhancements

This section provides a summary of views for enhancing SR and/or BSR to provide more XR-specific information to the scheduler. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, some companies have provided simulations results.

**Status of inputs in the contributions:**

* **Companies with view (11):** Ericsson, Futurewei, ZTE/Sanechips, InterDigital, Sony, vivo, Huawei/HiSilicon, Samsung, Google, LG, Apple
  + **BSR enhancements (9)**
    - **Supportive (8)**: Ericsson (in RAN2), ZTE/Sanechips, InterDigital, Sony, vivo, Huawei/HiSilicon, Google, LG
    - **Not supportive (1):** Futurewei
  + **SR enhancements (5)**
    - **Supportive (3)**: Samsung, LG, Apple
    - **Not supportive (2):** Ericsson, Futurewei
* **Capacity performance results (6):** Available (Huawei/HiSilicon, Ericsson, CATT, ZTE/Sanechips, Intel, InterDigital)

**Moderator’s observation and suggestion for discussion:**

With respect to BSR enhancements, only one company has expressed concern based on anticipating that the capacity gain would be limited. Some of the proponents have provided capacity performance results and the gain. Given that, discussion is needed if the concern is remained. Another aspect related to BSR enhancement is that whether the related work and study is within RAN1 or RAN2 scope. One company has stated clearly that it is within RAN2 scope. Clarity on this aspect is useful for management of the work in RAN1.

With respect to SR enhancements, 3 companies have considered this enhancement necessary. However, another company expresses different view. Currently, capacity performance evaluation results are not available. It is important to discuss how to continue the discussion regarding this enhancement.

From Moderator perspective, it would be beneficial to discuss at least around the following key questions:

* **Key question:** **Regarding BSR enhancement, can RAN1 conclude that it is beneficial given analysis and performance evaluation provided to show the benefit? In that case, does RAN1 consider the enhancements are within RAN2 scope, or assume L1 study is needed?**
* **Key question:** **Regarding SR enhancement, considering the discussion on pros and cons of multi-bit SR, what is the view on the necessity and benefit of this enhancement?**

|  |  |
| --- | --- |
| **Company** | **Proposals and Observations** |
| Ericsson | **Proposal 11** Deprioritize studying SR enhancements at physical layer to improve capacity performance of XR traffic.  **Proposal 12** The BSR enhancements to improve capacity performance of XR traffic are not handled by RAN1. |
| Futurewei | **Observation 3**: For enhancement for dynamic scheduling/grant transmissions to improve XR capacity, the proposed techniques related to single DCI scheduling multi-PDSCH/PUSCH are trying to reduce PDCCH/DCI overhead, which is not the bottleneck for XR system capacity. The space for improvement for proposed techniques related to SR/BSR is very limited. |
| ZTE/Sanechips | **Observation 20:** For both 10Mbps@60fps traffic model and 20Mbps@60fps traffic, more than a half proportion of packet sizes are overestimated using existing BSR tables.  **Observation 21:** In uplink transmission, overestimated packet sizes may cause capacity performance loss. And uplink transmission with precise BSR indication can bring capacity performance gain.  **Proposal 6:** Dynamic grant enhancement technique, including e.g., enhanced BSR indication, can be considered to improve capacity for XR service. |
| InterDigital | **Proposal 12**: Support UE providing traffic pattern info associated with PDU sets (e.g. in enhanced BSR) when requesting for DG |
| Sony | **Observation 3**: 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.  **Proposal 7**: Consider packet arrival rate information in the BSR report to enhance L1 scheduling. |
| vivo | **Observation 3**: It is beneficial to study enhanced BSR mechanism for XR traffic to facilitate timelier and matched UL scheduling. |
| Huawei/HiSilicon | **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.  **Proposal 3**: To enable proactive UL scheduling, support enhancing BSR report such that the reported BSR size includes both the current buffer size and estimated size of next UL frame that will arrive shortly.  **Observation 10**: Proactive UL scheduling can be beneficial, i.e., if gNB can know the potential UL frame arrival and size, gNB can proactively schedule PUSCH resource to the UE so that UE can transmit UL frame as soon as it arrives, instead of reporting BSR first and then wait for scheduling. |
| Samsung | **Proposal 6/7**: Apply BPSK/QPSK to SR to indicate 2-4 BSR values in order to reduce latency for UL scheduling. |
| Google | **Proposal 9**: Support providing timing information as part of the BSR reporting  **Proposal 10**: Support providing traffic priority information as part of the BSR reporting |
| LG | **Proposal 3**: For XR-specific capacity improvement, enhancement on SR/BSR can be considered.  **Proposal 4**: If scheduling techniques for XR-awareness information is supported, PDB information can be reported via SR/BSR for XR-specific capacity improvement |
| Apple | **Proposal 3**-5: study multiple bit SR design for buffer size reporting. |

### 3.3.1 Initial discussion

Moderator recommends to focus the discussion on the following:

#### Proposal 3-3-1:

* Study of whether/how to enhance BSRto improve capacity performance of XR traffic is within RAN2 scope and is not handled by RAN1.
  + Note that RAN1 can use the assumption of enhanced BSR for CG and DG related studies RAN1.

#### Proposal 3-3-2:

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether the study of multi-bits SR enhancements is beneficial to improve XR capacity performance.
  + Option 2: Decide by RAN1#110-bs whether the study of multi-bits SR enhanceofments is beneficial to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Support 3-3-1. For 3-3-2, prefer Option 2. |
| Qualcomm | Support 3-3-1. For 3-3-2, prefer Option 1 (unless proponents need extra meeting to provide simulation results) |
|  |  |

## 3.4 Other dynamic scheduling enhancements

Companies have proposed other enhancements as listed in the table below. 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.

**Moderator’s observation and suggestion for discussion:**

It is important to have a discussion to assess the necessity and benefit these enhancements.

From Moderator perspective, some questions are listed below to facilitate the discussion:

* **XR-specific playoutDelayForMediaStartup scheme (CATT): The proponent has provided detailed analysis and capacity and power saving performance evaluation to justify the enhancement. Considering the description of the scheme, it appears that the proposed enhancement is higher layer, and not L1. What are the physical layer attributes of the technique? Is the related work within RAN1, or RAN2, or both?**
* **XR-dedicated PDCCH Monitoring Window (CATT): The proponent has investigated the impact of capacity enhancement techniques on power saving, and provided system level evaluation results for the proposed scheme that provides capacity performance gain with increasing power saving gain.**
* **UL scheduling assisted/controlled by UL control (Qualcomm, Sony, Lenovo): Is it correct to assume these proposals on high level belong to the same category? Considering the descriptions provided in respective contributions and the referenced simulation results, what is the view on the necessity and benefit of this family of enhancements?**

### 3.4.1 Place holder for discussion

TBD

|  |  |
| --- | --- |
| **Company** | **Proposal and Observations** |
| CATT | Table 1: The evaluation result comparison between the XR-PMW with  and the Baseline scheme 1 (UE always on)   |  |  |  |  |  | | --- | --- | --- | --- | --- | | 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 (Baseline scheme 1) | 11.5 | 95.83% | 0.0% | 0.0% | | DG scheduling with C-DRX(16,12,4) | 10.9 | 90.83% | -5.2% | 2.4% | | DG scheduling with C-DRX(16,8,4) | 6.48 | 54.00% | -43.7% | 12.75% | | DG scheduling  with C-DRX(6,4,2) | 10.7 | 89.17% | -6.96% | 6.18% | | XR-PWM scheme 1:  XR-PMW (16,12) | 10.8 | 90.00% | -6.09% | 4.13% | | XR-PWM scheme 2:  XR-PMW (16,12) with go-to-sleep | 10.8 | 90.00% | -6.09% | 24.39% | | XR-PWM scheme 3:  XR-PMW (16,12)  with PDCCH skipping and go-to-sleep | 10.7 | 89.17% | -6.96% | 29.92% |   **Observation 1: Under the same system load, the XR-PMW could obtain the less than 10% capacity performance gap than that of the UE always on for DG scheduling and obtain 24.39%~29.92% PSG compared to that of the UE always on for DG scheduling.**  **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.  Table 2: The performance comparison between baseline scheme 2 (C-DRX (16, 12, 4)) and  XR-PMW with PDCCH skipping and go-to-sleep   |  |  |  |  |  | | --- | --- | --- | --- | --- | | 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) (Baseline scheme 2) | 10.9 | 90.83% | 0.0% | 0.0% | | XR-PWM scheme 1:  XR-PMW with (16,12) | 10.8 | 90.00% | -0.92% | 1.69% | | XR-PWM scheme 2:  XR-PMW with go-to-sleep | 10.8 | 90.00% | -0.92% | 21.47% | | XR-PWM scheme 3:  XR-PMW  with PDCCH skipping and go-to-sleep | 10.7 | 89.17% | -0.93% | 26.88% |   **Observation 2: Under the similar capacity performance, the XR-PMW with go-to-sleep and XR-PMW with PDCCH skipping and go-to-sleep can obtain 21.47% and 26.88% PSG than the C-DRX with (16, 12, 4), respectively.**  **Proposal 2**: The XR-dedicated PDCCH Monitoring Window should be considered as the dynamic scheduling enhancement scheme for improving the capacity of XR-specific traffic.  **Proposal 3**: The XR-specific playoutDelayForMediaStartup scheme should be considered as the dynamic scheduling enhancement scheme for its significant capacity gain and obvious power saving gain. |
| Qualcomm | **Proposal 9**: To increase capacity and reduce power consumption, study partial uplink transmission, and investigate necessary signalling to enable it  **Proposal 10**: 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 |
| Sony | **Proposal 6**: 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). |
| Lenovo | **Proposal 5**: Study techniques providing timely PHR, e.g., UL DCI triggering a PHR.  **Proposal 6**: Study if PHR should be further enhanced based on XR traffic arrival periodicity or UL pose periodicity. |

# 4 Other capacity enhancements

The following agreement was made in RAN1#109-e.

|  |
| --- |
| **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.* |

Companies’ view described in the respective contributions regarding this agreement are summarized in this section for different candidate enhancements area.

As opposed to the candidate enhancements that were summarized in sections 2 and 3, fewer companies have provided input regarding these candidate enhancements. Therefore, for each area, the Moderator has included a selected part of the discussions from the corresponding contributions to provide an overview of the expressed views. More details including performance evaluation results if available, can be found in corresponding contributions.

## 4.1 Delta MCS and Soft HARQ-ACK feedback

**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 (1):** Available (Qualcomm)

**Moderator’s observation and suggestion for discussion:**

From Moderator perspective, at least a discussion around the questions below are useful:

* **Key questions: Considering the discussions from proponents, as well as the opponents in respective contributions, what is the view on the necessity and benefit of the proposed enhancements? Considering the related history in previous releases, what is the view on the prospect of this enhancement in Rel-18?**

|  |  |
| --- | --- |
| **Company** | **Summary of discussion proposals and observation** |
| Qualcomm | With Soft HARQ-ACK, the UE provides enhanced HARQ-ACK feedback beyond the single bit ACK/NACK status in the form of a Delta MCS based on PDSCH decoding. By allowing the UE to provide additional information based on reception of a transport block, soft HARQ-ACK allows the gNodeB to adapt the scheduling of retransmissions and thereby allows the UE to decode the transport block without waiting for too many additional HARQ round trips.  Large bit-rate requirements of XR traffic may require wideband RB allocations. When adapting the scheduling based on soft HARQ-ACK, if the RB allocation is already wideband, it is not possible to increase the frequency resources further. One possibility is to use the time domain instead – the gNodeB can repeat the retransmission multiple times based on the soft HARQ-ACK feedback. We next present simulation results showing gains of such a scheme over a baseline scheme without HARQ-ACK enhancements.    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    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  **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.**  **Proposal 11: Support soft HARQ-ACK for capacity enhancement of XR capacity.** |
| Apple | As XR traffic does provide some unique challenges and opportunities for system design, in our view, a component of CSI enhancements can be also included in Rel-18 XR.  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 3-1: Study soft HARQ-ACK feedback according to PDSCH reception to support low latency traffic efficiently.** |
| 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.  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 introduce 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 8: 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.*** |
| MediaTek | **Observation 5: The soft-ACK reporting enhancement using delta-CQI/MCS was discussed in Rel-16/17 URLLC. Some concerns were brought up including**   * **Necessity of OLLA enhancements with existing P/SP-CSI reporting** * **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 and multiplexing of delta-CQI/MCS and HARQ**   **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.** |
| 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 3: 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.**  **Proposal 4: For link adaptation for XR, reuse the 4-bit full sub-band CQI together with implementation-based CQI filtering*.*** |
| Ericsson | Both *Delta MCS and Soft HARQ-ACK feedback* are mechanisms that provide gNB with increased knowledge of the radio conditions (SINR) prevailed at the time of transmission. By comparing the SINR at time of transmission with the SINR gNB expects when performing link adaptation (LA), the gNB can both perform a better outer loop LA adjustment and perform a better LA decision for a potential re-transmission. 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.  Proposal: Deprioritize further study of Delta MCS and Soft HARQ feedback.  On the other hand, in Rel-17 IIoT/URLLC discussions of CSI enhancement the technique of DMRS-based CSI was explicitly excluded. However, in our view, a DMRS-based CSI reporting where UE reports a CQI value indicating the quality of a received PDSCH can provide the gNB the same or better information as Delta-MCS and Soft HARQ-ACK feedback can provide.  **Observation: A DMRS-based CSI reporting can provide gNB with same or better information as Delta-MCS and Soft HARQ-ACK feedback.** |
| Samsung | CSI reporting enhancements through reporting of “soft-ACK” or “delta-MCS” were considered in Rel-17 URLLC - 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: *Use of “delta-MCS” has narrow applicability, requires conditions that may not be realistic, may not be possible to test due to UE proprietary implementation, and is not expected to result to DL capacity gains for XR.*** |
| LG | (Common view for all link adaptation enhancements*):* In general, enhanced link adaptation could achieve faster and correct channel estimation, so that overall system throughput could be increased. However, in the perspective of XR, we think it is difficult to say that link adaptation could be XR-specific. To be XR-specific, in our view, the techniques has beneficial point for XR scenarios or XR traffic characteristic. Meanwhile, XR scenario generally assumes periodic traffic for a long time. Considering that, the benefit of faster channel estimation would be limited to only first few transmissions for XR. Also, if it is discussed in terms of capacity, the trade-off between existing CSI and proposed enhancement in terms of resource overhead should be identified first, as it affects UL capacity performance.  **Proposal: De-priorotize study on enhacement of link adaptation.** |

### 4.1.1 Initial discussion

Proponents have provided comprehensive simulation results and analysis. It is important proper feedback is provided with respect to this topic. Moderator recommends to focus the discussion on the following:

#### Proposal 4-1-1:

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether to study CQI reporting based on Delta MCS and Soft HARQ-ACK to improve XR capacity performance.
  + Option 2: Decide by RAN1#110bs whether to study CQI reporting based on Delta MCS and Soft HARQ-ACK to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Prefer Option 2. RAN1 should strive to discuss the general evaluation assumption for this specific enhancement. Besides, we suggest to capture the simulation/evaluation results of this enhancement and form some observations for this enhancement in this meeting. If offline time permitted, we should let the proponent to elaborate on the enhancement mechanism using 1 or 2 minutes to let companies get a more compresensive view on it. |
| Qualcomm | Prefer Option 2. In order to have a meaningful assessment, we may need more simulation results from interested companies. We can agree on the assumptions this meeting and come back with more results next meeting where we can make a more calculated decision. |
|  |  |

## 4.2 Cooperative MIMO scheme via precoding technique

**Status of inputs in the contributions:**

* **Companies with view (3):** Futurewei, Ericsson, LG
  + **Supportive (1)**: Futturewei
  + **Not supportive (2):** Ericsson, LG
* **Capacity performance results (1):** Available (Futurewei)

**Moderator’s observation and suggestion for discussion:**

From Moderator perspective, at least a discussion around the questions below are useful:

* **Key questions: Considering the discussions from proponents, as well as the opponents in respective contributions, what is the view on the necessity and benefit of the proposed enhancements? Is XR SI is preferred to investigate the proposed enhancement?**

|  |  |
| --- | --- |
| **Company** | **Summary of discussion proposals and observation** |
| Futurewei | **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.**    Figure 4/5: Capacity Results with BiT precoding: Dense Urban/Urban Macro FR1, Uneven loads  Table 4: Capacity of the XR system assuming BiT precoding (with offset), data packet rate of 45Mbps, with slot configuration of [DDDUU]   |  |  | | --- | --- | | **Scheme** | Capacity (users/cell) (Uneven UE Load) | | **Dense Urban FR1** | ~13.1 | | **Urban Macro FR1** | ~6.6 |   **Observation 5: TDD ZF performance can be significantly improved by flexible A-SRS triggering with dynamically indicated partial frequency sounding.**  **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.**  Table 5: Capacity of DU assuming ZF and BiT precoding (with offset)   |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Scenario** | **App** | **PDB** | **Bit rate** | **Fps** | **MIMO** | **Capacity** | | | | | | | **[DDDUU]** | | | **[DDDSU]** | | | | **ZF** | **BiT** | **BiT**  **Gain** | **ZF** | **BiT** | **BiT**  **Gain** | | **DU** | AR/VR | 10 ms | 45Mbps | 60 | MU | 8 | 13.1 | 64.8% | 12.2 | 16.9 | 38.5% | | 30 Mbps | 60 | MU | 13.7 | 19.9 | 45.3% | 21.7 | 25.8 | 18.9% | |  | CG | 15 ms | 45Mbps | 60 | MU | 12.7 | 16.9 | 33.1% | 17.4 | 21.7 | 24.7% | | 30 Mbps | 60 | MU | 21.5 | 25.6 | 19.1% | 27.1 | 30.1 | 11.1% |   **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 7: Support cooperative MIMO via DL interference probing based on SRS enhancements to improve XR system capacity for TDD.** |
| 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.  **Proposal: 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.** |
| LG | (Common view for all link adaptation enhancements*)*  **Proposal: De-prioritize study on enhancement of link adaptation.** |

### 4.2.1 Initial discussion

Proponents have provided comprehensive simulation results and analysis. It is important proper feedback is provided with respect to this topic. Moderator recommends to focus the discussion on the following:

#### Proposal 4-2-1:

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether to study cooperative MIMO schemevia DL interference probing based on SRS to improve XR capacity performance.
  + Option 2: Decide by RAN1#110bs whether to study cooperative MIMO schemevia DL interference probing based on SRS to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Prefer Option 2. RAN1 should strive to discuss the general evaluation assumption for this specific enhancement. Besides, we suggest to capture the simulation/evaluation results of this enhancement and form some observations for this enhancement in this meeting. If offline time permitted, we should let the proponent to elaborate on the enhancement mechanism using 1 or 2 minutes to let companies get a more compresensive view on it. |
| Qualcomm | Prefer Option 1 (unless proponents need extra meeting to provide simulation results) |
|  |  |

## 4.3 Enhanced CQI feedback based CBG transmission

**Status of inputs in the contributions:**

* **Companies with view (4):** Nokia/NSB, Futurewei, Ericsson, LG
  + **Supportive (1)**: Nokia/NSB
  + **Not supportive (3):** Futurewei, Ericsson, LG
* **Capacity performance results (1):** Available (Nokia/NSB)

**Moderator’s observation and suggestion for discussion:**

From Moderator perspective, at least a discussion around the questions below are useful:

* **Key questions: Considering the discussions from proponents, as well as the opponents in respective contributions, what is the view on the necessity and benefit of the proposed enhancements?**

|  |  |
| --- | --- |
| **Company** | **Summary of discussion proposals and observation** |
| Nokia/NSB | For CBG-based HARQ operation (useful for XR), the full TB is seldom retransmitted as only the potentially erroneously received CBGs are subject to retransmission. 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 study an enhanced CQI (eCQI) scheme that 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.  Notice that the eCQI does not involve any changes to the definitions of CSI measurement resources, and it does not results in high uplink reporting overhead, as the eCQI also is just a pointer to a CQI index table. Hence, it requires only modest specification changes as building on the existing CQI measurement and reporting framework. We summarize the suggested eCQI as follows:   |  |  | | --- | --- | | (a) AR/VR in FR1 at 30Mbps with X=99% | (b) CG in FR1 at 30Mbps with X=99% |   Figure 1. DL Capacity evaluation of the different link adaptation schemes (with/without eCQI) for CG traffic (Video Single-Stream) and AR/VR (Video Single-Stream) 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).  **Proposal 7: 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*.***  **Observation 6: Using different MCS index for each of the CBGs that contain data from a specific RB with a different reliability, can help in a more efficient resource allocation and possible capacity enhancement for the XR use cases.**  **Proposal 12: A new DCI format should be introduced to support different MCS index for each CBG in PDSCH. This new format can be an extension of Format 1\_1 (see details in 3GPP TS 38.212 and 38.214) where additional fields express the MCS of each CBGs to ensure diverse reliability requirements.**  **Proposal 13: Reporting of several MCSs for one TB can be done in several ways. The simplest case can be to report one MCS index per CBG. This option will of course add more complexity compared to the current mechanisms but can be optimized in greater detail to avoid sub-optimal resource allocation. An alternative is to have a base MCS index as a default value for the TB and report delta MCS reported for each CBG.**  **Proposal 14: In order to reduce the complexity at the receiver, other implementations may use a fixed modulation scheme and control the reliability by different code rates and thus reporting a base modulation of the TB, plus one code rate per CBG (or groups of CBGs).**  **Proposal 15: A new DCI format should be introduced to show the dependencies between CBGs. This new format can be an extension of Format 1\_1 (see details in 3GPP TS 38.212 and 38.214) where additional fields clarify the dependency information among the CBGs and indicate new data from each of the CBG bundles.**  **Proposal 16: CBG dependency information can be used at the UE receiver side to enable forwarding of the data from each RB to higher layers upon correct reception of it.** |
| Ericsson | The technique *Enhanced link adaptation for CBG-based transmission* we understand as mainly implementation and it is not related to specification enhancement although the proponent mention that CSI reporting could be improved by limiting the number of Code Block Groups that should fail with a 10% probability. Our understanding is that since mapping of coded bits is frequency-first, all Code Blocks (CBs) will experience similar SINR. That is, all CBs could be regarded to have same error probability . For large BWP when a CB only will cover a part of the bandwidth, it is possible to use NR’s interleaved VRB-to-PRB mapping to average out SINR for all CBs and to make the CBs having similar error probability. When CSI is determined by the UE, it is our understanding that the UE reports a CQI corresponding a TB such that  where is the number of CBs for the TB. From the above equation gNB could determine the CB error probability and clearly also the CBG failure rate from the number of CBs per CBG . Furthermore, from the gNB could determine the SINR from which the link adaptation could choose a MCS such that the CBG failure rate is below some preferred value.  **Observation: Current CSI reporting framework enables link adaption to choose a MCS such that the CBG failure rate is below a preferred value while VRB-to-PRB mapping can average out SINR for all CBGs.**  We agree that CBG-based transmission is likely beneficial for XR but based on our understanding we do not see a motivation to change the CSI reporting for CBG-based transmission.  **Proposal: Deprioritize further study of CSI enhancements specific to CBG-based transmission.** |
| 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.  **Proposal 3: 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.**  **Proposal 4: For link adaptation for XR, reuse the 4-bit full sub-band CQI together with implementation-based CQI filtering.** |
| LG | (Common view for all link adaptation enhancements*)*  **Proposal: De-prioritize study on enhancement of link adaptation.** |

### 4.3.1 Initial discussion

Proponents have provided comprehensive simulation results and analysis. It is important proper feedback is provided with respect to this topic. Moderator recommends to focus the discussion on the following:

#### Proposal 4-3-1

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether to study CQI report enhancements based CBG to improve XR capacity performance.
  + Option 2: Decide by RAN1#110bs whether to study CQI report enhancements based CBG to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Prefer Option 2. RAN1 should strive to discuss the general evaluation assumption for this specific enhancement. Besides, we suggest to capture the simulation/evaluation results of this enhancement and form some observations for this enhancement in this meeting. If offline time permitted, we should let the proponent to elaborate on the enhancement mechanism using 1 or 2 minutes to let companies get a more compresensive view on it. |
| Qualcomm | Prefer Option 1 (unless proponents need extra meeting to provide simulation results) |
|  |  |

## 4.4 CQI report for different BLER and different XR flows

**Status of inputs in the contributions:**

* **Companies with view (4):** Rakuten, Samsung, Ericsson, LG
  + **Supportive (2)**: Samsung, Rakuten
  + **Not supportive (2):** Ericsson, LG
* **Capacity performance results (0):** Not available

**Moderator’s observation and suggestion for discussion:**

From Moderator perspective, at least a discussion around the questions below are useful:

* **Key questions: Considering the discussions from proponents, as well as the opponents in respective contributions, what is the view on the necessity and benefit of the proposed enhancements?**

|  |  |
| --- | --- |
| **Company** | **Summary of discussion proposals and observation** |
| Samsung | Link adaptation should be different for TBs with I-frames/slices and for TBs with P-frames/slices at least in terms of CQI reporting because the corresponding BLERs and the scheduling strategy including retransmissions are likely to be materially different. Rel-17 supports CQI mapping to either 10-1 or 10-5 target BLER. At least the 10-5 value is not appropriate for XR (too low and would result to poor spectral efficiency) while the 10-1 value is too large for CBs of I-frames, particularly when considering the PDB. Using an intermediate value of 10-3 target BLER can be considered because, although the network may to some extent infer that CQI from another target BLER value such as 10-1, the actual CQI for a given BLER is UE implementation dependent.  **Proposal: Support (a) configuration of BLER for CQI reporting and (b) CQI with multiple values for respective multiple types of video frames.** |
| Rakuten | XR traffic contains multiple flows, each with a different set of characteristics and requirements. For example, the reliability and delay requirements of a video flow can be different than that of a pose/control data flow. To help the scheduler better allocate the resources to match the requirements of different flows, enhancements on CSI reporting mechanisms can be studied to adapt transmission parameters more efficiently for different flows.  **Proposal: Consider enhancements of CSI reporting for multiple XR traffic flows.** |
| Ericsson | Already in Rel-15 it was discussed to define more CQI tables between 0.1 and 1e-5 since not all URLLC services has the extreme 1e-5 reliability requirement. Still, it was concluded that no additional table was needed. For URLLC with more relaxed requirements than 1e-5 it was left for gNB to maintain a coding model for UE decoding performance in order to map CQI defined for 0.1 or 1e-5 BLER target to a SINR value and then use the SINR and the coding model to determine which MCS is suitable for e.g. 1e-3 BLER target. For URLLC this was judged to work fine. Although XR has larger packets as compared to URLLC, we do not see how a new CQI table with a BLER target of, say 1e-3, would help link adaptation to better select an MCS for XR. Current MCS tables are designed such that one step in MCS corresponds roughly to 1 dB step in required SINR to maintain same BLER. For a large Transport Block Size (TBS) the LDPC BLER curves for different MCS are quite close to stair-step like such that 1 dB change in SINR can easily change BLER from 0.9 to 1e-5. This also means that for a fixed SINR, it is often impossible find a MCS that yield a target BLER of say 1e-3. Either a MCS that yield a higher BLER or a MCS that yield a lower BLER must be selected. Our understanding is that a new CQI table with BLER target between 0.1 and 1e-5 will not provide any significant gain or ease the task faced by the link adaption.  **Proposal: Deprioritize further study of new CQI tables with a BLER target for XR purpose** |
| LG | (Common view for all link adaptation enhancements)  **Proposal: De-prioritize study on enhancement of link adaptation.** |

### 4.4.1 Initial discussion

Moderator recommends to focus the discussion on the following:

#### Proposal 4-4-1:

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether to study CQI report for different BLER and different XR traffic to improve XR capacity performance.
  + Option 2: Decide by RAN1#110-bs whether to study CQI report for different BLER and different XR traffic to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Prefer Option 2. RAN1 should strive to discuss the general evaluation assumption for this specific enhancement. Besides, we suggest to capture the simulation/evaluation results of this enhancement and form some observations for this enhancement in this meeting. If offline time permitted, we should let the proponent to elaborate on the enhancement mechanism using 1 or 2 minutes to let companies get a more compresensive view on it. |
| Qualcomm | Prefer Option 1 (unless proponents need extra meeting to provide simulation results) |
|  |  |

## 4.5 Enhancements based Measurement gap

**Status of inputs in the contributions:**

* **Companies with view (5):** MediaTek, Nokia/NSB, Ericsson, LG, Futurewei
  + **Supportive (2)**: MediaTek, Nokia/NSB
  + **Not supportive (3):** Ericsson (in XR SI), LG, Futurewei
* **Capacity performance results (2):** Available (MediaTek, Nokia/NSB)

**Moderator’s observation and suggestion for discussion:**

From Moderator perspective, at least a discussion around the questions below are useful:

* **Key questions: Considering the discussions from proponents, as well as the opponents in respective contributions, what is the view on the necessity and benefit of the proposed enhancements? What is the preferred WI/SI to investigate the proposed enhancement?**

|  |  |
| --- | --- |
| **Company** | **Summary of discussion proposals and observations** |
| MediaTek | **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 4 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   * current spec only allows RRC reconfiguration to change the MG settings or enable/disable MG.   **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”)  **Proposal 1:** Support dynamic L1 based MG activation/deactivation for XR capacity enhancement.   * The structure of a MG is similar to a DRX cycle, both including a duration and a period. This dynamic L1 based MG activation/deactivation is to the MG like R16 WUS is to the CDRX. |
| Nokia/NSB | Scheduling restrictions due to intra-freq measurements (SMTC) **Observation 1**: 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 3. Percentage of satisfied XR users obtained from system-level simulations for DU, with/without scheduling restrictions during SMTC windows of 5 ms for every 20 ms time period.***  **Proposal 9:** FR2 solutions for the gNB to instruct the UE to prioritize PDCCH/PDSCH decoding during a sub-set of SMTC windows shall be further studied such that XR payloads can be scheduled timely without unnecessary scheduling restrictions.  **Proposal 10:** 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. Detailed solution is FFS. Scheduling restrictions due to inter-freq meas. gaps **Observation 2:** 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 5.1.  **Observation 3:** 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 5.1).  **Proposal 11:** For UEs configured with inter-frequency measurement gaps, solutions where the gNB can signal the UE to skip a measurement gap or the UE can signal the intend to skip a measurement gap (to avoid scheduling restrictions) shall be further considered. The gNB-2-UE signaling for this may be realized via a new compact DCI format |
| Ericsson | As measurement gap is a part of mobility framework and it can’t be taken out of context. Allowing scheduling in measurement gaps may have serious impact on mobility in the whole system, because inter-cell measurements performed by UE are usually aligned with broadcast channels of neighbouring cells and under control of upper layers. Thus, any change in measurement gap framework should be assessed carefully by all relevant RAN groups. Moreover, measurement gaps decrease overall system capacity even for eMBB users and not for XR traffic alone, therefore, it is a generic issue.  Based on above discussion, we propose to approach mobility-related enhancements via relevant working item.  **Proposal: Do not consider measurement gaps-based enhancements in XR study. Such enhancements can be investigated under mobility enhancements WI if necessary.** |
| 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.  **Proposal 5: 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.** |
| LG | (Common view for all link adaptation enhancements)  **Proposal: De-prioritize study on enhancement of link adaptation.** |

### 4.5.1 Initial discussion

Proponents have provided comprehensive simulation results and analysis. It is important proper feedback is provided with respect to this topic. Moderator recommends focusing the discussion on the following:

#### Proposal 4-5-1:

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether to study the measurement gaps based enhancement techniques to improve XR capacity performance.
  + Option 2: Decide by RAN1#110-bs whether to study the measurement gaps based enhancement techniques to improve XR capacity performance
  + Note: Any measurement gap based enhancements that impacts layer 3 is depriorotized.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Prefer Option 2. RAN1 should strive to discuss the general evaluation assumption for this specific enhancement. Besides, we suggest to capture the simulation/evaluation results of this enhancement and form some observations for this enhancement in this meeting. If offline time permitted, we should let the proponent to elaborate on the enhancement mechanism using 1 or 2 minutes to let companies get a more compresensive view on it.  Since this enhancement is proposed by us, we want to provide some supplement details on how to do the simulation. To accomodate the measurement gap impact on scheduling, the CDRX framework can be used. By setting proper ON duration, OFF duration, and set inactive timer to zero, it should not be hard to generate simulation results with measurement gap and see the amount of capacity drop with measurement gap present, either for all UEs or 20% cell edge UEs (with worst signal quality). |
| Qualcomm | We support MTK in realizing how important this topic and that it is crucial to be addressed since it affects capacity. Prefer that RAN2 decides on solutions. |
|  |  |

## 4.6 Inter/Intra UE mux/prioritization enhancements

**Status of inputs in the contributions:**

* **Companies with view (5):** LG, FGI, Futurewei, Nokia/NSB, Ericsson
  + **Supportive (2)**: LG, FGI
  + **Not supportive (3):** Futurewei, Nokia/NSB, Ericsson
* **Capacity performance results (0):** Not available

**Moderator’s observation and suggestion for discussion:**

From Moderator perspective, at least a discussion around the questions below are useful:

* **Key questions: Considering the discussions from proponents, as well as the opponents in respective contributions, what is the view on the necessity and benefit of the proposed enhancements?**

|  |  |
| --- | --- |
| **Company** | **Summary of discussion proposals and observations** |
| LG | It would be desirable to prioritize XR traffic having stringent requirements like short PDB or higher reliability not only over eMBB but also over other XR traffics.  Considering XR services and multiple flows of XR characteristics, priority handling for XR traffic would need to be improved. Until Rel-17, it was assumed that eMBB service uses low priority (LP) and URLLC or important traffics uses high priority (HP). However, a single XR service could have various traffic flows, and all those would need to be treated as higher priority than eMBB, but it may be not necessary to treat as high priority as URLLC. Moreover, it would be meaningful to prioritize one traffic flow among multiple XR traffic flows. Therefore, 2-level of priority may be not sufficient to handle all of those cases.  For example, If we try to prioritize or protect a transmission of I-frame from a transmission of P-frame, it should be necessary to distinguish I-frame from P-frame in terms of scheduling. If there is an URLLC scheduling as well, 3-level of priority may be necessary to handle the case.  If dynamic scheduling is used, gNB may be able to choose priority of each transmission carefully for each slot. However, as mentioned above, most of XR service would use SPS/CG for supporting periodic traffic flow, where SPS/CG cannot change its priority after the configuration. Therefore, XR-specific priority handling would be required so that UE can prioritize XR service over eMBB while prioritizing URLLC over XR.  **Proposal 10: For XR-specific capacity improvement, it can be considered to study XR-specific priority handling.** |
| FGI | XR is a new type of service that have some characteristics of eMBB traffic, e.g., high data rate, and some characteristics of URLLC traffic, e.g., low latency. Obviously, XR traffic can be prioritized over eMBB traffic due to the tight PDB in XR. However, whether XR traffic should be prioritized over URLLC or XR traffic should have the same PHY priority as URLLC traffic needs further discussing. The latency requirement for URLLC is at most 1 ms in release 16, while the latency requirement for XR may be around 5 – 30 ms, which is much more looser than the one for URLLC. Therefore, we think URLLC traffic should be prioritized over XR traffic and XR traffic should be prioritized over URLLC. Since, the current specificiations cannot use PHY priority to distinguish XR traffic and URLLC traffic, we propose to introduce a new PHY priority for XR.  **Observation 3: Because the latency requirement for XR traffic may be tighter than the latency requirement for eMBB traffic, XR traffic should be prioritized over eMBB traffic.**  **Observation 4: Because the latency requirement for URLLC traffic is much more tighter than the latency requirement for XR traffic, URLLC traffic should be prioritized over XR traffic.**  **Proposal 7: RAN1 to introduce a new XR-specific PHY priority for intra-UE multiplexing.** |
| Nokia/NSB | **Observation 4:** Intra-UE multiplexing data from different RBs with dissimilar reliability targets into one TB with a single MCS is not efficient.  **Observation 5:** XR traffic is composed of several flows (e.g. video, audio, haptic, etc.) that require a wide range of reliability. Intra-UE multiplexing all these flows into one TB with a single MCS that is selected to satisfy the most strict reliability results in a poor link utilization and a lower user capacity. |
| Futurewei | A set of proposed techniques related to inter-UE/intra-UE multiplexing are given below to improve XR capacity.  Before investigating these proposals, a few things need to be clarified and defined. First, the scenarios must be defined to study the inter-UE/intro-UE multiplexing issues and performance and these scenarios will be different from the scenarios agreed so far and the relevance of such scenarios and issues to capacity improvement objective is not clear. Furthermore, for these to-be-defined scenarios, proper baseline scheme along with its configuration is to be defined. Note that some overall multiplexing scheme, inter/intra-UE as well as eMBB/XR/URLLC combinations are all under consideration and situation can be quite complicated.  **Proposal 6: For enhancement for multiplexing techniques to improve XR capacity, the scenarios need to be clarified and defined first before investigating the proposals.** |
| Ericsson | Enhancements on Inter-UE prioritization/multiplexing Regarding inter UE pre-emption enhancements, we understand the main proposal is to enhance DL pre-emption signalling accuracy in frequency domain to let XR PDSCH transmission recover after being pre-empted by URLLC transmission or another XR UE transmission of higher priority (e.g., I-frame or audio/data packet). We understand such enhancements are based on assumptions that are questionable (more details in the contribution)   * Assumption on pre-emption of XR traffic * Assumption on pre-emption of one type of stream to prioritize another stream * Assumption that pre-emption indication is coarse in frequency and can be improved   **Observation: Pre-emption of XR traffic has low relevance and enhancements of current signaling mechanisms are not justified.** Enhancements on Intra-UE prioritization/multiplexing According to our understanding the main suggestion is to increase number of physical layer priorities from two levels (one bit) to more levels (more than one bit).  Considering the whole PHY layer priority framework because of Rel-16 and Rel-17 enhancements, we see no opportunity to enhance it (details in contribution).  Other than that, according to our understanding, the fundamental bottleneck for intra-UE multiplexing/prioritization is usage of only one processing chain in a UE per carrier which poses out-of-order rule to dynamically scheduled transmissions. Without adding multiple processing chains to one carrier, the framework likely can’t be improved.  **Proposal: Deprioritize further study of Inter/Intra-UE prioritization/multiplexing enhancements** |

### 4.6.1 Initial discussion

Moderator recommends to focus the discussion on the following:

#### Proposal 4-6-1:

* Select one of the following options in RAN1#110:
  + Option 1: Decide by RAN1#110 whether to study intra/inter UE prioritization/multiplexing enhancements to improve XR capacity performance.
  + Option 2: Decide by RAN1#110 whether to study intra/inter UE prioritization/multiplexing enhancements to improve XR capacity performance.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| MTK | Prefer Option 2. RAN1 should strive to discuss the general evaluation assumption for this specific enhancement. Besides, we suggest to capture the simulation/evaluation results of this enhancement and form some observations for this enhancement in this meeting. If offline time permitted, we should let the proponent to elaborate on the enhancement mechanism using 1 or 2 minutes to let companies get a more compresensive view on it. |
|  |  |
|  |  |

## Other enhancements

Companies have proposed other enhancements as listed in the table below. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for these enhancements, capacity performance evaluations are not currently available.

**Moderator’s observation and suggestion for discussion:**

It is important to have a discussion to assess the necessity and benefit these enhancements.

From Moderator perspective, some questions are listed below to facilitate the discussion:

* **Cross-carrier HARQ retransmission (MediaTek): What is the view on the necessity and benefit of this family of enhancements?**
* **Dropping mechanism (NEC, Rakuten): Is it correct to assume these proposals on high level belong to the same category? Does the dropping mechanism L1 related? Considering the descriptions provided in respective contributions, what is the view on the necessity and benefit of this family of enhancements?**

|  |  |
| --- | --- |
| **Company** | **Proposal and Observations** |
| MediaTek | **Observation 4**: The sub-6 TDD bands are widely deployed for 5G-NR. They suffer however from large latency, penalizing the XR deployment in these bands, and the UL/DL TDD pattern is the bottleneck for the XR latency for deployment on sub-6 TDD bands.  **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 |
| NEC | **Proposal 6**: Specify a higher layer parameter of ‘frame per second’ for the frame rate of XR traffic.  **Proposal 9**: Study mechanism of packet dropping based on the PDB requirement, in order to avoid resource waste due to the out-of-date packets. |
| Rakuten | **Proposal 5**: Study dropping mechanisms for packets that are not likely to meet the packet delay budget. |

### Place holder fro discussion

TBD

# Conclusion

This document provides a summary of the contributions submitted to RAN1#110 under Agenda item 9.11.2 regarding the study of candidate enhancement techniques for XR capacity improvements, together with an overview and high level key questions to facilitate the initial discussions.

# References

|  |  |  |
| --- | --- | --- |
| [**R1-2205751**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205751.zip) | XR Capacity Evaluation and Enhancements | FUTUREWEI |
| [**R1-2205844**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205844.zip) | XR-specific capacity enhancements techniques | TCL Communication Ltd. |
| [**R1-2205878**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205878.zip) | Discussion on XR-specific capacity enhancements techniques | Huawei, HiSilicon |
| [**R1-2205917**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205917.zip) | Discussion on capacity enhancements for XR | Ericsson |
| [**R1-2206008**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206008.zip) | Discussion on XR specific capacity enhancements techniques | Spreadtrum Communications |
| [**R1-2206062**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206062.zip) | Discussion on XR specific capacity enhancements | vivo |
| [**R1-2206132**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206132.zip) | Discussion on XR-specific capacity enhancements | Sony |
| [**R1-2206226**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206226.zip) | XR-specific capacity enhancements | Nokia, Nokia Shanghai Bell |
| [**R1-2206329**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206329.zip) | Discussion on XR specific capacity enhancements techniques | OPPO |
| [**R1-2206385**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206385.zip) | NR enhancement for XR capacity improvement | CATT |
| [**R1-2206475**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206475.zip) | Discussion on XR-specific capacity enhancements | NEC |
| [**R1-2206519**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206519.zip) | XR-specific capacity enhancement techniques | Lenovo |
| [**R1-2206602**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206602.zip) | Discussion on XR specific capacity enhancement techniques | Intel Corporation |
| [**R1-2206703**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206703.zip) | Discussion on XR specific capacity enhancement for NR | China Telecom |
| [**R1-2206847**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206847.zip) | Considerations on XR Capacity Improvements | Samsung |
| [**R1-2206932**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206932.zip) | Discussion on XR-specific capacity enhancements techniques | CMCC |
| [**R1-2206960**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206960.zip) | Discussion on SPS and CG enhancements for XR capacity improvement | ETRI |
| [**R1-2206964**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206964.zip) | On XR-specific capacity enhancements techniques | Google Inc. |
| [**R1-2207009**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207009.zip) | On XR specific capacity improvement enhancements | MediaTek Inc. |
| [**R1-2207043**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207043.zip) | Discussion on XR-specific capacity enhancement techniques | LG Electronics |
| [**R1-2207062**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207062.zip) | XR specific capacity enhancements | ZTE, Sanechips |
| [**R1-2207077**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207077.zip) | Discussion on XR specific capacity enhancements | CEWiT |
| [**R1-2207095**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207095.zip) | Disscusion on XR-specific capacity enhancements techniques | FGI |
| [**R1-2207254**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207254.zip) | Capacity enhancement techniques for XR | Qualcomm Incorporated |
| [**R1-2207264**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207264.zip) | Discussion on XR-specific capacity enhancements techniques | InterDigital, Inc. |
| [**R1-2207301**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207301.zip) | Discussion on XR-specific capacity improvements | Rakuten Mobile, Inc |
| [**R1-2207352**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207352.zip) | XR-specific capacity enhancements techniques | Apple |
| [**R1-2207427**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207427.zip) | Discussion on XR specific capacity improvement enhancements | NTT DOCOMO, INC. |