3GPP TSG-RAN WG1 Meeting #109-e R1- 22xxxxx

E-meeting, May 9th – 20th, 2022

Agenda Item: 9.11.2

Source: Moderator (Ericsson)

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

Document for: Discussion, Decision

# 1 Introduction

The objectives of the SID on XR enhancements for NR in Rel-18 are listed in the following [1]:

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| --- |
| The study is to be based on Release 17 TR 38.838, on corresponding Release 17 work from SA4 (as per SP-210043) and on Release 18 work from SA2 (as per SP-211166).  Objectives on XR-awareness in RAN (RAN2):   * Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial for the gNB to be aware of. * Study how the above information aids XR-specific traffic handling.   Objectives on XR-specific Power Saving (RAN1, RAN2):   * Study XR specific power saving techniques to accommodate XR service characteristics (periodicity, multiple flows, jitter, latency, reliability, etc...). Focus is on the following techniques:   + C-DRX enhancement.   + PDCCH monitoring enhancement.   Objectives on XR-specific capacity improvements (RAN1, RAN2):   * Study mechanisms that provide more efficient resource allocation and scheduling for XR service characteristics (periodicity, multiple flows, jitter, latency, reliability, etc…). Focus is on the following mechanisms:   + SPS and CG enhancements;   + Dynamic scheduling/grant enhancements. |

This document provides the summary of the discussions regarding the last SID objective regarding XR-specific capacity improvements during RAN1#109-e under the following email thread assigned by RAN1 Chair:

//This one is to use NWM – please use RAN1-109-e-NWM-R18-XR-04 as the document name

[109-e-R18-XR-04] Email discussion on XR capacity enhancement by May 20 – Sorour (Ericsson)

* Check points: May 13, May 20

# Discussion topics

## Performance evaluations and methodologies

The following table lists the proposals and observations in the contributions submitted in this meeting related to the performance evaluations and methodologies for XR capacity enhancements techniques.

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| --- | --- |
| **Company** | **Proposals and Observations** |
| FUTUREWE | Observation 1: For the FR1 Dense Urban Scenario and with the assumption of zero forcing precoding, the capacity of the XR system is ~8.0 UEs/cell for uneven UE load, with data packet rate of 45Mbps, with slot configuration of [DDDUU]. Observation 2: For the FR1 UMa Scenario and with the assumption of zero forcing precoding, the capacity of the XR system is ~5.2 UEs/cell for uneven UE load, with data packet rate of 45Mbps, with slot configuration of [DDDUU]. Observation 3: For the Dense Urban Scenario with the BiT precoding assumption, the gain is 64.8% for the XR system capacity with the assumption of having uneven, with data packet rate of 45Mbps, with slot configuration of [DDDUU]. Observation 4: For the UMa Scenario with the BiT precoding assumption, the gain is 26.9% for the XR system capacity with the assumption of having uneven load, with data packet rate of 45Mbps, with slot configuration of [DDDUU]. 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. |
| vivo | Observation 2: It is benifical to use CG PUSCH for conveying UL pose/control stream, as well as for BSR reporting for XR traffic. Observation 5: It is beneficial to study potential enhancements for UL packet discarding for XR traffic. |
| ZTE, Sanechips | Observation 3: Compared to legacy SPS, MCS update techniques are beneficial to increase resource utilization, which results in capacity performance enhancement. Observation 4: Unused resources release techniques help UE save power consumption from blind SPS PDSCH detection. Observation 7: Multiple CG configurations with resource release and resource indication can provide capacity performance gain compared to legacy multiple CG configurations. Observation 8: For both 10Mbps@60fps traffic model and 20Mbps@60fps traffic, more than a half proportion of packet sizes are overestimated using BS level table in [3]. Observation 9: In uplink transmission, overestimated packet sizes may cause capacity performance loss. And uplink transmission with precise BSR indication can bring capacity performance gain. Observation 10: Delta MCS information for re-transmission is capable of increasing significantly XR capacity performance. Observation 11: The delta MCS value is relatively small, so that the overhead of signaling can be reduced. Observation 12: Enhanced preemption indication is capable of enhancing capacity performance when multi-streams model is considered in the system. Observation 13: Network coding technique is capable of enhancing the reliability of transmission. Observation 14: For 30Mbps@60fps, capacity performance is increased about [12.66%] with network coding for DL VR/AR traffic model in DL FR1 indoor scenario. Observation 15: Compared with PDCP duplication, network coding improves the system mean throughput by 8.97%, and improves the 5% UE throughput by 21.3%. |
| Ericsson | Observation 6 Current BSR coding model introduces uncertainties impacting system capacity with XR traffic. Observation 7 Including additional delay information in BSR can increase system capacity. Observation 8 If late application packets are not of value for an XR service, solutions dropping application packets that are expected to be late will allow for increased XR capacity. Proposal 7 For performance evaluation of candidate capacity enhancement techniques, reuse as much as possible the evaluation methodology and simulation assumptions in TR 38.838. |
| InterDigital, Inc. | Observation 1: Achieving high system capacity with XR traffic in UL and DL in different deployment scenarios (e.g. InH, DU, UMa) is extremely challenging Observation 2: Given the interdependencies between the PDUs, all PDUs in a PDU set need to be successfully delivered within a PDU set-level latency requirement for counting towards capacity Observation 3: In multi-stream scenario, the PDUs in different traffic streams need to be received by UE (in DL) or application server (in UL) within a maximum inter-stream jitter value to be counted towards capacity Observation 4: Transitioning from InH to DU deployment scenario has a significant impact on the capacity as shown by a large drop in #UEs/cell that can be supported for all XR applications Observation 5: In DU deployment scenario, FIFO based scheduling slightly outperforms PF at low load, while PF scheduling yields best performance as the load increases  Observation 6: UL capacity of multi-stream traffic is typically less than that of single-stream traffic when using PF and FIFO based scheduling approaches. Observation 7: Resource sharing based scheduling approach (e.g. allocation of RBs to all UEs in cell) enables UL capacity achieved with multi-stream traffic to be similar with that of single stream traffic Observation 8: PF-based scheduling is generally suited for maximizing purely throughput-based performance. However, the limiting factors for capacity due to the PDB requirements make PF-based scheduling less suited for XR traffic Observation 9: As enhancement schemes, FIFO and resource sharing based scheduling can be better suited to meet XR-specific traffic requirements such as PDB and high throughput, and can in turn yield improved capacity performance when compared to a purely PF based approach. Observation 10: Handling of lower size of per-PDU set (e.g. for I-frame, P-frame), on average, for DL multi-stream traffic case can result in slightly higher percentage of satisfied UEs compared to the single stream case Proposal 3: RAN1 to perform evaluations of XR-specific resource allocation and scheduling enhancement techniques for evaluating the capacity performance Proposal 4: Reuse the baseline evaluation assumptions (e.g. deployment scenarios, SLS parameters, traffic models) in TR 38.838 when evaluating capacity performance Proposal 5: Starting point for potential enhancement techniques for capacity can be those identified during Rel-17 SI (e.g. delay aware scheduling, prioritizing/pre-empting important streams in DL/UL, multi-TB scheduling, enhanced BSR) |
| Nokia, Nokia Shanghai Bell | Observation 1: Adding more eMBB users deteriorates the QoE of the XR users. This is the key point that should be considered when using more realistic simulation scenarios with multiple types of traffic. Observation 2: Use of CBG-based HARQ transmissions is beneficial for XR use cases, given the large transport block sizes, as well as the PDB that allows for couple of HARQ retransmissions. Observation 3: The current link adaptation mechanisms, and the corresponding UE CQI feedback designs are suboptimal for CBG-based transmissions. Observation 4: Application of enhanced CQI scheme can enable enhanced OLLA to improve the performance of the CBG-based transmission. For instance, as shown in Figure 2, the number of satisfied users has increased by 2 times for the case with enhanced CQI and eOLLA. Proposal 1: Use the capacity evaluation methodology from TR 38.838 as a starting point, when developing the methodology for capacity enhancements studies in Release 18 Study on XR Enhancements for NR . Proposal 2: To facilitate efficient study of applicable capacity enhancements schemes, identify the minimum set of simulation parameters and deployments. Example areas for potential down scoping: e.g., deployment scenario, frequency range. Proposal 3: The proposed unified set of traffic model parameters for capacity enhancements evaluations is summarized in Table 1. Proposal 4: Use the baseline KPIs for capacity evaluation from TR 38.838 and Rel17 XR over NR SI. Proposal 5: It is suggested to include one optional simulation case with XR and best effort eMBB users. All the scenario assumptions for DU and InH, as well as the XR traffic models and XR performance KPIs remain the same as in [2], while just adding N full buffer eMBB background users per cell. The default value of N is 1, but other values are also acceptable.  Proposal 6: For the option with XR and best effort eMBB users, we suggest defining additional standard KPIs for eMBB performance such as: average aggregated eMBB cell throughput, 5%-ile, 50%-ile and 95%-ile eMBB user throughput. Other KPIs to reflect the eMBB performance are not excluded. |
| MediaTek Inc. | Observation 3: 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). In measurement gap, NW cannot schedule UE to transmit/receive data. l A system level simulation shown 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). |
| Qualcomm Incorporated | Observation 2: Soft HARQ-ACK is observed to provide a significant gain in XR capacity over baseline HARQ-ACK. Observation 3: The gain of soft HARQ-ACK relative to baseline HARQ-ACK increases when the HARQ round trip delay increases. |

**Moderator’s summary:**

Few companies have provided simulations results as part of the analysis of the capacity enhancement techniques. The techniques are based on physical layer enhancements, higher layer enhancements or both, but companies provided system level evaluation results since RAN1 has traditionally been the home for carrying out simulations to provide the quantitative analysis.

* **Companies with simulation results in respective contributions**
  + FW, vivo, ZTE, Ericsson, IDC, Nokia, MTK, QC

Irrespective of the techniques, general proposals on the assumptions and/or role of simulations are provided which are categorised as the following:

* **Proposals to confirm reusing Rel-17 XR SI simulation assumptions, as well as minimum set for Rel-18 SI.**
  + Ericsson, Nokia
* **Proposals to emphasize on inclusion of performance evaluations for analysis of the techniques**
  + Nokia, IDC
* **Proposals to further identify a mixed traffic simulation assumptions to facilitate efficient study** 
  + Nokia

### 2.1.1 Discussion 1st round

**Moderator’s comment:**

This section can focus on general aspects related to the evaluation methodologies as well as discussions on collection and organization of the simulations results.

With respect to simulation results presented in a contribution to investigate an enhancement technique, companies are encouraged to provide their views and comments in the section covering the related discussions of the enhancement technique. For the review, please consider the information provided in the related contributions.

Therefore, the related proposals for discussions on evaluation methodologies for the first round of discussions are presented below. In the feedback table, companies’ views on these proposals as well as other aspects are kindly requested.

**Proposal 1-1:**

* For performance evaluation of candidate capacity enhancement techniques for Rel 18 XR SI,
  + the capacity evaluation methodology and KPIs from TR 38.838 are reused.
    - the minimum set of the traffic model parameters in the table below are reused as baseline, similarly to Rel-17 XR evaluation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Traffic models** | | **Data rate**  **[Mbps]** | **Packet arrival rate**  **[fps]** | **PDB**  **[ms]** |
| DL | AR/VR | 30 | 60 | 10 |
| CG | 30 | 60 | 15 |
| UL | VR/CG: Pose/control | 0.2 | 250 | 10 |
| AR: Option 1 (single stream model) | 10 | 60 | 30 |

**Proposal 1-2:**

* To analyze the candidate capacity enhancement techniques, RAN1 strives to evaluate the capacity performance gain by the techniques.

**Proposal 1-3:**

* Include one optional simulation case with XR and best effort eMBB users as the following:
  + Add N full buffer eMBB background users per cell. The default value of N is 1.
    - Other values are not excluded.
  + Define additional standard KPI for eMBB performance as the average aggregated eMBB cell throughput, 5%-ile, 50%-ile and 95%-ile eMBB user throughput.
    - Other KPIs to reflect the eMBB performance are not excluded.
  + Note: All the scenario assumptions for DU and InH, as well as the XR traffic models and XR performance KPIs remain the same as in TR 38.838

|  |  |
| --- | --- |
| **Questions:**   * **Q1**: What is your view on discussion above and the Proposals 1-1, 1-2, 1-3?   + Please indicate whether in general you are supportive, and whether you have suggestions to improve the description of the proposals. * **Q2:** Please share any other comment that helps this discussion, including views on aspects regarding the collection and organization of the simulation results. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | We are generally fine with proposals.  We have one comment on proposal 1-3. We understand that eMBB UE degrades XR traffic performance but also need to be served. However, it should be discussed what best effort eMBB performance means and how to measure it.  If we consider full buffer eMBB UE in a cell, considering latency requirements and traffic arrival of XR, gNB should reserve some resources for XR from eMBB UE. In this circumstance, best effort eMBB performance would be highly dependant to scheduler’s prediction of resource usage for XR, unless considering UL/DL cancellation/pre-emption during evaluation. We think it is not main purpose of new KPI of eMBB UE.  We are open to discuss how to take in account impact of eMBB UE. |
| Samsung | No issue with proposal 1-2 but it seems unnecessary.  Proposal 1-3 is meaningful but having a default value of N=1 and full buffer rather defeats the purpose (e.g. the results for XR would be similar as if a chunk of the available BW, on average, was cut off to serve eMBB – e.g. 15 MHz instead of 20 MHz were available on average or something similar for other larger BWs).  Also, although proposal 1-3 (with proper parameters) would be essential for realistic XR capacity evaluations, it is unlikely to have any impact on the discussions for mechanisms to improve XR capacity. Then, the question is whether it would offer any actual benefit for the short XR SI given all other issues. |
| InterDigital | We are fine with proposals 1-1 and 1-2. For proposal 1-3, similar to the comments provided by LG and Samsung, we do not see how consideration of best effort eMBB UEs could provide new insights in terms of improving capacity for XR UEs. However, as an optional simulation case as indicated by proposal 1-3, we are open to further discussing the proposal, including consideration of new KPIs. |
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## SPS and CG enhancements

The following table lists the proposals in the contributions submitted in this meeting, discussing views on SPS and CG enhancement techniques. 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.

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| --- | --- |
| **Company** | **Proposals** |
| Huawei, HiSilicon | Proposal 1: Further study capacity enhancements techniques to address variable frame size issue, including mechanisms to allow re-allocating the unused configured grant (CG) resources. |
| CATT | Proposal 3: The SPS enhancement should be considered for XR-specific traffic transmission, such as the SPS is with the additional resource indication. Proposal 4: The Configured Grant UL transmission should be enhanced to support low latency and large data rate transmission of XR traffic. |
| vivo | Proposal 1: Study potential CG PUSCH enhancements for XR video traffic, e.g., aligning with the non-integer periodicity. |
| ZTE, Sanechips | Proposal 1: Semi-persistent scheduling enhancement techniques, including e.g., indication of unused resources and updated MCS level can be studied for XR service transmission. Proposal 2: Resources indication/release can be considered for enhancing configured grant transmission. |
| Ericsson | Proposal 1 Dynamic grant should be considered as a baseline for capacity enhancement study. Proposal 2 Enhancement study of CG/SPS should be limited to non-video traffic with very predictable packet size, e.g., UL pose/BSR. Proposal 3 Study enhancements on CG/SPS periodicity to better match with XR traffic periodicity (including possible jitter) and TDD patterns. |
| 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. |
| Sony | 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 3: Multi CS-RNTIs configuration for multi flows in XR can be considered.  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. |
| Samsung | Proposal 1: Consider support of multi-TRP/panel transmission for SPS PDSCH. Proposal 6: Study mechanisms to enable CG-PUSCH transmissions from XR UEs with variable packet sizes without a-priori reservation of corresponding resources. |
| Panasonic | Proposal 1: SPS/CG/SR should efficiently handle the non-integer periodicity transmissions, including the video stream frame periodicities like 16.66667, 11.11111, and 8.33333 ms. Proposal 2: Among followings, which approach(s) are taken should be discussed further. Approach 1: Rounding the non-integer transmission instances: the beginning of SPS/CG/SR resource is rounded according to the non-integer periodicity matched to the radio resource granularity. Approach 2: Enabling/disabling the non-integer periodicity instances: A new virtual cycle is defined, which contains enable/disable states and supports non-integer periodicities. The SPS/CG/SR configurations can be linked to the virtual cycle. Only the overlapping resources with the enable state should be considered as valid for transmission or reception. Approach 3: An SPS/CG/SR configuration is configured with alternating periodicities, each periodicity is associated to a number of occasions. Approach 4: DCI to reconfigure Group of SPS/CG/SR: A DCI (re)configures several SPS/CG/SR configurations together. |
| OPPO | Proposal 2: Use the same design principle to solve the periodicity mismatch between XR traffic and DRX, search space set configuration and SPS/CG transmission. Proposal 3: SPS HARQ-ACK enhancement to reduce the HARQ-ACK overhead for jitter solution should be further studied. (e.g. Multiple SPS PDSCH occasions share one HARQ-ACK bit) Proposal 4: For SPS or configured grant transmission, allocate multiple PDSCH/PUSCH transmission occasions in each period should be further studied. Proposal 5: Adaptive resource allocation for SPS transmission should be further studied (e.g. by CG-UCI). Proposal 6: Early termination of the CG transmissions (in one XR period) should be further studied( e.g. by CG-UCI). |
| TCL Communication Ltd. | 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. |
| 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.  Proposal 3-5: Study whether code block group based transmission can be used to support QoS enhancement at lower layers. |
| CMCC | Proposal 1. Adaptive SPS/CG scheduling with simplified DCI can be considered for XR service. Proposal 2. Multiple periodicities configuration for one SPS configuration can be considered for XR service, which the multiple periodicities are used by turns. |
| NTT DOCOMO, INC. | Proposal 1: Study dynamic update of SPS/CG parameters for XR, e.g., periodicity, resource allo-cation, MCS, or TCI state/spatial relation. Proposal 2: Study multiple SPS PDSCHs or CG PUSCHs in one SPS/CG periodicity for XR (one DCI scheduling multiple PDSCHs/PUSCHs has already been supported in Rel-17 for FR2-2. It can be a starting point for studying multiple SPS PDSCHs / CG PUSCHs in one periodicity, and the work-load is expected to be not large.). |
| 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 |
| LG Electronics | Proposal 1: 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 2: It can be considered to activate/release multiple SPS/CG and/or other semi-static configuration with least number of DCIs.  Proposal 3: It can be considered to define UE behaviour on interaction between SPS/CG configurations, in order to improve overall UE capacity. |
| ETRI | Proposal 1: To efficiently serve XR traffics having non-integer periodicities, study an extension of SPS configuration to allow different periodicities to different SPS periods (e.g. P1=9ms, P2=8ms, and P3=8ms). Proposal 2: To efficiently handle XR traffic size and arrival timing uncertainty, study dynamic adaptation of SPS resources based on DCI without SPS deactivation/activation. Proposal 3: Study how to improve SPS reliability performance outside the DRX active time (e.g. to configure a supplementary SS set to allow immediate SPS retransmissions outside the active time. ) |
| Nokia, Nokia Shanghai Bell | Proposal 7: When introducing SPS enhancements, a clear benefit of SPS/eSPS for XR use cases should be provided. Proposal 8: When introducing CG enhancements, a clear benefit of CG/eCG for XR use cases should be provided. |
| MediaTek Inc. | Proposal 11: Legacy CG to be used for XR UL for pose/control information and no further enhancement required.  Proposal 12: The hybrid DG/CG scheme should be used to address the jitter for UL AR. |
| CEWiT | Proposal 1: Study enhancements to support transmission of traffic with non-integer periodicity using SPS. Proposal 2: Study enhancements to support dynamic adaptation of SPS parameters. Proposal 3: Study enhancements for SPS to handle jitter. Proposal 4: Study solutions to support multi-PDSCH transmission using SPS. |
| Intel Corporation | Proposal 1: RAN1 should investigate dynamic adaptation of SPS transmission procedure for efficient resource allocation. 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. |
| Qualcomm Incorporated | 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 methods to dynamically adapt the SPS and CG parameters to the traffic bursts. Proposal 6: 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 7: For XR, consider studying a design where a short control signal can be sent within a window before the SPS and can be used to cancel, control the occasion start time, or control other SPS parameters. 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. Proposal 10: For XR, consider studying introducing pre-configured data resources that can be activated or deactivated either explicitly or implicitly. |
| Asia Pacific Telecom co. Ltd | Proposal 3: RAN1 should study mechanisms for adaptively updating the parameters used for an activated SPS/Type-2 CG configuration without reconfiguring or reinitializing the SPS/Type-2 CG configuration. Proposal 4: RAN1 should study mechanisms for adaptively updating the parameters used for Type-1 CG configuration without reconfiguring the CG configuration. |

**Moderator’s summary:**

Many companies shared views regarding the enhancements for SPS/CG.

**Regarding enhancing CG/SPS to accommodate XR packets with large and variable sizes**, views are split in the sense that one group of companies consider CG/SPS based transmissions for these packets and hence propose enhancement. The other group consider that dynamic scheduling should be used in these cases and CG/SPS should be used for small size and predictable XR traffic.

* **Observation 2-1-A:** SPS/CG based transmissions of XR traffic with large and varying packet sizes is motivated and the corresponding enhancements are beneficial.
  + NEC, Sony, Panasonic, TCL, Apple, CMCC, CEWiT, SPS, QC, Asia Pacific, DCM, Lenovo, LG, OPPO
* **Observation 2-1-B**:Dynamic scheduling-based transmissions of XR traffic with large and varying packet sizes is motivated, and hence corresponding enhancements for CG/SPS based transmissions are not needed.
  + HW/HiSi, Ericsson, vivo, Samsung, Nokia, MTK

Companies with views in line with **Observation 2-1-A** have proposed to study at least the following areas for CG/SPS enhancements:

1. Multiple PUSCHs/PDSCHs in a period using same or different configurations (NEC, Panasonic, DC; Lenovo, LG, QC)
2. Dynamic adaptation of SPS/CG parameters (CMCC, TCL, Sony, ZTE, DCM, ETRI, CEWiT, QC)
3. SPS/CG set switching or skipping mechanisms (QC)
4. SPS HARQ-ACK enhancements (OPPO)
5. CG-UCI enhancements (Apple)
6. Other enhancements

**Regarding the non-integer periodicity**, majority of companies propose enhancements to support non-integer periodicities, while there are companies with the view that no enhancements is needed reusing the existing multiple CG/SPS configuration framework.

* **Observation 2-2-A:** Study support of non-integer periodicity for SPS configurations/Configured grant configurations.
  + Vivo, Ericsson, Sony, Panasonic, TCL, Apple, CMCC, DCM, Lenovo, LG, CEWiT, ETRI, QC, Asia Pacific
* **Observation 2-2-B**: Regarding the non-integer periodicity issue, it can be solved by configuring multiple sets of configured grants
  + HW/HiSi, [Nokia], [MTK], [Spreadtrum]

Companies with views in line with **Observation 2-2-A** have proposed to study at least the following areas to support non-integer periodicities:

1. Introduce non-integer periodicity (Apple)
2. Multiple periodicities configuration for one SPS configuration can be considered for XR service, which the multiple periodicities are used by turns (CMCC)
3. Dynamic update of periodicity (DCM)
4. Rounding the non-integer transmission instances (Panasonic):
5. Enabling/disabling the non-integer periodicity instances using a virtual cycle (Panasonic)
6. Other approaches

**Moderator’s recommendation for discussion:**

Considering the landscape of views, it is it important to first focus on a high-level discussion to understand the motivations for/against different views at this meeting.

### 2.2.1 Discussion 1st round

In the feedback table, companies’ views on SPS/CG enhancements proposals are kindly requested.

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| --- | --- |
| **Questions:**   * **Q1**: Which of the **Observations 2-1-A or 2-1-B** is aligned with your view? **Why?** How do you justify the need or lack of need for related enhancement study?   + Please indicate and motivate your position. Please include key questions and reasons with consideration to the concerns from the other group. * **Q2**: Which of the **Observations 2-2-A or 2-2-B** is aligned with your view? **Why?** How do you justify the need or lack of need for related enhancement study?   + Please indicate and motivate your position. Please include key questions and reasons with consideration to the concerns from the other group. * **Q3:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | Answer to Q1: We think SPS/CG would be useful to support XR traffic with integer or non-integer periodicity, with lower PDCCH overhead. SPS/CG is orgianlly to save PDCCH overhead for periodic traffic. In XR, the benefit still exist. Moreover, since SPS/CG always can be overridden by dynamic scheduling, it doesn’t harm to other dynamic scheduling enhancement.  Known issues on SPS/CG are resource inefficiency and handling varying packet sizes. Actually those are inter-connected, since resource inefficiency can be caused from redundant SPS/CG occasion for supporting various packet size. We think it is desirable for XR SPS/CG to introduce precise resource allocation method and selective resource usage without ambiguity between UE and gNB.  Answer to Q2: our view is aligned with Observation 2-2-A; we think non-integer periodicity is difficult to support only with multiple configuration. Based on contributions in this meeting, for supporting single video stream, at least 3 of SPS/CG configurations would be necessary (50/3 = 16.67 ms). If if we consider two or more video stream or additional audio and pose data having different characteristic, we should save the number of required SPS/CG configuration. Current maximum number of SPS/CG configuration are not sufficient to solve non-integer periodicity by multiple set of configurations. |
| Samsung | Q1: No need for SPS enhancements (agree with 2-1-B). DCI overhead is negligible for XR and DCI can always result to better link adaptation/capacity than SPS which is the objective. Any SPS enhancements will also result to increased UE power consumption (e.g. for multiple SPS configurations to decode large TBS) and/or will require DCI for adaptation while still remaining suboptimal than usual DG-PDSCH. Basically, XR traffic is a clear use-case for DG-PDSCH and does not conform with almost any of the requirements for using SPS PDSCH.  Q2: Do not agree with 2-2-A, partly agree with 2-2-B. For SPS, please see response to Q1. For CG, pose/control does not have non-integer periodicity and hence there is no issue while video will be difficult/impossible in practive to support with CG due to the required resources that will need to be reserved and the inability for dynamic link adaptation which is critical to capacity for XR. Basically, no SPS/CG enhancements are needed due to the non-integer periodicity of XR video traffic.  Q3: CG enhancements may be considered in order to address the overhead from the required resource reservation. |
| OPPO | **Q1:** We support 2-1-A. Comparing to dynamic scheduling based solution, SPS/CG enhancements can reduce DCI/UCI overhead and therefore increase PDCCH/PUCCH capacity.  Take AR/VR 30Mbps for example: the maximum packet size is 93750 bytes and the minimum packet size is 31250 bytes. Even for the minimum packet size, multiple-PUSCHs/PDSCH transmissions are needed, so the PDCCH/PUCCH saving of using SPS/CG is not small.  Dynamic adaptation of SPS/CG can be achieved at a cost of using small size indication, even without blind decoding.  Some SPS/CG enhancements are applicable to power saving purpose anyway. For example, skipping redundant SPS HARQ-ACK bits is beneficial for both PUCCH capacity and UE power saving.  **Q2:** We support 2-2-A. The non-integer periodicity issue occurs not only for SPS/CG transmission, but also with DRX and search space set configuration. We won’t say 2-2-B does not work, but think it deserves a study to find whether there is a better solution (even likely with spec impacts) over 2-2-B to solve all these issues in a more efficient way, by taking into account the complexities for both implementation and RRC signaling. |
| InterDigital | **Q1:** We think 2-1-A (SPS/CG-based) can be suitable for XR given that it leverages on the predictability of XR traffic and minimizes the overhead due to DCI/UCI tranmissions. While variable PDU/frame sizes and jitter are issues that impact the efficiency of SPS/CG-based solutions as well as dynamic-scheduling based solutions for XR, we think the enhancements related to dynamic adaptation of SPS/CG parameters could offer the flexibility needed to address the correspdoning issues.  In some scenarios (e.g. presence of large standard deviation in frame size or wide jitter range), we think 2-1-B (dynamic scheduling-based) can be beneficial as any gains in terms of overhead reduction offered by SPS/CG-based solutions may become negligible due to frequent adaptations. In this regard, we are open for considering both SPS/CG-based and dynamic scheduling-based enhancements in the study.  **Q2:** We prefer the solutions related to 2-2-A for addressing the non-integer periodicity issue as well as other issue related to handling of multiple flows. We also think one of the solutions that can be considered under 2-2-A includes enhancements to multiple SPS/CG configurations. Regarding 2-2-B, whether and how the solution for reusing the multiple CG/SPS configuration framework is robust enough to handle the non-interger periodicity issue, especially when considering a realistic scenario with presence of some jitter, is not clear and may be futher studied. |
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## Dynamic scheduling/grant enhancements

The following table lists the proposals in the contributions submitted in this meeting, discussing views on dynamic scheduling enhancement techniques. 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.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| Spreadtrum Communications | Proposal 2: The legacy HARQ-ACK mechanism and its enhancement should be investigated when assistance information from higher layer to physical layer is introduced for XR capacity enhancement. |
| vivo | Proposal 3: Study potential enhancements for multi-PXSCH scheduling, e.g. multiple PUCCHs can be indicated by a DL DCI scheduling multiple PDSCHs. |
| Ericsson | Proposal 1 Dynamic grant should be considered as a baseline for capacity enhancement study. Proposal 4 Study enhancements for multi-slot dynamic scheduling schemes including efficient MCS indication to serve XR traffic in both DL and UL directions. |
| Samsung | Proposal 2: Consider support of CBG-based HARQ-ACK reports for multi-slot PDSCH scheduling.  Proposal 3: Consider support of multiple HARQ-ACK occasions for multi-slot PDSCH scheduling.  Proposal 5: Apply BPSK/QPSK to SR to indicate 2-4 BSR values in order to reduce latency for UL scheduling. |
| OPPO | Proposal 1: For multi-PDSCH/PUSCH transmission, the exiting mechanisms for NR up to 71GHz spectrum should be reused as much as possible. |
| InterDigital, Inc. | Proposal 3: RAN1 to perform evaluations of XR-specific resource allocation and scheduling enhancement techniques for evaluating the capacity performance |
| TCL Communication Ltd. | Proposal 4: Enhancements of search space set configuration should be considered for XR. Proposal 5: Dynamic scheduling multi-PDSCH and multi-PUSCH for XR can be considered. Proposal 6: TB processing over multiple slots with no limit of CB and transmission layers can be considered for XR. |
| Apple | Proposal 3-5: Study whether code block group based transmission can be used to support QoS enhancement at lower layers. |
| CMCC | Proposal 3. Multi-TB scheduling with single DCI on the same cell can be considered to schedule multi-flow transmission of XR service. Proposal 4. Cross-carrier HARQ feedback and cross-carrier retransmission can be considered for XR service. |
| 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 4: Study if multi-PD(U)SCH scheduling should be further enhanced based on application awareness. 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. |
| LG Electronics | Proposal 4: For XR-specific capacity improvement, enhancement on scheduling request can be considered. Proposal 5: At least for jitter handling with dynamic PUSCH scheduling, it is necessary to consider UL grant scheduling overlapped or non-overlapped PUSCH resources. |
| MediaTek Inc. | Proposal 1: Under CA with different TDD patterns, data retransmission can take place on the carrier different from its initial transmission Proposal 2: Under CA with different TDD patterns, common HARQ processes pool per cell group should be introduced. Proposal 8: Multiple PDSCH scheduling could be used for the scheduling of data for a single UE across multiple slots. Multiple slots could be scheduled using a single Downlink Control information (DCI) carrying the grant of the Physical Downlink Control Channel (PDCCH). Proposal 9: New DCI formats could be defined for the XR traffic or for the PDU sets scheduling.  Proposal 10: Two stages DCI could be explored for the XR traffic or for the PDU sets scheduling. |
| Intel Corporation | 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 PUSCH scheduling to reduce DCI overhead.  • Multiple PUSCH/PDSCH scheduling solution adopted for B52.5GHz can be a starting point. |
| Qualcomm Incorporated | Proposal 9: 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 |
| Asia Pacific Telecom co. Ltd | Proposal 1 The mechanism for scheduling multiple PDSCHs/PUSCHs via a single DCI developed for Rel-17 NR-U (60 GHz) can be the baseline for NW to schedule data from XR traffic by DGs. Proposal 2 RAN1 should study how to enhance the mechanism for scheduling multiple PDSCHs/PUSCHs via a single DCI originally designed for Rel-17 NR-U (60 GHz) for XR. |

**Moderator’s summary:**

Few companies have commonly identified that studying enhancements of the **single DCI scheduling multiple PXSCHs** can be beneficial for XR. Furthermore, few specific enhancement technigues corresponding to this study area (i.e. enhancements of single DCI scheduling multi-PDSCHs/PUSCHs) are identified by companies. The corresponding main proposals are listed below:

**Proposal 3-1: Study enhancements of legacy procedures for single DCI scheduling multi-PDSCHs/PUSCHs**

* QC, Ericsson, MTK, Lenovo, vivo, TCL. Asia Pacific, Intel, CMCC, OPPO

**Proposal 3-1-A:** For single DCI scheduling multi-PDSCHs/PUSCHs, extendg capability of to FR1/FR2 (Intel, Asia)

**Proposal 3-1-B:** For single DCI scheduling multi-PDSCHs, study HARQ-ACK and CBG enhancements (vivo, Samsung, Lenovo, TCL)

**Proposal 3-1-C:** For single DCI scheduling multi-PDSCHs, study allowing different configurations per PDSCH/PUSCH, e.g., for MCS indication (QC, Ericsson)

**Proposal 3-1-D:** For single DCI scheduling multi-PDSCHs, study update of granted PDSCHs/PUSCHs after the granting DCI (QC)

Companies have also identified other areas for enhancements for **dynamic scheduling** that are not specific to single DCI scheduling multiple PXSCHs,but are beneficial for XR. The corresponding main proposals are listed below:

**Proposal 3-2-A:** Study enhancement on scheduling request for XR (LG, Samsung)

**Proposal 3-2-B:** Study HARQ-ACK enhancements based on XR specific assistance information for capacity improvement (Spreadtrum, Lenovo)

**Proposal 3-2-C:** Study whether code block group-based transmission can be used to support QoS enhancement at lower layers for XR (Apple)

**Proposal 3-2-D:** Study cross-carrier HARQ feedback and cross-carrier retransmission for XR service (CMCC, MTK)

**Proposal 3-2-E:** Study enhancements of search space set configuration for XR (TCL)

**Proposal 3-2-F:** Study Study techniques providing timely PHR for XR services (Lenovo)

**Proposal 3-2-G:** Study two stages DCI for the PDU sets scheduling of XR traffic (MTK)

**Proposal 3-2-H:** At least for jitter handling with dynamic PUSCH scheduling, it is necessary to consider UL grant scheduling overlapped or non-overlapped PUSCH resources (LG)

### 2.3.1 Discussion 1st round

In the feedback table, companies’ views on dynamic scheduling enhancements proposals are kindly requested.

|  |  |
| --- | --- |
| **Questions:**   * **Q1-1**: What is your view regarding the study topic in Proposal 3-1 during XR SI?   + Please indicate and motivate whether you are supportive or not. Please motivate your reasons. * **Q1-2**: What is your view regarding the specific study areas by Proposal 3-1-A to Proposal 3-1-D during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q2**: What is your view regarding the specific study areas by Proposal 3-2-A to Proposal 3-2-H during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q3:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | **Answer to Q1-1**: we think it is ambiguous what legacy procedure is. Multi-slot scheduling has been introduced as a solution for B52.5GHz scenario. Thus, we think the legacy procedure should be existing multi-slot scheduling mechanism. If so, we are fine with the proposal.  **Answer to Q1-2**: For 3-1-A/B/C, we are fine to study for multi-slot scheduling. For 3-1-D, we think it is not necessarily in part of multi-slot scheduling, so it should be in 3-2 family. For example, gNB can update single PUSCH by UL grant, if the PUSCH is scheduled with sufficiently long grant-to-PUSCH delay.  **Answer to Q2**: For 3-2-A, we think assist information is higly useful at least for XR UL scheduling. 3-2-A would be possible solution to transfer traffic characteristic, when traffic arrived at UE side.  For 3-2-B, we are not sure fast adapation is necessary for XR, since XR scenario generally assumes periodic traffic. If it is discussed in terms of capacity, it should be identified trade-off between CSI and HARQ-ACk enhancement in terms of resource overhead.  Proposal 3-2-H is to allow UE to update UL grant itself among options given by gNB. Since gNB cannot predict UE traffic arrival correctly, gNB can give options to UE in a form of overlapped grant, then UE can choose proper UL grant according to traffic arrival. We think this proposal is benefial for supporting various UL packet sizes. |
| Samsung | It seems Q1-1 is a super-set of Q1-2 and the intention is to down-scope the elements of Q1-2?  We think it would be sufficient for RAN1 to only consider very simple enhancements to Rel-17 and even that should be with lower priority because DCI overhead is not an issue for XR (doesn’t have any measurable impact on capacity) and single-PDSCH/PUSCH scheduling DCI offers better link adaptation than multi-PDSCH/PUSCH scheduling DCI.  For Q1-1 and Q1-2, we therefore support to further consider (with lower priority than other issues) 3-1-A and 3-1-B and drop 3-1-C and 3-1-D as they would require substantial spec support for no meaningful benefit.  For Q2, we support 3-2-A as it can reduce latency for having a relatively accurate scheduling of UL video traffic which will consequently increase capacity.  For 3-2-B, additional benefit over existing mechanisms for link adaptation, based on CSI reports and SRS, is unclear and will be difficult to evaluate.  For 3-2-C, we think XR is an ideal use-case for CBG-based HARQ-ACK but Rel-17 seems sufficient (to obtain HARQ-ACK statistics for CBGs for QoS).  3-2-D has been considered before but was not adopted due to a large associated impact to RAN2 specifications/gNB implementation for the MAC operation – that issue has not changed.  For 3-2-E, R17 provides full flexibility for dynamic configuration of search space sets.  3-2-F is unlikely to have any impact on capacity as XR UEs are unlikely to be power limited and, even if so, it is not reasonable to expect frequent PHR triggering events.  For 3-2-G, we do not think any DCI enhancement are motivated for XR capacity because there would be very few XR UEs scheduled per slot (clearly in FR2, but also even if there is no other UE in the system in FR1) and because DCI overhead is negligible compared to XR video TBS (even if DCI overhead was somehow reduced by 100% without impact on link adaptation, there would still not be any measurable impact on XR capacity).  For 3-2-H, we do not think the UE should be transmitting without the gNB knowing how the UE is transmitting, even if the possible configurations are limited. That would still require resources to be reserved and complicate the gNB implementation as the XR TB sizes are large. Further, pose/control does not have jitter while video should be DG-based (not possible to realistically support with CG). |
| OPPO | Q1-2: P3-1-B can be considered. For single DCI scheduling multi-slot PDSCHs, to separate HARQ-ACK feedback for each of multi-PDSCHs is beneficial to reduce the latency. |
| InterDigital | **Q1-1:** We are generally fine with Proposal 3-1. For simplicity, we think Proposal 3-1 can be reformulated as “Proposal 3-1: Study enhancements of ~~legacy procedures for~~ single DCI scheduling multi-PDSCHs/PUSCHs”.  **Q1-2:** We think Proposals 3-1-A and 3-1-C can be considered due to benefits related to flexibility, lower latency and potential capacity improvement. |
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## Scheduling awareness related enhancements

The following table lists the proposals in the contributions submitted in this meeting, discussing views on BSR enhancements and XR application awareness that facilitates e.g., delay-aware scheduling and packet dropping mechanisms. 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.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| Spreadtrum Communications | Proposal 1: Assistance information from higher layer to physical layer should be considered for XR capacity enhancement. |
| CATT | Proposal 2: The gNB scheduling awareness schemes should be considered to improve the capacity performance of XR-specific traffic. |
| vivo | Proposal 2: Study mechanisms for the UE to adjust the conveyed content and/or attribute(s) of a dynamically granted UL transmission before performing the UL transmission, e.g. re-purposing a re-transmission grant for a new transmission or vice versa. |
| ZTE, Sanechips | Proposal 3: Buffer size reporting enhancement techniques, including e.g., enhanced BSR indication, can be considered for improving capacity for XR service. |
| Ericsson | Proposal 5 Study enhancements of BSR consisting of improving BSR granularity and including delay information in the BSR relevant to XR traffic. Proposal 6 Study mechanisms for dropping late application packets as possible solutions to increase XR capacity. |
| NEC | Proposal 6: Specify a higher layer parameter of ‘frame per second’ for the frame rate of XR traffic. Proposal 7: Study mechanism of packet dropping based on the PDB requirement, in order to avoid resource waste due to the out-of-date packets. |
| InterDigital, Inc. | Proposal 1: Capture in TR, XR-specific enhancements for capacity that support adaptations based on PDU set characteristics in UL and DL Proposal 2: Capture in TR, XR-specific enhancements for capacity that support transmission of multiple associated/correlated traffic streams in UL and DL Proposal 5: Starting point for potential enhancement techniques for capacity can be those identified during Rel-17 SI (e.g. delay aware scheduling, prioritizing/pre-empting important streams in DL/UL, multi-TB scheduling, enhanced BSR) |
| Lenovo | Proposal 1: Study the benefits of indicating the remaining delay budget for a packet and/or a PDU set: • gNB indicating such delay budget to UE for DL/UL packet and/or PDU set • UE indicating such delay budget to gNB for UL/DL packet and/or PDU set Proposal 10: Investigate leveraging XR application awareness (e.g., video slice and stream awareness, video slice importance) to map video slices to TB CBGs for optimized transmissions and retransmissions of XR traffic. |

**Moderator’s summary:**

Most of the enhancements related to the proposals are not physical later related, however the proposals are motivated to emphasize the importance of availability of XR-specific information that can be used to improve the XR capacity performance. Therefore:

* **Moderator’s observation:** The proposals suggest that RAN1 can study the benefit of availability of the XR-specific information for resource allocation and corresponding procedures by investigating the XR capacity performance improvements, although how the information is provided is not within the RAN1 scope. The proposals seem to address What information is useful, and How it can be used used to improve XR capacity.

The proposals above are summarized in the following:

**Proposal 4-1:** Study the benefits of XR application awareness scheduling to improve XR capacity

* Spreadtrum, CATT, Ericsson, IDC, Lenovo

**Proposal 4-2:** Study BSR enhancement to improve XR capacity

* vivo, ZTE, Ericsson, IDC

**Proposal 4-3:** Study the benefits of indicating the remaining delay budget for a packet and/or a PDU set

* Lenovo, Ericsson

**Proposal 4-4:** Study mechanism of packet dropping based on the PDB requirement

* Ericsson, NEC

**Proposal 4-5:** Study mechanisms for the UE to adjust the conveyed content and/or attribute(s) of a dynamically granted UL transmission before performing the UL transmission, e.g., re-purposing a re-transmission grant for a new transmission or vice versa

* vivo

### 2.4.1 Discussion 1st round

In the feedback table, companies’ views on the scheduling awareness related enhancements proposals are kindly requested.

|  |  |
| --- | --- |
| **Questions:**   * **Q1**: What is your view regarding study the scheduling awareness related enhancements in RAN1? Do you share similar observation as Moderator? * **Q2**: What is your view regarding Proposals 4-1 to 4-5 and related studies during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q3:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | **Answer to Q1:** we do share feature lead’s view. We also think that it is difficult for RAN1 to dicsuss without any background though traffic-aware scheduling is useful for XR service. It would be safer to have minimized scope to discuss or to ask RAN2 which type of information can be obtained or managed at UE and gNB side.  **Answer to Q2:** we are fine to study with proposal 4-2/4-5 since it can be within a scope of RAN1. |
| Samsung | Q1: Agree with the moderator that XR-traffic specific information/scheduling awareness can improve capacity.  Q2: OK to further consider proposals 4-1/4-3/4-4.  Proposal 4-2 is not relevant to RAN1 and can be submitted to RAN2.  Proposal 4-5 is problematic to UE implementation and to processing timelines which are likely to be tight for XR. Also, it is unlikely for the assumed cause to be frequent in order for a solution to offer a meaningful benefit (otherwise, there is a general problem with the scheduler) |
| OPPO | Q1: FL mentions “The proposals seem to address What information is useful, and How it can be used used to improve XR capacity”. But it is clearly stated in Rel-18 XR SID that “*It is expected that SA Working Groups would lead the work on identifying necessary enhancements to improve XR awareness, and that RAN will be made aware of these enhanced parameters and can potentially tailor the radio processing of XR traffic*”. So it does not seem a RAN task to decide “What information is useful”. As of “How it can be used to improve XR capacity”, we wonder whether it is in RAN1 scope. So our preference is NOT to handle awareness-related discussion in RAN1, except the discussion to respond SA2 LS. |
| InterDigital | **Q1:** We share the same understanding with FL  **Q2:** We are ok with Proposals 4-1 to 4-4. Regarding Proposal 4-5, the mechansim described by the proposal seems to indicate further complexity to scheduling (reprioritization may be involved?) and the benefits are not clear. |
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## Link adaptation and MIMO enhancements

The following proposals to enhance the link adaptation to improve XR capacity are presented for discussions at this meeting. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that for some enhancements techniques, companies have provided simulations results.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| FUTUREWEI | Proposal 1: Study enhancements to MU-MIMO with a large number of antennas in order to increase the system capacity of XR  Proposal 2: Support cooperative MIMO via DL interference probing based on SRS enhancements to improve XR system capacity for TDD. |
| ZTE, Sanechips | Proposal 4: Link adaptation enhancement for re-transmission techniques, including e.g. delta MCS, can be studied for XR service transmission to improve capacity performance. |
| Samsung | Proposal 4: Consider CSI report enhancements to address the different BLER requirements of different XR flows. Proposal 7: For operation in FR2, allow a UE to perform beam management and CSI reporting during the DRX Off cycle. |
| Apple | Proposal 3-1: Study soft HARQ-ACK feedback according to PDSCH reception to support low latency traffic efficiently. |
| Nokia, Nokia Shanghai Bell | Proposal 9: Further study enhanced CQI schemes that guides the gNB on the maximum MCS scheme, subject to controlling CBG errors is proposed. Such a mechanism may e.g. ensure that only a certain maximum subset of CBGs will need retransmission with a controllable probability. |

**Moderator’s summary:**

The proposals above can be categorised as below.

* **Proposed study areas for link adaptation enhancements to improve XR capacity**
  1. **Delta MCS (ZTE)**
  2. **Soft HARQ-ACK feedback (Apple)**
  3. **Cooperative MIMO scheme via precoding technique - bi-directional training(FW)**
  4. **Enhanced link adaptation for CBG-based transmission (Nokia)**
  5. **CSI report enhancements to address the different BLER requirements of different XR flows (Samsung)**
  6. **Beam management and CSI reporting during the DRX Off cycle for FR2 (Samsung)**

### 2.5.1 Discussion 1st round

In the feedback table, companies’ views on the link adaptation enhancements proposals are kindly requested.

|  |  |
| --- | --- |
| **Questions:**   * **Q1**: What is your view regarding study link adaptation enhancements during XR SI?   + Please indicate and motivate whether you are supportive or not. * **Q2**: What is your view regarding the specific proposed study areas 1 to 6 for link adaptation enhancements during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q3:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | **Answer to Q1:** we are not sure enhancement on link adapation is necessary for XR, since XR scenario generally assumes periodic traffic. If it is discussed in terms of capacity, it should be identified the trade-off between existing CSI and proposed enhancement in terms of resource overhead, which affects UL capacity performance.  **Answer to Q2:** we are supportive to none of them. |
| OPPO | Q1: Share the view with LG.  Q2: These study areas are either too MIMO-specific and applicable to many other topics than XR, or already studied in earlier SI/WI w/o agreeable adoption. We support none of them for this SI. |
| Samsung | Due to its requirements for large BW and short latency, XR is more suitable for FR2 (not FR1).  For UE power savings, it is beneficial to have short DRX cycles 🡪 unlike eMBB, there is no time for beam failure recovery during the OnDuration – a UE cannot enter OnDuration with a failed beam.  Also, XR has multiple flows with different BLER requirements – link adaptation should be based on the BLER target for the corresponding flow.  The above are the reasons for proposing the fifth and sixth items in the above list.  CBG-based related enhancements are also worth considering, and we therefore also support, in general, the fourth item. Delta-MCS or soft HARQ-ACK were considered in Rel-17 URLLC and are not suitable to XR (traffic is not sporadic, plenty of CBG-based HARQ-ACK based on current specifications). |
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## Intra/Inter-UE multiplexing and prioritization enhancements

Few companies consider enhancements of inter-UE/intra-UE multiplexing and prioritization techniques are beneficial for XR capacity improvements and proposed the following proposals. 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.

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| ZTE, Sanechips | Proposal 5: Adaptive inter-UE/intra-UE multiplexing techniques, including e.g. finer granularity preemption indication, should be studied for transmission to improve system capacity performance. |
| InterDigital, Inc. | Proposal 5: Starting point for potential enhancement techniques for capacity can be those identified during Rel-17 SI (e.g. delay aware scheduling, prioritizing/pre-empting important streams in DL/UL, multi-TB scheduling, enhanced BSR) |
| III | Proposal#1: In order to properly accommodate the XR service, we propose to increase the priority index to be more than one bit. Proposal#2: We propose both the time and frequency domains shall be considered to reduce delay impacts, when the XR frame is preempted. Proposal#3: Because the XR service is delay sensitive, we propose the case of XR service preempting URLLC shall be considered. |
| LG Electronics | Proposal 6: For XR-specific capacity improvement, it can be considered to study XR-specific priority handling. |

**Moderator’s summary:**

The proposals above can be categorised as below.

* **Proposed study areas for inter-UE/intra-UE multiplexing and prioritization enhancements to improve XR capacity**
  1. **Finer granularity pre-emption indication (ZTE)**
  2. **Pre-emption in both time and frequency domains (III)**
  3. **XR-specific priority handling (LG, III)**

### 2.6.1 Discussion 1st round

In the feedback table, companies’ views on the inter-UE/intra-UE multiplexing and prioritization enhancement techniques are kindly requested.

|  |  |
| --- | --- |
| **Questions:**   * **Q1**: What is your view regarding study inter-UE/intra-UE multiplexing and prioritization enhancement techniques during XR SI?   + Please indicate and motivate whether you are supportive or not. * **Q2:** What is your view regarding the specific proposed study areas 1 to 3 for inter-UE/intra-UE multiplexing and prioritization enhancements during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q3:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | **Answer to Q1:** as described in our contribution, we see some XR traffic should prioritize over eMBB but not over URLLC. In terms of scheduling, it would be beneficial to introduce such UE behaviour at least for SPS/CG, whose priority cannot be adopted dynamically.  **Answer to Q2:** we are supportive to study area 3. Current Rel-16/17 procedure should be baseline. |
| Samsung | We do not see any use cases for a UE to have to support both XR and URLLC services and therefore there is no need to consider the third item (can be done based on Rel-17). There is also no need for the first two items as XR does not have the latency restrictions of URLLC and cannot be transmitted over few symbols with intra-slot scheduling. Therefore, our view for Q1 and Q2 is negative. |
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## Network coding

Two companies consider network coding schemes are beneficial for XR capacity improvements and proposed the following proposals. For more detailed descriptions and discussions please refer to the corresponding companies’ contributions. Please note that the companies have provided simulations results to motivate the proposed enhancements.

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| --- | --- |
| **Company** | **Proposals** |
| ZTE, Sanechips | Proposal 6: Network coding techniques should be considered for XR service transmission to improve capacity performance. |
| Lenovo | Proposal 8: Study the application of NC for XR traffic and its influence on L1/L2 stack. Proposal 9: Study efficient and backwards-compatible feedback procedures for NC and investigate role of existent HARQ feedback loop. |

### 2.7.1 Discussion 1st round

In the feedback table, companies’ views on the Network coding proposals are kindly requested.

|  |  |
| --- | --- |
| **Questions:**   * **Q1**: What is your view regarding study Network coding during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q2:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| OPPO | Q1: We are not supportive to open network coding for XR in RAN1, because:   1. Network coding breaks the packet into copies of sub-packets and sends them to the destination node via different network routes. This seems to be a method not taking delay budget as a critical issue as for XR. 2. Normally NC is not a physical layer procedure, so even if RAN can consider it, it should not start from RAN1. 3. If RAN/SA want to start NC someday, we prefer to start it as a general improvement method at first, rather than for a specific application area like delay-sensitive XR. |
| Samsung | Similar views with OPPO. |
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## Measurement gaps-based enhancements

One company proposes to study enhancements based on measurement-gap framework to improve consequently the XR capacity performance. For more detailed descriptions and discussions please refer to the corresponding company contribution. Please note that the company has provided simulations results to motivate the proposed enhancements.

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| --- | --- |
| **Company** | **Proposals** |
| MediaTek Inc. | Proposal 3: For capacity enhancement of XR application, RAN1 to exploit possible solutions to smartly prioritize XR decoding in measurement gap and skip the inter-frequency measurement (in measurement gap) with orchestrated gNB/UE coordination.  Proposal 4: Support dynamic L1 based MG activation/deactivation. 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 DRX.  Proposal 5: Reuse current R16/R17 RRM relaxation condition (or create new conditions more suitable for XR) to allow scheduling in MG to transform the R16/R17 RRM power saving gain into capacity gain. For example, the following conditions can be considered:   lowMobilityEvaluation (38.304) for stationary UE   ~cellEdgeEvaluation (38.304) for not-at-cell-edge UE  Proposal 6: Define new MG patterns for joint optimization with the XR eDRX cycles ( e.g. 16.6 ms). Otherwise, the measurement gap may overlap with the DRX on duration and deteriorate XR capacity. |

### 2.8.1 Discussion 1st round

In the feedback table, companies’ views on the proposals above regarding enhancements based on measurement-gap framework are kindly requested.

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| --- | --- |
| **Questions:**   * **Q1**: What is your view regarding study the proposed enhancement based on measurement gaps related procedures during XR SI?   + Please indicate and motivate whether you are supportive or not of any of these studies. * **Q2:** Please share any other comment that helps this discussion. * **Companies are kindly requested to provide any update/correction on the discussion and/or their respective positions.** | |
| **Company** | **Comments** |
| LG | **Answer to Q1:** it is necessary to identify how many TO can be affected by measurement gap. Considering proposed jitter handling method, we think UE can handle XR traffic with the delay of few slots even when UE loses transmission occasion for some reasons. |
| Samsung | For Q1, support to further consider the proposed enhancement. |
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## Other

Please use the feedback table below to provide any general or specific comments related to the XR capacity enhancement study in RAN1. Particularly, comments that help to focus the discussion during the SI are very appreciated.

|  |  |
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| **Company** | **Comments** |
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# Conclusion

TBD

# References

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| --- | --- | --- | --- |
| **1** | [**RP-220285**](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_95e/Docs/RP-220285.zip) | **Revised SID: Study on XR Enhancements for NR** | **Nokia (Rapporteur)** |
| **2** | [**R1-2203065**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203065.zip) | XR Capacity Evaluation and Enhancements | FUTUREWEI |
| **3** | [**R1-2203132**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203132.zip) | Discussion on XR-specific capacity enhancements techniques | Huawei, HiSilicon |
| **4** | [**R1-2203349**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203349.zip) | XR capacity consideration | Spreadtrum Communications |
| **5** | [**R1-2203485**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203485.zip) | NR enhancement for XR capacity improvement | CATT |
| **6** | [**R1-2203586**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203586.zip) | Discussion on XR specific capacity enhancements | vivo |
| **7** | [**R1-2203607**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203607.zip) | Discussion on XR specific capacity enhancements techniques | ZTE, Sanechips |
| **8** | [**R1-2203639**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203639.zip) | Discussion on capacity enhancements for XR | Ericsson |
| **9** | [**R1-2203689**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203689.zip) | Discussion on XR-specific capacity enhancements | NEC |
| **10** | [**R1-2203745**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203745.zip) | Considerations on capacity enhancements techniques for XR | Sony |
| **11** | [**R1-2203928**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203928.zip) | Considerations on XR Capacity Improvements | Samsung |
| **12** | [**R1-2203934**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2203934.zip) | Discussion on XR specific capacity improvement techniques | Panasonic |
| **13** | [**R1-2204029**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204029.zip) | Discussion on XR specific capacity enhancements techniques | OPPO |
| **14** | [**R1-2204124**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204124.zip) | Discussion on XR specific capacity enhancements | InterDigital, Inc. |
| **15** | [**R1-2204129**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204129.zip) | Discussion on XR specific capacity enhancements techniques | III |
| **16** | [**R1-2204178**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204178.zip) | XR-specific capacity enhancements techniques | TCL Communication Ltd. |
| **17** | [**R1-2204265**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204265.zip) | Views on XR specific capacity enhancements techniques | Apple |
| **18** | [**R1-2204327**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204327.zip) | Discussion on XR-specific capacity enhancements techniques | CMCC |
| **19** | [**R1-2204401**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204401.zip) | Discussion on XR specific capacity improvement enhancements | NTT DOCOMO, INC. |
| **20** | [**R1-2204415**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204415.zip) | XR-specific capacity enhancement techniques | Lenovo |
| **21** | [**R1-2204634**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204634.zip) | Discussion on XR-specific capacity enhancement techniques | LG Electronics |
| **22** | [**R1-2204656**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204656.zip) | Discussion on capacity enhancements techniques for XR | ETRI |
| **23** | [**R1-2204675**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204675.zip) | Discussion on XR-specific capacity enhancements | Nokia, Nokia Shanghai Bell |
| **24** | [**R1-2204699**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204699.zip) | On XR specific capacity improvement enhancements | MediaTek Inc. |
| **25** | [**R1-2204759**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204759.zip) | Discussion on potential SPS enhancements for XR | CEWiT |
| **26** | [**R1-2204819**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2204819.zip) | Discussion on capacity enhancements for XR applications | Intel Corporation |
| **27** | [**R1-2205056**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2205056.zip) | Capacity enhancement techniques for XR | Qualcomm Incorporated |
| **28** | [**R1-2205072**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_109-e/Docs/R1-2205072.zip) | Disscusion on XR-specific capacity enhancements techniques | Asia Pacific Telecom co. Ltd |

# Appendix

TBD