3GPP TSG-RAN WG1 Meeting #112bis-e R1-23xxxxx

e-Meeting, April 17th – 26th, 2023

Agenda Item: 9.8.1

Source: Moderator (Ericsson)

Title: Moderator Summary#1 – XR Specific Capacity Improvements

Document for: Discussion, Decision

# 1 Introduction

In RAN plenary 98-e, the Rel-18 WI on eXtended Reality (XR) was agreed and was further revised in RAN#99, with the following objectives:

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| Specify the enhancements related to power saving:  - DRX support of XR frame rates corresponding to non-integer periodicities (through at least semi-static mechanisms e.g. RRC signalling) (RAN2).  Specify the enhancements related to capacity:  - Multiple Configured Grant (CG) PUSCH transmission occasions in a period of a single CG PUSCH configuration (RAN1, RAN2);  - Dynamic indication of unused CG PUSCH occasion(s) based on Uplink Control Information (UCI) by the UE (RAN1, RAN2);  - Buffer Status Report (BSR) enhancements including at least new Buffer Status Table(s) (RAN2);  - Delay reporting of buffered data in uplink (RAN2);  - Discard operation of PDU Sets for DL and UL (RAN2, RAN3);  Specify the enhancements for XR Awareness:  - Signalling by CN of semi-static information per QoS flow (e.g. PDU set QoS parameters), dynamic information per PDU set (PDU Set information and Identification) and End of Data Burst indication (RAN3, RAN2);  - Impact of identifying by UE of PDU Sets, Data bursts and PSI, as needed (RAN2);  - Provisioning by UE of XR traffic assistance information e.g. periodicity, UL traffic arrival information (RAN2, RAN3);  - Support signalling the congestion information from RAN to the CN in alignment with SA2 (RAN3); |

Among the above objectives, RAN1 is tasked to carry out the normative work for the enhancements defined by the following two objectives:

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| - Multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration (RAN1, RAN2);  - Dynamic indication of unused CG PUSCH occasion(s) based on UCI by the UE (RAN1, RAN2); |

This document provides a summary of the contributions submitted to RAN1#112bis-e under Agenda item 9.8.1 regarding the normative work on the enhancement techniques for XR capacity improvements. It is also intended to facilitate the discussions regarding the topics under Agenda Item 9.8.1 with respect to the following assignment by the RAN1 Chair:

[112bis-e-R18-XR-02] Email discussion on XR-specific capacity enhancements by April 26 – Sorour (Ericsson)

* Check points: April 21, April 26

# 2 Multiple transmission occasions per CG period

This section captures the summary of the discussions regarding the design aspects of the following WID objective:

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| - Multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration (RAN1, RAN2); |

## 2.1 TDRA design

**Moderator summary:**

In previous meeting, the following agreement was made:

Agreement

For determination of the time domain resource allocation of CG PUSCHs associated to a multi-PUSCHs CG, the following alternatives for further study:

* Alt-A: TDRA determination based on repetition framework.
  + Alt-A1: Follow the time domain resource mapping of Type A repetition
    - N configured by higher layers or indicated by activation DCI
    - Single SLIV is determined from TDRA
    - The same SLIV in N PUSCH in consecutive slots per CG period
      * FFS for non-consecutive slots
    - FFS details, including related RRC parameters
  + Alt-A2: Follow the time domain resource mapping of Type B repetition
    - N configured by higher layers or indicated by activation DCI
    - Single SLIV is determined from TDRA
      * The SLIV used for 1st PUSCH per CG period.
    - N consecutive nominal PUSCHs with same duration per CG period
    - Note: N is not necessarily the repetition factor.
    - FFS details, including related RRC parameters
* Alt-B: TDRA determination based on NR-U framework
  + - N and M configured by higher layers
    - Single SLIV is determined from TDRA.
      * The SLIV used for 1st PUSCH per CG period.
    - M consecutive PUSCH TOs with same duration in slot. The M PUSCH TOs are used in N consecutive slots per CG period
    - Note: N and M are configured independently from *cg-nrofSlots-r16* and *cg-nrofPUSCH-InSlot-r16,* respectively*.* M and N configuration is independent from *cgRetransmissionTimer* configuration.
    - FFS details, including related RRC parameters
* Alt-C: TDRA determination based on single DCI scheduling multiple PUSCHs
  + Alt-C1: Follow Rel-16 single DCI scheduling multiple PUSCHs
    - TDRA configured by pusch-TimeDomainAllocationListForMultiPUSCH-r16 with k2-r16
    - A row of TDRA with N entries determines the time domain resources allocation of N PUSCH TOs per period
      * Note: N PUSCH TOs should be consecutive PUSCH TOs in consecutive slots.
    - FFS details, including related RRC parameters
  + Alt-C2: Follow Rel-17 single DCI scheduling multiple PUSCHs
    - TDRA configured by pusch-TimeDomainAllocationListForMultiPUSCH-r16 with extendedK2-r17
    - A row of TDRA with N entries determines the time domain resources allocation of N PUSCH TOs per period
      * Note: N PUSCH TOs can be non-consecutive PUSCHs and/or in non-consecutive slots.
    - FFS details, including related RRC parameters

**Companies’ view:**

* Alt-A (10): FW, CATT, Spreadtrum, TCL, OPPO, MTK, NEC, Panasonic, FGI, xiaomi
  + - * Alt-A1: Spreadtrum, OPPO, MTK, NEC, Panasonic, FGI
      * Alt-A2: Spreadtrum, TCL, NEC
* Alt-B (11+2): FW, IDC, HW/HiSi, Google, CMCC, Samsung, Apple; Nokia/NSB, NEC, DENSO, xiaomi, Intel (Type 1), Sony (Type 1)
* Alt-C-2 (13+2): E///, QC, vivo, ZTE/Sanechips, Spreadtrum, LG, DCM, OPPO, ~~Nokia/NSB~~, Panasonic, DENSO, FGI, Sharp, CAICT, Intel(Type 2), Sony(Type 2)

**Moderator’s observation:**

**Observation 1:** The supported alternatives are A, B and C2. Alt-C2 has the majority support. Proponents of Alt-A2 also support other alternatives (except TCL).

**Observation 2:** Some companies suggest modifying Alt-A or Alt-B approaches to support non-consecutive slots (e.g., CATT, MTK, CMCC, [Google]). Some companies suggest deferring the PUSCH transmission opportunities or consider available slots to support non-consecutive slots (e.g., Nokia, Panasonic). It is not clear to Moderator how that approach is different from Rel-17 MultiPUSCH TDRA if a configured/indicated row uses same SLIVs. More clarification is needed.

**Observation 3:** Some companies indicated different alternatives for Type-1 and Type-2 CG (e.g., Intel, Sony), while some companies emphasize on unified solution (e.g., ZTE).

Table 1: Summary of Contributions inputs for Section 2.1

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| **Company** | **Contributions inputs** |
| Futurewei | **Observation 1**: Both the repetition framework (i.e., Alt-A) and NR-U framework in Rel-16 (i.e., Alt-B) can support the configuration of multiple CG PUSCH transmission occasions in a period of a single CG PUSCH in Rel-18 XR Enhancements.  **Proposal 1**: Support at least the same symbol allocation for the multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration in Rel-18 XR Enhancements.  **Proposal 2**: The configured multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration in Rel-18 XR Enhancements can take repetition framework (i.e., Alt-A) or NR-U framework in Rel-16 (i.e., Alt-B) as the baseline. |
| Ericsson | **Observation 1** Alt-A, Alt-B and Alt-C are comparable with respect to complexity and specification impacts are comparable, with slight differences.  **Observation 2** The design choice should ensure the usefulness of the feature for realistic scenarios.  \* For TDD operation, the UL opportunities occur in different slots, and typically, one CG PUSCH is used per slot.  \* For proper resource management, there may be a need of different sizes of UL resources in different slots.  **Observation 3** Alt-C2 provides the needed flexibility to make the feature useful for different scenarios, as oppose to Alt-A, Alt-B and Alt-C1 which inherit simplifications and restrictions by design.  **Proposal 1** Multi-PUSCHs scheduling by a single DCI in Rel-17 is considered as the baseline for the design of multi-PUSCHs CG in Rel-18 (i.e. Alt-C2).  **Proposal 2** A row with multiple SLIVs of a TDRA table determines the SLIVs associated to the PUSCHs within a period of a multi-PUSCHs CG.  \* Note: pdsch-TimeDomainAllocationListForMultiPDSCH-r16 is reused for the TDRA table as in Rel-17.  \* Note: For activation/release of a Type-2 multi-PUSCHs CG, the time domain resource assignment field in the DCI format can indicate a row with multiple SLIVs as opposed to Rel-17.  **Proposal 3** The activation/release DCI for Type-2 multi-PUSCH CG is based on the non-fallback DCI format 0\_1. |
| Qualcomm | **Proposal 1**: Support Alt-C2 for the determination of TDRA for multiple PUSCH occasions in the CG period  \* Alt-C2: Follow Rel-17 single DCI scheduling multiple PUSCHs  **Proposal 2**: TDRA for multiple PUSCHs in the CG period can be indicated in a similar way to that of multiple PUSCHs scheduled by a single DCI specified for Rel-17  \* timeDomainAllocation field in the rrc-ConfiguredUplinkGrant IE in the CG configuration indicates an entry with multiple {K2, SLIV}s of the TDRA table  **Proposal 5**: Support the following proposals. Discuss them in the following order of importance  \* Support activation DCI for multi-PUSCH CG configuration |
| CATT | **Proposal 1**: The Alt-A: TDRA determination based on repetition framework should be supported for the SLIV determination, in which  \* N PUSCH occasions in a CG period with the same SLIV can be configured by higher layers or indicated by activation DCI;  \* The configuration of consecutive and non-consecutive CG PUSCH occasions should both be supported to give the flexibility of gNB implementation for the adaptation of different XR traffic;  \* The time gap between the adjacent CG PUSCH occasions could be configured by higher signaling;  \* The single TB transmission over multiple CG occasions should be supported. |
| vivo | **Observation 1**: To serve XR UL traffic including that of pose/control stream and/or video stream, CG PUSCH occasions configured by one or multiple CG configurations, and from one or multiple serving cells may be needed.  **Proposal 1**: For multiple CG PUSCH occasions in a period of a single CG configuration, Alt-C2 is supported.  \* Alt-C2: Follow Rel-17 single DCI scheduling multiple PUSCHs  o TDRA configured by pusch-TimeDomainAllocationListForMultiPUSCH-r16 with extendedK2-r17  o A row of TDRA with N entries determines the time domain resources allocation of N PUSCH TOs per period  \* Note: N PUSCH TOs can be non-consecutive PUSCHs and/or in non-consecutive slots.  o FFS details, including related RRC parameters  **Proposal 2**: For multiple CG PUSCH occasions in a period of a single CG configuration, if Alt-C2 is supported, further discussion on the validation of DCI scrambled by CS-RNTI for activation/release of CG configuration(s) is needed, e.g., how to set the value of NDI field in case of multiple NDI bits. |
| ZTE/Sanechips | **Observation 1**: Flexible TDRA assignment for multiple CG PUSCH transmission occasions in a period has benefits on resource efficiency and minor spec impact.  **Observation 2**: Alt-C2: TDRA determination based on Rel-17 single DCI scheduling multiple PUSCHs for time domain resource allocation of multi-PUSCH CG is not applicable to CG Type 1.  **Proposal 1**: Support Alt-C: TDRA determination based on single DCI scheduling multiple PUSCHs for time domain resource allocation of enhanced CG configuration.  **Proposal 2**: Support Alt-C2: TDRA determination based on Rel-17 single DCI scheduling multiple PUSCHs for time domain resource allocation of multi-PUSCHs CG.  **Proposal 3**: An unified TDRA determination, including e.g. multiple{time offset, SLIV}, should be considered for multi-PUSCHs CG of CG Type 1 and CG Type 2.  **Proposal 4**: The mechanism of Rel-17 single DCI scheduling multiple PUSCHs can be reused for TDRA determination of multi-PUSCHs CG of CG Type 2, while extending timeDomainOffset field can be considered for TDRA determination of multi-PUSCHs CG of CG Type 1.  **Proposal 5**: Combining legacy field timeDomainOffset and the new parameter for intervals between two adjacent transmission occasions to achieve multiple {time offset, SLIV} can be considered for TDRA determination of multi-PUSCHs CG of CG Type 1. |
| Spreadtrum Comm. | **Proposal 1**: Two alternatives can be considered as starting point for determination of the TDRA associated to multiple CG PUSCH TOs based on the existing specifications:  \* Alt-A: configure multiple PUSCH following the time domain resource mapping of both PUSCH repetition Type A and Type B repetition framework can be considered.  \* Alt-C2: configure multiple PUSCH following Rel-17 single DCI scheduling multiple PUSCHs since N PUSCH TOs can be in non-consecutive PUSCHs and/or in non-consecutive slots. |
| TCL Comm. | **Observation 1**: XR services have the following characteristics.  - The non-integer periodicity  - Jitter of packet arrival time  - Low latency and large packet size  - Varying packet size  - Multiple flows  **Proposal 1**: Follow the time domain resource mapping of Type B repetition can be used for multiple TOs within a CG configuration.  - Single SLIV is determined from TDRA  o The SLIV used for 1st PUSCH per CG period.  - N consecutive nominal PUSCHs with same duration per CG period  **Proposal 2**: The number of multiple TOs within a CG configuration can be indicated by TDRA |
| IDC | **Observation 1**: Enhanced CG scheme with flexible (re)allocation of PUSCH occasions based on indication (UCI) on unused PUSCH occasions outperforms DG and baseline CG schemes. The performance improvement offered by enhanced CG over baseline CG is more pronounced for stringent PDB requirements (e.g. 10ms)  **Proposal 1**: Support TDRA based on NR-U framework as baseline for multi-PUSCH CG  **Proposal 2**: For multi-PUSCH CG configuration, reuse the following CG parameters from R16 NR-U CG:  Number of consecutive PUSCH occasions per slot  Number of slots per CG period |
| HW/HiSilicon | **Observation 1**: The framework based on NR-U can apply for both CG Type 1 and CG Type 2.  **Observation 2**: The framework based on PUSCH repetition type B may introduce unnecessary complexity and is not suitable for XR traffic.  **Observation 3**: The framework based on single DCI scheduling multiple CG PUSCH is not suitable for CG Type 1 and additional workload is needed.  **Observation 4**: The number of CG PUSCH occasions may vary in different CG periods due to TDD configuration, thus bring inaccuracy and difficulty for gNB configuration.  **Observation 5**: In a CG period, the MCS of TBs transmitted on the earlier CG PUSCH occasions can be larger than the later ones, since earlier transmitted TBs have more retransmission opportunities and larger MCS can increase resource efficiency.  **Observation 6**: In a CG period, the number of PRBs of the earlier CG PUSCH occasions can be larger than the later ones. Once the gNB has no enough time to re-allocate the resource, less resource would be wasted. |
| Lenovo | **Observation 1**: Indication of unused time units (e.g., slots) may simplify support of UCI indication for multiple CG configurations.  **Proposal 1**: Support Alt-C2 for time domain resource allocation of CG PUSCHs associated to multi-PUSCHs CG. |
| LG | **Proposal 1**: Support multiple CG occasions in a period based on a TDRA table where each row includes multiple SLIV values for CG.  \* FFS : DMRS mapping type, repetition type, numberOfRepetitions  **Proposal 2**: It is necessary to investigate how to support the repetition for each of multiple SLIVs in a same TDRA row.  **Proposal 3**: It is necessary to investigate how to determine TDRA table for Type-1 CG for new resource allocation method.  **Proposal 4**: Discuss how to apply the enhanced TDRA for Type-1 CG.  **Proposal 5**: Support separated K2 offset per SLIV for flexibility.  \* Each K2 starts from the slot where previous SLIV ends. |
| DCM | **Proposal 1**: Support Alt C-2 for TDRA of multiple CG PUSCHs in one CG period, i.e. following Rel-17 single DCI scheduling multiple PUSCHs.  **Proposal 2**: Relax the limitation for validation of CG PUSCH activation DCI, when the TDRA field in the activation DCI indicates multiple SLIVs. |
| Google | **Proposal 1**: The TDRA determination based on NR-U framework should be extended to XR with some enhancements.  **Proposal 2**: The legacy configuredGrantTimer can be used for each PUSCH occasion of the multiple CG PUSCH transmission occasions instead of the cg-RetransmissionTimer used in NR-U.  **Proposal 7**: The design of multiple CG-PUSCH transmission occasions should take into considertation the operation in TDD. |
| OPPO | **Proposal 1**: Down-select one from the following alternatives for determining the time domain resource allocation of CG PUSCHs within one multi-PUSCHs CG period:  \* Alt-A1: Follow the time domain resource mapping of Type A repetition.  \* Support non-consecutive-slot allocation.  \* Alt-C2: Follow Rel-17 single DCI scheduling multiple PUSCHs |
| MTK | **Observation 1**: XR UL video traffic characteristics based on large and varying packet size and strict latency requirements are the underlying motivations for XR-specific configured grant enhancements in Rel-18.  **Proposal 1**: TDRA framework uses PUSCH repetition type-A as baseline (Alt-A1).  **Proposal 2**: A time offset parameter configured semi-statically by the network indicates the time gap between the 1st and the 2nd PUSCH TOs in number of slots.  **Proposal 3**: The rest of the PUSCH TOs from the 2nd TO onwards (i.e., the 2nd, 3rd, etc. TOs) are assigned in back-to-back UL slots (based on Alt-A1 PUSCH repetition type-A framework as baseline). |
| CMCC | **Proposal 1**. Support Alt-B to use TDRA determination based on the NR-U framework for multi-PUSCHs CG.  **Proposal 2**. Support to configure N non-consecutive slots within a CG period and/or M non-consecutive PUSCH transmission occasions in a slot in TDD frame structure. |
| Samsung | **Observation 1:** Use of “multi-CG PUSCH” is expected to be associated with few transmissions.  **Proposal 1**: Extend the Rel-16 NR-U design using cg-nrofSlots and cg-nrofPUSCH-InSlot to non-shared spectrum to support "multi-CG PUSCH". No enhancement is necessary.  **Proposal 2**: TDRA, FDRA, and MCS are same for all CG-PUSCHs of a "multi-CG PUSCH". |
| Apple | **Observation**: as the tempo mismatch issue for configured grants may not be addressed through the support of new CG periodicity in Rel-18, it is expected that the start time of a CG period may not be aligned with the arrival of traffic.  **Proposal 6**: Consider both licensed spectrum access and unlicensed/shared spectrum access in the TDRA design. For unlicensed spectrum access, only those TDRA patterns allowed in NR-U design can be configured. |
| Nokia/NSB | **Observation 1**: Alt-C framework (TDRA determination based on single DCI scheduling multiple PUSCHs) is only applicable for Type 2 CG configuration. For Type 1 CG configuration, such framework will not work as it requires DCI to provide the entry to TDRA list.  **Observation 2**: The benefits of different SLIVs for each slot in Alt-C (TDRA determination based on single DCI scheduling multiple PUSCHs) are unclear.  **Observation 3**: In Alt B (TDRA determination based on NR-U framework), by transmitting over available slots and continue counting each slot, we can transmit over up to 8 UL slots per CG period, which shall be enough for video frame in UL (e.g., with max 40 slots per CG period as per current RRC specification, TDD structure DDDSU, and 30 kHZ).  **Observation 4**: The feature AvailableSlotCounting from repetition framework allows to count only available slots (e.g., UL slots) and can support transmission over non-consecutive UL slots in Alt-B (TDRA determination based on NR-U framework).  **Proposal 1**: Compare Alt-B (TDRA determination based on NR-U framework) and Alt-C (TDRA determination based on single DCI scheduling multiple PUSCHs) in terms of potential benefits and drawbacks and select one framework to support multi-PUSCHs per CG period in licensed band.  **Proposal 2**: Consider NR-U framework to support multi-PUSCHs per CG period in licensed band.  **Proposal 3**: To support non-consecutive transmission when configuring multi-PUSCHs per CG, consider the following solutions: (i) AvailableSlotCounting from repetition framework or (ii) transmitting over available slots (e.g., UL slot) and continue counting each slot.  **Proposal 8**: First decide on the framework to be adopted for multi-PUSCHs per CG period and solution to handle the non-consecutive slot transmission and then decide on the max number of PUSCHs per CG period. |
| NEC | **Proposal 1**: support consecutive time domain resource allocation based on existing repetition type A, type B or NR-U framework. |
| Panasonic | **Proposal 1**: A combination of Alt-A1 and Alt-C2 should be considered for designing the time domain resource allocations for multi-PUSCHs CG. An activation DCI can contain a single time domain resource assignment field and an entry in the RRC parameter pusch-TimeDomainAllocationList have multiple time resource allocations. Each PUSCH occasions can be deferred to a next available slot in case of a collision with DL slot. |
| DENSO Corp. | **Observation 1**: For determination of TDRA of CG PUSCHs associated to a multi-PUSCHs CG, the following options can be considered.  - Option.1: Reusing the framework for scheduling multiple PUSCHs by a single DCI  - Option.2: Reusing the framework for NR-U CG  **Observation 2**: TDRA determination based on single DCI scheduling multiple PUSCHs can provide more flexibility as it can configure different K2 or SLIV per each CG PUSCH occasion. |
| FGI | **Proposal 1**: Adopt Alt-A1 or Alt-C2 for determination of the time domain resource allocation of CG PUSCHs associated to a multi-PUSCHs CG. |
| Intel | **Proposal 1**: For TDRA determination of multi-PUSCHs CG at least for Type1 CG, NR-U framework (Alt-B) can be leveraged.  \* Single SLIV is determined from TDRA.  o The SLIV used for 1st PUSCH per CG period.  \* M consecutive PUSCH TOs with same duration in slot. The M PUSCH TOs are used in N consecutive slots per CG period. N and M configured by higher layers.  \* Note: N and M are configured independently from cg-nrofSlots-r16 and cg-nrofPUSCH-InSlot-r16, respectively.  **Proposal 2**: For Type 2 CG transmission based on activation DCI, leverage single DCI based Rel-17 FR2-2 multiple PUSCHs scheduling solution to indicate TDRA for the multiple PUSCHs in a CG period via the activation DCI. |
| xiaomi | **Proposal 12**: Alt-A and Alt-B should be prioritized for determination of the TDRA of CG PUSCHs associated to a multi-PUSCHs CG. |
| Sharp | **Proposal 1**: TDRA determination based on single DCI scheduling multiple PUSCHs in Rel-17 to allow non-consecutive PUSCHs and/or in non-consecutive slots.  **Proposal 2**: The configuration/indication parameters of CG PUSCHs in a multi-PUSCHs CG configuration are the same. |
| Sony | **Observation 1**: The non-integer and jitter characteristics of XR traffic (also known as a quasi-periodic traffic) may require enhancements of the existing NR.  **Observation 2**: CG-PUSCH transmission as in legacy NR may require enhancements to support XR traffic, particularly on supporting the payload of a quasi-traffic that may not be the same but varies within a range.  **Observation 3**: Different type of TDRA determination of CG PUSCHs associated to a multi-PUSCHs CG can be supported for CG Type-1 and CG Type-2.  The related proposals are given below:  **Proposal 1**: Support TDRA determination based on NR-U framework (Alt-B) and TDRA determination based on single DCI scheduling multiple PUSCHs (Alt-C2). ALT-B is supported for Multi-PUSCHs CG for Type-1 and ALT-C2 is supported for Multi-PUSCHs CG for Type-2. |
| CAICT | **Proposal 1**: Support Alt-C2 (Follow Rel-17 single DCI scheduling multiple PUSCHs) for determination of TDRA for multi-PUSCHs CG. |

### 2.1.1 Initial Discussions

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

This topic needs more discussions to narrow down the options. For the initial discussions, Moderator suggests companies to share the views on the following.

**Suggestion 1:** Focus on Alt-A1, Alt-B and Alt-C2. Note that Alt-A2 can be obtained from Alt-B (discarding the segmented PUSCH).

**Suggestion 2:** Discuss your view that which of the following properties are important to be accommodated by the final solution:

1. Need for back-2-back PUSCHs within a slot?
2. Need for SLIVs with different sizes?
3. Need for PUSCH transmission in non-consecutive slots?

**Suggestion 3:** Explain if one of the alternatives provides a desired property, why another alternative with modification should be used instead (please see **Observation 2** above).

**Questions:** Please provide your view in the table below regarding the following questions:

* **Q1:** What is your view regarding Moderator’s suggestions? What is your suggestion to facilitate a selection, including compromising/changing preferences?
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

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| **Company** | **Comment** |
| **ZTE, Sanechips** | 1. For the questions listed in Suggestion 2: 2. As to back-2-back PUSCH within a slot, we share the intention of reducing latency herein, but given the large packet size of XR traffic, a CG PUSCH occasion may occupy most symbols within a slot, then it makes more sense to me to allocate two consecutive valid slots as CG PUSCH occasions. 3. For different SLIVs of CG occasions in a period, we see the benefit that it provides flexibility of TDRA determination for UE multiplexing in a cell, which also contributes to improving resource efficiency. However, we can be flexible to use same SLIV in a CG period. 4. PUSCH transmission in non-consecutive slots is one of the most important properties of UL transmission of large packet. In case of XR traffic, it should be very clear and understandable that different PUSCHs can be transmitted at different/non-consecutive slots for a TDD configuration (e.g., DDDSUDDDSU..). 5. For Suggestion 1: 6. We agree to focus on Alt-A1, Alt-B and Alt-C2 firstly. In our view, these three candidate schemes have comparable specification impact, wherein Alt-A1 and Alt-B should deal with the case of non-consecutive UL slots, and Alt-C2 should tackle the TDRA determination for CG Type 1.   In summary, we think Alt-C2 is best from the flexibility perspective, including configure flexible time offsets and multiple SLIVs. Moreover, if same SLIV is applied in a CG period, we think Alt-B is workable with necessary clarification/spec change, in which a number of consecutive CG occasions are determined. |
| **Nokia, NSB** | Thank you for providing a nice summary! \*We also edited the observations above. Please, find our views related to Q1 and Q2 below:  **A1:**  **Suggestion 1:** We are ok to focus on three alternatives as suggested by Moderator but we also think that the discussion shall be related to support of multiple PUSCHs per CG period, and not related to support TBoMs. Please, see the proposed modification in A2.  **Suggestion 2:**  **Suggestion 2.2:** We do not think that different SLIV for each slot will provide any benefits to XR capacity. The XR video frame size is unknown when CG is configured, the random guess on what will be the required SLIV for each slot in every CG period will not provide any benefits in our view. The proponents are suggested to motivate the need for different SLIVs per each slot.  **Suggestion 2.3:** We think that video frame will be transmitted in consecutive **available** slots, as the motivation of enhancing CG was to decrease the latency. Therefore, Alt-B with consecutive available slots will work. FFS: how to count the slots (e.g., count all slots, or count only available slots).  **Suggestion 3:** As commented in S 2.3, Alt-B with consecutive available slots will work. FFS: how to count the slots (e.g., count all slots, or count only available slots).  We see the following issues with Alt-C: Alt-C it is only applicable to Type-2 CG, there will be a need for changes in activation/deactivation DCI, another solution for Type-1 CG will be required, different SLIVs are not motivated as of yet. It is clear that Alt-C will provide much more spec impact than adopting already existing solution from unlicensed band (Alt-B).  **A2:**  **Please, find the modification to Suggestion 1:**  **Suggestion 1:** Focus on Alt-A1 (without TBoMs support), Alt-B and Alt-C2. Note that Alt-A2 can be obtained from Alt-B (discarding the segmented PUSCH).  We propose to add the following bullet to Suggestion 2 (important to be accommodated by the final solution)  **Suggestion 2:**  4. It is important that the solution will be applicable to both Type-1 and Type-2 CG (as we agreed to support both types during RAN1#112). |
| **CATT** | Suggestion 1:  Since we agreed that we supported both Type-1 and Type-2 CGs, we had to mark that Alt-C2 would only support Type-2 CGs in the summary of the proposal.  Suggestion 2:  The point (3) PUSCH transmission in non-consecutive slots is the most important aspect of multi-CG-PUSCH for XR. In particular, the configuration of UL CG-PUSCH is per slot in TDD semi-static configuration. There would not be exact alignment between the multi-CG-PUSCH configuration in TDD configuration and UL XR traffic arrival rate with 16.67 ms duty cycle.  For (1), the back-to-back slot is not the required condition of multi-CG-PUSCH for XR in particular the TDD system.  For (2), SLIV with different size would not work for Type-1 CGs. |
| **NewH3C** | A1:  Suggestion 1: We are fine with three alternatives as suggested by Moderator  A2.  For (1), back-2-back PUSCHs within a slot isn’t necessary for XR  For (2), SLIV with different size will increase complexity of implementation and signaling overhead |
| **Qualcomm** | We can focus on first suggestion 1. In particular, we are supportive of Alt C-2. This may provide the best scheduling flexibility.  Regarding suggestion 2, Alt C-2 can also achieve consecutive PUSCH occasions of existing NR-U or repetition features. Back-2-back does not seem necessary for XR traffic. Different SLIV and non-consecutive slots allow for more flexible network scheduling of multiple users.   1. Need for back-2-back PUSCHs within a slot? 2. Need for SLIVs with different sizes? 3. Need for PUSCH transmission in non-consecutive slots? |
| **Google** | We are OK with suggestion 1 by the moderator to focus on Alt-A1, Alt-B and Alt-C2  We don’t think there is need to have back-to-back PUSCHs within the slot and need for SLIVs of different sizes for XR. Also, we think that ideally a Data Burst would be transmitted in consecutive slots at the start of the CG period to reduce latency and allow for enough time for any retransmissions to meet the PSDB |
| **Samsung** | Thank you for the all the efforts!  Fine with suggestion 1.  For suggestion 2:   1. No need for back-2-back PUSCHs within a slot – XR is not URLLC with small TBs and symbol-level latency. The TBs for video frames are large, latency will not change from back-to-back PUSCHs within a slot, and spectral efficiency will be worse due to smaller coding gains and additional DM-RS overhead (which may also negatively impact latency). 2. No need for SLIVs with different sizes, especially in a semi-static manner after activation – it also doesn’t work for Type-1 CG. 3. No need for transmissions in non-consecutive slots. The whole objective for introducing that feature is to minimize latency – otherwise, SR+DG is always a far better alternative, especially for the large TBs of XR. Of course, transmissions colliding with DL symbols in TDD will be dropped – so, slots should be all consecutive *available* slots as for repetitions.   For suggestion 3, Alt-B with consecutive available slots is all that is needed. As also mentioned by others, there is no justification to complicate the specifications using Alt. C. |
| **Futurewei** | Firstly, we support down selecting one alternative which can be applied to both types of CGs (including Type 1 CG and Type 2 CG), otherwise, it will make the configuration more complicated and is not preferred.  We are ok with Suggestion 1: Focus on Alt-A1, Alt-B and Alt-C2. If considering large packet size of XR traffic, Alt-A2 may have lower priority compared with Alt-A1, because the XR packet may need to be transmitted via multiple uplink slots. Additionally, as FL mentioned, Alt-A2 can also be obtained from Alt-B if that case is necessary.  Regarding the 3 questions in Suggestion 2, we share our view as below:   1. Need for back-2-back PUSCHs within a slot?    * [FW]: For unlicensed carriers, it is really needed to increase LBT success opportunity with back-2-back PUSCHs with a slot. For licensed carrier, we don’t think it is mandatory, even it can reduce latency for XR traffic in some extent. However, if we considering large packet size for XR traffic, the back-2-back PUSCH within a lot may be a better choice, since it can carry as much as possible data for XR packet within a slot. So, we support back-2-back PUSCHs within a slot if multiple PUSCH occasions within a lot are needed. 2. Need for SLIVs with different sizes?    * [FW]: We support at least the same SLIV used for all PUSCH occasions as mentioned in our contribution-R1-2302317. Same SLIV is preferred to reduce configuration complexity of multiple PUSCH occasion in a period. 3. Need for PUSCH transmission in non-consecutive slots?    * [FW]: If considering to support different TDD frame structures, e.g., DDDSU etc., uplink slots are not contiguous, PUSCH transmission in non-consecutive slots need to be supported.   Suggestion 3: Explain if one of the alternatives provides a desired property, why another alternative with modification should be used instead (please see Observation 2 above).  **[**FW**]:** Both the repetition framework (i.e., Alt-A) and NR-U framework in Rel-16 (i.e., Alt-B) can support the configuration of multiple CG PUSCH transmission occasions in a period of a single CG PUSCH in Rel-18 XR Enhancements with slight enhancements. However, for Alt-C, it will inevitably increase physical layer signaling overhead and cannot be applied to Type 1 CG directly, which needs more standard efforts. |
| **InterDigital** | Q1: We think the moderator’s suggestions, as always, are quite constructive and useful.  Q2: Our views regarding the suggestions are:  **Suggestion 1:**   * Ok to focus on the listed alternatives   **Suggestion 2:**   1. Need for back-2-back PUSCHs within a slot?    * Having back-to-back PUSCHs in a slot would be sufficient to handle UL transmission of PDUs/PDU sets in the UE buffer. Do not see the need for having non-consecutive PUSCHs in a slot. 2. Need for SLIVs with different sizes?    * It is not clear to us what benefit having SLIVs with different sizes will provide from XR traffic characteristics perspective than having SLIVs with equal size. In fact, there could be further UE complexity for determining the number of unused PUSCHs when the SLIV sizes are unequal. 3. Need for PUSCH transmission in non-consecutive slots?    * We do not think there is a need to support non-consecutive slots in a CG period, assuming the non-consecutive slots here refer to some UL slots in a TDD frame (separated by a set of DL slots) which are not configured in the CG configuration.   **Suggestion 3:**  We are fine with an alternative that adequately addresses the issue of transmitting XR traffic within PDB/PSDB and results in low spec impact. We do not see the need for having high scheduling flexibility (e.g. non-consecutive PUSCHs, unequal SLIV sizes) if this comes with the expense of high spec effort. |
| **Xiaomi** | Thank you for your nice summary!  For Suggestion 1:  We are fine with the first suggestion to focus on Alt-A1, Alt-B and Alt-C2.  For Suggestion 2(2):  We find no motivation to configure SLIVs with different sizes for CG occasions within a CG period. The gNB can configure a reasonable SLIV for all CG occasions, each CG occasion can meet the maximum requirements of the XR traffic. Since unused CG can be represented by UE as "unused", the gNB can reallocate resources corresponding to the unused CG occasion(s) and there is no waste of the resources. |
| **Sharp** | Fine with Suggestion 1 for down-selection.  For Suggestion 2, we think 2.1 back-to-back PUSCH within a slot and 2.2. SLIV with different sizes are not necessary. And 2.3 PUSCH transmission in non-consecutive slots should be supported. |
| **Apple** | Back-to-back PUSCH within a slot or SLIV for different durations can be useful. |
| **vivo** | Q1: for Suggestion 1, we are fine. For Suggestion 2, we think the important properties depends on the usage of multi-PUSCH CG. For example, if it is used for XR service, e.g., UL video with large packet and variable packet size, the second bullet is important. If it is used to solve the issue of collision between configured PUSCH TOs and semi-static DL symbol, , the third bullet is important. Once multi-PUSCH CG is supported, it can be up to gNB to decide how to use it, that is why we think Alt-C2 is preferred, which can realize all the three properties depending on the usage. |
| **OPPO** | We are OK with suggestion 1.  Considering large packet size is one of main characteristics of XR services, large TB sizes should be used for XR transmission as much as possible, in order to minimize the redundant information and reduce the HARQ processes consumed in one CG period. Therefore, we think back-2-back PUSCHs within a slot is not necessary, i.e. Alt-B can be excluded for further studied.  On the other hand, we think PUSCH transmission in non-consecutive slots has at least the following benefits:   1. Avoid the unavailable CG PUSCH which conflicts with DL symbol(s) in TDD carrier; 2. Non-integer period can be solved by one CG configuration. For example, one CG configuration is used to support 60fps for UL video, the periodicity is configured as 50ms with 3 CG PUSCH occasions.     Therefore, we propose focus on Alt-A1and Alt-C2:   * Alt-A1 should support non-consecutive-slot allocation; * For Alt-C2, SLIVs with different sizes is not supported unless significant benefits can be provided. |
| **TCL** | Thank you for the great work!  For suggestion 1:  In previous meetings, it has been agreed that both CG type 1 and Type 2 can be support multiple-PUSCHs, however, Alt C does not workable for CG type 1.  For suggestion 2:   1. Back-2-back PUSCHs within slot is benefit for latency reduction. 2. No need for SLIV with different sizes, the packet size of XR is varying in time and the actual size does not know by gNB/UE in advanced, so in our understanding, different SLIVs within a CG cannot bring any benefit for XR.   For TDD configuration, PUSCH transmission in non-consecutive slots is naturally. |
| **DOCOMO** | Thanks for the good summary!  On suggestion 1, we support to focus on Alt-A1, Alt-B and Alt-C2.  On suggestion 2, we think back-to-back transmission is not needed. Regarding same/different SLIV and consecutive/non-consecutive slots, Alt-C2 can achieve both.  Regarding additional spec impact by Alt-C2 mentioned by some companies, we think the spec impact would be very little. For activation DCI, DCI 0\_1 supporting indicating a TDRA with multiple SLIVs is already supported. It only needs to relax the limitation on activation DCI validation. For type 1 and type 2 support, we think Alt-C2 is also applicable to type 1 CG PUSCH, by configuring a TDRA index including multiple SLIVs for the parameter *timeDomainAllocation* in *rrc-ConfiguredUplinkGrant*. |
| **LG** | We are fine with Suggestion 1 for down-selection.  Regarding suggestion 2, here are our views.   1. Back-to-back PUSCH could be useful for covering various traffic size efficiently. 2. SLIV with different size is also useful to cover mixed traffic or to fit TDD patterns. 3. PUSCH transmission in non-consecutive slots are useful to cover non-integer periodicity case with a single CG configuration   Regarding suggestion 3, we think Alt. C2 can cover most of cases, that’s why we proposed to support Alt. C2. We don’t see the clear reason to support other alternatives when one can cover all the case. |
| **MediaTek** | Suggestion 1:  We are fine with focusing on Alt-A1, Alt-B and Alt-C2. Perhaps, even a better approach is to merge Alt-A1 and Alt-B with an open sub-bullet to decide whether multiple back-2-back PUSCH within a slot is supported or not. Based on company inputs above, most companies who prefer Alt-B do not see a need to support back-2-back PUSCH within a slot. From our perspective, there are really two approaches: Alt-A1/Alt-B vs. Alt-C2  Suggestion 2:   1. Back-2-back PUSCH within a slot is not needed. XR traffic has large packet size and latency is not as strict as eURLLC. 2. Different SLIV configuration per PUSCH is not needed. We don’t see any benefit to have different SLIVs. Some companies consider slots with flexible DL/UL symbols as the motivation for different SLIV. But, if TDRA configures such slot, only the UL symbols will be valid anyways from UE perspective. 3. PUSCH TDRA should be in consecutive **UL** slots. That means, the allocated slots in time domain can be non-consecutive in TDD configurations. However, TDRA configuration can simply provide a number of slots for multiple PUSCH. Then, the slots that are “UL” will be the valid slots in non-consecutive manner. For example, if TDD pattern is “DDDSUDDDSU…” and TDRA configures 10 consecutive slots, There will be 2 valid UL slots.   Suggestion 3:  In our view, all alternatives require some modifications. For example, it’s not clear how Alt-C2 can be used for type-1 CG PUSCH or how it can be signaled via DCI 0\_0. |

## 2.2 HARQ process ID determination

**Moderator’s summary:**

In previous meeting, the following agreement was made:

**Agreement**

For determination of HARQ process IDs associated to PUSCHs in multi-PUSCHs CG assuming one TB per PUSCH, consider the following alternatives:

* **Alt. 1:** The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured, and applying "the period duration divided by X instead of the period duration.
  + The HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period.
  + Alt 1-1; X = 1
  + Alt 1-2: X is the number of configured PUSCHs in a period
  + Alt 1-3: X is provided by RRC configuration.
  + FFS details
* **Alt. 2:** Support that UE can decide, as in NR-U, the HARQ IDs for the multiple CG PUSCH transmission occasions and indicate the decided HARQ IDs to gNB if multiple HARQ processes are used for the multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration
  + FFS details
* **Alt. 3:** The HARQ process ID for the configured PUSCHs in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured.
  + FFS on potential enhancements different from previous alternatives
  + Alt 3-1: Note: Same HP ID would be used for all PUSCHs within a period.
    - FFS details
  + Alt 3-2: Note: Different HP ID could be used for all PUSCHs within a period.
    - FFS details
* Alt. 4: The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured.
  + The HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period
  + FFS on potential enhancements different from previous alternatives
* Alt 5: Support that UE can decide, as in NR-U, the HARQ IDs for the first CG PUSCH transmission occasions and indicate the decided HARQ IDs to gNB if multiple HARQ processes are used for the multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration
  + The HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period
  + FFS details
* Alt 6**:** FFS other solutions

Note: The case of one TB map to multiple PUSCHs is not considered here.

**Companies’ view:**

* **Alt. 1:** E///, QC, IDC, DCM, OPPO, MTK, DCM, OPPO, LG, TCL, Apple, Google, CATT, Nokia/NSB, CMCC, FGI, NEC, DENSO, FW (w time-offset), HW/HiSi (w time-offset)
  + **Alt. 1-1:** TCL, Apple
  + **Alt. 1-2:** E///, QC, IDC, HW/HiSi, DCM, OPPO, MTK, FW (w time-offset),HW/HiSi (w time-offset)
  + **Alt. 1-3:** DCM, OPPO, LG, FW (w time-offset)
* **Alt. 2**
  + Yes: FW, Vivo, OPPO, Spreadtrum, Samsung, DENSO
  + No: ZTE, HW/HiSi, Google, CATT
* **Alt. 3**
  + Yes: MTK (Alt. 3-2)
  + No: E///, vivo, HW/HiSi, MTK (Alt. 3-1)
* **Alt. 4:** vivo, HW/HiSi, Lenovo, Spreadtrum, Samsung, IDC, Sharp, CIACT, Intel, [MTK]
  + **Alt-4 without FFS (i.e. Alt 1-1):** 
    - Samsung, Lenovo, Spreadtrum, IDC, Sharp, CIATC, Intel
  + **Alt-4 with FFS (i.e. Alt. 1 w update):** 
    - vivo (Alt. 1-1 w increment Y)
    - HW/HiSi (Alt. 1-2 w time-offset)
* **Alt. 5**
  + **Yes:** FW
  + **No:** ZTE, E///, HW/HiSi, Google, CATT
* **Other comments:** MTK, Xiaomi, Panasonic
* **Proposal 7** : Legacy CG HARQ ID formula is modified to include the current PUSCH TO index to determine corresponding HARQ ID.
* **Proposal 11 (xiaomi)**: RAN1 should postpone discussing HP process IDs until the maximum number of TO that can b(MTK)e configured in a CG period is agreed.
* **Proposal 3 (Panasonic)**: To increase the HP ID utilization, a minimum time period should be defined for reusing the HP ID. The HP ID can be reused for a PUSCH occasions if the minimum time period has passed.

**Moderator’s observations:**

* **Observation 1:** Regarding Alt-2 and Alt-5 (UE based implementation), few companies expressed clearly that are not supporting such approach. While the supporting companies for Alt-2 and/or Alt-5, expressed support for other alternatives as well (Alt. 1 or Alt. 4).
* **Observation 2:** Regarding Alt-3, few companies expressed clearly that are not supporting such approach. A company that supports Alt. 3-2, also supports Alt. 4.
  + **From these two observations, Moderator suggests focusing on Alt. 1 and Alt.4.**
* **Observation 3:** Regarding Alt. 4, as shown above, a set of companies prefer Alt. 4 without any further changes that would be equivalent to Alt. 1-1. Another set, 2 companies’ proposal is modified version of Alt. 1. One company uses the same principal w different adjustment. Note that MTK has a proposal based on adjustment of the legacy proposal (without applying the increment rule). Hence, it is captured as Alt. 6 and not part of Alt. 1 or Alt.4
  + **Alt.4 can be merged in Alt.1.**
* **Observation 4:** Companies e.g., LG also can additionally express that X should be a configurable value different than 1, or number of PUSCHs in a period (i.e., Alt. 1-3). MTK also proposes to consider legacy proposal without increment and use other adjustment instead.
* **Observation 5:** Regarding xiaomi proposal, the proposed solution work for any number of maximum TOs per period. Hence, it is recommended to instead discuss to reach to a solution. Regarding Panasonic proposal, it is not clear how the corresponding solution should be formulated and whether the maximum number of HARQ IDs together with HARQID offset, somehow implicitly define a window.

**Based on above observations, the expressed views are re-arranged as the following:**

**Alt. 1:** E///, QC, IDC, DCM, OPPO, MTK, DCM, OPPO, LG, TCL, Apple, Google, CATT, Nokia/NSB, CMCC, FGI, NEC, DENSO, FW (w time-offset), HW/HiSi (w time-offset), Samsung, Lenovo, Spreadtrum, IDC, Sharp, CIATC, Intel

* **Alt. 1-1:** TCL, Apple, Samsung, Lenovo, Spreadtrum, IDC, Sharp, CIATC, Intel, vivo (increment w Y>1)
* **Alt. 1-2:** E///, QC, IDC, HW/HiSi, DCM, OPPO, MTK, FW (w time-offset), HW/HiSi (w time-offset)
* **Alt. 1-3:** DCM, OPPO, LG, FW (w time-offset)

**Alt. 6:** MTK (Proposal 7)

Table 2: Summary of Contributions inputs for Section 2.2

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| Futurewei | **Observation 2**: Due to the regular periodicity of the configured CG resources for CG PUSCH configuration being not guaranteed, the legacy HARQ process ID determination mechanism based on regular periodic resource allocation (i.e., Alt. 1, Alt. 3, and Alt. 4) can't be applied directly to the multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration for uplink XR traffic.  **Proposal 3**: Support that the periodicity of CG resources in legacy HARQ process ID determination formula (i.e., Alt. 1, Alt. 3, and Alt. 4) can be replaced with non-integer periodicity of XR traffic or a nominal periodicity of CG resources which is the same as non-integer periodicity of XR traffic if formula based HARQ process ID determination supported.  **Observation 3**: To overcome (or reduce) jitter impacts on CG PUSCH resource allocation, a time offset value, between the regular arrival time of XR traffic and the CG PUSCH resource allocation, needs to be introduced, which may impact the HARQ process ID determination results for formula based HARQ process ID determinations (i.e., Alt 1-2 and Alt 1-3).  **Proposal 4**: Support that a time offset value is introduced for the formula based HARQ process ID determination (i.e., Alt. 1-2 and Alt. 1-3) to avoid jitter impacts on CG PUSCH resource allocation and HARQ process ID determination if formula based HARQ process ID determination supported (i.e., Alt. 1).  **Proposal 5**: Support that UE can decide, as in NR-U, the HARQ process ID(s) (i.e., Alt.2 and Alt.5) for the multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration for uplink XR traffic and indicate the decided HARQ process ID(s) to gNB. |
| Ericsson | **Proposal 4** For HARQ process ID determination of multi-PUSCHs CG, prioritize Alt-1 and Alt-2 for further down-selection.  **Proposal 5** For HARQ process ID determination of multi-PUSCHs CG, prioritize Alt-1 over Alt-2 for further down-selection.  **Proposal 6** Support Alt. 1-2 for HARQ process ID determination of PUSCHs in multi-PUSCHs CG. |
| vivo | **Proposal 4**: For determination of HARQ process IDs associated to CG PUSCHs in multi-PUSCHs CG assuming one TB per CG PUSCH, consider the following alternatives:  \* Alt. 2: Support that the UE can decide, as in NR-U, the HARQ process IDs for the multiple CG PUSCH occasions and indicate the decided HARQ process IDs to the gNB if multiple HARQ processes are used for the multiple CG PUSCH occasions in a period of a single CG PUSCH configuration.  \* Alt. 4: The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured.  o The HARQ process IDs of the remaining CG PUSCHs in the period are determined by incrementing Y to the HARQ process ID of the preceding PUSCH in the same period  \* Y is an integer value larger than 1, e.g., Y is the number of configured CG PUSCHs in a period or is configured independently by RRC signalling |
| Qualcomm | **Proposal 4**: Support Alt 1-2 for HARQ Process ID determination for multiple PUSCH occasions in the CG period  \* HARQ process ID for the first valid PUSCH in a CG period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured  \* Apply "the CG period duration divided by X = the number of configured PUSCH occasions in a CG period" instead of the CG period duration |
| ZTE/Sanechips | **Observation 3**: The principle of maximum gap between CG PUSCH occasions using the same HARQ process ID is beneficial to minimize the HARQ process ID congestion. While the principle of limited total number of HARQ process ID used by CG is help for avoiding HARQ process ID starvation.  **Observation 4**: Same HARQ process ID pattern for each CG period is capable of achieving maximum gap between CG PUSCH occasions using the same HARQ process ID and minimum total number of HARQ process ID used by CG, if all transmission occasions in each period are used.  **Observation 5**: A cyclic-shifted HARQ process ID pattern for each CG period is capable of achieving maximum gap among CG PUSCH occasions using the same HARQ process ID and having minimum total number of HARQ process ID used by CG, if unused transmission occasions exist in CG periods.  **Proposal 6**: Do not support HARQ process ID determination to be determined by UE implementation, including e.g., Alt 2 and Alt 5 in the agreement of HARQ process ID determination in RAN1#112 meeting.  **Proposal 7**: The unused HARQ process ID of the unused transmission occasion should be considered, if the determination of HARQ process IDs associated to PUSCHs in multi-PUSCHs CG is supported, including e.g., Alt 1, Alt 3 and Alt 4 in the agreement of HARQ process ID determination in RAN1#112 meeting. |
| TCL Comm. | **Proposal 4**: For XR, when multiple TOs within a CG is configured, the HARQ-ID for the first configured/valid PUSCH within a CG configuration is determined based on current mechanism which is defined in TS 38.321, then the HARQ-ID of the remaining TOs within a CG period is determined by incrementing the HARQ-ID of the preceding TO within a CG configuration. |
| IDC | **Proposal 3**: For multi-PUSCH CG, update the HPI formula to consider the number of PUSCH occasions in a CG period |
| HW/HiSi | **Observation 7**: The HARQ process IDs of each CG PUSCH in one period are the same according to the formula in Alt. 3, which would increases gNB scheduling complexity and decreases XR capacity.  **Proposal 4**: Further study HARQ process ID determination mechanism with the following principles  \* Minimize signalling overhead  \* Maximize the gap between CG PUSCH occasions using the same HARQ process ID, considering the number of unused occasions in a period  \* Minimize the total number of HARQ process used by CG  **Proposal 5**: The determination of the HARQ process ID of multi-PUSCHs CG is not left to UE implementation, i.e., do not support Alt 2 and Alt 5.  **Proposal 6**: On HARQ process ID determination, support enhancement based on Alt 4 or Alt 1-2 by skipping HARQ process ID increment over unused CG PUSCH occasion(s)  \* HARQ Process ID = [floor(CURRENT\_symbol/(periodicity/X)) + offset] modulo nrofHARQ-Processes  \* Where X is the number of configured PUSCH occasions in a CG period, and the 'offset' equals to the number of unused PUSCH occasion(s) of the last CG period. |
| NTT DOCOMO | **Proposal 4**: Support Alt 1 for HP ID determination of multiple CG PUSCHs in one CG period, i.e.  \* The HARQ process ID for the first valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured, and applying "the period duration divided by X instead of the period duration.  \* X is the number of configured PUSCHs in a period, or X is provided by RRC configuration.  \* The HARQ process ID of the remaining valid PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding valid PUSCH in the period. |
| Google Inc. | **Proposal 3**: For the HPI determination, Alt-1 should be supported:  \* The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured, and applying "the period duration divided by X instead of the period duration.  **Proposal 4**: For the HPI determination, Alt. 2 and Alt. 5 where the UE is deciding on the HPI for its UL transmission should not be supported |
| OPPO | **Proposal 3**: For determination of HARQ process IDs associated to PUSCHs in a multi-PUSCHs CG configuration, solution is selected from {Alt.1-2, Alt.1-3, Alt.2}. |
| MTK | **Observation 2**: Existing HARQ process ID determination formula in TS38.321 does not work with multiple PUSCH transmission occasions as it does not assign different HARQ IDs for each PUSCH within one single GCG period.  **Proposal 4**: HARQ process ID determination is based on a modified version of the formula from the legacy CG procedure when cg-RetransmissionTimer is not configured (e.g., Alt-1, Alt-3-2, Alt-4).  **Proposal 5**: Assigning same HARQ ID to multiple PUSCH TOs (e.g., Alt-3-1) is NOT considered.  **Proposal 6**: When RAN1 reaches an agreement on HARQ ID determination, RAN1 shall send an LS to RAN2 to consult them about the feasibility of the RAN1 agreement on the HARQ ID determination formula modification.  **Proposal 7**: Legacy CG HARQ ID formula is modified to include the current PUSCH TO index to determine corresponding HARQ ID.  **Proposal 8**: The parameter "current PUSCH TO index" shall be formulated in a non-ambiguous manner. |
| CATT | **Proposal 3**: The following HPID determination method could be supported:  • The HPID for the multiple CG PUSCHs in a CG period determined and reported by UE should not be supported in Rel-18 XR work item.  • The HARQ process ID based on the Alt-1 would be enhanced that the HPID of first CG occasion can be calculated as the legacy method and the HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period by an offset, e.g. 2.  • The single TB transmission mapping to one or more CG occasions could reduce the number of HARQ process ID and should be further studied based on the repetition framework. |
| Nokia/NSB | **Proposal 4**: RAN1 should investigate further Alt 1 for HARQ process ID determination and not consider other alternatives anymore. |
| Apple | **Proposal 7**: Alt. 1-1 is adopted for HPID determination. |
| IDC | **Proposal 3**: For multi-PUSCH CG, update the HPI formula to consider the number of PUSCH occasions in a CG period |
| xiaomi | **Proposal 11**: RAN1 should postpone discussing HP process IDs until the maximum number of TO that can be configured in a CG period is agreed. |
| LG | **Proposal 6**: Support Alt. 1-3 for HARQ process ID allocation for multiple CG occasions in a period. |
| Lenovo | **Proposal 2**: Support Alt. 4 for HARQ process ID determination.  \* A HARQ process ID is assigned to a configured CG PUSCH occasion. |
| Spreadtrum comm. | **Proposal 2**: Alt 2 and Alt 4 can be considered as a baseline for determination of HARQ process IDs associated to PUSCHs in multi-PUSCHs CG:  \* Alt 2: Support that UE can decide, as in NR-U, the HARQ IDs for the multiple CG PUSCH transmission occasions and indicate the decided HARQ IDs to gNB if multiple HARQ processes are used for the multiple CG PUSCH transmission occasions in a period of a single CG PUSCH configuration  \* Alt 4: The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured. |
| CMCC | **Proposal 4**. Support Alt. 1 for determination of HARQ process IDs associated to PUSCHs in multi-PUSCHs CG.  \* For the first configured/valid PUSCH in a CG period:  o HARQ Process ID = [floor(CURRENT\_symbol / (periodicity / X))] modulo nrofHARQ-Processes + harq-ProcID-Offset2, where X equals the number of configured PUSCHs in a CG period  \* For the remaining PUSCHs in the CG period:  o HARQ Process ID = (increment the HARQ process ID of the preceding PUSCH in the period) modulo nrofHARQ-Processes |
| Samsung | **Proposal 3**: For HPN determination for "multi-CG PUSCH", apply Alt-2 or Alt-4. |
| Sharp | **Proposal 4**: The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured.  \* The HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period |
| FGI | **Proposal 2**: Adopt Alt. 1 for determination of HARQ process IDs associated to PUSCHs in multi-PUSCHs CG. |
| Panasonic | **Proposal 3**: To increase the HP ID utilization, a minimum time period should be defined for reusing the HP ID. The HP ID can be reused for a PUSCH occasions if the minimum time period has passed. |
| CAICT | **Proposal 2**: HARQ process IDs are allocated to valid PUSCHs other than configured PUSCH occasions in a period.  **Proposal 3**: The HARQ process ID for the first valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured. The HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period. |
| DENSO CORP. | **Observation 3**: For determination of HARQ process ID of CG PUSCHs associated to a multi-PUSCHs CG, the following options can be considered.  - Option.1: As in DG scheduling multi-PUSCHs, the HARQ process ID is determined by incrementing the HARQ process ID of the preceding PUSCH in the CG period.  - Option.2: As in NR-U CG, the UE can select the HARQ process IDs for multiple CG PUSCH occasions and transmit them on the UCI.  **Observation 4**: Given that multi-PUSCHs CG may have some unused occasions due to the random jitter and various packet size of the XR service, it seems effective to allow the UE to select the HARQ process IDs, as in NR-U CG, so as not to reserve too many HARQ process IDs. |
| NEC | **Proposal 4**: regarding the HP ID determination, support Alt .1 for the semi-static method, and further study Alt .2 and Alt. 5 for UE determined method based on whether UCI can be transmitted multiple times in a CG period. |
| Intel | **Proposal 4**: Support Alt-4 for HARQ-ID determination of multi-PUSCHs CG.  \* The HARQ process ID for the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured.  o The HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period |

### 2.2.1 Initial Discussions

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

Considering the summary and observations above, Moderator suggests the following for discussion:

**Aim for decision at this meeting.**

* **Suggestion 1:** Focus on Alt. 1-1 and Alt. 1-2.
* **Suggestion 1-2:** Further discuss whether to include time-offset as proposed by HW/HiSi and FW for Alt. 1-2
* **Suggestion 1-3:** Further discuss whether to increment with Y>1 as proposed by vivo for Alt. 1-1.
* **Suggestion 2:** Discuss Atl. 6 to understand companies views.
  + In case of low interest after understanding its properties, Moderator suggests down-prioritizing this approach too.

**Questions:** Please provide your view in the table below regarding the following questions:

* **Q1:** What is your view regarding Moderator’s suggestions for progress on HARQ ID determination design?
* **Q2:** Please review the motivations for different solutions and answer the following:
  + **Regarding suggestion 1:** Please indicate/motivate your preference between Alt 1-1 and Alt 1-2.
  + **Regarding suggestion 1-2/1-3:** Please indicate/motivate your view on proposed adjustments.
  + **Regarding suggestion 2:** Please indicate/motivate your view on the proposed adjustment.
* **Q3:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | * For Suggestion 1: We are fine with focusing on Alt 1-1 and Alt 1-2.   We also highlight that the HP ID of unused TO should be taken into account, in that respect, in fact **Alt 1-1** is more robust compared to the other.   * For Suggestion 1-2: Again, if the HP ID of unused TO was considered as unused for CG PUSCH TOs, adding time-offset into the formula would be necessary. In this case, we can maximize the time gap between the PUSCHs using same HP ID. Furthermore, the time offset can be the number of used transmission occasions, or the last used HP ID of the used transmission occasions in previous CG period. * For Suggestion 1-3: We’re fine to discuss and understand the intention and benefits of this approach. |
| **Nokia, NSB** | **Q1:** agree with moderator’s suggestion.  **Q2:**  **Regarding suggestion 1:** Our preference is Alt 1-2. It is understood that Alt 1-1 is simply re-using the current formula, based on the legacy CG procedure when cg-RetransmissionTimer is not configured. Alt 1-1 will lead to the same HARQ IDs across neighboring CG periods, which potentially will lead to the problems with ReTx or not available CG PUSCH occasion, thus it is not preferred.  **Regarding suggestion 1-2:** we do not see an issue if Alt 1-2 is not extended with time offset. However, considering the additional time offset will bring the ambiguity at gNB side as it is not clear, why gNB did not receive during the first/second/etc. occasion (jitter issues, UE skipped the UL, etc.).  **Regarding suggestion 1-3:** We are ok to further compare two options of modifying the formula, i.e., periodicity/X or increased IDs in one period by Y>1.  **Regarding suggestion 2:** The approach is also based on modification the formula. If the IDs will be distributed the same way as for Alt 1-2, we think Alt 1-2 is better as less modifications to formula. |
| **CATT** | We are OK on Suggestion 1-1 to focus on Alt 1-1 and 1-2.  Suggestion 1-2, CATT suggests an offset value between adjacent period of XR traffic generation duration to avoid collision. An “offset” value could be considered but not necessary “time offset”  We are OK with suggestion 1-3.  We don’t see the need to further discussion suggestion 2. |
| **New H3C** | We agree with suggestion 1-1 |
| **Qualcomm** | Support Alt 1-2 for HARQ Process ID determination for multiple PUSCH occasions in the CG period |
| **Google** | **Q1**: We agree with the moderator proposal to focus on Alt 1-1 and 1-2.  **Q2:**  **Regarding suggestion 1:** We support Alt 1-2. However, for simplicity and to avoid any future rounding issues, we prefer to multiply floor(CURRENT\_symbol/periodicity) by X instead of dividing the periodicity by X.  **Regarding suggestion 1-2:** introducing an offset to account for the unused occasions could create some mismatch between the UE and the gNB if the gNB misses the reception of the UCI indicating the unused occasions. Let’s assume we have 4 CG occasions per CG period and the UCI is transmitted on the 2nd occasion to indicate the 4th occasion as unused. In this case, the offset is equal to 1. If the gNB misses the reception of the 2nd occasion carrying the UCI, the gNB would consider the offset is equal to 0 in the following CG period and the UE would consider the offset is equal to 1.  **Regarding suggestion 2:** we support discussing it. Actually, In Alt 1-1, the HARQ process ID of the remaining PUSCHs in the period is determined by incrementing the HARQ process ID of the preceding PUSCH in the period and this can also be captured in the formula with CG occasion index *I* as below  HARQ Process ID = [X \* floor(CURRENT\_symbol/periodicity) + I ] modulo nrofHARQ-Processes |
| **Samsung** | In practice, having the UE indicate the HARQ process will be fine as it can be expected that the network will switch to DG PUSCH once BSR is available after first (very) few CG PUSCHs. That also avoids additional specification impact.  For progress, OK with suggestion 1 but there is no motivation to further discuss suggestion 1-1 or 1-2 if no problem is identified for the alternatives of suggestion 1. |
| **Futurewei** | For Q1: in Suggestion 1, Alt. 2 also needs to be focused on since it has the best flexibility for HARQ process ID determinations. For example, if a CG PUSCH transmission occasion, of the multiple CG PUSCH transmission occasions, is not used by UE, UE need not allocate HARQ process ID for the unused CG PUSCH transmission occasion. Furthermore, periodicity mismatch issue and jitter range issue have much less impacts on UE based HARQ process ID determination. We are ok with other FL suggestions.  For Q2: Please review the motivations for different solutions and answer the following:   * + **Regarding suggestion 1:** Please indicate/motivate your preference between Alt 1-1 and Alt 1-2.     - [FW]: We prefer Alt 1-2 between Alt 1-1 and Alt 1-2, since Alt 1-1 can introduce much more duplications for HARQ IDs of different PUSCH occasions, which will impact retransmission throughput for different PUSCH occasions.   + **Regarding suggestion 1-2/1-3:** Please indicate/motivate your view on proposed adjustments.     - [FW]: We think the finally adopted solution should be much flexible enough to support more possible traffic models/patterns of XR even in future, since XR is still an infantile field and new applications would continuously come out in the years ahead, meanwhile, new traffic model/pattern of XR more likely would also be introduced in future. For example, based on the latest RAN2 agreement in RAN2#121, RAN2 thinks uplink jitter may be present for XR (e.g., for tethering use cases). Therefore, the new introduced traffic model/pattern of XR in future should have as less standardization impacts on the finally adopted solution as possible. In that sense, we support that a time offset value is introduced for the formula based HARQ process ID determination (i.e., Alt. 1-2 and Alt. 1-3) to avoid jitter impacts on CG PUSCH resource allocation and HARQ process ID determination if formula based HARQ process ID determination supported (i.e., Alt. 1-2 and Alt. 1-3).   + **Regarding suggestion 2:** Please indicate/motivate your view on the proposed adjustment.     - [FW]: support that a time offset value is introduced for the formula based HARQ process ID determination (i.e., Alt. 1-2 and Alt. 1-3) to avoid jitter impacts.   For Q3: we revise suggestion 1 as below:  **suggestion 1:** Please indicate/motivate your preference between Alt 1-1, Alt 1-2 and Alt. 2. |
| **InterDigital** | Q1: We agree with moderator’s suggestions  Q2: Our preference is Alt 1-2, given that it can be supported with a simple update to the existing HPI and addresses the issue of HPI collision across CG periods to some extent by accounting for the number of PUSCHs in a CG period. |
| **Xiaomi** | Since most companies want to talk about HP ID directly, we agree with moderator’s suggestion. We’re fine to discuss benefits of the approach in suggestion 1-3. |
| **Sharp** | We support moderator’s suggestions, and are open with Alt 1-1 or Alt 1-2. |
| **Apple** | We support Alt. 1-1. |
| **vivo** | For Suggestion 1: We think alt 2 is the simplest alternative which is supported in the current specification. It should not be precluded.  For Suggestion 1-2: we think the unused HARQ process ID can be used for DG PUSCH, there is no need to introduce addition time-offset.  For Suggestion 1-3: between alt 1-1 and alt 1-2, we slightly prefer alt 1-1. For alt 1-1, with Y>1, the first configured/valid PUSCH in a period is determined based on the legacy CG procedure when cg-RetransmissionTimer is not configured without additional update regrading X. Meanwhile, it can avoid the collision of HARQ process ID for different CG PUSCHs in consecutive periods. |
| **OPPO** | We suggest focus on Alt. 1-2 and Alt. 2.  Alt 1-1 may lead scheduling limitation, because multiple HP ID will be used in adjacent periods, as shown in below. We think Alt.2 has least impact on the specification, since it has been supported in NR-U. |
| **TCL** | Q1: We agree with the moderator proposal to focus on Alt 1-1 and 1-2. In our views, the current mechanism can be reused as much as possible to mitigate the impact of spec, thus, we prefer Alt 1-1.  Q2: We are OK with suggestion 1-3. |
| **DOCOMO** | Q1: We agree with the suggestion.  Q2: Our preference is Alt 1-2. |
| **LG** | We can support Alt 1-2, and Alt. 1-3 can be considered as compromise solution between Alt. 1-1 and Alt 1-1  Regarding suggestion 1-2, we support to add time-offset which can help adjusting starting HARQ process ID when multiple CG configurations are configured.  Regarding suggestion 1-3, we don’t see the clear motivation to support incrementing with Y>1  Regarding suggestion 2, we prefer to focus on listed solution. |
| **MediaTek** | **Suggestion 1:** We are fine to focus on Alt 1-1 and Alt 1-2. We prefer Alt 1-2. As suggested by Google, it is safer to multiply by X after the floor operation rather than dividing the periodicity by X before the floor operation. This is better to avoid potential rational number issues.  **Suggestion 1-2:** If the HARQ ID assignment is skipped for unused TO, there will be potential misunderstandings between gNB and UE. This is a serious issue since it will impact HARQ re-transmission reliability. A HARQ ID should be assigned for all PUSCH TOs, even if they are not used by the UE.  **Suggestion 1-3:** Yes, HARQ ID should be incremented for each PUSCH. The formula should be as follows. Y is an integer that is equal to the PUSCH TO index in a CG period. So, such formulation would increment the HARQ ID by 1.  HARQ Process ID = [X \* floor(CURRENT\_symbol/periodicity) + Y ] modulo nrofHARQ-Processes  **Suggestion 2:** Our Proposal-7 is not actually a different alternative. It’s related to Alt 1-2. So, our suggestion to introduce “current PUSCH TO index” is basically to have the HARQ ID increments for each PUSCH TO, as defined by “Y” in the formula above. We need to formulate this parameter in the specifications as well. |

## FDRA and MCS determination

**Moderator’s summary:**

In previous meeting, the following agreement was made:

**Agreement**

For the PUSCHs parameters in a multi-PUSCHs CG configuration, the configuration/indication parameters except MCS and FDRA of CG PUSCHs in a multi-PUSCHs CG configuration are the same

* FFS: For MCS and FDRA, study further to decide whether/how to be different.
* FFS: Applicability to type-1 and type-2
* Note: TDRA and HP ID are not in this scope of the above statement.

Companies’ view regarding the FDRA and MCS design are summarized below:

* **MCS design**
  + Same MCS
    - E///, CATT, DCM, MTK, Panasonic, Intel, xiaomi, Lenovo, Samsung, OPPO
  + Different MCS
    - QC, ZTE, HW/HiSi, Nokia/NSB, Apple, CMCC, Sharp, Sony, TCL
* **FDRA design**
  + Same FDRA
    - E///, CATT, DCM, MTK, Nokia/NSB, Panasonic, Intel, xiaomi, Lenovo, Samsung, OPPO
  + Different FDRA
    - QC, ZTE, HW/HiSi, Apple, Sharp, Sony, TCL

**Moderator’s Observation:**

Majority of companies prefer the same MCS and FDRA. With respect to motivation both camps provided respective motivations (see respective contributions). However, regarding the design solutions to enable different MCS and/or FDRA parameters only ZTE, HW/HiSi and Nokia/NSB have elaborated somewhat regarding the preferred solutions as summarized below:

* **Solutions for different MCSs**
* For Type-1 CG, *mcsAndTBS* field in RRC signaling should be extended to a sequence for indicating multiple MCS levels
  + ZTE, HW/HiSi, ~~Nokia/NSB~~
* For Type-2 CG:
  + Extend MCS field in DCI signaling. FFS details to reduce overhead
    - ZTE, ~~Nokia/NSB~~
  + Combine DCI indication and RRC in indicate MCS. FFS details
    - HW/HiSi
  + A reference or baseline MCS is indicated in RRC ignaling (type 1 CG) or in activation DCI (type 2 CG). The MCS change is indicated in an implicit manner. Details FFS
    - Nokia/NSB
* **Solutions for different FDRAs**
* For Type-1 CG, *frequencyDomainAllocation* in RRC signaling should be extended to a sequence for indicating multiple FDRAs
  + ZTE, HW/HiSi
* For Type-2 CG
  + Extend FDRA field in DCI signaling. FFS details to reduce overhead
    - ZTE
  + Combine DCI indication and RRC in indicate FDRA. FFS details
    - HW/HiSi

Table 3: Summary of Contributions inputs for Section 2.3

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| Ericsson | **Proposal 7** The PUSCHs corresponding to a multi-PUSCHs CG apply the same FDRA and MCS index for both Type-1 and Type-2 CG. |
| Qualcomm | **Proposal 3**: Support different MCS and FDRA parameter values for multiple PUSCH occasions in the CG period |
| CATT | **Proposal 2**: The other parameters including MCS and FDRA in a multi-PUSCHs CG configuration should be the same. |
| ZTE/Sanechips | **Observation 6**: Flexibility of FDRA has benefits on frequency diversity as well as resource efficiency, and flexibility MCS level is helpful for successful data transmission in PDB limitation.  **Observation 7**: In Case 1, i.e., the transmission occasions in one CG period are used for transmitting a single XR packet, UCI is not able to indicate the transmission occasion usage in multiple CG periods, due to bare prior knowledge of packet size, TDRA/FDRA/MCS level in the following periods.  **Proposal 8**: The overhead of activation signaling should be considered, if multiple FDRAs and/or multiple MCS levels are supported for multi-PUSCHs CG. |
| HW/HiSi | **Proposal 3**: The MCS and number of PRBs for each CG PUSCH occasion in a CG period can be different |
| DCM | **Proposal 5**: Support same MCS/FDRA parameter indication/configuration for multiple CG PUSCHs in one CG period. |
| MTK | **Proposal 9**: Same MCS and FDRA values apply to all PUSCH Tos in a CG configuration with multiple PUSCH. |
| Nokia/NSB | **Observation 5**: Changing MCS over multi-PUSCHs does not necessarily lead to change of FDRA.  **Proposal 5**: RAN1 should target for common solution to support different MCS for multi-PUSCHs within a CG period which can be applied to both Type-1 CG and Type-2 CG.  **Proposal 6**: RAN1 should support different MCS schemes for multi-PUSCHs within a CG period and investigate different solution options (e.g., explicit vs. implicit manner). |
| Panasonic | **Proposal 2**: The same MCS/FDRA parameters should be considered for a multi-PUSCHs CG. |
| Intel | **Proposal 3**: MCS and FDRA indication parameters are the same for different PUSCHs in a CG period. |
| Apple | **Proposal 1**: study enhancement to CG-UCI to support indication of MCS and/or PRB adjustment for configured grant. |
| Xiaomi | **Proposal 13**: FDRA of CG PUSCHs in a multi-PUSCHs CG configuration should be same.  **Proposal 14**: MCS of CG PUSCHs in a multi-PUSCHs CG configuration should be same. |
| Lenovo | **Proposal 3**: Same MCS/FDRA is applied to CG occasions within a period. |
| CMCC | **Proposal 3**. Support different MCS configurations for different PUSCHs in a CG period. |
| Samsung | **Proposal 2**: TDRA, FDRA, and MCS are same for all CG-PUSCHs of a “multi-CG PUSCH”. |
| Sharp | **Proposal 3**: Additional mechanisms for MCS and FDRA adjustments can be considered. |
| Sony | **Proposal 2**: Support the configuration/indication of the parameters MCS and FDRA of CG PUSCHs in a multi-PUSCHs CG configuration can be different. |
| OPPO | **Proposal 2**: It is not supported to indicate different MCSs/FDRAs for the different CG PUSCHs in a multiple CG-PUSCHs configuration. |
| TCL | **Proposal 11**: Multiple Tos with different MCS within a CG configuration for XR can be considered. |

### Initial Discussions

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

Based on the views expressed and observations above, there are two options to choose from.

**Suggestion 1:** **Aim for decision at this meeting**.

**Suggestion 2:** Consider the following proposal.

**Proposal 1-3-1:**

Decide one of the options below. If Option 2 is select, choose the preferred alternative.

**Option 1:** For CG PUSCHs in a multi-PUSCHs CG configuration, MCS of the CG PUSCHs in the CG configuration are the same

**Option 2:** For CG PUSCHs in a multi-PUSCHs CG configuration, MCS of the CG PUSCHs in the CG configuration can be different as the following:

* For Type-1 CG, *mcsAndTBS* field in RRC signaling should be extended to a sequence for indicating multiple MCS levels
* For Type-2 CG:
  + Alt-1: Extend MCS field in DCI signaling. FFS details to reduce overhead
  + Alt-2: Combine DCI indication and RRC in indicate MCS. FFS details
  + Alt-3: A reference or baseline MCS is indicated in RRC ignaling in activation DCI. The MCS change is indicated in an implicit manner. Details FFS

**Proposal 1-3-2:**

Decide one of the options below. If Option 2 is select, choose the preferred alternative.

**Option 1:** For CG PUSCHs in a multi-PUSCHs CG configuration, FDRA of the CG PUSCHs in the CG configuration are the same

**Option 2:** For CG PUSCHs in a multi-PUSCHs CG configuration, FDRA of the CG PUSCHs in the CG configuration can be different as the following:

* For Type-1 CG, *frequencyDomainAllocation* in RRC signaling should be extended to a sequence for indicating multiple FDRAs
* For Type-2 CG
  + Alt-1: Extend FDRA field in DCI signaling. FFS details to reduce overhead
  + Alt-2: Combine DCI indication and RRC in indicate FDRA. FFS details

**Question:** Please provide your view in the table below regarding the following questions:

* **Q1:** Please indicate your view on moderator’s suggestions and **Proposal 1-3-1** and **Proposal 1-3-2** and motivate your preference.Proponents of Option 2 are requested to provide more details for Type-2 CG solutions in listed alternatives.
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | For Proposal 1-3-1, as highlighted in the context, we see the benefit of flexibility and signaling impact as well, thus option 1 is preferable. But we can be flexible for option 1.  For Proposal 1-3-2, option 2 is preferable, and we can also be flexible for option 1. |
| **Nokia, NSB** | **\*We edited the observations above, highlighted in red.**  One potential problem due to the same MCS across multiple CG PUSCH occasions is the achievable reliability due to the reduced transmission time window for the later coming PDUs within the same PDU set. In order to simultaneously fulfil the requirements of PDU set delay budget (PSDB), without the introduction of support different MCS schemes, most likely we have to configure very robust MCS schemes for all TBs carrying the same PDU set. Clearly this will lead to reduced spectral efficiency. In our view, it would be beneficial to investigate options to support different MCSs over multi-PUSCHs within a CG period.  **Proposal 1-3-1:**  **We thus support Option 2 with modifications to be applicable to both type-1 and type-2 CG.**  **Option 2:** For CG PUSCHs in a multi-PUSCHs CG configuration, MCS of the CG PUSCHs in the CG configuration can be different as the following:   * For Type-1 CG: * *Alt-1: mcsAndTBS* field in RRC signaling should be extended to a sequence for indicating multiple MCS levels * *Alt-2:* A reference or baseline MCS is indicated in RRC ignaling (type 1). The MCS change is indicated in an implicit manner. Details FFS * For Type-2 CG:   + Alt-1: Extend MCS field in DCI signaling. FFS details to reduce overhead   + Alt-2: Combine DCI indication and RRC in indicate MCS. FFS details   + Alt-3: A reference or baseline MCS is indicated in activation DCI. The MCS change is indicated in an implicit manner. Details FFS   **Proposal 1-3-2:**  We think that different FDRA similar to different SLIV is not necessary as the video frame size will not be known in advance when configuring the CG. Thus, it is fine to have the same FDRA for each slot. Therefore, we support **Option 1.** |
| **CATT** | We are OK with moderator’s proposal.  We have questions on the proposal of different MCS and FDRA. Are the configuration value sets per slot or per XR traffic period by RRC semi-statically? How do they work in semi-static configuration? |
| **New H3C** | We are fine with moderator’s proposal. |
| **Qualcomm** | For both Proposal 1-3-1 and Proposal 1-3-2 we prefer Option 2. We can keep the details as FFS after deciding narrowing down the scope on which of the Options to support. |
| **Google** | We are OK with the moderator’s proposals. We support option 1 in Proposal 1-3-1 and option 1 in Proposal 1-3-2 to simplify the design. |
| **Samsung** | OK with the moderator’s proposal. However, it would be good to make more progress and conclude at this meeting as there is nothing requiring “further study” and nothing changed since last meeting.  In our opinion, proposals related to having different FDRA/TDRA/MCS for different CG-PUSCH Tos are ad-hoc and there is no justification for the network to operate XR with anything other than optimum settings for all CG-PUSCH Tos considering that latency is to be minimized, retransmissions are not deterministic, and that unused Tos will anyway be indicated as unused. Support Option 1. |
| **Futurewei** | For Proposal 1-3-1, we are ok with Option 1: For CG PUSCHs in a multi-PUSCHs CG configuration, MCS of the CG PUSCHs in the CG configuration are the same, which has much lower signaling overhead and lower complexity for UE and gNB.  For Proposal 1-3-2, we are ok with Option 1: For CG PUSCHs in a multi-PUSCHs CG configuration, FDRA of the CG PUSCHs in the CG configuration are the same, which has much lower signaling overhead and complexity for UE and gNB. |
| **InterDigital** | For both Proposals 1-3-1 and 1-3-2, we prefer Option 1 to keep the spec impact/effort low and manageable. However, we are open for considering Option 2, if further benefits/gains are well clarified. |
| **Xiaomi** | We agree with moderator’s proposal.  As mentioned in our contribution, gNB can configure the MCS for the UE based on the worst case. In this case, the time-frequency resources corresponding to CG occasion will be large. However, considering that unused CG occasions can be indicated as “unused” Ues and reused by the gNB, it will not cause serious waste of resources. Therefore, there is no need to configure different MCS.  Configuring different FDRA for different CG occasions within a CG period may cause some resource fragmentation, so we support option1. |
| **Sharp** | For both Proposals 1-3-1 and 1-3-2, we prefer Option2, and Alt-2 for Type 2 CG. |
| **Apple** | For both PRB and MCS, we support option 2. |
| **Vivo** | Proposal 1-3-1: option 1  Proposal 1-3-2: option 1  During the SI phase, simulations results were provided for different FDRA for different PUSCHs, but no obvious gain was observed., we think option 1 should be supported for simplicity unless significant gain are shown. |
| **OPPO** | We support Option 1 in both Proposal 1-3-1 and Proposal 1-3-2.  The CG PUSCH parameters should be configured based on long-term measurements, therefore different PUSCH parameters for CG PUSCHs in a multi-PUSCHs CG configuration seems not necessary. |
| **TCL** | For multiple-PUSCHs within a CG configuration configured for XR, the remaining delay for each TOs within a CG is different and some TOs located on the end of a CG may have not enough delay budget to enable re-transmission, thus, low MCS can be configured for the end of TOs within a CG to improve the reliability. Thus, we support option 2 in Proposal 1-3-1.  For Proposal 1-3-2, we prefer option 1, and we also accept option 2. |
| **DOCOMO** | We support Option 1 for both Proposal 1-3-1 and Proposal 1-3-2 for simplicity. |
| **LG** | We support Option 1 for both proposals. |
| **MediaTek** | We don’t see a clear need to have different MCS/FDRA per PUSCH. So, our preference is Option-1 in Proposal 1-3-1 and Option-1 in Proposal 1-3-2. |

## 2.4 Other topics

**Moderator’s summary:**

With respect to the feature multi-PUSCHs CG, companies have raised other aspects for discussions and decisions similar to the previous meeting. The topics are listed below including the direction of expressed views:

**Topic 1) Retransmission of multiple TBs with a single DCI with corresponding initial transmissions with CG PUSCHs**

* Support: E///, vivo, Google
* Not Support: Samsung

**Topic 2) Repetition for a multi-PUSCHs CG configuration**

* Support: QC, Spreadtrum, TCL
* Not support: E///, DCM, Samsung

**Topic 3) CBG retransmission for multiple CG PUSCHs**

* Support: Samsung

**Topic 4) One TB over multiple slots**

* Not support: Nokia, Samsung

**Topic 5) Frequency hopping as legacy CG**

* Support: E///

**Topic 6) CG-DFI based retransmission for multi-CG PUSCH**

* Support: Google, FW, IDC

**Topic 7) Collision resolution for CG PUSCHs**

* Support: Samsung

Table 4: Summary of Contributions inputs for Section 2.4

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| Futurewei | **Proposal 6**: Retransmissions of the multiple CG PUSCH transmission occasions, in a period of a single CG PUSCH configuration, are based on dynamic uplink grant(s) via dynamic grant resources and UE assumes ACK(s) in absence of reception of feedback after a timer expires if retransmissions for the multiple CG PUSCH transmission occasions supported. |
| Ericsson | **Proposal 8** PUSCH repetition is not supported. The same redundancy version (i.e., RV=0) is applied for the configured grant PUSCHs.  **Proposal 9** PUSCH Intra-slot frequency hopping is supported. PUSCH Inter-slot frequency hopping is not supported.  **Proposal 10** Scheduling re-transmission of multiple TBs for corresponding initial transmission of the TBs by configured grant is supported for DCI format 0\_1 scrambled with CS-RNTI. |
| vivo | **Proposal 3**: Scheduling multiple PUSCHs for retransmission by a DCI scrambled by CS-RNTI can be considered. |
| Qualcomm | **Proposal 5**: Support the following proposals. Discuss them in the following order of importance  \* Support retransmission of TBs for multiple CG PUSCHs by a dynamic UL grant  \* Support PUSCH repetition for multi-PUSCH CG  \* Support CBG based retransmission for multiple CG PUSCHs by a dynamic UL grant |
| Nokia/NSB | **Observation 6**: One TB over multiple slots is related to coverage enhancements and not to capacity enhancements.  **Proposal 7**: Down prioritize one TB over multiple slots in Rel18 WI XR Enhancements for NR. |
| Spreadtrum Comm. | **Proposal 3**: PUSCH repetition is supported for multi-PUSCHs CG configuration. |
| TCL Comm. | **Proposal 3**: Repetition for multi-PUSCH transmissions within a CG configuration can be supported. |
| NTT DOCOMO | **Proposal 3**: Not support joint operation of multiple CG PUSCH occasions in a CG period and CG PUSCH repetitions.  \* For example, if rep-K is configured with value K in ConfiguredGrantConfig, and the TDRA field in the activation DCI indicates multiple SLIVs, UE may transmit on the multiple CG PUSCH occasions in one CG period, with each CG PUSCH occasion with single repetition. |
| Google | **Proposal 5**: Single DCI scheduling multiple PUSCH occasions retransmission should be used to reduce PDCCH signalling overhead and the UE monitoring effort.  **Proposal 6**: DCI format 0\_1 scrambled with CS-RNTI and with the DFI flag enabled and set to 1 can be used for the UL XR traffic to carry the HARQ-ACK bitmap for all HARQ processes transmitted in the CG periods. |
| Apple | **Proposal 8**: RAN1 discusses and decides whether retransmission of a transport block previously carried by CG-PUSCH can be sent by a CG-PUSCH. |
| Samsung | * Providing a single TB over multiple CG-PUSCHs may be beneficial for improving coding gains for very small individual TBs (and for some TB CRC overhead reduction) but that is not the case for the very large TBs associated with XR while TB retransmissions will be practically impossible to handle and a resulting TB size may be larger than what a UE can currently support. * Re-transmission of multiple TBs by a single DCI was effectively discussed during the SI and is not supported. * CBG retransmission for multiple CG PUSCHs was discussed during the SI and is not supported. Although in principle a beneficial enhancement, the low target BLER required to meet PDB would limit any potential gain. * There is no need to support repetitions as the PDB cannot be met in such cases.   **Proposal 7: Extend the collision resolution procedure for SPS PDSCHs to CG-PUSCHs.** |
| IDC | **Proposal 4**: HARQ design from R16 NR CG is used as baseline for multi-PUSCH CG  **Proposal 5**: For multi-PUSCH CG, the HARQ feedback for multiple PUSCHs and dynamic assignments for retransmissions are provided in single DCI  **Proposal 6**: For multi-PUSCH CG, the UE monitors for PDCCH carrying the HARQ feedback for multiple PUSCHs in the first DL slot that is K slots after the last used PUSCH occasion |

### 2.4.1 Initial Discussions

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

Considering the topics, Moderator’s observation and suggestions are as the following:

* **Topic 1)** Retransmission of multiple TBs with a single DCI with corresponding initial transmissions with CG PUSCHs
  + This topic can be discussed independently from the progress on the code feature design.
  + Moderator suggests seeking the group view for discussion on this topic.
* **Topic 2)** Repetition for a multi-PUSCHs CG configuration
  + It seems the direction can be correlated to the outcome of TDRA design. If Alt-B (NR-U based) is supported, it is more straightforward to inherit repetition as well. If Al-C (Multi-PUSCH TDRA) is supported, it is more straightforward to inherit no-repetition as well. If Alt-A (repetition based) is supported, not clear what to do. Regardless, it seems the design choice for TDRA gives more clarity how to proceed on this topic.
  + Note that this does not imply that the discussion to motivate repetition. However, a decision on TDRA provides better clarity for the design as whole.
  + Moderator suggests considering this discussion after TDRA design is settled. Note that a decision for repetition is needed for core design of feature.
* **Topic 3)** CBG retransmission for multiple CG PUSCHs
  + This topic can be discussed independently from the progress on the code feature design.
  + Moderator suggests seeking the group view for discussion on this topic.
* **Topic 4)** One TB over multiple PUSCHs
  + The baseline is one TB per CG PUSCH. It is helpful to know whether the design of multi-PUSCHs CG should accommodate one TB over multiple PUSCHs in a way that is different from TBoMs. Clarity on this aspect is important for the decisions regarding HARQ process ID, etc.
  + Moderator suggest seeking the group view whether this topic can be down-prioritized, considering the concerns raised.
* **Topic 5)** Frequency hopping as legacy CG
  + Moderator’s understanding is that considering the following agreement, the legacy FH should be applied (i.e. support intra-slot FH as oppose to inter-slot FH).

**Agreement**

For the PUSCHs parameters in a multi-PUSCHs CG configuration, the configuration/indication parameters except MCS and FDRA of CG PUSCHs in a multi-PUSCHs CG configuration are the same

* FFS: For MCS and FDRA, study further to decide whether/how to be different.
* FFS: Applicability to type-1 and type-2
* Note: TDRA and HP ID are not in this scope of the above statement.
  + Moderator suggests confirming this understanding to conclude this topic.
* **Topic 6)** CG-DFI based retransmission for multi-CG PUSCH
  + Enabling DFI based CG-DFI mechanism is only supported for NR-U.
  + Moderator suggests seeking the level of interest in the group.
* **Topic 7)** Collision resolution for CG PUSCHs
  + Moderator suggests proponents providing more information to check the level of interest

**Questions:** Please provide your view in the table below regarding the following questions:

* **Q1:** Please indicate your view regarding the **moderator’s suggestions** regarding the topics above.
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | For Topic 2), I don’t think Alt C precludes the repetition for a multi-PUSCHs CG configuration, potential enhancement is still possible. Besides, we have more interests to discuss Topic 1) and Topic 3).  For other topics, we support moderator’s suggestions. |
| **Nokia, NSB** | **Please, find our views related to topics above:**  **Topic 1:** In our view, this topic is out of scope of the WI as it is DG enhancement, we also see no benefits from the enhancement for capacity improvements. We propose to down-prioritize it in Rel18 XR WI.  **Topic 2:** Ok to discuss after TDRA design is agreed, however, we think that the support of repetition can be decided already now. We propose to down-prioritize repetition in XR WI Rel18 as this feature will not increase capacity and our objectives are aiming for capacity enhancements.  **Topic 3:** Ok to down-prioritize CBG support in Rel 18 XR WI.  **Topic 4:** we think that TBoMs shall be de-prioritized in XR WI Rel18 similar to repetition, it will not provide any capacity enhancements while the goal of this WI is particularly to enhance capacity.  **Topic 5:** Ok  **Topic 6:** motivation to support CG-DFI is unclear, there is no problem with channel access in licensed as in unlicensed. Support to down-prioritize.  **Topic 7:** It seems rather general CG enhancement and some resolution principles are already specified, so not clear what exactly need to be solved on top. |
| **CATT** | **Topic 1:** There is no justification of benefit for this proposal  **Topic 2:** We need to support XR with coverage enhancement feature in Rel-17. Thus, this should be considered in the TDRA discussion.  **Topic 3:** No benefit is shown for CGB-based retransmission.  **Topic 4:** One TB mapping to more one CG occasions should be seriously discussed with the high variation of XR packet size. If the resource of CG is configured to be small to adapt to the variation of XR packet size, one TB mapping to one CG would suffer channel coding performance degradation for smaller codeblock size. If the resource of one CG is configured to be large, it would not fit to all variation of XR packet size. Thus, there would be lots of redundant to fill in the CG-PUSCH.  **Topic 5:** We didn’t see any performance benefits being shown with frequency hopping.  **Topic 6:** There is no justification of CG-DFI  **Topic 7:** There is no justification of the need of collision resolution. |
| **New H3C** | we support moderator’s all of suggestions |
| **Qualcomm** | Among all the Topics, Topic 7) is a critical one. The other ones are beneficial enhancements and can be discussed after the basic functions of the multi-PUSCH CG are sorted out. |
| **Google** | We support discussing topic 1 as it reduces the signaling overhead for the CG PUSCH occasions retransmissions. We think it is still within the scope as it consists of enhancing the multiple-PUSCH CG scheme.  For topic 2, we agree with the moderator to discuss this after TDRA design is settled  For topic 3, we would be interested in CBG-based retransmission if it shows capacity gain for the XR traffic when used in combination with the multiple-PUSCH CG.  We don’t see any capacity or performance gain in topic 4 and topic 5.  We support exploring topic 6 and extending the NR-U DFI design to XR, it allows for fast feedback for multiple CG occasions and reusing the remaining CG PUSCH occasions for retransmissions if needed without the need for additional dynamic allocation  Topic 7 could be discussed with low priority |
| **Samsung** | **Topic 1**: It is again the multi-PUSCH scheduling which has already been discussed. It would be good to not keep repeating the same discussions. The overall probability that retransmission of multiple TBs will be needed in a same HARQ-ACK feedback cycle is negligible and, even if it was not, DCI overhead savings are a non-issue for XR.  **Topic 2**: There is no justification for supporting repetitions with XR nor has there been any analysis showing that PDB can be met in case of repetitions for the scenarios that motivated the introducing of multi-PUSCH CG.  **Topic 3**: Already discussed during the SI and not agreed – same as for Topic 1 and no need to repeat the same discussions.  **Topic 4**: No need for TBoMS in XR. TBoMS is for very small TBs where coding gains can be obtained by having a larger TB spread over multiple PUSCHs. For XR, things would actually be worse with TBoMS as retransmission of huge TBs would be needed.  **Topic 5**: No need to further consider – the RB allocations for XR will anyway be large and frequency diversity will be inherent.  **Topic 6**: No need for DFI. Retransmissions will be atypical for XR and DCI-based ones are sufficient as there isn’t a DCI overhead issue even if BLER of ~10% was to be assumed.  **Topic 7**: Support. Collision resolution is specified for SPS PDSCH but not for CG-PUSCH as there was no corresponding use case. In XR, considering at a minimum pose control and a single stream of video frames, collisions will occur due to different periodicities. |
| **Futurewei** | We support Topic 1 as mentioned in our proposal below,  **Proposal 6**: Retransmissions of the multiple CG PUSCH transmission occasions, in a period of a single CG PUSCH configuration, are based on dynamic uplink grant(s) via dynamic grant resources and UE assumes ACK(s) in absence of reception of feedback after a timer expires if retransmissions for the multiple CG PUSCH transmission occasions supported.  For Topic 6, CG-DFI is designed for unlicensed carrier, which is not applied for licensed carrier and should not be supported.  For other Topics, we are ok with FL suggestions. |
| **InterDigital** | **Topic 1:** Ok to continue discussion. From our view, feedback associated with different PUSCH occasions provided in single DCI for retransmission can be beneficial from overhead reduction perspective.  **Topic 2:** Fine with moderator’s suggestion  **Topics 3 - 5:** Ok to down-prioritize in Rel-18, unless further benefits/gains can be shown.  **Topic 6:** Ok to consider once more progress is made on TDRA design aspects. |
| **Xiaomi** | We support moderator’s suggestions except topic 3.The topic 3 can be down-prioritized. |
| **Sharp** | Support moderator’s suggestions. |
| **vivo** | For topic 1, if Alt-C is supported, we think it is simple to support retransmission of multiple TBs with a single DCI.  For topic 2, we think the motivation to support repetition is not clear. We are fine with moderator’s suggestion.  For topic 3, we think this topic should be deprioritized.  For topic 4, we think TBoMs is mainly for power saving and should be deprioritized.  For topic 5, we prefer to following FH for multi-PUSCH for DG.  For topic 6, enabling DFI based CG-DFI mechanism is only supported for NR-U. we prefer to keep this.  For topic 7, we think the issue needs more clarification. |
| **OPPO** | Topic 1: Independent HARQ process is transmitted in multiple CG PUSCHs, so the benefits of retransmission of multiple TBs with a single DCI with corresponding initial transmissions with CG PUSCHs are unclear.  Topic 3: Legacy CGB retransmission can be reused for each of the multiple CG PUSCHs, and no additional enhancement is needed.  Topic 4: We suggest independent TB and HARQ process is transmitted in each CG PUSCH. This is the simplest and most efficient way. |
| **TCL** | Topic 2: Ok to discuss after TDRA design is agreed, anyway, repetition is one of most straightforward way to improve the reliability of XR traffic.  For other topics, we support moderator’s suggestions |
| **DOCOMO** | For topic 1, we are open to discuss this issue.  For topic 2, agree with moderator’s suggestion.  For topic 3, suggest to deprioritize this issue in this meeting.  For topic 4, agree with moderator’s suggestion to deprioritize this issue.  For topic 5, agree with moderator’s understanding on frequency hopping.  For topic 6, agree with moderator’s understanding that CG-DFI is supported in unlicensed spectrum. And even in unlicensed spectrum, we don’t think enhancement is needed.  For topic 7, we don’t’ think this issue needs enhancement. Legacy behavior is enough. |
| **LG** | As moderator mentioned, Topic 2 and 5 seems necessary to clarify and finalize core design. We support to discuss Topic 2 and confirm Topic 5.  Regarding other topics, we don’t see the clear motivation or justification. |
| **MediaTek** | Topic 1: This is DG enhancements, hence out of scope.  Topic 2: Not clear to us how TB repetitions can be beneficial to system capacity under agenda “XR-specific capacity enhancements”. This should also be out of scope from our perspective.  Topic 3: We don’t expect much gain from CBG retransmissions.  Topic 4: We can down-prioritize TBoMs.  Topic 5: No need for frequency hopping. |

# 3 Indication of unused transmission occasions

This section captures the summary of the discussions regarding the design aspects of the following WID objective:

|  |
| --- |
| - Dynamic indication of unused CG PUSCH occasion(s) based on UCI by the UE (RAN1, RAN2); |

## 3.1 What information the UCI contains? (UCI content)

**Moderator’s summary:**

In previous meeting, the following agreement was made:

**Agreement**

For dynamic indication of unused CG PUSCH transmission occasion(s) based on a UCI, the following options for further down-scoping, are considered for the information provided by the UCI:

* **Option 1:** The UCI determines the consecutive CG PUSCH TO(s) that are indicated as “unused”
  + **Option 1-1:** The UCI provides the number of consecutive TO(s) in time domain.
    - Applicable numbers can be determined from information obtained from configuration.
    - FFS details
  + **Option 1-2**: The UCI provides a time duration/range that includes the consecutive TO(s) in time domain.
    - Applicable time duration/range can be determined from information obtained from configuration
    - FFS details
* **Option 2:** The UCI determines the CG PUSCH TO(s) that are indicated as “unused” (consecutive/non-consecutive TO(s) in time domain)
  + **Option 2-1**: The UCI provides a bitmap where a bit corresponds to a TO within a time duration/range. The bit indicates whether the TO is “unused”.
    - Applicable time duration/range can be determined from information obtained from configuration
    - FFS details
  + **Option 2-2:** The UCI provides a bitmap where a bit corresponds to TOs within a time duration/range. The bit indicates whether all TOs within the time duration/range are “unused”.
    - Applicable time duration/range can be determined from information obtained from configuration
    - FFS details
* FFS whether/how the unused TO(s) can be associated to multiple CG configuration.
* Other options are not precluded. Proponent companies to provide details.

**Companies’ view:**

**Option 1 (~~12~~ 13):** FW, E///, HW/HiSi, vivo, ZTE, DCM, MTK, FGI, xiaomi, New H3C, NEC, Intel, Samsung

* **Option 1-1:** FW, HW/hiSi, DCM, MTK, xiaomi, Intel
* **Option 1-2:** E///, [ZTE], LG, DCM

**Option 2 (15)** QC, CATT, vivo, Spreadtrum, IDC, Google, OPPO, Lenovo, Nokia/NSB, Panasonic, DENSO, [TCL], xiaomi, CMCC, CAICT

* **Option 2-1:** QC, Google, OPPO, xiaomi, CAICT
* **Option 2-2:** CATT, [Spreadtrum], Lenovo, Nokia/NSB, Panasonic
* **Option 2-3:** xiaomi (**Proposal 2**)

**Option 3:** Nokia/NSB (**Proposal 9**)

**Moderator’s observation:**

**Observation 1:** Option 2 has the majority of support.

**Observation 2:** Regardless of the option, the main part of the design related to design of corresponding RRC parameters. Therefore, it is important to converge to an option as soon as possible and start discussing the design details.

**Observation 3:** Some companies’ solutions are applicable only to multi-PUSCHs CG configuration. Solutions are needed to be generalized to be applicable to any CG configuration.

**Observation 4:** Some companies have provided other solutions as listed above.

Table 5: Summary of Contributions inputs for Section 3.1

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| Futurewei | **Proposal 8**: Support that bitfield of the UCI jointly indicates a quantity of unused CG PUSCH occasions starting from the last CG PUSCH transmission occasion of the multiple CG PUSCH transmission occasions (i.e., Option 1-1).  **Observation 4**: To guarantee the indicated unused CG PUSCH occasion(s) to be really recycled to other UEs, time offset between UCI and the indicated unused CG PUSCH occasion(s) should be equal to or greater than the PUSCH preparing time for at least one of the other UEs.  **Proposal 9**: Indicating unused CG PUSCH occasion(s) to gNB can be determined based on a time offset threshold, indicated by gNB, between UCI and the unused CG PUSCH occasion(s). |
| Ericsson | **Observation 4** The term "UTO" refers to "unused transmission occasion(s)" and is used only for convenience in the discussion.  **Observation 5** The term "UTO-UCI" refers to "unused transmission occasion(s) indicated by uplink control information (UCI)" and is used only for convenience in the discussion.  **Observation 6** A previous UCI has indicated a CG PUSCH TO as "unused". Overriding means that a later UCI indicates the CG PUSCH TO as NOT "unused".  **Proposal 11** For dynamic indication of unused CG PUSCH transmission occasion(s) based on a UCI, the CG PUSCH TO(s) that can be indicated as "unused" are consecutive (i.e., Option 1 from agreement in RAN1#112)  \* The UCI provides a time duration that includes the consecutive TO(s) in time domain (i.e., Option 1-2 from agreement in RAN1#112)  **Proposal 12** For a configured grant configuration, the UTO-UCI when indicated, provides a pattern that is used to determine the PUSCH resource(s) of the configured grant that the UE is not expected to use for transmission.  **Proposal 13** For a configured grant configuration, a new list (UTO table) is included in the configuration of the configured grant. The UTO table consists of a list of UTO patterns that the UE can select from. The UTO-UCI is an index to a row of the UTO table.  **Proposal 14** For a configured grant configuration, the following options can be considered for design of the UTO pattern structure:  \* Alt-A: A UTO pattern indicates an offset and duration to determine a time interval. The UE is not expected to use the CG PUSCH TOs within the time interval for CG PUSCH transmission.  \* The offset determines the start of the window from the end of the CG PUSCH that carries the corresponding UTO-UCI indicating the UTO pattern.  \* The duration determines the end of the window.  \* Alt-B: UTO pattern indicates a bitmap, each bit corresponding to a time interval or a set of consecutive TOs. The UE is not expected to use the CG PUSCH TOs within the time interval or the set of consecutive TOs corresponding to a bit in the bitmap with value '1' (or '0') for CG PUSCH transmission. The bitmap indicates consecutive '1's (or '0's), if any.  \* Any two consecutive bits in the bitmap corresponds to two consecutive time intervals or two sets of back-to-back consecutive TOs  \* The 1st time interval or set of consecutive TOs corresponding to the 1st bit in the bitmap start from the end of the CG PUSCH that carries the corresponding UTO-UCI indicating the UTO pattern after an offset value. The offset is determined based on e.g., configuration or a rule.  **Proposal 15** A UTO pattern can correspond to "no unused" configured grant PUSCH.  **Proposal 16** Prioritize Alt-A for design of the UTO pattern structure.  **Proposal 17** The UE is expected to provide consistent information when indicating the UTO patterns. |
| Qualcomm | **Observation 1**: The UCI indicating unused CG PUSCH occasion(s) is beneficial because  \* gNB can reallocate resources of the unused PUSCH occasion to other UEs  \* UE can save power by selecting a proper amount of resources for PUSCH transmission  \* gNB can save power by skipping PUSCH blind detection on the unused PUSCH occasion  **Proposal 8**: For multiple overlapping PUSCH occasions, a UE is allowed to utilize the CG PUSCH occasion with the smallest RB allocation that best fits the size of its buffered data  **Proposal 9**: For the dynamic indication of unused CG PUSCH occasion(s), RAN1 should consider the case that multiple PUSCH occasions overlap in time. The UE indicates at most one of the overlapping PUSCH occasions is not unused  **Proposal 10**: Support Option 2-1 that the UCI provides a bitmap where a bit corresponds to a TO within a time duration/range. The bit indicates whether the TO is "unused" (consecutive/non-consecutive in time domain)  **Proposal 14**: UE can send updated indication to indicate a different set of unused PUSCH occasions than those indicated by an early indication. gNB uses the most recent indication received from the UE  \* Support the case that a CG PUSCH occasion previously indicated as NOT unused is later indicated as unused  \* Do not support the case that the CG PUSCH occasion previously indicated as unused is later indicated as NOT unused |
| HW/HiSi | **Proposal 7**: Support Option 1-1 that UCI indicates the last M CG PUSCH occasion(s) within a CG period are unused.  **Proposal 12**: No need to consider the UCI indicate the unused occasions in multiple periods. |
| CATT | **Proposal 6**: Either of following alternatives could be supported:  • Alt-1: A UCI would multiplex with each transmitted CG PUSCH occasions, which provides a bitmap where a bit corresponds to a TO or a TO group within a time duration/range. The bit indicates whether the TO or TO group is "unused".  • Alt-2: A UCI would multiplex with the configured CG PUSCH occasions, which provides a bitmap where a bit corresponds to a TO or a TO group within a time duration/range. The bit indicates whether the TO or TO group is "unused". |
| vivo | **Proposal 5**: When a CG PUSCH occasion is indicated as "unused", the UE is expected not to transmit PUSCH on that CG PUSCH occasion. For any other CG PUSCH occasion that is NOT indicated as "unused", the UE is allowed to transmit or not to transmit PUSCH on that CG PUSCH occasion as per legacy specification.  **Proposal 8**: For dynamic indication of unused CG PUSCH occasion(s) based on UCI by the UE, RAN1 discusses whether/how to sort/index configured CG PUSCH occasions, e.g. sorting/indexing based on starting times of CG PUSCH occasions, as well as indexes of corresponding CG configurations, indexes of corresponding serving cells, etc., if necessary.  **Proposal 9**: For dynamic indication of unused CG PUSCH occasion(s) based on UCI by the UE, RAN1 discusses whether/how to determine sets of CG PUSCH occasions from the configured CG PUSCH occasions, where each of the sets is associated with the dynamic indication in a UCI, e.g. sets of CG PUSCH occasions is determined explicitly based on a configured periodicity and offset, or implicitly based on CG period.  **Proposal 10**: If the UCI provides a bitmap where a bit corresponds to CG PUSCH occasions within a time duration/range, to determine the time duration/range, the solution adopted in CBG grouping can be reused.  **Proposal 11**: For the information provided by the UCI about unused CG PUSCH occasions, both Option 1 (to indicate consecutive unused CG PUSCH occasion(s)) and Option 2 (to indicate unused CG PUSCH occasion(s) which may be consecutive or non-consecutive) can be considered. |
| ZTE/Sanechips | **Observation 8**: In Case 2, i.e., the transmission occasions in multiple CG periods are used for transmitting a single XR packet, UCI is able to indicate the transmission occasion usage in multiple CG periods. And the transmission occasions in multiple CG periods are used to transmit TBs for a single XR packet.  **Observation 9**: UCI indicating the usage of transmission occasions in a single period can be regarded as supporting UCI for unused transmission occasion(s) in multi-PUSCHs CG. While UCI indicating the usage of transmission occasions in multiple periods can be regarded as supporting UCI for unused transmission occasion(s) in legacy CG/Rel-16 multiple CG configurations.  **Proposal 9**: Suggest to specify the UCI indicates the unused transmission occasion(s) in one CG period.  **Proposal 12**: Support that the UCI can also indicate that all the transmission occasions are used in one time duration. |
| Spreadtrum Comm. | **Observation 1**: The bit field in the UCI to indicate the unused PUSCH TOs is related to the location of the unused PUSCH TOs and when to transmit CG PUSCH includes UCI in a time duration.  **Observation 2**: Due to the PUSCH preparation time and gNB processing delay, the remaining re-allocated PUSCH occasion(s) may be reduced if the UCI is carried in the last PUSCH to be used. |
| Lenovo | **Proposal 5**: UCI indicates a bitmap of unused status of CG PUSCH occasions.  \* If CG occasions are grouped for the sake of unused CG occasion indication, a CG occasion group is indicated as unused only if all CG occasions within the group (potentially excluding the CG occasion of the UCI) are unused CG occasions.  **Proposal 6**: UCI indicates whether a time unit (e.g., slot) is unused.  **Proposal 7**: UCI field indicating unused CG occasions has a fixed (configured) size.  o UCI can indicate unused past and future occasions  **Proposal 8**: UCI indicates unused CG occasions within a time duration defined by a length and a start time; wherein  \* the length is one (or multiple) period(s) of CG configuration in which UCI is transmitted  \* and the start time is the beginning of a CG period of the CG configuration  o FFS beginning is subject to a symbol offset >=0  **Proposal 9**: The applicable time window does not include symbols for reception of SS/PBCH blocks and/or DL symbols indicated by tdd-UL-DL-ConfigurationCommon and/or symbols corresponding to a measurement gap.  \* FFS: other symbols/CG occasions (e.g., cancelled by UL-CI or SFI) |
| LG | **Observation**: The re-scheduling time (in gNB side) should be guaranteed in between where UE transmit URI and the beginning of unused resources indicated by the URI.  **Observation**: The range of unused resource that can be indicated by URI might be limited without XR-awareness information.  **Proposal 9**: The range of unused resource that can be indicated by URI is determined based on where URI is transmitted.  \* The first CG PUSCH indicated by URI starts no earlier than X symbol after where URI transmission ends, where X is re-scheduling time required by gNB.  \* The last CG PUSCH starts no later than Y symbol after the beginning of the first CG PUSCH, where Y is provided by gNB configuration based on UE capability  \* FFS: How to define X and Y  **Proposal 10**: No URI information is created/constructed for a resource in a time window starting from the end of PUSCH where URI transmitted and which ends after X symbols, where X is re-scheduling time required by gNB,  **Proposal 11**: Support Alt. 1-2 to construct URI information.  **Proposal 12**: If URI indicate a time window or a CG occasion as unused, UE treats other PUSCHs overlapped in a time with the indicated time window or the indicated CG occasion as unused. |
| NTT DOCOMO | **Proposal 9**: For UCI indicating unused TOs, support option 1, i.e. the UCI indicates consecutive unused TOs.  **Proposal 10**: The first TO for the UCI indication range can be determined considering following two alternatives:  \* Alt 1: the first TO with X slots/symbols/TOs/CG periods after the ending/starting symbol of CG PUSCH carrying the UCI.  \* The definition of X may need to consider required time for gNB to utilize the unused CG occasion information for other UEs.  \* Alt 2: the first indicated TO is indicated by the UCI, e.g. Y slots/symbols/TOs/CG periods after the ending/starting symbol of CG PUSCH carrying the UCI.  \* Limitation on candidate values of the offset may be necessary, e.g. Y is no smaller than a certain value, in order to leave time for gNB to utilize the unused CG occasion information for other UEs. |
| Google Inc. | **Proposal 8**: Support Option 2-1 using a bitmap where a bit corresponds to a TO within a time duration/range. |
| IDC | **Proposal 7**: The UCI includes a bitmap for indicating the unused/used CG PUSCH occasions in one or multiple slots or CG periods (Option 2) |
| OPPO | **Proposal 6**: Support Option 2-1, i.e. the UCI provides a bitmap where a bit corresponds to a TO within a time duration/range. The bit in the bitmap only confirms a TO is "unused" but does not confirm the TO is "used". |
| MTK | **Observation 3**: Indicating UCI for the unused occasions at every transmission occasion has benefits in cases where large jitter occurs or in some DL-UL patterns in TDD configurations.  **Proposal 12**: UCI contains one bit field, which indicates the number of unused PUSCH transmission occasions by the UE as an integer value. The indication is limited to PUSCH TOs within current CG period (e.g., Option 1-2). |
| Samsung | **Proposal 6**: The UCI provides the number of consecutive CG-PUSCH TOs (Option 1-1). The indication is applicable to a single CG-PUSCH period.  **Observation 2**: There is no need to support indication of unused CG-PUSCH TOs for multiple CG configurations.  **Observation 3**: XR-related use cases and benefits need to first be concluded for a decision to support indication of unused CG-PUSCH TOs for a first CG-PUSCH configuration in CG-PUSCH transmissions of a second CG-PUSCH configuration. |
| Apple | **Proposal 10**: to support the use of occasion starting from any occasion within a CG period, consider  **3.** With a common reference timing for the provided information from multiple occasions (e.g., the common reference timing is the start of the first occasion in a CG period), the UCI payload is identical from multiple occasions.  a. Option 1-2: [the starting time of unused occasion, number of unused occasions], or [the end time of unused occasion, number of unused occasions]. We note SLIV encoding can be used for both.  b. Option 1-1: With Option 1-1, the reference timing is the last occasion in a CG period. The number of unused occasions is counted in reference to the last occasion. The counted value is zero if the last occasion is used. The counted value is ones if the last occasion is not used, but the second last occasion is used, etc.  c. Option 2-1: a N-bit bitmap is used where N is the number of occasions in a CG period. In the bitmap, "0" can be used to indicate unused occasions, "1" can be used to indicate used occasions. The kth bit in the bitmap corresponds to the kth occasion in a CG period.  **4.** With separate referencing timing for the provided information from multiple occasions, e.g., the reference timing is according to PUSCH carrying the UCI.  a. Option 1-2: [the starting time of unused occasion, number of unused occasions], or [the end time of unused occasion, number of unused occasions]. We note SLIV encoding can be used for both.  b. Option 1-1: With Option 1-1, the reference timing is the current occasion in a CG period. The number of unused occasions is counted in reference to the current occasion. The counted value is one if the next occasion is used. The counted value is zero if the next occasion is not used.  c. Option 2-1: a N-bit bitmap is used where N is the number of occasions in a CG period. In the bitmap, "0" can be used to indicate unused occasions, "1" can be used to indicate used occasions. The first bit in the bitmap corresponds to the current occasion.  **Proposal 11**: if indication of unused CG periods within a window is supported, to support the use of a CG period starting from any CG period within the window, consider:  **3.** With a common reference timing for the provided information from multiple occasions (e.g., the common reference timing is the start of the first occasion in a CG period), the UCI payload is identical from multiple occasions.  An M-bit bitmap is used where M is the number of CG periods within a window. In the bitmap, "0" can be used to indicate unused CG periods, "1" can be used to indicate used CG periods. The kth bit in the bitmap corresponds to the kth CG period in the window.  **4.** With separate referencing timing for the provided information from multiple occasions, e.g., the reference timing is according to PUSCH carrying the UCI.  An M-bit bitmap is used where M is the number of CG periods within a window. In the bitmap, "0" can be used to indicate unused CG periods, "1" can be used to indicate used CG periods. The first bit in the bitmap corresponds to the current CG period. |
| Nokia/NSB | **Proposal 9**: RAN1 should take into account the impacts of potential overlapping between UL channels (i.e., DG PUSCH and CG PUSCH) when designing UCI content. Possible options:  \* Option 2-2: The UCI provides one bit indication for the next TO (e.g., 0 - used or undefined; 1 - unused);  \* Option 3: UCI provides the number of needed CG occasions based on the configured TBS of the CG resources and the size of the buffered data that can be transmitted via the CG. NW figure out which ones are used/not used based on the number reported and the scheduled overlapped occasions. |
| Sony | **Proposal 5**: The UCI carries a bitmap where a bit corresponds to TOs within a time duration/range in the future. The bit indicates whether all TOs within the time duration/range are "unused" (known as Option 2-2). |
| Panasonic | **Proposal 7**: The unused indication of PUSCH occasions should be applied to all configured CGs. It should provide a bitmap to time durations, in which PUSCH occasions within them will not be used by the UE. |
| DENSO Corp. | **Proposal 1**: RAN1 to study introducing a bitmap into the UCI, where each bit can indicate whether the corresponding PUSCH occasion is unused or not.  **Proposal 2**: The bitmap size for the indication of unused occasion(s) can be equal to the number of configured PUSCH occasions, regardless of whether they are valid.  **Observation 5**: Considering UL jitter and the mismatch between CG periodicity and XR frame rate, the UE may not know the amount of UL data to indicate unused occasion(s) in the first configured PUSCH occasion within a CG period. |
| FGI | **Proposal 5**: The UCI indicates the number of the last CG PUSCH TO(s) that are unused. |
| TCL | **Proposal 5**: Both a set of unused TOs located in the front and the end of a CG configuration can be considered for CG enhanced for XR.  **Proposal 6**: The UCI determines the CG PUSCH TO(s) that are indicated as "unused" based on bitmap.  **Proposal 7**: A new UCI will be introduced in R-18 for indicating the un-used TOs within a CG configuration.  **Observation 2**:There is a gap between XR periodic UL traffic and CG configuration.  **Proposal 8**: A fixed transmission pattern of CG within an integer periodicity for XR can be considered.  **Proposal 9**: Additional TOs after the end of the configured TO within a CG period and activate more than one CG configurations simultaneously can be considered. |
| xiaomi | **Observation 1**: Option 1-2 provides unnecessary information in the process of indicating the information of the unused TO.  **Observation 2**: Option 2-2 will cause some indication errors when the indication granularity does not match the unused TO.  **Observation 3**: Option 1-1 has the problem of missing indication for the unused TO or error indication for the used TO.  **Observation 4**: Option 2-1 has a higher signaling overhead compared with option 1-1, especially if the time duration includes a large number of TO.  **Observation 5**: Option 2-3 can balance signaling overhead with indicating flexibility by configuring the appropriate pattern table.  **Observation 7**: The time-frequency resources corresponding to the reserved TO will be wasted if the usage status of the reserved TO cannot be updated.  **Observation 9**: The number of TO that can be configured in a CG period should be discussed before the discussion of the HP process ID  **Proposal 1**: For option 1-1, the following three potential alternatives require further discussion.  > Alt. 1: Start TO + Number of TO  > Alt. 2: Start TO + End TO  > Alt. 3: Start TO + Default end TO  **Proposal 2**: Option 2-3 should be taken into account as follows:  o Option 2-3: The UCI provides a table row index where the index corresponds to an unused TO pattern within a time duration/range. All TOs in the unused TO pattern within the time duration/range are "unused".  \* Applicable time duration/range can be determined from information obtained from configuration  \* FFS details  **Proposal 3**: Option 1-1, option 2-1 and option 2-3 should be prioritized for Multi-PUSCHs CG.  **Proposal 4**: The time duration/range corresponding to dynamic indication information should be discussed in RAN1.  **Proposal 7**: Three potential options can be considered to define the timeline for dynamic indication, as follows:  > Option 1: From the TO including the UCI to the time window  \* FFS details  > Option 2: From the TO including the UCI to the first TO in the time duration  \* FFS details  > Option 3: From the TO including the UCI to the first unused TO in the time duration  \* FFS details |
| CMCC | **Proposal 7**. Support Option 2, i.e., the UCI provides a bitmap where a bit indicates whether the corresponding CG PUSCH occasion(s) is "unused". |
| Sharp | **Proposal 5**: The UCI that provides information about unused CG PUSCH transmission occasions is defined as a new XR-specific CG UCI.  **Proposal 6**: A transmitted CG PUSCH includes the UCI, if it is transmitted in a transmission occasion determined satisfying given condition(s), e.g. a first transmitted PUSCH in a CG period, or a first PUSCH transmission within a multiple of CG periods.  **Proposal 7**: The UCI determines the CG PUSCH TO(s) that are indicated as "unused" (consecutive/non-consecutive TO(s) in time domain), and the UCI provides a bitmap where a bit corresponds to a TO within a time duration/range. The bit indicates whether the TO is "unused". |
| New H3C | **Proposal 3**: For dynamic indication of unused CG PUSCH transmission occasion(s) based on a UCI, Option 1: The UCI determines the consecutive CG PUSCH TO(s) that are indicated as "unused" is supported. |
| CAICT | **Proposal 4**: The UCI provides a bitmap where a bit corresponds to a TO within a time duration/range. The bit indicates whether the TO is "unused". |
| NEC | **Proposal 2**: support option 1 for the information provided by UCI, i.e., The UCI determines the consecutive CG PUSCH TO(s) that are indicated as "unused".  **Proposal 3**: consider repetition and retransmission mechanism for the UCI for unused CG occasions indication. |
| Intel | **Proposal 6**: Introduce a new UCI to indicate the number of unused PUSCH occasions.  \* Whether to multiplex the new UCI to CG PUSCH should be configurable  \* The UCI provides the number of consecutive unused TO(s) in time domain (Option 1-1).  o UCI may include ??log?\_(2 ) I? bits in a field, which is used to indicate I number of unused TO(s). |

From Moderator point of view, it is important to discuss the above aspects.

### 3.1.1 Initial Discussions

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

This topic needs more discussions to narrow down the options. For the initial discussions, Moderator suggests companies to share the views on the following.

**Suggestion:** As it is important to start the detailed design, companies are encouraged be flexible such that we can converge to one option, e.g., option 2.

**Question:** Please provide your view in the table below regarding the following questions:

* **Q1:** What is your view regarding Moderator’s suggestion? What is your suggestion to facilitate a selection, including compromising/changing preferences?
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | 1. We should focus on the UCI indication in case of multi-PUSCH CG, which is the basic case for the topic of XR. (Not prioritize legacy CG configuration)   2. We support option 1-1 for simplicity. And for option 2-1, it should be clarified that in which case the non-consecutive unused transmission occasions occur in one CG period.  3. Considering the signaling overhead, solutions for reducing signaling e.g., option 2-2 can be further considered. |
| **Nokia, NSB** | As commented in our Tdoc, Option 1 and Option 2-1 (indication for N slots) have certain drawbacks. UE does not know well in advance which slots it is going to use due to potential overlapping between UL channels (i.e., DG PUSCH and CG PUSCH). So in most cases UE will be able to identify the Unused slot, when it used all slots required to transmit the video frame. Therefore, we suggest the following options:  • Option 2-2: The UCI provides one bit indication for the next TO (e.g., 0 – used or undefined; 1 - unused); FFS details.  • Option 3: UCI provides the number of needed CG occasions based on the configured TBS of the CG resources and the size of the buffered data that can be transmitted via the CG. NW figure out which ones are used/not used based on the number reported and the scheduled overlapped occasions. FFS details |
| **CATT** | CATT’s proposal is more closed to option 2-1. Each UCI bit is associated with one TO or one TO group when one TB mapping to multiple TOs in a TO group.  Since the overhead is not the main issue for UCI indication of unused CG occasions when UCI is multiplexed with CG-PUSCH, the number of available bits for UCI indication should be sufficient for bitmap without any confusion. |
| **New H3C** | We slightly prefer option 1 and open to discuss about option 2. |
| **Qualcomm** | We support Option 2, in particular 2-1. The reason non-consecutive can be useful is for future proof use- cases such as for example if there is UL jitter and the CG PUSCHs are used to transmit a mixture of traffics with different tempos such as video and pose. Then this will allow us not to be limited and have to come back in the future to revisit the design. The bitmap seems a straightforward way provide the indication of unused. |
| **Google** | We support Option 2-1 for its simplicity and its flexibility. Option 2-2 is not very optimal as you may need to indicate a group of CG occasions mapping to the same bit as used even if some of them are unused. |
| **Samsung** | We object to option 2 (Samsung also supports option 1-1). There is no reason to introduce a bitmap, particularly when the justification for introducing the feature of multi-PUSCH CG was to minimize latency. If there are TOs where the UE is semi-statically(!) configured to not transmit, the feature itself might as well not being supported and can always rely on SR+DG. |
| **Futurewei** | Option 2 has better flexibility, with the cost of higher signaling overhead, compared with Option 1, since the UCI in Option 2 can indicate non-consecutive TO(s) in time domain. However, in our understanding, this feature has no benefits or advantages for XR traffic because the data of XR packet generally occupies one or more consecutive PUSCH occasions in the front of the multiple PUSCH occasion in a period. In that sense, Option 1 is better choice with much less signaling overhead compared with Option 2, and it can indicate the consecutive unused TO(s) of the multiple TO(s) in a period. Option 1-2 is almost the same as Option 1-1, except for the additional concept of duration/range, which increases complexity of Option 1 and is not preferred. Therefore, we are ok with Option 1-1 with much less signaling overhead and lower complexity. |
| **InterDigital** | Ok with moderator’s suggestion. Although our preference is Option 2, we are open to consider other options, including Option 3 proposed by Nokia. |
| **Apple** | **In Apple’s contribution, we have the following proposals. A key consideration is to support the starting the transmission of a CG from an arbitrary TO in a CG period. Among all the options, we prefer Option 2-1.**  **Proposal 10**: to support the use of occasion starting from any occasion within a CG period, consider  **3.** With a common reference timing for the provided information from multiple occasions (e.g., the common reference timing is the start of the first occasion in a CG period), the UCI payload is identical from multiple occasions.  a. Option 1-2: [the starting time of unused occasion, number of unused occasions], or [the end time of unused occasion, number of unused occasions]. We note SLIV encoding can be used for both.  b. Option 1-1: With Option 1-1, the reference timing is the last occasion in a CG period. The number of unused occasions is counted in reference to the last occasion. The counted value is zero if the last occasion is used. The counted value is ones if the last occasion is not used, but the second last occasion is used, etc.  c. Option 2-1: a N-bit bitmap is used where N is the number of occasions in a CG period. In the bitmap, "0" can be used to indicate unused occasions, "1" can be used to indicate used occasions. The kth bit in the bitmap corresponds to the kth occasion in a CG period.  **4.** With separate referencing timing for the provided information from multiple occasions, e.g., the reference timing is according to PUSCH carrying the UCI.  a. Option 1-2: [the starting time of unused occasion, number of unused occasions], or [the end time of unused occasion, number of unused occasions]. We note SLIV encoding can be used for both.  b. Option 1-1: With Option 1-1, the reference timing is the current occasion in a CG period. The number of unused occasions is counted in reference to the current occasion. The counted value is one if the next occasion is used. The counted value is zero if the next occasion is not used.  c. Option 2-1: a N-bit bitmap is used where N is the number of occasions in a CG period. In the bitmap, "0" can be used to indicate unused occasions, "1" can be used to indicate used occasions. The first bit in the bitmap corresponds to the current occasion.  **Proposal 11**: if indication of unused CG periods within a window is supported, to support the use of a CG period starting from any CG period within the window, consider:  **3.** With a common reference timing for the provided information from multiple occasions (e.g., the common reference timing is the start of the first occasion in a CG period), the UCI payload is identical from multiple occasions.  An M-bit bitmap is used where M is the number of CG periods within a window. In the bitmap, "0" can be used to indicate unused CG periods, "1" can be used to indicate used CG periods. The kth bit in the bitmap corresponds to the kth CG period in the window.  **4.** With separate referencing timing for the provided information from multiple occasions, e.g., the reference timing is according to PUSCH carrying the UCI.  An M-bit bitmap is used where M is the number of CG periods within a window. In the bitmap, "0" can be used to indicate unused CG periods, "1" can be used to indicate used CG periods. The first bit in the bitmap corresponds to the current CG period. |
| **vivo** | We are fine to focus on option 2. It is helpful to narrow down the options.  For option 2, if bitmap to indicate consecutive or non-consecutive TOs can be supported, flexibility of UCI indication for the unused TOs can be achieved compared to option 1.  The signaling overhead for option 2 can be controlled by NW, i.e., the range of bitmap is configured by NW. |
| **OPPO** | We support Option 2-1 for flexibility. |
| **TCL** | We support option 2 for its flexibility. |
| **DOCOMO** | Though our first preference is option 1, option 2-1 is also fine for us. |
| **LG** | We are fine to have non-consecutive resource indication for this feature, however, it is necessary to further discuss on the detail approach. We would like to have general agreement to scope down to non-consecutive resource indication with FL’s observations. |
| **MediaTek** | We don’t see a need for non-consecutive TO indication. We support Option 1-1. Each UCI indication is limited to its current CG period only.  Our suggestion to facilitate progress within the group is to discuss what CG periodicity makes more sense. If one CG periodicity is 16ms (~similar to XR traffic periodicity), UCI can only indicate unused PUSCH TOs within the current CG period. Because UE cannot decide which PUSCH TOs will be needed before the next XR packet becomes available at higher layers. In this configuration, Option-1 (consecutive slot indication) makes more sense.  If one CG periodicity is 5ms as an example (~much smaller than XR traffic periodicity of 16.667ms), UCI can indicate unused PUSCH TOs for the next 2 slots. In this configuration either Option-1 (consecutive slot indication) or Option-2 (non-consecutive slot indication) would work. |

## 3.2 When the UCI is sent? (UCI transmission occasions)

**Moderator’s summary:**

In previous meeting, the following agreement was made:

**Agreement**

For dynamic indication of unused CG PUSCH occasion(s) based on a UCI, the following options for further down-scoping with possible revision, are considered for the transmission occasion of the UCI:

* **Option 1:** A transmitted CG PUSCH, includes the UCI.
  + FFS details
* **Option 2:** A transmitted CG PUSCH includes the UCI, if it is transmitted in an occasion determined by RRC.
  + FFS details
* **Option 3:** A transmitted CG PUSCH includes the UCI, if it is transmitted in a pre-defined transmission occasion.
  + FFS details
    - Example of a pre-determined occasion: 1st configured PUSCH TO in a CG period or 1st configured PUSCH TO in a multiple CG periods
* **Option 4:** A transmitted CG PUSCH includes the UCI, if it is transmitted in a transmission occasion determined satisfying given condition(s).
  + FFS details
    - Examples of a condition: A first transmitted PUSCH in a CG period, or a first PUSCH transmission within a multiple of CG periods.

Other options are not precluded. Proponent companies to provide details.

**Companies’ view:**

* **Option 1:**
  + **Yes:** E///, QC, vivo, ZTE, HW/HiSi, Nokia, Lenovo, Google (modification), MTK, Samsung, Apple, DENSO, Intel
  + **No:** DCM
* **Option 2:** FW , ZTE, IDC, xiaomi, DENSO
* **Option 3:** 
  + **Yes:** Spreadtrum, HW/HiSi, xiaomi, OPPO, New H3C
  + **No:** Nokia
* **Option 4:**
  + **Yes:** FGI, Intel
  + **No:** E///, Nokia, DCM
* **Other options:** FW (MAC CE/DCI), IDC (L1/L2)

**Moderator’s observation:**

**Observation 1:** Majority of companies support Option 1 and opposed by one companies. Option 4 has the least supporting companies while it is opposed by 3 companies.

**Observation 2:** Regarding Option 2 and 3, they are supported equally while a company opposes Option 3.

Table 6: Summary of Contributions inputs for Section 3.2

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| Futurewei | **Proposal 7**: Support that gNB can transmit, to UE, RRC message(s) (or MAC CE/DCI) indicating the candidate positions for UCI transmission (i.e., Option 2). |
| Ericsson | **Proposal 21** For dynamic indication of unused CG PUSCH occasion(s) based on a UCI, for the transmission occasion of the UCI, Option 4 is not supported.  **Proposal 22** For dynamic indication of unused CG PUSCH occasion(s) based on a UCI, for the transmission occasion of the UCI, any transmitted CG PUSCH, includes the UCI (i.e., Option 1). |
| Qualcomm | **Proposal 7**: For transmission occasions of the UCI indicating unused CG PUSCH occasion(s)  \* Support Option 1: A transmitted CG PUSCH includes the UCI  \* FFS: The first transmitted PUSCH over CG PUSCH occasions indicated by the same UCI includes the UCI |
| vivo | **Proposal 12**: For CG PUSCH(s) to include the UCI providing information about unused CG PUSCH occasions, each transmitted CG PUSCH includes the UCI. |
| ZTE/Sanechips | **Observation 11**: Considering the efficiency and reliability, transmitting the UCI in one CG PUSCH transmission occasion is more suitable.  **Proposal 10**: The signaling overhead of the UCI signaling should be considered for down selection of Option 1or Option 2.  **Proposal 11**: Support UCI signaling is transmitted in the first valid/transmitted CG PUSCH. |
| Spreadtrum Comm. | **Proposal 5**: For dynamic indication of unused CG PUSCH occasion(s) based on a UCI, support that a transmitted CG PUSCH includes the UCI, if it is transmitted in a pre-defined transmission, examples of a pre-determined occasion can be as following:  • 1st configured PUSCH TO in a CG period or 1st configured PUSCH TO in a multiple CG periods  • The last configured PUSCH TO in a CG period or last configured PUSCH TO in a multiple CG periods.  • Both the penultimate configured and last configured PUSCH TO in a CG period, or both the penultimate configured and last configured PUSCH TO in a multiple CG periods. |
| IDC | **Proposal 8**: The location for transmitting the UCI on unused PUSCH occasions is configured in RRC or indicated in L1/L2 signaling |
| HW/HiSi | **Proposal 8**: Regarding when to transmit the UCI, Option 3 and Option 1 (if UCI size is small) is preferred. |
| Nokia/NSB | **Proposal 10**: Do not support Option 3 and Option 4 for the possible transmission occasions of the UCI.  **Proposal 11**: Support Option 1, sending UCI indication every PUSCH and only once per slot.  \* FFS: The benefits of other UCI periodicities can be further discussed and if shown to be beneficial, RRC configured periodicities can be considered (Option 2). |
| Lenovo | **Proposal 4**: A transmitted CG PUSCH includes the UCI. |
| LG | **Proposal 7**: URI is transmitted on every CG occasion where UE sends PUSCH. (Option 1) |
| Google Inc. | **Proposal 9**: Support a modified version of Option 1:  \* A transmitted CG PUSCH within a confiurable time window includes the UCI. |
| MTK | **Proposal 11**: UCI is multiplexed in PUSCH at every transmission occasion (e.g., Option-1). The last PUSCH TO does not carry UCI if the unused TO indication is limited to PUSCH within the current CG period. |
| Samsung | **Proposal 5**: If a UE is configured to provide the UCI for a CG PUSCH configuration, there are no restrictions on the CG-PUSCH transmissions that include the UCI (Option 1). |
| FGI | **Proposal 4**: The UCI is multiplexed in the first transmitted PUSCH in a CG period. |
| Apple | **Proposal 9**: A transmitted CG PUSCH, includes the UCI (option 1). |
| xiaomi | **Observation 6**: Sending CG PUSCH carrying the dynamic indication based on UCI in the TO in the first half of CG period can better meet the timeline, and the UCI can also indicate more TOs in the CG period.  **Proposal 5**: Details of option 2 and option 3 should be updated as follows:  \* Option 2: A transmitted CG PUSCH includes the UCI, if it is transmitted in an occasion determined by RRC.  o A number N can be configured by RRC, and the first N PUSCH TOs within a CG period/ a multiple CG periods includes the UCI, and N=1  \* Option 3: A transmitted CG PUSCH includes the UCI, if it is transmitted in a pre-defined transmission occasion.  o A number N can be predefined by specification, and the first N PUSCH TOs within a CG period/ a multiple CG periods includes the UCI, and N=1 |
| NTT DOCOMO | **Proposal 7**: For determining which CG PUSCH includes the UCI, option 1 and option 4 are not supported. Support option 2 or option 3. |
| Panasonic | **Proposal 5**: The gNB should define the candidate PUSCH occasions for carrying the unused indication by RRC. |
| Sony | **Proposal 4**: Support a transmitted CG PUSCH includes the UCI, if it is transmitted in a pre-defined transmission occasion (known as Option 3) and if it is transmitted in a transmission occasion determined satisfying given condition(s) (known as Option 4). |
| OPPO | **Proposal 4**: The UCI is transmitted in the first N PUSCH TO(s) in a multi-PUSCHs CG period, where N is configured by RRC. |
| New H3C | **Proposal 2**: For dynamic indication of unused CG PUSCH occasion(s) based on a UCI, Option 3 on a transmitted CG PUSCH including the UCI, if it is transmitted in a pre-defined transmission occasion is supported. |
| DENSO Corp. | **Proposal 3**: RAN1 to study the following options regarding when the UCI is sent.  - Option.1: The UCI is multiplexed in the first transmitted CG PUSCH within a CG period.  - Option.2: The UCI is multiplexed in all transmitted CG PUSCHs. |
| Intel | **Proposal 5**: Consider the following two options for further discussion regarding TO(s) of UCI.  \* Option 1: A transmitted CG PUSCH includes the UCI.  \* Option 4: A transmitted CG PUSCH includes the UCI, if it is transmitted in a transmission occasion determined satisfying given condition(s).  o FFS details  \* Examples of a condition: A first transmitted PUSCH in a CG period, or a first PUSCH transmission within a multiple of CG periods. |
|  |  |

### 3.2.1 Initial Discussions

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

Based on the observations, the following is recommended.

**Moderator’s Suggestions: Aim to make decision at this meeting.**

* **Prioritize Option 1, 2, 3.**
* **Among this options, discuss whether it is possible to support Option 1.**

**Question:** Please provide your view in the table below regarding the following questions:

* **Q1:** What is your view regarding Moderator’s suggestions.
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | For simple UL traffic of XR, jitter is considered as ignored (at least in the study item). In this case, we think Option 3 is sufficient, and can work well.  Whereas, we can also accept more conservative approach, i.e., option 1.(with multiple UCI transmissions) |
| **Nokia, NSB** | We agree with moderator’s suggestion to prioritize Option 1, 2, 3. Furthermore, Option 3 can be covered by Option 2 via configuring periodicities in RRC. Therefore, we propose to narrow down the scope to Option 1 and Option 2. Our preference is Option 1 as it is the most reliable and easy from spec point of view. If RRC configured periodicities (Option 2) are shown to be more beneficial than sending UCI in every CG-PUSCH, it is also ok to support Option 2. |
| **CATT** | Since overhead is not any issue, Option 1 to have UCI transmitted on every CG-PUSCH. When UCI indicated unused CG occasions are sent at every CG-PUSCH, the gNB could use the repetitive reception of UCI for confirmation with the same bitmap values of UCI. If the gNB receive different UCI values, the updated UCI values could be used for correction or over-write of previous values. |
| **New H3C** | We support option 3 is sufficient and there is different between option 2 and option 3 because option2 need RRC configuration and introduce signaling overhead. So we suggest focusing on option 1 and option 3. |
| **Qualcomm** | Support Option 1 at least. Option 1 is simple and more robust than the other solutions. |
| **Google** | We proposed to modify Option-1 to give flexibility to the gNB to configure the occasions where the UCI could be transmitted as shown below. This allows for a trade-off between reliability, flexibility and overhead.    Can the moderator please add this alternative under Option 1 to check the support, i.e.,   * **Option 1-1:** A transmitted CG PUSCH, includes the UCI. * **Option 1-2:** A transmitted CG PUSCH within a configured window, includes the UCI. |
| **Samsung** | Option 1 is superior. There is no issue with UCI overhead (few UCI bits vs. thousands of data bits in a CG-PUSCH), offers best reliability which is important for the purpose of that UCI, and does not unnecessarily complicate the specifications. |
| **Futurewei** | Option 1 has highest flexibility and robust. Even the signaling overhead of Option 1 is not a big problem as mentioned by some companies, the complexity for both UE side and gNB side is still too high, since UE needs to perform encoding and multiplexing for each of the TOs and gNB also needs to perform corresponding detection for each of the TOs. Another problem for Option 1 is that the UCI indication could not be used by gNB if the transmission occasion of the UCI is too close to the unused transmission occasion indicated by UCI. Hence, Option 1 is not preferred from our point of view.  Option 3 and Option 4 are almost similar, and have the lowest flexibility and robust compared with other options, especially in dynamic jitter impact situation for XR traffic, for instance, if considering jitter impacts on the 1st configured PUSCCH transmission occasion, the fixed 1st configured PUSCCH transmission occasion may be not a good choice to carry UCI.  In Option 2, the transmitted CG PUSCH including the UCI can be indicated by RRC, which are fully flexible and robust enough, except for some extra downlink indication signaling overhead. However, in our understanding, Option 2 is not necessary to be limited to only RRC signaling, and dynamic signaling including MAC CE and DCI (e.g., CG activation DCI) can also be considered as well. Therefore, from our point of view, Option 2 is preferred compared with other three options. |
| **InterDigital** | Ok with the suggestion to prioritize some options. We are ok with Options 1 and 2, with some preference towards Option 2 due to lower overhead and the possibility for the UE to provide info on unused PUSCHs when the network may need and make best use of the info. |
| **Xiaomi** | We are fine with moderator’s suggestion to prioritize Option 1, 2, 3.  A CG occasion later in a CG period carries the UCI, the CG occasion that is indicated as “unused” may not meet the timeline. Whichever option is adopted, it should be ensured that the UCI is transmitted in CG occasion in the first half of the CG period as possible. |
| Apple | **We support Option 1 for the reason provided in our contribution: 1. Simpleness for UE/gNB operation, 2. Robust operation, 3. Simpleness in specification development.** |
| **vivo** | We support option 1.  For other options, there would be issue of UCI transmission if the CG occasions for UCI are missed. For example, if packet arrival time is after the CG occasion for UCI, UE does not have the opportunity to transmit the UCI. Furthermore, if a UCI in the CG occasion that is configured for UCI transmission is missed by gNB, gNB has to blind detect all the sub-sequent TOs since these occasions may or may not be used. |
| **OPPO** | We support moderator’s suggestion to prioritize Option 1, 2, 3.  Among these three options, we do not recommend option 1, because redundant information is transmitted, especially in the last TO per CG period. |
| **TCL** | Option 1 is ok for us. |
| **DOCOMO** | We support moderator’s suggestion to prioritize Option 1, 2, 3.  We slightly prefer option 2/3. But option 1 is also fine for us. |
| **LG** | We support Option 1. It is simple and robust solution.  Option 2 or 3 would limiting the occasion where UE can start the transmission. |
| **MediaTek** | We are fine with the suggestion. We prefer Option-1. |

## 3.3 How the UCI is sent? (UCI type, encoding, mux)

**Moderator’s summary:**

In previous meeting, the following agreements were made:

**Agreement**

The physical channel that carries the UCI that provides information about unused CG PUSCH transmission occasions is CG PUSCH.

**Agreement**

Encoding and multiplexing for “the UCI that provides information about unused CG PUSCH transmission occasions” in a CG PUSCH applies encoding and multiplexing procedures for CG-UCI as baseline.

* FFS on details

**Agreement**

Consider the following alternatives for “the UCI that provides information about unused CG PUSCH transmission occasions” for down-selection or revision

* Alt. 1: “The UCI that provides information about unused CG PUSCH transmission occasions” is defined as a new UCI.
  + FFS on details
* Alt. 2: “The UCI that provides information about unused CG PUSCH transmission occasions” is added as new field(s) to the CG-UCI.
  + FFS on details
* Alt. 3: “The UCI that provides information about unused CG PUSCH transmission occasions” replaces/re-purposes some field(s) of the CG-UCI.
  + FFS on details

**Companies’ view:**

**UCI type:**

Regarding when the UCI type based on Alt. 1, 2 or 3, companies views are summarized as the following:

* **Alt. 1:** E///, QC (lic), vivo, ZTE/Sanechips, Spreadtrum, IDC, HW/HiSi, DCM (licensed), Nokia, Samsung, FGI, CMCC, Lenovo, CATT, Panasonic, H3C, Sony, CAICT, Intel
* **Alt. 2:** DCM (unlic.), QC (unlic), LG, MTK, Google
* **Alt. 3:** Spreadtrum, Nokia, MTK, xiaomi, CAICT, [Apple]

**Details of encoding and multiplexing the UCI:**

* Reuse the multiplexing and encoding rule of CG UCI signaling
  + E///, ZTE/Sanechips, CAITC, Samsung, DCM
* Priority of the UCI
* Same priority as corresponding configured grant CG PUCHs (similarly to CG-UCI)
  + E///
* Beta-offset
  + (CAICT): The beta-offset value of UTO-UCI could be the same as that of HARQ-ACK and/or CG-UCI.
  + (Samsung): The UCI indicating unused CG PUSCH transmission occasions is a new UCI that is encoded and multiplexed as HARQ-ACK. If operation on shared spectrum is to be supported and if CG-UCI is configured, the UCI is also appended to CG-UCI prior to encoding and multiplexing.
  + (Ericsson): Beta offset can be configured for UTO-UCI and reused instead of beta-offset for CG-UCI, when applicable.
    - If CG-UCI is not present, the beta offset for UTO-UCI is used in the procedures instead of CG-UCI beta offset, when applicable.
    - If UTO-UCI is jointly encoded with CG-UCI, the same beta offset is used in the procedures instead of CG-UCI beta offset, when applicable.

**Moderator’s observation:**

**Observation 1:** On UCI type, clearly majority of companies prefer Alt. 1. Some companies propose for use Alt. 1 for licensed band and Al.2/Alt. 3 for unlicensed band Moderator explains that for unlicensed, Alt.1 and Alt.2/Alt.3 are practically the same where the total UCI includes legacy CG-UCI and the UCI with “unused information”. This is obtained for Alt.1 by appending/cascading and for Alt. 2/Alt. 3 by extension, replacing. However, with Alt.1, from specification point of view, the properties of “the UCI for unused” can be independently maintained as it is a new feature and not mixed with legacy CG-UCI. Therefore, Moderator recommends Alt. 1.

**Observation 2**: for encoding and multiplexing, companies suggest to “reuse” CG-UCI procedures.

**Observation 3**: On priority, it seems to have the same priority as the corresponding CG PUSCH is a reasonable approach. That implies the priority of this UCI would be the same as CG-UCI if it is present. With respect to multiplexing with HARQ-ACK and CSI, the same rule as legacy would be reused.

**Observation 4**: On bets offset, there are two approaches that mainly different in case CG-UCI is not present: when CG-UCI is not present, configured a beta offset for new UCI (E///) or use HARQ-ACK beta-offset (CIATC, Samsung). When CG-UCI is present, use the same (E///, Samsung, CIATC). In moderator understanding, E/// reuses the CG-UCI framework when CG-UCI is present or not. Samsung and CAICT reuses CG-UCI framework when CG-UCI is present and HARQ-ACK when CG-UCI is not present (even if HARQ-ACK itself is not multiplexed in CG-PUSCH).

Table 7: Summary of Contributions inputs for Section 3.3

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| Ericsson | **Proposal 18** "The UCI that provides information about unused CG PUSCH transmission occasions" (i.e., UTO-UCI) is defined as a new UCI (Alt.1 is supported).  **Proposal 19** For a configured grant configuration, UTO-UCI if present has the same priority as the configured grant PUSCHs.  **Proposal 20** The existing CG-UCI encoding and multiplexing procedures are reused for encoding and multiplexing of UTO-UCI in a configured grant PUSCH in absence or presence of other UCIs being multiplexed in the PUSCH, by apply the following adjustments:  \* If CG-UCI is not present and/or not multiplexed in PUSCH, UTO-UCI is used instead of CG-UCI in the corresponding procedures for encoding of CG-UCI and/or HARQ-ACK and/or CSI, whichever is present.  \* If CG-UCI is present and is multiplexed in PUSCH, the jointly encoded UTO-UCI and CG-UCI (by appending UTO-UCI to CG-UCI) is used instead of CG-UCI in the corresponding procedures for encoding of CG-UCI and/or HARQ-ACK and/or CSI, whichever present.  \* Beta offset can be configured for UTO-UCI and reused instead of beta-offset for CG-UCI, when applicable.  \* If CG-UCI is not present, the beta offset for UTO-UCI is used in the procedures instead of CG-UCI beta offset, when applicable.  \* If UTO-UCI is jointly encoded with CG-UCI, the same beta offset is used in the procedures instead of CG-UCI beta offset, when applicable. |
| Qualcomm | **Proposal 6**: For the UCI that provides information of unused CG PUSCH transmission occasion(s)  \* When the UE is configured to transmit the CG-UCI, the UCI is added as new field(s) into the CG-UCI  \* Otherwise, it is transmitted in a new UCI |
| vivo | **Proposal 14**: The UCI that provides information about unused CG PUSCH transmission occasions is defined as a new UCI, i.e., a new table with field(s) dedicated to providing the information. |
| ZTE/Sanechips | **Observation 10**: Beta offset parameter can be adjusted to guarantee the reliability of the UCI.  **Proposal 13**: Support Alt 1: design new UCI signaling providing information about unused CG PUSCH transmission occasions.  **Proposal 14**: Reuse the multiplexing and encoding rule of CG UCI signaling for the new UCI signaling. |
| Spreadtrum Comm. | **Proposal 4**: A new field or replaces/re-purposes some field(s) in the CG-UCI to provide information about unused CG PUSCH TOs should be further studied. |
| IDC | **Proposal 9**: Define new UCI for providing information on unused CG PUSCH occasions (Alt-1) |
| HW/HiSi | **Proposal 10**: The UCI that indicates unused CG PUSCH TO(s) is defined as a new UCI (i.e., Alt 1).  **Proposal 11**: Different from CG-UCI, the encoding and multiplexing order of XR UCI should be lower than HARQ-ACK. |
| NTT DOCOMO | **Proposal 6**:  \* In licensed spectrum, support Alt 1, i.e. "The UCI that provides information about unused CG PUSCH transmission occasions" is defined as a new UCI.  \* Multiplexing/encoding of the new UCI on CG PUSCH can reuse multiplexing/encoding procedures for legacy CG-UCI on CG-PUSCH in unlicensed spectrum.  \* In unlicensed spectrum, support Alt 2, i.e. "The UCI that provides information about unused CG PUSCH transmission occasions" is added as new field(s) to the CG-UCI. |
| LG | **Proposal 15**: Support Alt. 2 to handle URI with CG-UCI.  **Proposal 16**: if cg-UCI-Multiplexing is configured, drop URI and HARQ-ACK is multiplexed into PUSCH when the HARQ-ACK PUCCH and PUSCH with URI are overlapped in a time. |
| Nokia/NSB | **Proposal 12**: Consider Alt1 or Alt3 and introduce a new UCI Table with indication of unused TOs (Alt 1) or replace/re-purpose some field(s) of the CG-UCI depending on the licensed/unlicensed operation (Alt 3).  **Proposal 13**: RAN1 to discuss/agree how UCI is sent after UCI table is agreed due to the dependency of UCI transmission on the UCI table. |
| MTK | **Proposal 10**: UCI that indicates the unused PUSCH occasions shall re-use the existing CG-UCI format (e.g., Alt-2 or Alt-3). |
| Samsung | **Proposal 4**: The UCI indicating unused CG PUSCH transmission occasions is a new UCI that is encoded and multiplexed as HARQ-ACK. If operation on shared spectrum is to be supported and if CG-UCI is configured, the UCI is also appended to CG-UCI prior to encoding and multiplexing. |
| FGI | **Proposal 3**: The UCI that provides information about unused CG PUSCH transmission occasions is defined as a new UCI. |
| CMCC | **Proposal 8**. Support Alt. 1 to define the UCI that provides information about unused CG PUSCH transmission occasions as a new UCI. |
| xiaomi | **Proposal 8**: Information about unused CG PUSCH transmission occasions can replace some field(s) of the CG-UCI. |
| Google | **Proposal 10**: Support Alt. 2  \* "The UCI that provides information about unused CG PUSCH transmission occasions" is added as new field(s) to the CG-UCI. |
| Lenovo | **Proposal 12**: New UCI type indicates unused CG occasions.  o FFS: beta offset and UCI priority |
| CATT | **Proposal 4**: For the UCI carried the unused CG TOs information (UTO-UCI), it could be multiplexed in PUSCH as following:  • The information bit of the UCI can be cascaded with HARQ-ACK and/or CG-UCI information bits for the simplicity.  • The beta-offset value of UTO-UCI could be the same as that of HARQ-ACK and/or CG-UCI.  **Proposal 5**: The Alt.1:"The UCI that provides information about unused CG PUSCH transmission occasions would be defined as a new UCI" should be supported. |
| Panasonic | **Proposal 4**: The unused indication of CG PUSCHs should be introduced as a new field to the CG-UCI. |
| New H3C | **Proposal 1**: For the UCI that provides information about unused CG PUSCH transmission occasions, Alt. 1: "The UCI that provides information about unused CG PUSCH transmission occasions" is defined as a new UCI is supported. |
| Sony | **Proposal 3**: Support a new UCI (i.e., Alt.1) to provide information about the unused CG PUSCH transmission occasions and also potentially other new parameters. |
| CAICT | **Proposal 5**: The UCI that provides information about unused CG PUSCH transmission occasions" is added as new field(s) to the CG-UCI, or replaces/re-purposes some field(s) of the CG-UCI. |
| Intel | **Proposal 6**: Introduce a new UCI to indicate the number of unused PUSCH occasions.  \* Whether to multiplex the new UCI to CG PUSCH should be configurable |
| Apple | Design examples   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | HPID | NDI | Channel Access info | Occasion-usage indication | Other indication (e.g., M)S) | | Unlicensed access | Yes | Yes | Yes | Yes |  | | Licensed access | No (if HPID is determined from specification & retransmission over CG is not supported) | No (if retransmission over CG is not supported) | No | Yes |  | |

### 3.3.1 Initial Discussions

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

Based on the observations, the followings are suggested.

**Moderator’s Suggestions: Aim to make decision at this meeting.**

* Consider Atl.1
* “Reuse” CG-UCI multiplexing/encoding procedures
* Same priority as the corresponding CG PUSCH
* Discuss options for Beta-offset

**Proposals according to the suggestions above:**

**Note that moderator for convenience has used the term “UTO-UCI”.**

**Proposal 2-3-1:**

* The UCI that provides information about unused CG PUSCH transmission occasions is defined as a “new UCI” (i.e. Alt. 1 of previous agreement)

**Proposal 2-3-2:**

* For a configured grant PUSCH configuration, the “UTO-UCI” has the same priority level as the configured grant PUSCH.
* Note: The term “UTO-UCI” refers to the “UCI that provides information about unused CG PUSCH transmission occasions” for convenience.

**Proposal 2-3-3:**

The existing CG-UCI encoding and multiplexing procedures are reused for encoding the “UTO-UCI” in a configured grant PUSCH in absence or presence of other UCIs being multiplexed in the PUSCH, by apply the following adjustments:

* If CG-UCI is not present and/or not multiplexed in PUSCH, the “UTO-UCI” is used instead of CG-UCI in the corresponding procedures for encoding of CG-UCI and/or HARQ-ACK and/or CSI, whichever is present.
* If CG-UCI is present and is multiplexed in PUSCH, the “UTO-UCI” is appended to CG-UCI is used instead of CG-UCI in the corresponding procedures for encoding of CG-UCI and/or HARQ-ACK and/or CSI, whichever present.
* FFS on beta offset
* Note: The term “UTO-UCI” refers to the “UCI that provides information about unused CG PUSCH transmission occasions” for convenience.

**Proposal 2-3-4:**

For multiplexing of the “UTO-UCI” on CG-PUSCH, select one of the options below for determining the beta-offset:

* Option 1:
  + Beta offset can be configured for the “UTO-UCI” and reused instead of beta-offset for CG-UCI, when applicable.
    - If CG-UCI is not present, the beta offset for the “UTO-UCI” is used in the procedures instead of CG-UCI beta offset, when applicable.
    - If the “UTO-UCI” is jointly encoded with CG-UCI, the same beta offset is used in the procedures instead of CG-UCI beta offset, when applicable.
* Option 2:
  + Beta-offset for HARQ is reused for the “UTO-UCI”.
* Note: The term “UTO-UCI” refers to the “UCI that provides information about unused CG PUSCH transmission occasions” for convenience.

**Question:** Please provide your view in the table below regarding the following questions:

* **Q1:** What is your view regarding Moderator’s suggestions and corresponding **Proposal 2-3-1**, **Proposal 2-3-2, Proposal 2-3-3 and Proposal 2-3-4**.
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | Proposal 2-3-1: We’re supportive to this proposal.  Proposal 2-3-2: We don’t support this proposal, since we think the CG-UCI for unlicensed spectrum should be separately discussed from the UTO-UCI. And that case is actually out of the scope of WID, it may be proper to be discussed in next release.  Proposal 2-3-3: we don’t support this proposal, the reason is same as for proposal 2-3-2. |
| **Nokia, NSB** | We generally agree with Proposal 2-3-1. However, it shall be noted that for unlicensed operation additional rules will be required in order to support both CG-UCI and new UCI. Therefore, we propose to modify the proposal   * The UCI that provides information about unused CG PUSCH transmission occasions is defined as a “new UCI” for licensed band (i.e. Alt. 1 of previous agreement) * FFS: for unlicensed band   **Proposal 2-3-2, Proposal 2-3-3: Generally ok**  **Proposal 2-3-4:**  We propose the same logic from CG-UCI beta-offset configuration, which is more or less Option 1 |
| **CATT** | We are OK with Proposals 2-3-1, 2-3-2, and 2-3-3. We support option 2 of Proposal 2-3-4. |
| **New H3C** | We are fine with Proposals 2-3-1, 2-3-2, and 2-3-3. |
| **Qualcomm** | We see benefits in having a new UCI and in reusing the UCI-CG. On one hand, a new UCI allows a clean slate design where new dropping can be considered such as when there giving this UCI less priority than HARQ-ACK. On the other hand having reusing the UCI-CG has less standards impact |
| **Google** | We are fine with Proposal 2-3-1 and Proposal 2-3-2 for the sake of progress.  However, for Proposal 2-3-3 and Proposal 2-3-4, it should be clarified if we are enabling the multiple PUSCH CG feature designed for XR for unlicensed as well as this may require more work and more details to be covered. |
| **Samsung** | As there is no study/agreement to support XR in shared spectrum, all statements relating to CG-UCI should be removed. Other than that, OK with the proposals. |
| **Futurewei** | For Proposal 2-3-1: We support FL proposal because the design is for licensed carrier.  For Proposal 2-3-2: We think “UTO-UCI” may have higher priority than the configured grant PUSCH for reliability and latency reasons. So, we don’t support this FL proposal.  For Proposal 2-3-3: We are ok with FL proposal.  For Proposal 2-3-4: We are ok with Option 1. |
| **InterDigital** | We support Proposal 2-3-1. We are generally fine with Proposals 2-3-2 and 2-3-3. |
| **Xiaomi** | We agree with Proposals 2-3-2 and 2-3-3. |
| **vivo** | Support all the 4 proposals. Regarding Proposal 2-3-4, Option 1 is slightly preferred for more flexibility. |
| **OPPO** | We support Proposal 2-3-1, Proposal 2-3-2, and Proposal 2-3-3. For Proposal 2-3-4, we prefer not introduce new Beta offset and the following option is proposed:   * Option 3:   + If CG-UCI is not present, HARQ-ACK beta offset is used in the procedures instead of CG-UCI beta offset, when applicable.   + If the “UTO-UCI” is jointly encoded with CG-UCI, the same beta offset is used in the procedures instead of CG-UCI beta offset, when applicable. |
| **TCL** | We are fine with Proposal 2-3-1 and Proposal 2-3-3. We support option 1 of Proposal 2-3-4. |
| **DOCOMO** | We are fine with Proposals 2-3-1, 2-3-2, 2-3-3, and 2-3-4.  For Proposal 2-3-4, we prefer option 1. |
| **LG** | For Proposal 2-3-1: We have similar view to Nokia. We are fine to have new UCI in licensed band, but we would like to remain as FFS for unlicensed band.  For Proposal 2-3-2: We are fine with proposal 2-3-2.  For Proposal 2-3-3: we think our proposal are missed due to our typos. It is not reasonable to have same multiplexing procedure with CG-UCI at least when cg-UCI-Multiplexing is not provided.  Based on the current specification, When a UE would multiplex HARQ-ACK information in a PUSCH transmission and *cg-UCI-Multiplexing* is not provided, CG PUSCH is dropped and HARQ-ACK is transmitted to PUCCH or another PUSCH. It is not suitable for UTO-UCI since gNB can receive CG PUSCH regardless of existence of UTO-UCI. We think it should be discussed.  Also, in licensed band, CG-UCI would not be present.  **Modified Proposal 2-3-3 by LG:**  The existing CG-UCI encoding and multiplexing procedures are reused for encoding the “UTO-UCI” in a configured grant PUSCH in absence or presence of other UCIs being multiplexed in the PUSCH, by apply the following adjustments:   * If CG-UCI is not present and/or not multiplexed in PUSCH, and if *cg-UCI-Multiplexing* is not provided, the “UTO-UCI” is used instead of CG-UCI in the corresponding procedures for encoding of CG-UCI and/or HARQ-ACK and/or CSI, whichever is present.   + If *cg-UCI-Multiplexing* is provided, When a UE would multiplex HARQ-ACK information in a PUSCH transmission that include UTO-UCI, UE multiplex HARQ-ACK in the PUSCH transmission and drop UTO-UCI. * FFS on beta offset * FFS: for unlicensed band,   + If CG-UCI is present and is multiplexed in PUSCH, the “UTO-UCI” is appended to CG-UCI is used instead of CG-UCI in the corresponding procedures for encoding of CG-UCI and/or HARQ-ACK and/or CSI, whichever present. * Note: The term “UTO-UCI” refers to the “UCI that provides information about unused CG PUSCH transmission occasions” for convenience.   For Proposal 2-3-4: we are generally fine with the proposal and support Option 1. For the case CG-UCI is present, it can be under “FFS: for unlicensed band” |
| **MediaTek** | Generally fine with the proposals.  Proposal 2-3-1 can also be discussed later, after we progress on UCI content and payload size.  For Proposal 2-3-4, we prefer Option-1.  HARQ feedback should have higher priority than UTO-UCI as HARQ UCI impacts PUSCH reliability. Separate beta-offset parameters needed for HARQ UCI and UTO-UCI. |

## 3.4 Other topics

**Moderator’s summary:**

With respect to the feature supporting indication of unused PUSCHs by UCI, companies have raised other aspects for discussions and decision. Some of these topics were discussed last meeting. Few of them are listed below:

* Topic 1) Timeline impact and/or requirements
  + Introduce timeline for indication of “unused” TOs
    - Support: xiaomi, NEC
    - Not support: QC, Samsung
    - Needs study: vivo
  + Impact on existing timelines due to “unused” TOs
    - E///
* Topic 2) Introduce Overriding “unused” indications
  + Support: CMCC, Samsung
  + Not support: vivo, LG
  + Needs study: E///, Nokia
* Topic 3) Applicability to multiple CG configurations
  + Support: QC, vivo, TCL
  + Not support: DCM
  + Needs study: E///, Lenovo, Panasonic
* Other topics including
  + Interaction with uplink skipping (QC, Samsung with opposing views)
  + Restriction to licenced (HW/HiSi)
  + Applicability of feature to TBoM on Type-2 CG (QC, DCM)
  + Support for Non-integer periodicities (MTK)
  + Partial CG resource usage (Apple)
  + …

Table 8: Summary of Contributions inputs for Section 3.4

|  |  |
| --- | --- |
| **Company** | **Contributions inputs** |
| **Futurewei** | **Observation 4: To guarantee the indicated unused CG PUSCH occasion(s) to be really recycled to other UEs, time offset between UCI and the indicated unused CG PUSCH occasion(s) should be equal to or greater than the PUSCH preparing time for at least one of the other UEs.**  **Proposal 9: Indicating unused CG PUSCH occasion(s) to gNB can be determined based on a time offset threshold, indicated by gNB, between UCI and the unused CG PUSCH occasion(s).** |
| Ericsson | **Proposal 23** Revisit the existing timeline constraints due to configured grant PUSCH to ensure the corresponding constraints are not applicable when a configured grant PUSCH transmission occasion is indicated unused.  **Proposal 24** Whether to support overriding is conditioned on satisfying at least the following design principles:  \* Commitment to transmit: When a CG PUSCH TO is previously indicated "unused", if a later UCI overrides the previous indication corresponding to the CG PUSCH TO, the UE shall "use" that CG PUSCH for transmission.  \* Satisfying timeline: When a CG PUSCH TO is previously indicated "unused", if a later UCI overrides the previous indication corresponding to the CG PUSCH TO, the time between the end of a CG PUSCH carrying the later UCI and the start of the overridden CG PUSCH shall not be less than a time duration provided by configuration.  \* Simplicity: The key design choices regarding e.g., content and timing of UCI, should not complicate enabling overriding if supported.  \* FFS on other conditions and disciplines from UE  **Proposal 25** Whether to support capability of indication of unused CG PUSCH TOs for multiple CG configurations, study at least the following:  \* whether multiple CG configuration belong the same or different cells  \* whether the key design choices regarding e.g., content and timing of UCI, complicates support of multiple CG configurations.  \* Whether the UCI is carried by all CG PUSCHs associated to all the CG configurations or a sub-set of them.  \* FFS on other conditions. |
| Qualcomm | **Observation 2**: It is possible to configure the UE with multiple overlapping CG PUSCH occasions in current specs but the gNB has to blind detect the PUSCH  **Observation 3**: Indication of unused CG PUSCH occasion(s) of multiple overlapping PUSCH occasions is useful for UE power savings and for reducing blind decoding at gNB (network energy savings)  **Observation 4**: For the dynamic indication of the unused CG PUSCH occasion(s) among a set of PUSCH occasions, the CG PUSCH occasions can be overlapping in time. The overlapping PUSCH occasions allow for higher resource efficiency  **Observation 5**: If the gNB does not receive the indication of unused CG PUSCH occasion(s) early enough it can always do blind detection of PUSCH. The explicit timeline makes the spec and UE implementation complicated.  **Proposal 11**: An explicit timeline between the indication and the indicated unused CG PUSCH occasion(s) is not needed for the UE to transmit the indication  **Proposal 12**: For a CG PUSCH occasion of the multi-PUSCH CG configuration that is indicated as NOT "unused", the UE follows existing CG PUSCH skipping rule when there is a collision between the CG PUSCH occasion and other higher priority resource or operation such as semi-static DL symbol, DG scheduled DL symbol, SFI DL or flexible symbol, etc.  **Proposal 13**: Support a single UCI to jointly provide information of CG PUSCH occasions belonging to different CG configurations, TRPs, or CCs  **Proposal 15**: Do not support the explicit indication of "used" CG PUSCH occasion(s)  **Proposal 16**: Support the indication of unused CG PUSCH occasion(s) when TBoMS is configured for the multi-PUSCH CG configuration  \* Each CG PUSCH occasion contains the multiple slots for the same TB  **Proposal 17**: Consider adding rules when a UCI (e.g. HARQ-ACK) is supposed to be multiplexed and sent on the CG PUSCH which the UE is requesting to skip, e.g.:  - Alternative 1: Transmit UCI on PUCCH and drop PUSCH  - Alternative 2: Transmit UCI on PUSCH and drop PUCCH  - Alternative 3: Disable CG PUSCH skip capability on the TD resources with overlapping PUCCH and PUSCH and when a UCI is supposed to be sent |
| vivo | **Proposal 6**: A CG PUSCH occasion indicated as unused earlier is not expected to be changed as NOT unused subsequently.  **Proposal 7**: For dynamic indication of unused CG PUSCH occasion(s) based on UCI by the UE, the dynamic indication in a UCI can be applied to the configured CG PUSCH occasions corresponding to one or multiple CG configurations, and locating on one or multiple serving cells.  **Proposal 13**: For dynamic indication of unused CG PUSCH occasion(s) based on UCI by the UE, RAN1 discusses whether/how a minimum duration is assumed for gNB processing, e.g. decoding of the UCI, and recycling of unused time-frequency resources. |
| HW/HiSi | **Proposal 9**: The UCI that indicates unused CG PUSCH TO(s) is not applied to unlicensed band.  **Proposal 13**: No need to consider CG enhancements to address UL jitter. |
| Nokia/NSB | **Proposal 14**: Overriding previous indication from used to unused is allowed.  **Proposal 15**: Decide on whether overriding a previous indication from unused to used is supported after the solution related to what information UCI contains is clear. |
| MTK | **Observation 4**: In XR traffic context, the CG periodicity set to a larger value (e.g., as large as the XR traffic periodicity, such as 16.667ms) will have better latency (and therefore system capacity per number of supported users) performance. This is particularly true when multiple PUSCH TOs are positioned in back-to-back UL slots in a single CG period.  **Proposal 13**: Further discussions on multiple PUSCHs in single CG design shall optimize for CG configurations with CG periodicities as large as XR traffic periodicity (e.g., ~16ms). |
| Apple | **Proposal 2**: UCI signaling supports the indication of the starting occasion and the number of occupied occasion(s).  **Proposal 3**: support partial resource/occasion usage in the frequency domain to allow statistical multiplexing of UE traffics minimizing collision.  **Proposal 4**: support partial resource/occasion usage in the time domain to allow statistical multiplexing of UE traffics minimizing collision.  **Proposal 5**: CG PUSCH occasions with the same CG configuration can be associated different number of OFDM symbols. |
| Spreadtrum Comm. | **Proposal 6**: It need to further discuss how to handle HARQ process ID of the unused CG PUSCH occasion(s) in the CG period. |
| Lenovo | **Proposal 10**: If a UCI indicates unused CG occasions of only a CG configuration, decide whether handling of overlapped CG occasions across the CG configuration and another CG configuration is needed.  **Proposal 11**: Discuss invalid UCI indications. |
| NTT DOCOMO | **Proposal 8**: UCI indicates unused TOs of the same CG configuration as CG PUSCH carrying the UCI.  **Proposal 11**: Study whether/how to support such CG-UCI indication along with CG PUSCH configured with single TB processing over multiple slots. |
| LG | **Proposal 8**: Following two principles are to be considered for the URI indication for a same PUSCH occasion.  \* Once a PUSCH occasion has been indicated as unused, it cannot be indicated as non-unused by URI  \* Only the PUSCH occasion previously not indicated as unused, can be indicated as unused by URI  **Proposal 13**: Support to apply URI transmitted via a CG configuration to the other CG configuration.  \* A parameter indicating CG configuration to which URI applies can be provided by gNB.  **Proposal 14**: a PUSCH indicated by URI and other PUSCH overlapped with the PUSCH are assumed to be dropped.  \* No MAC PDU is generated for those CG PUSCHs. |
| CMCC | **Proposal 5**. Support to introduce a UCI overriding mechanism, which allows UE to re-transmit UCI to override the inaccurate indication of the unused CG PUSCH occasions in previous UCI.  **Proposal 6**. A field in UCI is introduced to indicate whether the UCI can be overridden (incredible) or not (credible). |
| Samsung | **Proposal 7**: Extend the collision resolution procedure for SPS PDSCHs to CG-PUSCHs.   1. One topic was the issue addressed by “Observation 2” above. 2. Another topic was a need for a timeline but that is unnecessary as a gNB is aware of the requirements for UE processing timelines and specifically of the PUSCH preparation timeline. 3. There is no reason to consider PUSCH skipping as such event will practically never occur for video frames (other than the indication for unused CG-PUSCH TOs). 4. ~~Providing a single TB over multiple CG-PUSCHs may be beneficial for improving coding gains for very small individual TBs (and for some TB CRC overhead reduction) but that is not the case for the very large TBs associated with XR while TB retransmissions will be practically impossible to handle and a resulting TB size may be larger than what a UE can currently support.~~ 5. ~~Re-transmission of multiple TBs by a single DCI was effectively discussed during the SI and is not supported.~~ 6. ~~CBG retransmission for multiple CG PUSCHs was discussed during the SI and is not supported. Although in principle a beneficial enhancement, the low target BLER required to meet PDB would limit any potential gain.~~ 7. ~~There is no need to support repetitions as the PDB cannot be met in such cases.~~ 8. Overriding a previous indication for unused CG-PUSCH TOs can be possible via providing UCI in every CG-PUSCH occasion where a later indication can be different from an earlier indication. |
| Panasonic | **Proposal 6**: It should be clear whether the unused indication is applicable to a single CG configuration or more CG configurations. |
| OPPO | **Proposal 5**: If a DG PUSCH overrides a CG PUSCH in the PUSCH TO which is determined to transmit a UCI, as allowed in R17, the UCI should be multiplexed in the DG PUSCH. |
| NEC | **Proposal 5**: study the timeline issues due to the multi-PUSCHs CG, including  a) how to handle the unused CG PUSCH occasion(s) and the UCI content if the time offset from the UCI to the unused CG PUSCH occasion(s) is smaller than the minimum preparation time for reusing the unused CG PUSCH occasion  b) if a high priority DG-PUSCH indicated by a scheduling DCI would overlap in time with a low priority CG-PUSCH occasion, how the PUSCH preparation time of the DG-PUSCH will be impacted if the low priority CG-PUSCH occasion is indicated as unused before the scheduling DCI. |
| xiaomi | **Observation 8**: The resource of the unused CG PUSCH transmission occasion can be allocated flexibly based on gNB's implementation.  **Proposal 6**: RAN1 should prioritize the discussion of the timeline for dynamic indication.  **Proposal 9**: Whether UE is allowed to send multiple dynamic indications with overlapping time windows should be discussed in RAN1.  **Proposal 10**: The gNB can allocate reusable resources to any UE, including the UE that sends UCI carrying the dynamic indication. |
| TCL | **Proposal 10**: When more than one CG configuration activation simultaneously, a UCI to indicate un-used TOs within more than one CG configurations can be considered. |

### 3.4.1 Initial Discussions

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

Considering the topics, Moderator’s observation and suggestions are as the following:

**General suggestion:** Prioritize the code feature design aspects (sections 3.1, 3.2 and 3.3). Use the discussion for better understanding of at least some of the topics in this section, 3.4.

* Topic 1) Timeline impact and/or requirements
  + 1-1) Introduce timeline for indication of “unused” TOs
  + 1-2) Impact on existing timelines due to “unused” TOs
    - Moderator’s observation/suggestion: Use the discussion for better understanding of the issues, motivations, solutions, and their necessity for each sub-topics1-1 and 1-2.
* Topic 2) Introduce Overriding “unused” indications
  + Moderator’s observation/suggestion: Use the discussion for better understanding of the issues, motivations, solutions, and their necessity.
* Topic 3) Applicability to multiple CG configurations
* Moderator’s observation/suggestion: Use the discussion for better understanding of the issues, motivations, solutions, and their necessity.
* Other topics including
  + Interaction with uplink skipping
    - Moderator’s observation/suggestion: Interaction with enhanced UL Skipping regarding UCI multiplexing needs clarification. Suggest discussing at a later stage.
  + Restriction to licenced
    - Moderator’s observation: The design is aimed to be generic and applicable to any CG.
  + Applicability of feature to TBoM on Type-2 CG
    - Moderator’s observation: The design is aimed to be generic and applicable to any CG.
  + Support for Non-integer periodicities
    - Moderator’s observation/suggestion: It was discussed during SI. Prefer not to re-open the topic.
  + Partial CG resource usage
    - Moderator’s observation/suggestion: It was discussed during SI. Prefer not to re-open the topic.
  + …

**Questions:** Please provide your view in the table below regarding the following questions:

* **Q1:** Please indicate your view regarding the **moderator’s observations/suggestions** regarding the topics above.
* **Q2:** Discuss any clarification/correction/comment/question on Moderator’s summary and suggestions or any other aspect helping the discussion and needed decisions.

**Note: Please ensure the information in companies’ contributions are considered for discussions.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| **ZTE, Sanechips** | For topic 1) I agree with moderator’s suggestion. And the timeline impact should be considered for multiple transmissions of the new UCI.  For topic 2) We are not clear with the use case. It should be clarified we assume that proper CG period is configured/adjusted when necessary)  For other topics, we’re fine with moderator’s suggestions. |
| **Nokia, NSB** | **We agree with general suggestion to prioritize the discussion on 3.1, 3.2, 3.3.**  **Please, find additional comments on topics above:**  **Topic 1:** agree that giving more time to distribute the resources is beneficial. However, the feature shall not be too complicated from spec point of view.  **Topic 2:** Overriding from Not Unused to Unused is fine, given that UE might not know in advance which occasion it will not use. However, changing from Unused to Not Unused need further study, i.e., how to ensure that gNB was not already distributed the resources, etc. In any case, both options will highly depend on the UCI design (e.g., if we choose the option that indicates the unused for the next occasion, the overriding might not be even needed). We propose to postpone the discussion after decision on: What information the UCI contains.  **Topic 3:** We have not seen a clear motivation to support indication for multiple CG configurations. The design will be complicated as we need to include another index for each indication. Therefore, we propose to down-prioritize it in Rel18 XR WI.  **Other topics:** generally,agree with moderator’s suggestion. However, the following moderator’s observation is not clear:   * + Applicability of feature to TBoM on Type-2 CG   Moderator’s observation: The design is aimed to be generic and applicable to any CG. |
| **CATT** | Topic 1: It is not necessary to define in the specification. UE should report the unused CG occasions any time. It is up to gNB implementation how to handle the resources of unused CG occasions.  Topic 2: This is an important issue for the late arrival of XR PDU within the duration of XR traffic. The over-write of the unused occasion indication would provide the gNB information when the XR traffic arrived and sent at an occasion which was marked as “unused” beforehand.  Topic 3: This is an implementation issue when multiple CG configurations are configured by gNB.  Topic 4: We need to identify the issues clearly before further discussion. |
| **New H3C** | We agree with FL’s suggestion |
| **Qualcomm** | Agree with moderators’ suggestion. For topic 1 we don’t think a timeline is necessary. The UE can still skip following legacy CG skipping.  For topic 3, we think indication of unused CG occasions for multiple CG configurations is very useful. In particular for the overlapping CG occasions, the gNB would avoid blind detection when the UE uses a certain occasion from the overlapping occasions. Besides, this allows the UE to send the UCI on the earliest CG PUSCH occasion across multiple configurations so that gNB has more time to reallocate the unused PUSCH resources to other UEs. |
| **Google** | Topic 1) We support discussing the timeline for the indication of unused TOs. The gNB needs time to receive the UCI indication, decode it and recycle the unused TOs to other UEs. A late indication may not be very beneficial for resource efficiency. However, network vendors could be reluctant to specify any timeline requirements as this is related to the gNB processing time.  Topic 2) we support discussing this topic and we agree with Nokia’s approach.  Topic 3) We think this should also be discussed. In UL XR, we can have multiple CG configurations, e.g., one for Pose/Control information, one for UL AR, one for UL audio, … Indication cross-CG configurations could be beneficial to reduce latency and signaling overhead. It also comes with low overhead cost by just adding an index of the targeted CG configuration. |
| **Samsung** | **Topic 1**: There is no reason to introduce a timeline. That makes assumptions on the gNB implementation/scheduler, a benefit from having the timeline does not exist, and specifications will be unnecessarily complicated.  **Topic 2**: Open to further discussion based on the comment from CATT.  **Topic 3**: A motivation is not clear and the proposal is not supported by the SI. It will only increase specification complexity. |
| **Futurewei** | We support Topic 1, especially for 1-1, as our observation and proposal below,  Observation 4: To guarantee the indicated unused CG PUSCH occasion(s) to be really recycled to other UEs, time offset between UCI and the indicated unused CG PUSCH occasion(s) should be equal to or greater than the PUSCH preparing time for at least one of the other UEs.  Proposal 9: Indicating unused CG PUSCH occasion(s) to gNB can be determined based on a time offset threshold, indicated by gNB, between UCI and the unused CG PUSCH occasion(s).  For Topic 3, we recall that it was discussed in study phase, but no conclusions, so we do not support rediscuss the same thing.  For other topics, we are ok with FL suggestions. |
| **InterDigital** | **Topic 1:** The discussion on timeline for sending UCI on unused PUSCHs can be reconsidered after making more progress on discussions in subsections 3.1 and 3.2.  **Topic 2:** We are open to discussing overriding the UCI on unused PUSCHs. At least the conditions under which the UE may be allowed to override the UCI can be discussed independent of other issues discussed in sections 3.1 and 3.2.  **Topic 3:** Although it can be beneficial if the UE is able to provide info on PUSCH usage across different CG configurations, it is not clear to us how or under what conditions can the UE determine such info on unused PUSCHs. |
| **Xiaomi** | We are fine to give more time to discuss topic 1 and 2.  **For Topic1:**  In our view, the most important purpose of the the discussion for XR-specific capacity enhancements is that unused CG occasions can be reallocated by the gNB. This requires ensuring that the gNB has sufficient time to perform this process. Therefore, the discussion of timeline is necessary.  **For Topic2:**  UE can reserve one or more CG occasions that are indicated to be used but actually unused. The main reason of this feature is that the UE does not know whether some CG occasions can be released to provide the gNB for reuse. And, overriding "unused" indications can reduce the waste of resources. |
| **vivo** | We think following topics need to be discussed together with the core features in 3.1~3.3. These topics may have impact on the detailed design for the core features.  For topic 1-1), how much processing time at gNB for the UCI indication of “unused” TO is needed can be further discussed.  For topic 2), it should be clarified what is the behaviour for a “unused” TO that is overridden as “NOT unused”. Is that mean a TO is to be “used” or may be “used”. If this behaviour would be allowed, UCI indication on “unused” TOs would not be useful since the TOs may or may not be “unused”.  For topic 3), we think the enhancement of UCI indication on unused TO should be applicable to multiple CG configurations. When CG is used for UL video traffic, not only variable packet size but also non-integer periodicity need to be handled. In such case, multiple CG configurations can be adopted. Besides, multiple CG configurations are supported since Rel-16. It is reasonable to apply the enhancement of UCI indication to multiple CG configurations case.   * Topic 1) Timeline impact and/or requirements   + 1-1) Introduce timeline for indication of “unused” TOs * Topic 2) Introduce Overriding “unused” indications * Topic 3) Applicability to multiple CG configurations |
| **TCL** | We are fine with FL’s suggestion. For topic 1, we support discussing the timeline for the indication of the un-used TOs due to some processing time will be needed.  For topic 2, we are not clear the motivation for this, as XR traffic is arrived with a periodic, then the CG configuration can be matched with the periodicity of XR.  For topic 3, We think this need to be discussed. In UL XR, multiple CG configurations can be used for XR to support multiple flows and reduce the latency when jitter is happened, indication un-used TOs within more than one CGs can be beneficial to signaling overhead, in addition, it’s also beneficial to avoid the resources waste for the CG configuration with no CG-UCI transmission chance, e.g. UE only choose one of CG configuration for one XR flow within more than one CG configurations. |
| **DOCOMO** | For topic 1, we don’t think it is necessary to introduce a new a timeline in the specification. It can be guaranteed by the offset between the UCI and the indicated TOs.  For topic 2, we are open to discuss this issue. We think at least “unused” overriding “used” can be supported.  For topic 3, we think the applicability for multiple CG applications may make the design more complicated and how much gain is not clear. We think it’s better to at least complete the design for only single CG configuration case.  For other topics, we are fine with moderator’ suggestion. |
| **LG** | We support to discuss topic 1/2/3  For Topic 1: it is true that certain time is necessary to apply UE’s decision at gNB side. To avoid transmitting unnecessary information, it is beneficial to discuss how to address the timeline. Regarding topic 1-1, we may need to consider the timeline for design on the information the UCI contains. We think it is unclear to discuss 1-2, which is relevant to PUSCH preparation time.  For Topic 2: it should be clarified how UE handle the duplicated indication.  For Topic 3: multiple configuration has various use cases in XR scenarios. It is definitely beneficial to discuss how the UCI is able to be applied to multiple configuration.  For other topics, we have a concerns on “restriction to licenced”. In terms of CG, the CG have lots of differences in between licensed and unlicensed. We are not sure that all we are discussing in this AI are applicable to unlicensed CG. We think it may necessary to take CG in licensed band as baseline. |
| **MediaTek** | We are open to discuss these topics more, but they should be low priority for now.  Our views:   * Topic 1: It would be worth to study the timeline impact. * Topic 2: We haven’t agreed to any “Not Unused” indication. So, overriding from “not unused” to “unused” should be possible anyways. * Topic 3: We don’t see a need for unused indication across multiple CG configurations.   One correction to moderator’s summary:   * Our proposal is not “Support for Non-integer periodicities”. We propose the following:   **Proposal 13**: Further discussions on multiple PUSCHs in single CG design shall optimize for CG configurations with CG periodicities as large as XR traffic periodicity (e.g., ~16ms).  So, our intention is to discuss and hopefully reach a conclusion on targeted CG periodicity values that companies should consider for XR-specific capacity enhancements. We see two possible approaches:   * Approach-1: The CG periodicity is about the same as XR traffic periodicity   + i.e., PUSCH TOs from one CG period are used to send one XR video frame.     - Example: CG period is set to 16ms * Approach-2: The CG periodicity is much smaller than XR traffic periodicity   + i.e., PUSCH TOs from multiple CG periods cab be used to send one XR video frame.     - Example: CG period is set to 4ms   Our proposal is to discuss the above two approaches and conclude one approach as the targeted configuration in our design discussions. So, we are not proposing non-integer periodicity. Apologies for being not clear with our proposal. |

# 4 Conclusion

TBD

# References

|  |  |  |
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| [**R1-2302317**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302317.zip) | XR-specific capacity enhancements | FUTUREWEI |
| [**R1-2302346**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302346.zip) | Discussion on CG enhancements for XR capacity | Huawei, HiSilicon |
| [**R1-2302399**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302399.zip) | Capacity Enhancements for XR | Ericsson |
| [**R1-2302429**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302429.zip) | Discussions on XR-specific capacity enhancements | New H3C Technologies Co., Ltd. |
| [**R1-2302501**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302501.zip) | Discussion on XR specific capacity enhancements | vivo |
| [**R1-2302563**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302563.zip) | Discussion on XR specific capacity enhancements | OPPO |
| [**R1-2302615**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302615.zip) | Discussion on XR-specific capacity enhancements | Spreadtrum Communications |
| [**R1-2302718**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302718.zip) | Design of Multiple CG Occasions | CATT |
| [**R1-2302811**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302811.zip) | Discussion on XR specific capacity enhancement techniques | Intel Corporation |
| [**R1-2302836**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302836.zip) | XR-specific capacity enhancements techniques | TCL Communication Ltd. |
| [**R1-2302856**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302856.zip) | Discussion on XR-specific capacity enhancements | Sony |
| [**R1-2302879**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302879.zip) | On XR-specific capacity enhancements techniques | Google Inc. |
| [**R1-2302893**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302893.zip) | Discussion on XR capacity enhancement techniques | Panasonic |
| [**R1-2302947**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302947.zip) | Discussion on XR specific capacity enhancements | ZTE, Sanechips |
| [**R1-2302997**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302997.zip) | Discussion on XR-specific capacity enhancements | xiaomi |
| [**R1-2303023**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303023.zip) | Discussion on XR-specific capacity enhancements | InterDigital, Inc. |
| [**R1-2303143**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303143.zip) | Capacity improvements for XR | Samsung |
| [**R1-2303190**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303190.zip) | Discussion on XR specific capacity enhancements | CAICT |
| [**R1-2303249**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303249.zip) | Discussion on XR-specific capacity enhancements | CMCC |
| [**R1-2303311**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303311.zip) | XR-specific capacity enhancements | Nokia, Nokia Shanghai Bell |
| [**R1-2303356**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303356.zip) | On XR capacity enhancements | MediaTek Inc. |
| [**R1-2303409**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303409.zip) | Discussion on XR-specific capacity enhancements | FGI |
| [**R1-2303428**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303428.zip) | Discussion on XR-specific capacity enhancements | LG Electronics |
| [**R1-2303460**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303460.zip) | Remaining issues on XR-specific capacity enhancements | Sharp |
| [**R1-2303498**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303498.zip) | XR-specific capacity enhancements | Apple |
| [**R1-2303533**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303533.zip) | XR-related CG Enhancements | Lenovo |
| [**R1-2303605**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303605.zip) | Capacity Enhancement Techniques for XR | Qualcomm Incorporated |
| [**R1-2303672**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303672.zip) | Discussion on XR-specific capacity enhancements | NEC |
| [**R1-2303724**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303724.zip) | Discussion on XR-specific capacity enhancements | NTT DOCOMO, INC. |
| [**R1-2303827**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303827.zip) | Discussion on XR-specific capacity enhancements | DENSO CORPORATION |

# Appendix

List of agreements