**3GPP TSG-RAN WG1 Meeting #100bisR1-200xxxx**

**e-Meeting, April 20th – April 30th, 2020**

**Agenda item:** **7.2.5.3**

**Source: Moderator (Apple Inc.)**

**Title: Outcome of the preparation email discussion on PUSCH enhancements for NR eURLLC (AI 7.2.5.3)**

**Document for: Discussion and Decision**

# 1 Introduction

In this contribution, Sections 2 to 6 summarize the issues raised in the contributions submitted under AI 7.2.5.3, PUSCH enhancements for NR Rel-16 URLLC.

Section 7 provides the outcome of the preparation email discussion, which defines the scope of email discussions for the AI.

# 2 TP for transmit power for PUSCH repetition Type B

It has been agreed in RAN1#100-e that:

*Agreements:*

*For PUSCH repetition Type B, PUSCH transmit power is determined based on the nominal repetition duration.*

But no TP was agreed due to no sufficient time for companies to carefully investigate the potential impact of different alternatives.

Here is a high level summary of how companies think this agreement should be captured (detailed TPs can be found in the corresponding contributions):

* Transmit power is defined for each nominal repetition
  + ZTE[2], Nokia/NSB[4], Panasonic[8] (including power control adjustment, PHR calculation), Samsung[13] (including power control adjustment and PHR calculation), QC[22] (including PHR calculation)
* CATT[12]
  + Rel-15 behavior is not clear in terms of whether a transmission occasion includes all repetitions or not.
  + Rel-16 transmit power can be defined either for a nominal repetition or for all the repetitions, depending on how Rel-15 behavior is interpreted.
* Ericsson[6]: TP to clarify the duration and the RS overhead.
* Panasonic[8]: P\_CMAX would need to be clarified when a nominal repetition goes across slot boundary.

Majority companies think the transmit power for PUSCH repetition Type B should be defined for each nominal repetition, including the power control adjustment, and PHR calculation.

Proposal:

# 3 UCI multiplexing on PUSCH for PUSCH repetition Type B

There are some open issues regarding UCI multiplexing on PUSCH for repetition Type B, including which PUSCH repetitions the UCI should be multiplexed on, and how to determine the resources for UCI.

## 3.1 Which PUSCH repetition(s) should UCI be multiplexed on?

Before discussing different proposals, it is worthwhile to understand how Rel-15 works in this aspect.

|  |  |
| --- | --- |
| First of all, whenever PUCCH(s) and PUSCH(s) overlap, the multiplexing timeline conditions defined in Clause 9.2.5 of TS 38.213 need to be satisfied; otherwise it is considered as an error case.  In terms of which PUSCH(s) the UCI is multiplexed, here is the excerpt from TS 38.213:   |  | | --- | | 9 UE procedure for reporting control information < omitted text >  If a UE transmits multiple PUSCHs in a slot on respective serving cells and the UE would multiplex UCI in one of the multiple PUSCHs and the UE does not multiplex aperiodic CSI in any of the multiple PUSCHs, the UE multiplexes the UCI in a PUSCH of the serving cell with the smallest *ServCellIndex* subject to the conditions in Clause 9.2.5 for UCI multiplexing being fulfilled. If the UE transmits more than one PUSCHs in the slot on the serving cell with the smallest *ServCellIndex* that fulfil the conditions in Clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in the earliest PUSCH that the UE transmits in the slot.  If a UE transmits a PUSCH over multiple slots and the UE would transmit a PUCCH with HARQ-ACK and/or CSI information over a single slot and in a slot that overlaps with the PUSCH transmission in one or more slots of the multiple slots, and the PUSCH transmission in the one or more slots fulfills the conditions in Clause 9.2.5 for multiplexing the HARQ-ACK and/or CSI information, the UE multiplexes the HARQ-ACK and/or CSI information in the PUSCH transmission in the one or more slots. The UE does not multiplex HARQ-ACK and/or CSI information in the PUSCH transmission in a slot from the multiple slots if the UE would not transmit a single-slot PUCCH with HARQ-ACK and/or CSI information in the slot in case the PUSCH transmission was absent.  < omitted text > |   As a very high-level summary,   * **Behavior 1**: In case PUCCH overlaps with multiple PUSCHs (carrying different TBs) in a slot, UCI is multiplexed in the earliest PUSCH in the slot. * **Behavior 2**: In case PUCCH overlaps with multiple PUSCH repetitions (in case of slot aggregation), UCI is multiplexed in all the overlapping PUSCH repetitions (in different slots).   In the end, UCI is multiplexed in at most one PUSCH in each slot. |

Generally speaking, for PUSCH repetition Type B, companies think it is good to reuse (some of) the Rel-15 behaviors, and the Rel-15 priority rules for PUSCH when determining UCI multiplexing (see Appendix C) should still be followed. Then the question is if UCI is to be multiplexed in a PUSCH with repetition Type B, how this should be handled.

First of all, it seems to be the consensus that the collision between UCI and PUSCH should be determined based on actual repetitions.

**Proposal 3-1: In case of PUSCH with repetition Type B, the determination of overlapping between PUCCH(s) carrying UCI and PUSCH is based on actual repetitions for PUSCH repetition Type B.**

For timeline consideration, there are two different options.

In case of PUCCH overlapping with PUSCH with repetition Type B,

* **Option A**: Multiplexing timeline conditions in Clause 9.2.5 of TS 38.213 shall be satisfied for all the overlapping actual repetitions. Otherwise it is considered as an error case.
  + ZTE[2], vivo[3], Nokia/NSB[4] (2nd preference), Ericsson[6], Intel[11], CATT[12], CMCC[14], Sharp[19], QC[22]
* **Option B**: It is not required that multiplexing timeline conditions in Clause 9.2.5 of TS 38.213 are satisfied for all the overlapping actual repetitions. UCI multiplexing only occurs on the actual repetition(s) satisfying the timeline conditions.
  + Huawei/HiSi[1], Nokia/NSB[4], OPPO[5], Sony[7], InterDigital[17] (?)

In terms of whether UCI can be multiplexed in one or more than one actual repetitions, there are also diverging views, because some companies prefer to follow Behavior 1 from Rel-15, while some other companies prefer to follow Behavior 2 from Rel-15. In addition, there are some considerations on the optimized selection of actual repetitions to improve the multiplexing performance. Note that this is independent from the timeline consideration above (Option A or B), and only actual PUSCH repetitions satisfying timeline conditions are considered.

In case PUCCH overlaps with multiple actual repetitions of PUSCH repetition Type B that satisfy the multiplexing timeline conditions,

* **Option 1**: UCI is multiplexed on the first actual repetition.
  + Huawei/HiSi[1], vivo[3], Nokia/NSB[4], Ericsson[6], Intel[11], InterDigital[17] (?), Sharp[19], QC[22]
* **Option 2**: UCI is multiplexed on all these overlapping actual repetitions
  + ZTE[2], Sony[7] (can consider), Panasonic[8], CATT[12], CMCC[14], MotM/Lenovo[20] (TP provided), Docomo[21]
    - Sony[7]: can consider splitting UCI, e.g. HARQ-ACK multiplexed on one actual repetition and CSI multiplexed on another actual repetition
    - MotM/Lenovo[20]: UE shall not multiplex UCI on an actual repetition that has less number of REs than the required number of REs for UCI multiplexing
* **Option 3**: UCI is multiplexed on the first actual repetition in each slot that includes overlapping actual repetitions.
  + LG[10]
* **Option 4**: UCI is multiplexed on the first actual repetition for which the capacity is not smaller than required UCI multiplexing resource.
  + OPPO[5], Sony[7]
    - OPPO[5]: If no overlapped actual PUSCH satisfies PUSCH/PUCCH multiplexing timeline and UCI multiplexing capacity requirement, then overlapped actual PUSCH(s) are dropped and PUCCH is transmitted.
    - Sony[7]: if none of the actual repetitions has sufficient resource, the earliest largest actual repetition is used for UCI multiplexing.
* **Option 5**: If a PUCCH carrying UCI overlaps with multiple actual PUSCH repetitions from one nominal PUSCH repetition within one slot, UCI is multiplexed on the first actual PUSCH repetitions with largest OFDM symbols. (*what if PUCCH overlaps with more than one nominal repetitions?*)
  + Samsung[13]
* **Option 6**: Among the PUSCH occasion, HARQ-ACK is multiplexed in the respective overlapped full PUSCH instance, or in the PUCCH otherwise.
  + ETRI[15]
* **Option 7**: UCI can be multiplexed on all overlapped nominal repetitions, and for each nominal repetition with multiple segmented actual repetitions, UCI can only be piggybacked on one or more actual repetitions with largest number of symbols. (*the highlighted part needs to be further clarified.*)
  + Spreadtrum[16]

Here are some questions for companies to consider further:

* Is any special handling necessary if a PUSCH repetition Type B goes across the slot boundary?
* Is an actual PUSCH repetition that is not transmitted also considered in the procedure?
  + Note that if not considered, there could be ambiguity between gNB and UE.

In addition, Fujitsu[9] proposed the following for the case with PUCCH repetitions.

* Overlapping between PUSCH repetition Type B and PUCCH repetitions
  + Fujitsu[9]: For the UL channels of the same PHY layer priority, UE drops the actual repetition(s) for PUSCH repetition type B which is overlapped in time with a PUCCH over a first number of slots.

## 3.2 UCI resource determination

In Rel-15, the UCI resources depend on the available REs in PUSCH and the TBS. As an example, the number of coded modulation symbols per layer for HARQ-ACK transmission is calculated as (Section 6.3.2.4.1.1 in TS 38.212)

,

where denotes the available RE number of the current PUSCH piggybacking the UCI, and  denotes the TBS of the PUSCH. Note that there are similar equations for CSI.

For PUSCH repetition Type B, TBS is determined based on the nominal repetition length. The question is then how the number of REs for UCI should be calculated? Based on the nominal repetition or actual repetition?

Using nominal repetition in the first part of the equation would provide more REs and better performance guarantee for UCI, while using actual repetition would allow more REs to be used for data transmission. This is also true for the second part of the equation.

Here is a summary of companies’ view based on the contributions:

* **Option 1**: The calculation is based on the nominal repetition, i.e., using the same number of REs as in TBS determination
  + Huawei/HiSi[1], ZTE[2], Vivo[3], OPPO[5], Panasonic[8], CMCC[14], InterDigital[17], Docomo[21] (2nd preference), QC[22]
  + Option 1a: with the additional limit of no more than the resources available in the actual repetition
    - ZTE[2], Panasonic[8] (?), CMCC[14], Docomo[21] (2nd preference), Sony
  + Option 1b: UE does not expect that the number of REs required by UCI is more than the number of available REs in the actual repetition on which the UCI is multiplexed.
    - Vivo[3]
* **Option 2**: The calculation is based on the actual repetition.
  + Samsung[13]
* **Option 3**: The first part of the equation is based on the nominal repetition, and the second part of the equation is based on the actual repetition.
  + Nokia/NSB[4] (TP provided), Panasonic[8], Intel[11], CATT[12] (detailed TP provided), Spreadtrum[16], Docomo[21]

In addition, Ericsson[6] proposed the following:

* Ericsson[6]: Increase the number of possible indices for beta offset that *dynamic-ForDCIFormat0\_2* can indicate to 8.

# 4 Remaining Issues on Interaction with DL/UL Directions for PUSCH repetition Type B

## 4.1 Conflict with SSB

* Symbols that are indicated by ssb-PositionsInBurst in SIB1 or ssb-PositionsInBurst in ServingCellConfigCommon for reception of SS/PBCH blocks are considered invalid symbols for PUSCH repetition Type B, and segmentation occurs around these invalid symbols:
  + ZTE[2], vivo[3], Nokia/NSB[4], CMCC[14], QC[22], WILUS[23]

## 4.2 Conflict with CORESET#0 in MIB

* CORESET for Type0-PDCCH CSS indicated by pdcch-ConfigSIB1 in MIB are considered as invalid symbols for PUSCH repetition Type B, and segmentation occurs around these symbols:
  + ZTE[2], Nokia/NSB[4], CMCC[14], QC[22]

## 4.3 Conflict with PRACH

* Follow Rel-15 behavior using the actual repetition
  + ZTE[2]
* Up to UE implementation
  + CMCC[14] (N symbol gap does not need to be considered)
* Vivo[2]: It is up to UE implementation to handle the conflict between PUSCH repetition Type B transmission and PRACH transmission, when PRACH and an actual repetition of PUSCH repetition Type B in a same slot or when a gap between a PRACH transmission and the actual repetition is less than N symbols where N=2 for µ=0 or µ=1, N=4 for µ=2 or µ=3, and µ is the SCS configuration for the active UL BWP.

## 4.4 Gap handling (Potential RRC impact)

* Huawei/HiSi[1], vivo[3]: no need for a new RRC parameter. Existing mechanisms are sufficient.
* Nokia/NSB[4]: Define gap handling for PUSCH repetition Type B in Sec. 6.1.2.1 of TS 38.214, by regarding symbols starting earlier than *N*RX-TX*T*C after the end of the last received semi-static DL symbol as invalid symbols.
  + FFS if *N*RX-TX*T*Cfrom half-duplex UEs is applied (i.e. Table 4.3.2-3 from TS 38.211) or if tighter requirements for PUSCH repetition Type B UEs can be defined.
* LG[10]: UE can ignore configured DL reception before NRx-Tx from segmented UL transmission including the effect of the timing advance
* Docomo[21]: Either introduce an RRC parameter to indicate the gap, or define in the spec that “it is considered as an invalid symbol that all X symbols after the last semi-static downlink symbols for each set of consecutive semi-static downlink symbols”
* QC[22]: XU symbols, if configured, after the last semi-static DL symbol, are considered as invalid symbols
* WILUS[23]: When a UE determines to transmit a Type-B PUSCH repetition, the UE should consider the *Ngap* symbols right after SS/PBCH block reception.
  + If there are less than *Ngap* symbols between the SS/PBCH block and a Type-B PUSCH repetition, the Type-B PUSCH repetition should be dropped.

## 4.5 Behavior for half-duplex CA

The 38.213 CR for half-duplex CA has been agreed in RAN1#100-e in R1-2001475. Here is a short summary of the behavior from CATT[12].

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| --- |
| For PUSCH on reference cell,   * For DG PUSCH and higher layer configured PUSCH on reference cell in a set of symbols, PUSCH transmission will not be affected by symbol direction indicated on other cells.   For PUSCH on other cell(s),   * For DG PUSCH or the first activated type 2 CG PUSCH in a set of symbols, PUSCH transmission will not be affected by symbol direction indicated on other cells. * For higher layer configured PUSCH in a set of symbols, a symbol can’t be used for PUSCH transmission, when   + the symbol is indicated semi-static downlink on reference cell, or   + UE is configured by higher layers to receive PDCCH, PDSCH, or CSI-RS on reference cell on the symbol, or   + UE detects a DCI scheduling downlink reception on reference cell on the symbol. |

Here is the list of proposals from the contributions:

* In case of half-duplex operation in CA, a symbol is considered as an invalid symbol for PUSCH repetition Type B transmission with Type 1 configured grant on another cell if the symbol overlaps with a symbol that is indicated as downlink by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated on the reference cell.
  + ZTE[2]
* In case of half-duplex operation in CA, a symbol is considered as an invalid symbol for PUSCH repetition Type B transmission in any of multiple serving cells if the symbol overlaps with a symbol that is indicated to the UE for reception of SS/PBCH blocks in any of multiple serving cells by ssb-PositionsInBurst in SystemInformationBlockType1 or by ssb-PositionsInBurst in ServingCellConfigCommon.
  + ZTE[2], WILUS[23]
* In case of half-duplex operation, symbols which are subject to half-duplex conflicts with UL dropping known semi-statically, are considered as invalid symbols for PUSCH repetition type B mapping in the UL transmission carrier.
  + Intel[11]
* For type 1 CG PUSCH and type 2 CG PUSCH other than the first activated PUSCH on the other cell in a set of symbols with PUSCH repetition type B, if one of the symbols is indicated as semi-static downlink on reference cell, or if the UE is configured by higher layers to receive PDCCH, PDSCH, or CSI-RS on reference cell in the symbol, or if the UE detects a DCI scheduling downlink reception on reference cell in the symbol, the symbol is invalid for PUSCH transmission and a PUSCH repetition is segmented around the symbol.
  + CATT[12]

It has been commented that the specifications for half-duplex CA may not be fully stable yet. Therefore, it is recommended to postpone the discussion later after the half-duplex CA specifications become stable.

# 5 Other Issues

## 5.1 A-CSI/SP-CSI on PUSCH with repetitions

It has been agreed in RAN1#100-e that:

*Agreements: (RRC impact)*

*Introduce reportSlotOffsetList-r16-ForDCIFormat0\_1 and reportSlotOffsetList-r16-ForDCIFormat0\_2 and update TS 38.214 accordingly*

* *FFS whether or not to always assume the number of nominal repetitions is equal to 1 when PUSCH with repetition Type B carries A-CSI/SP-CSI only.*

Regarding the FFS and A-CSI/SP-CSI on PUSCH with UL-SCH, here is the summary of companies’ views based on the contributions.

* ZTE[2]
  + the number of nominal repetitions indicated by the DCI is also applicable to PUSCH with repetition Type B that carries A-CSI/SP-CSI only. (no spec changes needed)
* Vivo[3]
  + For A-CSI triggered without UL-SCH
    - PUSCH repetition Type A:
      * if pusch-AggregationFactor>1 is used to indicate the number of repetitions, UE always assumes number of repetitions equals to 1.
      * If numberofrepetitions is used to indicate the number of repetitions, UE does not expect that A-CSI only on PUSCH is triggered with numberofrepetitions >1.
    - PUSCH repetition Type B
      * UE does not expect that A-CSI only on PUSCH is triggered with numberofrepetitions >1.
      * When it is triggered with numberofrepetitions =1, A-CSI is multiplexed on the first actual repetition.
  + For A-CSI triggered with UL-SCH
    - PUSCH repetition Type A
      * if pusch-AggregationFactor>1 or numberofrepetitions >1 is used to indicate the number of repetitions, A-CSI is multiplexed on one of the repetitions. FFS which one.
    - PUSCH repetition Type B
      * if numberofrepetitions >1 is used to indicate the number of repetitions, A-CSI is multiplexed on the first actual repetition.
* Ericsson[6]
  + Transmit A-CSI on the first actual repetition in each nominal repetition
  + Understanding of Rel-15 behavior: A-CSI in transmitted in all aggregated slots regardless of whether UL-SCH is present or not.
* CATT[12]
  + For PUSCH repetition type B with CSI report only, CSI is transmitted on the first repetition and the first nominal repetition is not expected to be segmented into multiple actual repetitions. (Understanding of Rel-15 behavior is that pusch-AggregationFactor does not apply to A-/SP-CSI only on PUSCH.)
  + PUSCH with UL-SCH and A-CSI (behaviour not defined for slot aggregation)
    - A-CSI is transmitted on the first repetition. For PUSCH repetition type B, if the first nominal repetition is segmented into multiple actual repetitions, CSI is transmitted on the first longest actual PUSCH repetition of the first nominal repetition.
* Spreadtrum[16]
  + The number of nominal repetitions is equal to 1 for PUSCH with repetition Type B carrying A-CSI/SP-CSI only.
* Sharp[19]
  + UE does not expect to use TDRA entries with *numberofrepetitions*> 1 when PUSCH with repetition Type B carries A-CSI/SP-CSI only.
* Note: there seems to be different understanding on Rel-15 behavior for PUSCH with slot aggregation, which is also one of the reasons why there are so many different proposals.

In addition, Sharp[19] proposed a TP to correct the TDRA description for A-CSI/SP-CSI on PUSCH without UL-SCH.

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| TS 38.214 V16.1.0 (2020-03)  6.1.2.1 Resource allocation in time domain  When the UE is scheduled to transmit a transport block and no CSI report, or the UE is scheduled to transmit a transport block and a CSI report(s) on PUSCH by a DCI, the *Time domain resource assignment* field value *m* of the DCI provides a row index *m* + 1to an allocated table. The determination of the used resource allocation table is defined in Clause 6.1.2.1.1. The indexed row defines the slot offset *K2*, the start and length indicator *SLIV*, or directly the start symbol *S* and the allocation length *L*, the PUSCH mapping type, and the number of repetitions (if *numberofrepetitions* is present in the resource allocation table) to be applied in the PUSCH transmission.  When the UE is scheduled to transmit a PUSCH with no transport block and with a CSI report(s) by a *CSI request* field on a DCI, the *Time domain resource assignment* field value *m* of the DCI provides a row index *m* + 1to the allocated table as defined in Clause 6.1.2.1.1. The indexed row defines the start and length indicator SLIV, or directly the start symbol *S* and the allocation length *L*, and the PUSCH mapping type to be applied in the PUSCH transmission and the *K2* value is determined as , where  are the corresponding list entries of the higher layer parameter  - *reportSlotOffsetListForDCI-Format0-2*, if PUSCH is scheduled by DCI format 0\_2 and *reportSlotOffsetListForDCI-Format0-2* is configured;  - *reportSlotOffsetListForDCI-Format0-1*, if PUSCH is scheduled by DCI format 0\_1 and *reportSlotOffsetListForDCI-Format0-1* is configured;  - *reportSlotOffsetList*, otherwise;  < Unchanged parts are omitted > |

## 5.2 Limit on the number of repetitions in a slot

We had the following agreements from RAN1#99:

*Agreements: (RAN1#99 Reno)*

*For PUSCH repetition type A and type B, the number of bits to indicate numberofrepetitions is 3.*

* *{1, 2, [3], 4, [6], 7, [8], 12, 16} are supported.*
* *FFS whether to have a limit on the number of nominal repetitions in a slot*

The value set for *numberofrepetitions* has been agreed in RAN1#100-e, but it remains open whether to have a limit on the number of nominal repetitions in a slot.

Here is a summary of companies’ views from RAN1#100bis-e contributions:

* Yes: Huawei/HiSi[1], Spreadtrum[16]
  + Limit on the number of actual repetitions per slot (SCS-dependent): Huawei/HiSi[1] (reuse Rel-15 UE features?),
* No:
  + CATT[12]

**Feature lead recommendation:** given that the issue is being addressed as part of UE feature discussion, it is recommended that we do not discuss it under this AI.

## 5.3 Miscellaneous issues

### Issue #1: Granularity for frequency hopping

Huawei/HiSi[1] pointed out using granularity of RB in frequency hopping starting position and offset may not be the best in aligning with RBG boundary, and proposed to use RBG as the granularity for PUSCH with RA type 1 scheduled by DCI format 0\_2. Note that this is not an issue specifically for PUSCH repetition type B. Rather, it is introduced by the RBG scheduling granularity in DCI format 0\_2 for RA type 1.

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| * In case of intra-slot frequency hopping, the starting RBG in each hop is given by: * In case of inter-slot frequency hopping, the starting RBG during slot *i* is given by: * In case of inter-repetition frequency hopping, the starting RBG in *i-th* repetition is given by: |

### Issue #2: TP for TDRA for configured grant

* Huawei/HiSi[1]:
  + A TP to add the definition of TDRA for a nominal/actual repetition for configured grant

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| 6.1.2.3.2 Transport Block repetition for uplink transmissions of PUSCH repetition Type B with a configured grant  The procedures described in this Clause apply to PUSCH transmissions of PUSCH repetition type B with a Type 1 or Type 2 configured grant.  For PUSCH transmissions with a Type 1 or Type 2 configured grant, for the *n*-th nominal repetition of the m-th repetition bundle, *n* = 0, …, *K* – 1, *m≥*0,   * The slot where the nominal repetition starts is given by , and the starting symbol relative to the start of the slot is given by . * The slot where the nominal repetition ends is given by , and the ending symbol relative to the start of the slot if given by .   Here, and *Sm* are the slot and the symbol where the *m*-th repetition bundle starts respectively, and are determined according to Clause 5.8.2 of [10, TS 38.321].  is the number of symbols per slot as defined in Clause 4.3.2 of [4, TS 38.211]. *S* and *L* are provided by *startSymbol* and *length* of the indexed row of the resource allocation table, respectively.  For PUSCH transmissions with a Type 1 or Type 2 configured grant, the invalid symbol(s) as well as the actual repetition(s) within each of the *K* nominal repetitions are determined according to the procedures for PUSCH repetition Type B defined in Clause 6.1.2.1. The higher layer configured parameters *repK-RV* defines the redundancy version pattern to be applied to the repetitions. If the parameter *repK-RV* is not provided in the *configuredGrantConfig*, the redundancy version for each actual repetition with a configured grant shall be set to 0. Otherwise, for the *n*th transmission occasion among all the actual repetitions (including the actual repetitions that are omitted) of the *K* nominal repetitions, it is associated with *(mod(n-1,4)+1)th* value in the configured RV sequence. If a configured grant configuration is configured with *startingFromRV0* set to *'off'*, the initial transmission of a transport block may only start at the first transmission occasion of the actual repetitions. Otherwise, the initial transmission of a transport block may start at … |

### Issue #3: TP for invalid symbol pattern for configured grant

* + A TP to clarify the invalid symbol pattern for configured grant

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| 6.1.2.1 Resource allocation in time domain < Unchanged parts are omitted >  For PUSCH repetition Type B, the UE determines invalid symbol(s) for PUSCH transmission scheduled by DCI format 0\_1, or scheduled by DCI format 0\_2, or corresponding to a configured grant as follows:  - A symbol that is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* is considered as an invalid symbol for PUSCH repetition Type B transmission.  - The UE may be configured with the higher layer parameter *InvalidSymbolPattern*, which provides a symbol level bitmap spanning one or two slots (higher layer parameter *symbols* given by *InvalidSymbolPattern*). …  < Unchanged parts are omitted > |

### Issue #4: TP for flexible start for configured grant

* + Correction on flexible start for configured grant with PUSCH repetition Type B

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| Text proposal for Clause 6.1.2.3.2 in TS 38.214 v16.1.0 --------------------------------------- Start of Text Proposal ----------------------------------------------  6.1.2.3.2 Transport Block repetition for uplink transmissions of PUSCH repetition Type B with a configured grant  The procedures described in this Clause apply to PUSCH transmissions of PUSCH repetition type B with a Type 1 or Type 2 configured grant.  For PUSCH transmissions with a Type 1 or Type 2 configured grant, the nominal repetitions and the actual repetitions are determined according to the procedures for PUSCH repetition Type B defined in Clause 6.1.2.1. The higher layer configured parameters *repK-RV* defines the redundancy version pattern to be applied to the repetitions. If the parameter *repK-RV* is not provided in the *configuredGrantConfig*, the redundancy version for each actual repetition with a configured grant shall be set to 0. Otherwise, for the *n*th transmission occasion among all the actual repetitions (including the actual repetitions that are omitted) of the *K* nominal repetitions, it is associated with *(mod(n-1,4)+1)th* value in the configured RV sequence. If a configured grant configuration is configured with *startingFromRV0* set to *'off'*, the initial transmission of a transport block may only start at the first transmission occasion of the actual repetitions. Otherwise, the initial transmission of a transport block may start at  - the first transmission occasion of the actual repetitions if the configured RV sequence is {0,2,3,1},  - any of the transmission occasions of the actual repetitions that are associated with RV=0 if the configured RV sequence is {0,3,0,3}, except the actual repetitions within the last nominal repetition when *K≥8*.  - any of the transmission occasions of the actual repetitions if the configured RV sequence is {0,0,0,0}, except the actual repetitions within the last nominal repetition when *K≥8*.  < Unchanged parts are omitted >  --------------------------------------------- End of Text Proposal ----------------------------------------- |

Note: Issue #4 is planned to be discussed under AI 7.2.5.6 (enhanced CG).

### Issue #5: Extended CP

* Extended CP
  + ZTE[2]: clarify L is from 0 to 11

### Issue #6: TP for segmentation of a nominal repetition

* Ericsson[6]: clarification on segmentation

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| **------------------ Text Proposal for 38.214 Section 6.1.2.1------------------**  …  For PUSCH repetition Type B, after determining the invalid symbol(s) for PUSCH repetition type B transmission for each of the *K* nominal repetitions, the remaining symbols are considered as potentially valid symbols for PUSCH repetition Type B transmission. If the number of potentially valid symbols for PUSCH repetition type B transmission is greater than zero for a nominal repetition, the nominal repetition consists of one or more actual repetitions, where each actual repetition consists of a consecutive set of as many potentially valid symbols that can be used for PUSCH repetition Type B transmission within a slot as possible. An actual repetition with a single symbol is omitted except for the case of *L*=1. An actual repetition is omitted according to the conditions in Clause 11.1 of [6, TS38.213]. The redundancy version to be applied on the *n*th actual repetition (with the counting including the actual repetitions that are omitted) is determined according to table 6.1.2.1-2.  …  **----------------------------------------------End of proposed TP ----------------------------------------------------** |

### Issue #7: Clarify the DMRS overhead assumption in TBS determination

* Panasonic[8]: TBS determination
  + clarify that the DMRS overhead assumption in TBS determination should be based on nominal repetition length

### 

The remaining issues do not seem to be critical at this point for this AI, therefore the recommendation is to de-prioritize the related discussions.

* Ericsson[6]: When only one bit is used to signal RV in DCI format 0\_2, it indicates either RV 0 or RV 2 (instead of RV 0 or 3). In addition to performance benefit, it is pointed in [6] that NR-U has specified “Table 7.3.1.1.2-34: Redundancy version” in 38.212 to signal RV0 and RV2.
  + Reason: RV {0, 2} performs better than {0, 3}
  + **FL recommendation**: this is a generic issue introduced by one-bit RV field in DCI format 0\_2. It is recommended to discuss this issue under AI 7.2.5.1.

A close up of a map

Description automatically generated

|  |
| --- |
| **------------------ Text Proposal for 38.212 Section 7.3.1.1.3 ------------------**  - Redundancy version – 0, 1 or 2 bits determined by higher layer parameter *NumberofbitsforRV-ForDCIFormat0\_2*  - If 0 bit is configured, *rvid* to be applied is 0;  - 1 bit according to Table ~~7.3.1.2.3-1~~ 7.3.1.1.2-34;  - 2 bits according to Table 7.3.1.1.1-2.  ----------------------------------------------End of proposed TP ---------------------------------------------------- |

* OPPO[5]
  + Configured grant timer starts or restarts for each nominal repetition. (*FL: any PHY specs impact?*)
* Fujitsu[9]: If a PUSCH of type B repetition is scheduled by a DCI and the DCI includes a DAI field, the value of the DAI field is applicable for the repetition(s) where HARQ-ACK information is multiplexed. (*FL: any spec changes needed?*)
* Spreadtrum[16]: Do not need to specially handle actual repetitions with 2-symbol length. (*FL: no spec impact?*)
* Apple[18]
  + Clarify UE behavior when (the overhead is configured too much)
    - (*FL: the same issue already exists in Rel-15?*)
  + A-CSI on PUSCH
    - For a repetition Type B PUSCH with M actual repetitions after segmentation which are not dropped due to orphan symbol treatment, when M<=2, the AP-CSI is carried over the (M)-th actual repetition, and when M > 2, then the AP-CSI is carried over the (M-1)-th actual repetition.
* QC[22]
  + Sec. 2 on the conflict of low priority dynamic DL transmission and high priority configured UL transmission
    - *FL comment: This seems to be a generic issue for intra-UE prioritization and multiplexing, not specific for PUSCH repetition Type B. Would suggest that this is discussed under AI 7.5.2.*

# 6 Scope of the email discussions

As guided by the chairman, each AI can have up to 3 email discussions.

Based on chairman’s guidance, the TP in Section 2 will be discussed separately. The scoping here is only for the issues in Sections 3, 4 and 5.

Based on the summary and the additional input from companies, the suggestion is to have 3 email discussions on the following:

|  |  |  |
| --- | --- | --- |
|  | Scope | Reason |
| Email #1 | Section 3 (UCI multiplexing on PUSCH for PUSCH repetition Type B) | Issues are essential. |
| Email #2 | Section 4.1 to 4.4 (interaction with DL/UL directions) | There are some open issues on the details that are essential. |
| Email #3 | Section 5.1 (A-CSI/SP-CSI on PUSCH) and Issues #5/#6/#7 in Section 5.3 | Issues in Section 5.1 are essential, and issues in Section 5.3 were selected based on companies’ interest shown during the preparation email discussion. |

It is suggested to postpone the remaining issues to the next meeting.

# References

1. [R1-2001549](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001549.zip) Corrections on PUSCH enhancement Huawei, HiSilicon
2. [R1-2001613](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001613.zip) Remaining issues on PUSCH enhancements for NR URLLC ZTE
3. [R1-2001671](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001671.zip) PUSCH enhancements for URLLC vivo
4. [R1-2001696](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001696.zip) Maintenance of PUSCH enhancements for Rel-16 NR URLLC Nokia, Nokia Shanghai Bell
5. [R1-2001775](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001775.zip) PUSCH enhancements for URLLC OPPO
6. [R1-2001786](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001786.zip) Remaining Issue of PUSCH Enhancements for NR URLLC Ericsson
7. [R1-2001816](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001816.zip) Remaining issues on PUSCH enhancements for URLLC Sony
8. [R1-2001872](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001872.zip) Remaining issues on URLLC PUSCH enhancement Panasonic Corporation
9. [R1-2001881](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001881.zip) Remaining issues on PUSCH enhancements for URLLC Fujitsu
10. [R1-2001921](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2001921.zip) Remaining issues of PUSCH enhancements for NR URLLC LG Electronics
11. [R1-2002000](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002000.zip) Corrections on PUSCH enhancements for URLLC Intel Corporation
12. [R1-2002084](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002084.zip) Remaining issues on PUSCH enhancements CATT
13. [R1-2002133](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002133.zip) Remaining issues for PUSCH enhancements Samsung
14. [R1-2002209](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002209.zip) Remaining issues on PUSCH enhancements for URLLC CMCC
15. [R1-2002251](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002251.zip) PUSCH enhancements ETRI
16. [R1-2002264](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002264.zip) Discussion on PUSCH enhancements for URLLC Spreadtrum Communications
17. [R1-2002305](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002305.zip) PUSCH enhancements for URLLC InterDigital, Inc.
18. [R1-2002331](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002331.zip) Remaining Issues in PUSCH enhancements Apple
19. [R1-2002392](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002392.zip) Remaining issues on PUSCH enhancements for NR URLLC Sharp
20. [R1-2002409](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002409.zip) UCI multiplexing in PUSCH repetition type B Motorola Mobility, Lenovo
21. [R1-2002444](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002444.zip) Remaining issues for PUSCH enhancements for Rel.16 URLLC NTT DOCOMO, INC.
22. [R1-2002546](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002546.zip) Remaining issues on PUSCH enhancements for URLLC Qualcomm Incorporated
23. [R1-2002636](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_100b\Docs\R1-2002636.zip) Remaining issues on PUSCH enhancement for NR URLLC WILUS Inc.

# Appendix A: Previous agreements on potential enhancements for PUSCH

### RAN1#94bis (Oct. 2018)

Agreements**:**

* One PUSCH transmission instance is not allowed to cross the slot boundary at least for grant-based PUSCH.

### RAN1#95 (Nov. 2018)

Agreements**:**

Support at least one of the following for one TB:

* One UL grant scheduling two or more PUSCH repetitions that can be in one slot, or across slot boundary in consecutive available slots
* One UL grant scheduling two or more PUSCH repetitions in consecutive available slots, with one repetition in each slot with possibly different starting symbols and/or durations
* N (N>=2) UL grants scheduling N PUSCH repetitions on consecutive available slots, with one repetition in each slot, and the i-th UL grant can be received before the end of the PUSCH transmission scheduled by the (i-1)th UL grant.
* FFS the definition of available slots

### RAN1 AH#1901 (Jan. 2019)

Agreements:

At least for scheduled PUSCH, for the option “One UL grant scheduling two or more PUSCH repetitions that can be in one slot, or across slot boundary in consecutive available slots” (also called as “mini-slot based repetitions”), if supported, it further consists of:

* Time domain resource determination
  + The time domain resource assignment field in the DCI indicates the resource for the first repetition.
  + The time domain resources for the remaining repetitions are derived based at least on the resources for the first repetition and the UL/DL direction of the symbols.
    - FFS the detailed interaction with the procedure of UL/DL direction determination
  + Each repetition occupies contiguous symbols.
  + FFS whether/how to handle “orphan” symbols (the # of UL symbols is not sufficient to carry one full repetition)
* Frequency hopping (at least 2 hops)
  + Support at least inter-PUSCH-repetition hopping and inter-slot hopping
  + FFS other FH schemes
  + FFS number of hops larger than 2
* FFS dynamic indication of the number of repetitions
* FFS DMRS sharing
* FFS TBS determination (e.g. based on the whole duration, or based on the first repetition)

Agreements:

At least for scheduled PUSCH, for the option “One UL grant scheduling two or more PUSCH repetitions in consecutive available slots, with one repetition in each slot with possibly different starting symbols and/or durations” (also called as “~~two~~multi-segment transmission”), if supported, it further consists of:

* Time domain resource determination
  + The time domain resource assignment field in the DCI indicates the starting symbol and the transmission duration of all the repetitions.
    - FFS multiple SLIVs indicating the starting symbol and the duration of each repetition
    - FFS details of SLIV, including the possibility of modifying SLIV to support the cases with S+L>14.
  + FFS the interaction with the procedure of UL/DL direction determination
* For the transmission within one slot,
  + If there are more than one UL period within a slot (where each UL period is the duration of a set of contiguous symbols within a slot for potential UL transmission as determined by the UE)
    - ~~Alt1: One repetition spans across more than one UL periods.~~
      * ~~This implies that DMRS is required for each UL period.~~
      * ~~Note: it is agreed in previous meetings that one PUSCH instance is not across a slot boundary~~
      * ~~Each repetition occupies contiguous symbols available for potential UL transmission across one or more UL periods~~
    - ~~Alt2:~~ One repetition is within one UL period.
      * FFS if more than one UL period is used for the transmission (If more than one UL period is used, this would override the previous definition of this option.)
      * Each repetition occupies contiguous symbols
  + Otherwise, a single PUSCH repetition is transmitted within a slot following Rel-15 behavior.
* ~~FFS Transmission of the repetitions spanning across more than two slots is not supported.~~
* Frequency hopping
  + Support at least inter-slot FH
  + FFS other FH schemes
* FFS TBS determination (e.g. based on the whole duration, or based on the first repetition, overhead assumption)

Agreements:

* Down-select between “mini-slot based repetitions” and “two-segment transmission”, aiming in RAN1#96
* FFS the option of using separate grants to schedule PUSCH repetitions in consecutive available slots

Agreements**:**

Companies are encouraged to provide more details in RAN1#96 at least for the following for potential enhancements of PUSCH:

* Details of the time domain resource determination, including the interaction with the DL/UL direction of the symbols
* Details of TBS determination
* What is different for scheduled PUSCH and configured grant?
  + E.g. for configured grant, should the transmission be allowed to postpone when conflicting with DL symbols?
* Comparison between the two schemes, including the potential performance evaluation/analysis (including latency, reliability, etc), complexity, overhead, etc.

### RAN1#96 (Feb. 2019)

Agreements**:**

* Capture the descriptions of option 1 to 6 (see R1-1903797 and previous agreements) in the TR.

Here is the description of Option 4 from TR 38.824:

*One or more actual PUSCH repetitions in one slot, or two or more actual PUSCH repetitions across slot boundary in consecutive available slots, is supported using one UL grant for dynamic PUSCH, and one configured grant configuration for configured grant PUSCH. It further consists of:*

* *The number of the repetitions signaled by gNB represents the “nominal” number of repetitions. The actual number of repetitions can be larger than the nominal number.*
  + *FFS dynamically or semi-statically signalled for dynamic PUSCH and type 2 configured grant PUSCH*
* *The time domain resource assignment (TDRA) field in the DCI or the TDRA parameter in the type 1 configured grant indicates the resource for the first “nominal” repetition.*
* *The time domain resources for the remaining repetitions are derived based at least on the resources for the first repetition and the UL/DL direction of the symbols.*
  + *FFS the detailed interaction with the procedure of UL/DL direction determination*
* *If a “nominal” repetition goes across the slot boundary or DL/UL switching point, this “nominal” repetition is splitted into multiple PUSCH repetitions, with one PUSCH repetition in each UL period in a slot.*
  + *Handling of the repetitions under some conditions, e.g., when the duration is too small due to splitting, is to be further investigated in the WI phase.*
* *No DMRS sharing across multiple PUSCH repetitions*
* *The maximum TBS size is not increased compared to Rel-15.*
* *FFS: L > 14*
* *S+L can be larger than 14*
* *FFS: The bitwidth for TDRA is up to 4 bits.*
* *Note: different repetitions may have the same or different RV.*

**Conclusion**:

* Finalize the details regarding how to use “option 1” vs. “option 2” during the WI phase using option 4, 5, and 6 (as in R1-1903797) as a starting point.

Agreements**:**

* Capture the simulation results in Section 3 in the TR.

### RAN1#96bis (Apr. 2019)

Agreements**:**

* Option 5 is not considered further as part of PUSCH enhancements.

Agreements**:**

For option 4, dynamic indication of the nominal number of repetitions in the DCI scheduling dynamic PUSCH is supported for PUSCH enhancements. The dynamic indication can be enabled or disabled by the gNB.

* FFS the exact signaling method
* FFS the exact DCI format(s)
* FFS the exact mechanism to enable or disable
* FFS the DCI activating type 2 configured grant PUSCH

Agreements:

For option 6,

* For dynamic PUSCH
  + For semi-static DL symbol(s), to down-select
    - Option 1: it is not expected that the resource allocation has conflict with semi-static DL symbol(s).
    - Option 2: if the resource allocation has conflict with semi-static DL symbol(s), the repetition is not transmitted.
  + For dynamically indicated DL symbol(s) (via format 2\_0), it is not expected at the UE that the resource allocation has conflict with dynamically indicated DL symbol(s).
    - Note: this is the same as Rel-15 behavior.
* For configured grant PUSCH,
  + For type 1 configured grant PUSCH, and PUSCH other than the first PUSCH (including all repetitions) associated with the type 2 configured grant activation,
    - If a repetition conflicts with semi-static DL symbol(s), the repetition is not transmitted.
    - FFS: If a repetition conflicts with dynamically indicated DL symbol(s) (via format 2\_0), the repetition is not transmitted.
  + FFS For the first PUSCH (including all repetitions) associated with the type 2 configured grant activation, follow the same handling as dynamic PUSCH.

Agreements:

* For option 6, at least for dynamic grants, it is not expected that one repetition (i.e., one SLIV) spans across slot boundary.

Agreements:

For both option 4 and 6, frequency hopping is supported

* FFS details

### RAN1#97 (May 2019)

Agreements:

* Adopt option 4 with the following update:
* The time domain resource assignment (TDRA) field in the DCI or the TDRA parameter in the type 1 configured grant indicates the resource for the first “nominal” repetition.
  + FFS the detailed interaction with the procedure of UL/DL direction determination

### RAN1#98 (Aug. 2019)

Agreements:

In terms of how to interpret L and K for all PUSCH transmissions, down-select between the following two:

* Alt 1: The time window within which valid symbols are used for transmission is L\*K.
  + FFS the definition of “valid symbols”
* Alt 2: The time window within which valid symbols are used for transmission can be longer than L\*K symbols, and it is extended at least in case of semi-static DL symbols.
  + FFS extension of the time window in case of dynamic DL symbols and/or semi-static flexible symbols and/or reserved symbols (if defined) and/or SSB symbols and/or type-0 CSS in CORESET#0 (as indicated by MIB)
  + FFS the definition of “valid symbols”
  + FFS whether to define a maximum time window size and if so, details

**Conclusion:**

In terms of how to handle the interaction of enhanced PUSCH with DL/UL directions, consider the following options:

* For DG PUSCH
  + If dynamic SFI is not configured,
    - Semi-static flexible symbols are used for PUSCH. Segmentation occurs only around semi-static DL symbols.
  + If dynamic SFI is configured
    - Option 1: behavior not dependent on dynamic SFI
      * Option 1-1: Semi-static flexible symbols are used for PUSCH. Segmentation occurs only around semi-static DL symbols.
        + FFS whether the conflict between dynamic SFI and symbols used for PUSCH transmission is considered as an error case, e.g.

Option 1-1a: The UE does not expect any semi-static flexible symbol to be indicated as DL within the PUSCH transmission time window.

Option 1-1b: No error case is defined and in general all semi-static flexible symbols are used for PUSCH within the PUSCH transmission time window.

* + - * Option 1-2: Semi-static DL/flexible symbols are not used for PUSCH. Segmentation occurs around semi-static DL/flexible symbols.
      * Option 1-3: Dynamic indication in UL grant on which set of semi-static flexible symbols are used for PUSCH. Segmentation occurs around semi-static DL and the dynamically indicated invalid symbols.
      * Option 1-4: Pre-defined rules to determine which set of semi-static flexible symbols are used for PUSCH. Segmentation occurs around semi-static DL and the invalid symbols as defined in the rules.
    - Option 2: the UE uses SFI to determine the symbols to transmit
      * In case SFI is configured and received
        + Option 2-1: Segmentation occurs around semi-static DL symbols and dynamic DL/flexible symbols
        + Option 2-2: Dynamic flexible symbols are used for PUSCH. Segmentation occurs around semi-static DL symbols and dynamic DL symbols
        + Option 2-3: Dynamic flexible symbols are used for PUSCH. A repetition is not transmitted if it conflicts with a dynamic DL symbol.
        + Option 2-4: A repetition is not transmitted if it conflicts with a dynamic DL/flexible symbol
      * In case SFI is configured and not received
        + A repetition is not transmitted if it conflicts with a semi-static flexible symbol.
* For CG PUSCH other than the first Type 2 CG PUSCH (including all the repetitions) activated by an UL grant
  + If dynamic SFI is not configured,
    - Semi-static flexible symbols are used for PUSCH. Segmentation occurs only around semi-static DL symbols.
  + If dynamic SFI is configured
    - Option 1: behavior not dependent on dynamic SFI
      * ~~Option 1-1: Semi-static flexible symbols are used for PUSCH. Segmentation occurs only around semi-static DL symbols.~~
        + *~~This does not seem to make much sense for CG. If semi-static flexible symbols are always used for CG PUSCH, the gNB can essentially configure these symbols as UL in semi-static configuration. – no need for this option?~~*
      * Option 1-2: Semi-static DL/flexible symbols are not used for PUSCH. Segmentation occurs around semi-static DL/flexible symbols.
      * *~~Option 1-3 from DG is not applicable for CG.~~*
      * Option 1-4: Pre-defined rules to determine which set of semi-static flexible symbols are used for PUSCH. Segmentation occurs around semi-static DL and the invalid symbols as defined in the rules.
    - Option 2: the UE uses SFI to determine the symbols to transmit
      * In case SFI is configured and received
        + Option 2-1: Segmentation occurs around semi-static DL symbols and dynamic DL/flexible symbols
        + *~~Option 2-2 does not make sense for CG. (Dynamic flexible symbols are used for PUSCH. Segmentation occurs around semi-static DL symbols and dynamic DL symbols)~~*
        + *~~Option 2-3 does not make sense for CG. (Dynamic flexible symbols are used for PUSCH. A repetition is not transmitted if it conflicts with a dynamic DL symbol.)~~*
        + Option 2-4: a repetition is not transmitted if it conflicts with a semi-static DL symbol and a dynamic DL/flexible symbol
      * In case SFI is configured and not received
        + A repetition is not transmitted if it conflicts with a semi-static flexible symbol.
* For the first Type 2 CG PUSCH (including all the repetitions) activated by an UL grant,
  + Alt 1: same behavior as DG PUSCH
  + Alt 2: same behavior as CG PUSCH without an associated UL grant
  + …
* FFS: in case of a repetition not being transmitted (as in the above bullets), whether a repetition is a nominal repetition or a repetition after segmentation due to semi-static DL symbol(s)/slot boundary
* FFS: whether to postpone or not, and if yes, under what condition(s)
* FFS: whether/how guard period is handled
* Note that segmentation at slot boundary is always performed, even though it is not explicitly mentioned in the bullets above.
* FFS: the handling of conflict with SSB/PRACH symbols, the handling of conflict with semi-statically configured DL reception, etc.
* Other options are not precluded

### RAN1#98bis (Oct. 2019)

Agreements:

* Do not support PUSCH mapping type A for Option 4.

Agreements:

* Rel-16 enhanced PUSCH scheme (including dynamic indication of the number of repetitions) is supported for DCI format 0\_1 and new UL DCI format (for DG and type 2 CG).
* Rel-16 enhanced PUSCH scheme is not supported for DCI format 0\_0 for DG and type 2 CG

Agreements:

For the dynamic indication of the number of repetitions for dynamic grant:

* Jointly coded with SLIV in TDRA table, by adding an additional column for the number of repetitions in the TDRA table
  + The maximum TDRA table size is increased to 64
  + No other spec impact is expected

Agreements:

* Support dynamic indication of the number of repetitions for Rel-15 PUSCH with slot aggregation using DCI formats 0\_1 & the new UL DCI format
  + The dynamic indication is done by using the same Rel-16 mechanism (Jointly coding the number of repetitions with SLIV in TDRA table)

Agreements:

For frequency hopping for Rel-16 PUSCH, the number of actual hopping locations in frequency is 2.

Agreements:

In case frequency hopping is enabled for Rel-16 PUSCH, to determine the frequency locations of the two hops, reuse Rel-15 RRC parameters and equations for format 0\_1, and introduce new RRC parameters (same as those of Rel-15) for new DCI UL format.

* FFS time domain hopping pattern

Agreements:

In terms of how to interpret L and K for Rel-16 PUSCH transmissions (for both DG & CG), Alt. 1 is adopted.

* That is, for the Rel-16 PUSCH with enhanced repetition transmission, the time window within which valid symbols are used for transmission is L\*K, starting from the first symbol indicated by the SLIV in TDRA field.

**Conclusion:**

Definitions:

* “Rel-16 PUSCH transmission scheme”: Option 4
* “Rel-15 PUSCH transmission scheme”: the transmission is done according to Rel-15 behavior, either with or without slot aggregation. With slot aggregation, the number of repetitions can be either semi-statically configured (as in Rel-15) or dynamically indicated (as agreed for Rel-16).

Agreements:

For DG and retransmission of CG, introduce one RRC parameter for each of the DCI format 0\_1 and the new UL DCI format, to indicate whether UE follows the behavior for “Rel-16 PUSCH transmission scheme” or the behavior for “Rel-15 PUSCH transmission scheme”.

* FFS: whether to restrict that “Rel-16 PUSCH transmission scheme” cannot be enabled for both DCI formats simultaneously

For Type 1 CG, introduce an RRC parameter per CG configuration to indicate whether UE follows the behavior for “Rel-16 PUSCH transmission scheme” or the behavior for “Rel-15 PUSCH transmission scheme”.

Agreements:

For Type 2 CG, UE uses the PUSCH transmission scheme (“Rel-16 PUSCH transmission scheme” or “Rel-15 PUSCH transmission scheme”) associated with the activating DCI format.

Agreements:

For the interaction with DL/UL directions, if dynamic SFI is configured, Option 1-4 is not further considered for both DG and CG

For the interaction with DL/UL directions, if dynamic SFI is configured, Option 1-2 is not further considered for DG.

Agreements:

For the interaction with DL/UL directions, if dynamic SFI is configured, Option 2-2 and 2-3 is not further considered for DG.

Agreements:

* For both DG and CG with “Rel-16 PUSCH transmission scheme”, if dynamic SFI is not configured, semi-static flexible symbols are used for PUSCH. Segmentation occurs at least around semi-static DL symbols.
  + FFS segmentation also around dynamically indicated invalid symbols for UL transmissions in the UL grant (if supported for DG and/or Type 2 CG) and/or semi-statically configured invalid symbols for UL transmissions (if supported)
  + FFS how to handle the conflict with dynamic DL transmission for CG

### RAN1#99 (Nov. 2019)

Agreements:

* For the initial Type 2 CG PUSCH transmission, the TDRA table follows the activating DCI.
* For the initial Type 2 CG PUSCH transmission with PUSCH repetition type A or B, the number of repetitions is provided by the activating DCI via *numberofrepetitions* if it is present in the corresponding TDRA table; otherwise, the number of repetitions is provided by *repK*.

Agreements:

* For the initial Type 1 CG PUSCH transmission with PUSCH repetition type B,
  + If one and only one of DCI formats 0\_1 and 0\_2 is configured with PUSCH repetition type B, the TDRA table corresponding to the DCI format (0\_1 or 0\_2) configured with PUSCH repetition type B is used.
  + If both 0\_1 and 0\_2 are configured with PUSCH repetition type B, the TDRA table corresponding to DCI format 0\_1 is used.
  + Note: For the initial Type 1 CG PUSCH transmission with PUSCH repetition type B, the case of none of the DCI formats 0\_1 and 0\_2 is configured with PUSCH repetition type B is an error case
* For the initial Type 1 CG PUSCH transmission, if it is configured with PUSCH repetition type A, use the TDRA table for USS in Rel-15.
* For the initial Type 1 CG PUSCH transmission with PUSCH repetition, the number of repetitions is provided via *numberofrepetitions* if it is present in the corresponding TDRA table; otherwise, the number of repetitions is provided by repK.
* FFS the value range of repK is extended for R16 repetition type A and/or type B

Agreements:

* For PUSCH repetition type B, L<=14

Agreements:

For PUSCH repetition type B, support the following frequency hopping:

* Inter-PUSCH-repetition FH
  + Details FFS
* Inter-slot FH
* FFS Intra-PUSCH-repetition FH

Agreements**:**

The column on the number of repetitions *numberofrepetitions* is always present in *PUSCH-TimeDomainResourceAllocationList-ForDCIformat0\_1* and *PUSCH-TimeDomainResourceAllocationList-ForDCIformat0\_2*.

* For DG with PUSCH repetition type A, if *numberofrepetitions* is present in the corresponding TDRA table, the number of repetitions is given by *numberofrepetitions*. Elseif the UE is configured with pusch-AggregationFactor, the number of repetitions is given by pusch-AggregationFactor. Otherwise the number of repetitions is 1.
* For DG with PUSCH repetition type B, the number of repetitions is given by *numberofrepetitions*.
  + Note that pusch-TimeDomainAllocationList-ForDCIformat0\_1/2 needs to be configured for PUSCH repetition type B.

Agreements:

For PUSCH repetition type A and type B, the number of bits to indicate *numberofrepetitions* is 3.

* {1, 2, [3], 4, [6], 7, [8], 12, 16} are supported.
* FFS whether to have a limit on the number of nominal repetitions in a slot

Agreements:

For how to indicate S and L in the TDRA table for PUSCH repetition type B, S and L are separately indicated (4-bit for S and 4-bit for L).

* S is from 0 and [13], L is from [1] to 14.
  + Note: The additional restrictions for a particular waveform and/or DMRS mapping type from R15 are still applicable

Agreements:

For both DG and CG with PUSCH repetition type B, the TBS is determined based on *L* indicated in TDRA table entry reusing Rel-15 mechanism.

Agreements:

For Type 1 CG with PUSCH repetition type B, introduce a new RRC parameter *frequencyHopping-PUSCHRepTypeB* per CG configuration to indicate the frequency hopping scheme, and reuse Rel-15 parameter *frequencyHoppingOffset* to determine the frequency locations.

* For Type 1 CG with PUSCH repetition type B, if *frequencyHopping-PUSCHRepTypeB* is not configured, frequency hopping is not enabled.

Agreements

Introduce a new RRC parameter frequencyHopping-ForDCIFormat0\_1.

* This parameter can only be configured when *PUSCHRepTypeIndicator-ForDCIFormat0\_1* is set to ‘*pusch-RepTypeB*’.

Agreement (RRC impact)

For DG PUSCH with PUSCH repetition type B, if dynamic SFI is configured, introduce a first RRC parameter that indicates one pattern for invalid symbols for PUSCH transmission repetition type B applicable to both DCI format 0\_1 and 0\_2, and introduce a second RRC parameter for each of DCI format 0\_1 and 0\_2 to indicate the presence of an additional bit in the DCI to indicate whether the pattern applies or not.

* If the first RRC parameter is not configured, semi-static flexible symbols are used for PUSCH. Segmentation occurs only around semi-static DL symbols.
* If the first RRC parameter is configured and the additional bit exists in a DCI,
  + Value ‘0’ means semi-static flexible symbols are used for PUSCH, and segmentation occurs only around semi-static DL symbols.
  + Value ‘1’ means that segmentation occurs around semi-static DL symbols and invalid symbols in the pattern, and the remaining symbols are used for PUSCH.
* If the first RRC parameter is configured and the additional bit does not exist in a DCI, segmentation occurs around semi-static DL symbols and invalid symbols in the pattern, and the remaining symbols are used for PUSCH.
* The first RRC parameter reuses the pattern definition of *rateMatchPattern* in time domain for PDSCH.

Note: Qualcomm has concerns over the above feature in terms of UE complexity. Majority of companies do not see this issue.

Agreement

For CG PUSCH with PUSCH repetition type B, if dynamic SFI is configured, segmentation occurs at least around semi-static DL symbols, which results in actual repetitions.

* If dynamic SFI is received for the entire duration of an actual repetition, an actual repetition is not transmitted if it conflicts with a dynamic DL/flexible symbol.
* If dynamic SFI is not received for at least one symbol of an actual repetition, an actual repetition is not transmitted if it conflicts with a semi-static flexible symbol.
* FFS the handling of semi-statically configured invalid symbols for PUSCH repetition type B transmissions (if supported)

Note that the cancellation behavior is the same as Rel-15, including Rel-15 cancellation timeline

Agreement

For DG PUSCH with PUSCH repetition type B, the RV for the first repetition is provided by DCI, and RV cycling is done across the repetitions using the RV sequence of {0, 2, 3, 1}.

* ~~FFS~~ “repetition” means ~~nominal or~~ actual repetition
  + ~~FFS In case “repetition” means nominal repetition, whether the same RV applies to all the actual repetitions corresponding to a nominal repetition.~~

Agreements:

For CG PUSCH with PUSCH repetition type B, RV cycling is done across repetition following the sequence in *repK-RV*,

* the first repetition uses the first value in repK-RV
* “repetition” means actual repetition

### RAN1#100-e (Feb. 2020)

**[100e-NR-L1enh\_URLLC-PUSCH\_Enh-01]**

Agreements:

For *numberofrepetitions* for PUSCH repetition type A and type B, {3, 8} are additionally supported. That is, {1, 2, 3, 4, 7, 8, 12, 16} are supported for *numberofrepetitions*. (RRC impact)

Agreements:

The value range for repK remains the same as in Rel-15.

Agreements:

For PUSCH repetition Type B, S is from 0 to 13, and L is from 1 to 14. (RRC impact)

Agreements: (RRC impact)

Introduce *reportSlotOffsetList-r16-ForDCIFormat0\_1* and *reportSlotOffsetList-r16-ForDCIFormat0\_2* and update TS 38.214 accordingly

* FFS whether or not to always assume the number of nominal repetitions is equal to 1 when PUSCH with repetition Type B carries A-CSI/SP-CSI only.

Agreements:

For PUSCH repetition Type B, PUSCH transmit power is determined based on the nominal repetition duration.

**Agreements:**

Adopt the following TP to TS 38.214:

|  |
| --- |
| **TP to TS 38.214, Sec. 5.2.1.4 and Sec. 6.1.2.1**  **5.2.1.4 Reporting configurations**  **<**Unchanged text is omitted>  For a semi-persistent or aperiodic CSI report on PUSCH, the allowed slot offsets are configured by the following higher layer parameters:  -     if triggered/activated by DCI format 0\_2 and the higher layer parameter reportSlotOffsetListForDCI-Format0-2 is configured, the allowed slot offsets are configured by ~~the higher layer parameter~~ reportSlotOffsetListForDCI-Format0-2 ~~reportSlotOffsetList-r16-ForDCIFormat0\_2~~, and  -     if triggered/activated by DCI format 0\_1 and the higher layer parameter reportSlotOffsetListForDCI-Format0-1 ~~reportSlotOffsetList-r16-ForDCIFormat0\_1~~ is configured, the allowed slot offsets are configured by ~~the higher layer parameter~~ reportSlotOffsetListForDCI-Format0-1 ~~reportSlotOffsetList-r16-ForDCIFormat0\_1~~, and  -     otherwise, the allowed slot offsets are configured~~]~~ by the higher layer parameter reportSlotOffsetList.  The offset is selected in the activating/triggering DCI.  **<**Unchanged text is omitted>    **6.1.2.1 Resource allocation in time domain**  **<**Unchanged text is omitted>  When the UE is scheduled to transmit a PUSCH with no transport block and with a CSI report(s) by a CSI request field on a DCI, the Time domain resource assignment field value m of the DCI provides a row index m + 1 to ~~an~~ the allocated table as defined in Clause 6.1.2.1.1 ~~which is defined by the higher layer configured pusch-TimeDomainAllocationList in pusch-Config~~. The indexed row defines the start and length indicator SLIV, and the PUSCH mapping type to be applied in the PUSCH transmission and the K2 value is determined as , where  are the corresponding list entries of the higher layer parameter  -     ~~[~~reportSlotOffsetListForDCI-Format0-2 ~~reportSlotOffsetList-r16-ForDCIFormat0\_2~~, if PUSCH is scheduled by DCI format 0\_2 and reportSlotOffsetListForDCI-Format0-2 is configured;  -     reportSlotOffsetListForDCI-Format0-1 ~~reportSlotOffsetList-r16-ForDCIFormat0\_1~~, if PUSCH is scheduled by DCI format 0\_1 and reportSlotOffsetListForDCI-Format0-1 ~~reportSlotOffsetList-r16-ForDCIFormat0\_1~~  is configured~~]~~;  -     reportSlotOffsetList, ~~[~~otherwise;~~]~~  in CSI-ReportConfig for the  triggered CSI Reporting Settings and  is the (m+1)th entry of .  **<**Unchanged text is omitted> |

**[100e-NR-L1enh\_URLLC-PUSCH\_Enh-02]**

**Conclusion on how FH is enabled/disabled for Type 2 CG** **with DCI format 0\_1** **in Rel-15**:

* For Type 2 CG in Rel-15 activated by DCI format 0\_1, if frequencyHopping in configuredGrantConfig is not configured, FH is disabled. If frequencyHopping in configuredGrantConfig is configured, FH for Type 2 CG is enabled if the frequency hopping flag field in the activation DCI is set to 1, and FH is disabled if the frequency hopping flag field in the activation DCI is set to 0.

Agreements:

For Type 2 CG PUSCH activated by a DCI format configured with PUSCH repetition Type B, the frequency hopping enabling/disabling and the frequency offset follows the indication in the activation DCI, and the frequency hopping scheme follows the corresponding RRC parameter for the activation DCI format. (RRC impact)

Agreements:

For PUSCH with repetition Type B, with inter-repetition FH, frequency hopping occurs for each nominal repetition.

Agreements:

For PUSCH repetition Type B, intra-PUSCH-repetition frequency hopping is not supported. (RRC impact)

Agreements:

Adopt the following TP to TS 38.212 (changes in red):

|  |
| --- |
| **TP to TS 38.212, Sec. 7.3.1.1.2** 7.3.1.1.2 Format 0\_1 **<**Unchanged text is omitted>  - Frequency hopping flag – 0 or 1 bit:  - 0 bit if only resource allocation type 0 is configured, or if ~~both~~ the higher layer parameter *frequencyHopping* is not configured and the higher layer parameter *~~frequencyHopping-ForDCIFormat0\_1~~* pusch-RepTypeIndicatorForDCI-Format0-1-r16 is ~~are~~ not configured to  ‘pusch-RepTypeB’, or if the higher layer parameter frequencyHoppingForDCI-Format0-1-r16 is not configured and pusch-RepTypeIndicatorForDCI-Format0-1-r16 is configured to ‘pusch-RepTypeB’, or if only resource allocation type 2 is configured;  - 1 bit according to Table 7.3.1.1.1-3 otherwise, only applicable to resource allocation type 1, as defined in Clause 6.3 of [6, TS 38.214].  **<**Unchanged text is omitted> |

**Agreements:**

Adopt the following TP to TS 38.214 (changes in red):

|  |
| --- |
| **TP to TS 38.214, Sec. 6.3.2**  6.3.2       Frequency hopping for PUSCH repetition Type B  For PUSCH repetition Type B (as determined according to procedures defined in Clause 6.1.2.1 for scheduled PUSCH, or Clause 6.1.2.3 for configured PUSCH), a UE is configured for frequency hopping by the higher layer parameter frequencyHopping-ForDCIFormat0\_2 in pusch-Config for PUSCH transmission scheduled by DCI format 0\_2, by frequencyHopping-ForDCIFormat0\_1 provided in pusch-Config for PUSCH transmission scheduled by DCI format 0\_1, and by frequencyHopping-PUSCHRepTypeB provided in rrc-ConfiguredUplinkGrant ~~configuredGrantConfig~~ for ~~[~~Type 1~~]~~ configured PUSCH transmission. ~~[~~The frequency hopping mode for Type 2 configured PUSCH transmission follows the configuration of the activating DCI format~~]~~. One of two frequency hopping modes can be configured:  -     Inter-repetition frequency hopping  -     Inter-slot frequency hopping  In case of resource allocation type 1, whether or not transform precoding is enabled for PUSCH transmission, the UE may perform PUSCH frequency hopping, if the frequency hopping field in a corresponding detected DCI format is set to 1, or if for a Type 1 PUSCH transmission with a configured grant the higher layer parameter frequencyHopping- PUSCHRepTypeB is provided, otherwise no PUSCH frequency hopping is performed. When frequency hopping is enabled for PUSCH, the RE mapping is defined in clause 6.3.1.6 of [4, TS 38.211].  **<**Unchanged text is omitted> |

**Agreements:**

Adopt the following TP to TS 38.214 (changes in red):

|  |
| --- |
| **TP to TS 38.214, Sec. 6.3.2**  6.3.2       Frequency hopping for PUSCH repetition Type B  **<**Unchanged text is omitted>  In case of inter-repetition frequency hopping, ~~[details to be added when agreements become available].~~ the starting RB for an actual repetition within the n-th nominal repetition (as defined in Clause 6.1.2.1) is given by:  A picture containing hanging  Description automatically generated,  where  is the starting RB within the UL BWP, as calculated from the resource block assignment information of resource allocation type 1 (described in Subclause 6.1.2.2.2) and is the frequency offset in RBs between the two frequency hops.  In case of inter-slot frequency hopping, the starting RB during slot  follows that of inter-slot frequency hopping for PUSCH Repetition Type A in Clause 6.3.1. |

**[100e-NR-L1enh\_URLLC-PUSCH\_Enh-03]**

Agreements:

The semi-static and dynamic indication of invalid symbols (related to *InvalidSymbolPattern*) for DG PUSCH repetition Type B in case dynamic SFI is not configured follows the same behaviour as for DG PUSCH repetition Type B in case dynamic SFI is configured.

Agreements:

For Type 1 CG PUSCH with repetition Type B, regardless of whether dynamic SFI is configured or not, if *InvalidSymbolPattern* is configured, the configured pattern is applied (that is, segmentation occurs around semi-static DL symbols and invalid symbols indicated by *InvalidSymbolPattern*).

Agreements:

For the first Type 2 CG PUSCH with repetition Type B (including all repetitions) after activation, regardless of whether dynamic SFI is configured or not, if *InvalidSymbolPattern* is configured, whether the configured pattern is applied follows the same procedure as specified for DG PUSCH according to the activation DCI.

Agreements:

For Type 2 CG PUSCH with repetition Type B (excluding the first Type 2 CG PUSCH, with all repetitions, after activation), regardless of whether dynamic SFI is configured or not, if *InvalidSymbolPattern* is configured, whether the configured pattern is applied follows the activation DCI.

Agreements:

For PUSCH repetition Type B, a UE is not expected to be indicated with an antenna port configuration that is invalid for the duration of any actual repetition.

Agreements:

For PUSCH with repetition Type B, an actual repetition with a single symbol is not transmitted.

**Agreements:**

Adopt the following TP to TS 38.214:

|  |
| --- |
| **TP to TS 38.214, Sec. 6.1.2.1**  6.1.2       Resource allocation  6.1.2.1            Resource allocation in time domain  <unchanged text omitted>  For PUSCH repetition Type B, the UE determines invalid symbol(s) for PUSCH repetition Type B transmission as follows:  -     A symbol that is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* is considered as an invalid symbol for PUSCH repetition Type B transmission.  -     ~~[If a UE is configured with higher layer parameter~~ *~~SlotFormatInficator,~~* ~~the]~~ The UE may be configured with the higher layer parameter *InvalidSymbolPattern*, which provides a symbol level bitmap spanning one or two slots (higher layer parameter *symbols* given by *InvalidSymbolPattern*). A bit value equal to 1 in the symbol level bitmap *symbols* indicates that the corresponding symbol is an invalid symbol for PUSCH repetition Type B transmission. The UE may be additionally configured with a time-domain pattern (higher layer parameter *periodicityAndPattern* given by *InvalidSymbolPattern*), where each bit of *periodicityAndPattern* corresponds to a unit equal to a duration of the symbol level bitmap *symbols*, and a bit value equal to 1 indicates that the symbol level bitmap *symbols* is present in the unit. The *periodicityAndPattern* can be {1, 2, 4, 5, 8, 10, 20 or 40} units long, but maximum of 40ms. The first symbol of *periodicityAndPattern* every 40ms/P periods is a first symbol in frame 𝑛𝑓 mod 4 = 0, where P is the duration of *periodicityAndPattern* in units of ms. When *periodicityAndPattern* is not configured, for a symbol level bitmap spanning two slots, the bits of the first and second slots correspond respectively to even and odd slots of a radio frame, and for a symbol level bitmap spanning one slot, the bits of the slot correspond to every slot of a radio frame. If *InvalidSymbolPattern* is configured, when the UE applies the invalid symbol pattern is determined as follows:  -     ~~if~~ *~~InvalidSymbolPatternIndicator-ForDCIFormat0\_1~~* ~~is configured when the PUSCH is scheduled by DCI format 0\_1, or if~~ *~~InvalidSymbolPatternIndicator-ForDCIFormat0\_2~~* ~~is configured when the PUSCH is scheduled by DCI format 0\_2,~~  ~~-     if [invalid symbol pattern indicator] field is set 1, the UE applies the invalid symbol pattern;~~  ~~-     otherwise, the UE does not apply the invalid symbol pattern;~~  -     If the PUSCH is scheduled by DCI format 0\_1, or corresponds to a Type 2 configured grant activated by DCI format 0\_1, and if *InvalidSymbolPatternIndicator-ForDCIFormat0\_1* is configured,  -     if invalid symbol pattern indicator field is set 1, the UE applies the invalid symbol pattern;  -     otherwise, the UE does not apply the invalid symbol pattern;  -     If the PUSCH is scheduled by DCI format 0\_2, or corresponds to a Type 2 configured grant activated by DCI format 0\_2, and if *InvalidSymbolPatternIndicator-ForDCIFormat0\_2* is configured,  -     if invalid symbol pattern indicator field is set 1, the UE applies the invalid symbol pattern;  -     otherwise, the UE does not apply the invalid symbol pattern;  -     otherwise, the UE applies the invalid symbol pattern.  For PUSCH repetition Type B, after determining the invalid symbol(s) for PUSCH repetition type B transmission for each of the *K* nominal repetitions, the remaining symbols are considered as potentially valid symbols for PUSCH repetition Type B transmission. ~~[~~If the number of potentially valid symbols for PUSCH repetition type B transmission is greater than zero for a nominal repetition, the nominal repetition consists of one or more actual repetitions, where each actual repetition consists of a consecutive set of potentially valid symbols that can be used for PUSCH repetition Type B transmission within a slot.~~]~~ An actual repetition is omitted according to the conditions in Clause 11.1 of [6, TS38.213]. The redundancy version to be applied on the *n*th actual repetition (with the counting including the actual repetitions that are omitted) is determined according to table 6.1.2.1-2. |

**Agreements:**

Adopt the following TP to TS 38.214:

|  |
| --- |
| **TP to TS 38.214, Sec. 6.1.2.1**  6.1.2       Resource allocation  6.1.2.1            Resource allocation in time domain  <unchanged text omitted>  For PUSCH repetition Type B, after determining the invalid symbol(s) for PUSCH repetition type B transmission for each of the K nominal repetitions, the remaining symbols are considered as potentially valid symbols for PUSCH repetition Type B transmission. [If the number of potentially valid symbols for PUSCH repetition type B transmission is greater than zero for a nominal repetition, the nominal repetition consists of one or more actual repetitions, where each actual repetition consists of a consecutive set of potentially valid symbols that can be used for PUSCH repetition Type B transmission within a slot.] An actual repetition with a single symbol is omitted except for the case of L =1. An actual repetition is omitted according to the conditions in Clause 11.1 of [6, TS38.213]. The redundancy version to be applied on the nth actual repetition (with the counting including the actual repetitions that are omitted) is determined according to table 6.1.2.1-2. |

**Agreements:**

Adopt the following TP to TS 38.214:

|  |
| --- |
| **TP to TS 38.214, Sec. 6.2.2**  6.2.2 UE DM-RS transmission procedure  <unchanged text omitted>  For PUSCH repetition Type B, the DM-RS transmission procedure is applied for each actual repetition separately based on the allocation duration of the actual repetition. A UE is not expected to be indicated with an antenna port configuration that is invalid for the allocated duration of any actual repetition. |

# Appendix B: Related Rel-15 RRC parameters

PUSCH-Config ::= SEQUENCE {

dataScramblingIdentityPUSCH INTEGER (0..1023) OPTIONAL, -- Need S

txConfig ENUMERATED {codebook, nonCodebook} OPTIONAL, -- Need S

dmrs-UplinkForPUSCH-MappingTypeA SetupRelease { DMRS-UplinkConfig } OPTIONAL, -- Need M

dmrs-UplinkForPUSCH-MappingTypeB SetupRelease { DMRS-UplinkConfig } OPTIONAL, -- Need M

pusch-PowerControl PUSCH-PowerControl OPTIONAL, -- Need M

frequencyHopping ENUMERATED {intraSlot, interSlot} OPTIONAL, -- Need S

frequencyHoppingOffsetLists SEQUENCE (SIZE (1..4)) OF INTEGER (1.. maxNrofPhysicalResourceBlocks-1)

OPTIONAL, -- Need M

resourceAllocation ENUMERATED { resourceAllocationType0, resourceAllocationType1, dynamicSwitch},

pusch-TimeDomainAllocationList SetupRelease { PUSCH-TimeDomainResourceAllocationList } OPTIONAL, -- Need M

pusch-AggregationFactor ENUMERATED { n2, n4, n8 } OPTIONAL, -- Need S

mcs-Table ENUMERATED {qam256, qam64LowSE} OPTIONAL, -- Need S

mcs-TableTransformPrecoder ENUMERATED {qam256, qam64LowSE} OPTIONAL, -- Need S

transformPrecoder ENUMERATED {enabled, disabled} OPTIONAL, -- Need S

codebookSubset ENUMERATED {fullyAndPartialAndNonCoherent, partialAndNonCoherent,nonCoherent}

OPTIONAL, -- Cond codebookBased

maxRank INTEGER (1..4) OPTIONAL, -- Cond codebookBased

rbg-Size ENUMERATED { config2} OPTIONAL, -- Need S

uci-OnPUSCH SetupRelease { UCI-OnPUSCH} OPTIONAL, -- Need M

tp-pi2BPSK ENUMERATED {enabled} OPTIONAL, -- Need S

...

}

ConfiguredGrantConfig ::= SEQUENCE {

frequencyHopping ENUMERATED {intraSlot, interSlot} OPTIONAL, -- Need S

cg-DMRS-Configuration DMRS-UplinkConfig,

mcs-Table ENUMERATED {qam256, qam64LowSE} OPTIONAL, -- Need S

mcs-TableTransformPrecoder ENUMERATED {qam256, qam64LowSE} OPTIONAL, -- Need S

uci-OnPUSCH SetupRelease { CG-UCI-OnPUSCH } OPTIONAL, -- Need M

resourceAllocation ENUMERATED { resourceAllocationType0, resourceAllocationType1, dynamicSwitch },

rbg-Size ENUMERATED {config2} OPTIONAL, -- Need S

powerControlLoopToUse ENUMERATED {n0, n1},

p0-PUSCH-Alpha P0-PUSCH-AlphaSetId,

transformPrecoder ENUMERATED {enabled, disabled} OPTIONAL, -- Need S

nrofHARQ-Processes INTEGER(1..16),

repK ENUMERATED {n1, n2, n4, n8},

repK-RV ENUMERATED {s1-0231, s2-0303, s3-0000} OPTIONAL, -- Need R

periodicity ENUMERATED {

sym2, sym7, sym1x14, sym2x14, sym4x14, sym5x14, sym8x14, sym10x14, sym16x14, sym20x14,

sym32x14, sym40x14, sym64x14, sym80x14, sym128x14, sym160x14, sym256x14, sym320x14, sym512x14,

sym640x14, sym1024x14, sym1280x14, sym2560x14, sym5120x14,

sym6, sym1x12, sym2x12, sym4x12, sym5x12, sym8x12, sym10x12, sym16x12, sym20x12, sym32x12,

sym40x12, sym64x12, sym80x12, sym128x12, sym160x12, sym256x12, sym320x12, sym512x12, sym640x12,

sym1280x12, sym2560x12

},

configuredGrantTimer INTEGER (1..64) OPTIONAL, -- Need R

rrc-ConfiguredUplinkGrant SEQUENCE {

timeDomainOffset INTEGER (0..5119),

timeDomainAllocation INTEGER (0..15),

frequencyDomainAllocation BIT STRING (SIZE(18)),

antennaPort INTEGER (0..31),

dmrs-SeqInitialization INTEGER (0..1) OPTIONAL, -- Need R

precodingAndNumberOfLayers INTEGER (0..63),

srs-ResourceIndicator INTEGER (0..15) OPTIONAL, -- Need R

mcsAndTBS INTEGER (0..31),

frequencyHoppingOffset INTEGER (1.. maxNrofPhysicalResourceBlocks-1) OPTIONAL, -- Need R

pathlossReferenceIndex INTEGER (0..maxNrofPUSCH-PathlossReferenceRSs-1),

...

} OPTIONAL, -- Need R

...

}

CG-UCI-OnPUSCH ::= CHOICE {

dynamic SEQUENCE (SIZE (1..4)) OF BetaOffsets,

semiStatic BetaOffsets

}

-- ASN1START

-- TAG-DMRS-UPLINKCONFIG-START

DMRS-UplinkConfig ::= SEQUENCE {

dmrs-Type ENUMERATED {type2} OPTIONAL, -- Need S

dmrs-AdditionalPosition ENUMERATED {pos0, pos1, pos3} OPTIONAL, -- Need S

phaseTrackingRS SetupRelease { PTRS-UplinkConfig } OPTIONAL, -- Need M

maxLength ENUMERATED {len2} OPTIONAL, -- Need S

transformPrecodingDisabled SEQUENCE {

scramblingID0 INTEGER (0..65535) OPTIONAL, -- Need S

scramblingID1 INTEGER (0..65535) OPTIONAL, -- Need S

...

} OPTIONAL, -- Need R

transformPrecodingEnabled SEQUENCE {

nPUSCH-Identity INTEGER(0..1007) OPTIONAL, -- Need S

sequenceGroupHopping ENUMERATED {disabled} OPTIONAL, -- Need S

sequenceHopping ENUMERATED {enabled} OPTIONAL, -- Need S

...

} OPTIONAL, -- Need R

...

}

-- TAG-DMRS-UPLINKCONFIG-STOP

-- ASN1STOP

# Appendix C: PUSCH prioritization rules for UCI multiplexed on PUSCH

|  |
| --- |
| Conclusion (RAN1#97)  For the issue raised in the draft CR [R1-1906302](x-msg://31/R1-1906302.zip), the intended UE behavior per specification is commonly understood as follows:   * For UCI multiplexing, within a PUCCH group, on PUSCH, the following two steps are performed with step 1 first, then followed by step 2:   + Step 1: UCI in overlapped PUCCH transmissions is multiplexed into one PUCCH resource (resource Z). This step is done per PUCCH slot.   + Step 2: UCI, that doesn’t include SR, in Z is multiplexed into one PUSCH, if Z overlaps with at least one PUSCH, following the priorities (sequentially from high to low) as listed below.     - First priority: PUSCH with A-CSI as long as it overlaps with Z     - Second priority: earliest PUSCH slot(s) based on the start of the slot(s)     - If there are still multiple PUSCHs overlap with Z in the earliest PUSCH slot(s), follow the following priorities (sequentially from high to low)       * Third priority: Dynamic grant PUSCHs > PUSCHs configured by respective ConfiguredGrantConfig or semiPersistentOnPUSCH       * Fourth priority: PUSCHs on serving cell with smaller serving cell index > PUSCHs on serving cell with larger serving cell index       * Fifth priority: Earlier PUSCH transmission > later PUSCH transmission   Note: The clarification applies to both cases with the same (except the second priority part) and different numerologies among PUCCH and PUSCHs. |