**3GPP TSG-RAN WG1 Meeting #101-eR1-200xxxx**

**e-Meeting, May 25th – June 5th, 2020**

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

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

**Title: Summary of [101-e-NR-L1enh-URLLC-PUSCH-02] (AI 7.2.5.3)**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution provides a summary of the following email discussion:

[101-e-NR-L1enh-URLLC-PUSCH-02] A-CSI/SP-CSI on PUSCH with repetition Type B (Section 3.1 and 3.2 of R1-2004224) by 5/27 and corresponding TP (if any) by 6/3 – Sigen (Apple)

Section 3 documents the agreements and the corresponding agreed TPs.

# 2 A-CSI/SP-CSI on PUSCH with repetition Type B

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.*

A-CSI/SP-CSI on PUSCH with repetition Type B was further discussed in RAN1#100bis-e (see the FL summary in [R1-2003006](ftp://ftp.3gpp.org/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2003006.zip)), without any agreements reached.

## 3.1 A-CSI/SP-CSI on PUSCH with repetition Type B without UL-SCH

Based on the contributions, it seems generally agreeable among the companies that **for A-CSI/SP-CSI on PUSCH with repetition Type B without UL-SCH, A-CSI/SP-CSI is transmitted on the first actual repetition, and other actual repetitions are discarded.** The following options have been discussed:

* **Option A: there is no scheduling restriction.**
  + ZTE[1], Ericsson[3] (?), Nokia/NSB[5], Intel[7], Samsung[9], DOCOMO[17]
  + This option provides the most flexibility for gNB scheduling. Don’t see the need for any scheduling restriction.
* **Option B: UE is not expected to be indicated with numberofrepetitions >1.**
  + vivo[2], Huawei/HiSilicon[4], Spreadtrum[11], Sharp[16]
  + The later repetitions would not be used anyway, so this constraint seems natural.
* **Option C: The first nominal repetition is not expected to be segmented into multiple actual repetitions.**
  + CATT[6], LG[12] (For the number of nominal repetition, follow same behavior with *pusch- aggregationfactor* in Rel-15), OPPO[14], Apple[15], QC[18]
  + This is the simplest solution for the UE (same as in Rel-15). This should not be a problem for at least A-CSI, because the gNB can always indicate the resources properly. For SP-CSI, the gNB should guarantee the performance for SP-CSI anyway.

**Companies please indicate which option(s) you prefer.**

|  |  |
| --- | --- |
| **Option A** | ZTE, Ericsson, Nokia/NSB, Intel, Samsung, DOCOMO |
| **Option B** | vivo, Spreadtrum, Sharp |
| **Option C** | CATT, OPPO, Apple, QC, Huawei/HiSilicon, |
| **Other** |  |

**Companies please provide detailed comments, if any.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | We do not see much issue with Option C, so we prefer it for simpler UE implementation. For A-CSI, the gNB can choose the right time domain resource so that the first nominal repetition is not segmented. For SP-CSI, it may be argued that e.g. Option 1 provides less scheduling constraint. However, the decoding performance of SP-CSI would need to be maintained, so it seems unreasonable that the allocated resources change from one occasion to another occasion. In this sense, the gNB should make sure sufficient amount of resources are available for SP-CSI report. |
| Nokia, NSB | As noted, we prefer Option A.   Option A vs. Option B: having no restrictions of Option A is not bringing any changes to UE complexity (as anyhow only the first nominal repetition is used) but gives the gNB more flexibility in choosing S+L for that one (from the overall set of all S+L with different repetition factors).  Option A vs Option C: We don’t see a need for this restriction here – as this again will limit the S+L operation from the configured TDRA table! To the comment by Apple, we can leave it to gNB implementation to guarantee sufficient resources here. |
| vivo | We are supportive of Option B.  Compared to the high reliability requirement for data transmission on PUSCH, the motivation to achieve high reliability for PUSCH transmission with number of repetitions > 1 for A-CSI only is not justified. Besides, for A-CSI, gNB can choose the right time domain resource so that the first nominal repetition is not segmented. While for SP-CSI, it is difficult for gNB to ensure each transmission occasion for SP-CSI without segmentation by a single activation DCI. We suggest a unified solution for both A-CSI and SP-CSI. Therefore, for A-CSI/SP-CSI on PUSCH without UL-SCH, the number of repetitions >1 is not preferred. |
| QC | We support Option C as it is already captured. Reason is for A/SP-CSI on PUSCH anyhow numberofrepetition>1 is discarded, i.e. no A/SP-CSI repetition is supported, as the main bullet of proposal says. Now for option A vs C, given that we are talking about PUSCH carrying A/SP-CSI without UL-SCH, there is no justification to support segmentation for such PUSCH. Hence, everything should be similar to PUSCH Type-A, i.e. Rel-15 procedure. |
| ZTE | Option A  Since the remaining actual repetitions will be disgarded, UE will anyway ignore the numberofrepetition. Option B imposes unnecessary restriction. For Option C, we don’t see clear motivation why let a UE supporting PUSCH repetition Type B falls back to PUSCH type A operation. |
| Samsung | We are OK with Option A or Option C. But considering other potential impact, e.g., resource calculation, Option C is slightly preferred.  We don’t think Option C is falling back to PUSCH type A. Option C just has some restriction when gNB chooses TDRA, which should also be OK with 64 entries. |
| Huawei,  HiSilicon | Since the CSI will be transmitted only on the first actual repetition, it seems there is no much difference for all the above three options, though there are some slight difference in terms of flexibility and UE complexity. We are fine with any of the above three option, but slightly prefer option C considering similar behavior for Rel-15. |
| Spreadtrum | The difference among the three options is small. But considering the implementation complexity for gNB may be relatively high to schedule a PUSCH transmission while guarantying that “The first nominal repetition is not expected to be segmented into multiple actual repetitions”, we slightly prefer Option B. |

## 3.2 CSI triggered by DCI on PUSCH with repetition Type B with UL-SCH

It seems unclear in Rel-15 specifications whether SP-CSI can be triggered by DCI on PUSCH with UL-SCH. For example, R1-2004676 (CATT) proposed a CR to clarify the behaviour. In this email discussion, there is no intention to debate whether SP-CSI can be triggered or not. The discussion (and agreements, if any) would apply to whatever is supported, whether it is A-CSI only, or it is A-CSI and SP-CSI (which would follow the conclusion from Rel-15 CR discussion).

For CSI triggered by DCI on PUSCH with repetition Type B with UL-SCH, the following options have been discussed:

* **Option 1: CSI is transmitted on the first actual repetition.**
  + vivo[2], Huawei/HiSilicon[4], Nokia/NSB[5] (first preference), Intel[7], Samsung[9], Spreadtrum[11], DOCOMO[17]
  + This may be more aligned with the agreements that UCI is multiplexed on the first overlapping actual repetition in case PUCCH would overlap with PUSCH repetition Type B.
* **Option 2: CSI is transmitted on the last actual repetition.**
  + CATT[6], Apple[15] (excluding the single-symbol repetition), QC[18]
  + Beneficial for providing more updated CSI report without delaying PUSCH scheduling. But there may be unnecessary delay on CSI report in some cases.
* **Option 3: CSI is transmitted on the first actual repetition that fulfils the CSI multiplexing timeline.**
  + ZTE[1], Ericsson[3], Nokia/NSB[5] (second preference)
  + There may be misalignment between gNB and UE due to TA impact.

OPPO[14]:

* UE is not expected that the gap between the first actual repetition and UL grant is smaller than CSI calculation timeline when A-CSI needs to be multiplexed in PUSCH. (*FL: This seems too restrictive. Rel-15 does not have this requirement either. The only thing is that UE may not update CSI if CSI computation timeline is not satisfied.*)
* A unified solution for A-CSI/SP-CSI on PUSCH with repetition Type B without UL-SCH and with UL-SCH is preferred. (*does this mean OPPO supports the first option above?*)

**Companies please indicate which option(s) you prefer.**

|  |  |
| --- | --- |
| **Option 1** | vivo, Huawei/HiSilicon, Nokia/NSB (first preference), Intel, Samsung, Spreadtrum, DOCOMO, ZTE |
| **Option 2** | CATT, Apple (excluding the single-symbol repetition), QC |
| **Option 3** | ZTE, Ericsson, Nokia/NSB (second preference) |
| **Other** |  |

**Companies please provide detailed comments, if any.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Our preference is Option 2. As explained in our contribution, having CSI transmitted on the first repetition either delays the PUSCH scheduling or prevents fresh CSI report. It had been argued that a separate DCI can be issued to trigger CSI report, but this would require a separate DCI and it can only be transmitted after the PUSCH ends. Since PUSCH repetition Type B is designed for URLLC, it is not expected that the transmission duration is overly long, and the potential delay for CSI report on the last repetition in some cases should not be long. |
| Nokia, NSB | We prefer Option 1 – but could compromise on Option 3 (if companies think there is an issue with PUSCH latency).  Clearly, as also explained in detail in our contribution Option 2 is the worst of the pack, as it will delay the CSI unnecessarily. |
| vivo | We prefer Option 1.  The use case for option 2 needs further clarification. Given the fact that the processing time for A-CSI on PUSCH with UL-SCH is larger than the time of PUSCH with UL-SCH only, it does not make too much sense to trigger A-CSI on the PUSCH for URLLC traffic if low latency for the URLLC traffic needs to be guaranteed. If latency is not that important, there is no much difference for the A-CSI multiplexed on the first or the last repetitions, since gNB shall guarantee there is sufficient CSI computation time at UE side if A-CSI is triggered on a PUSCH with repetitions. If latency of CSI report does need to be cared, for example, gNB can transmit another DCI to trigger A-CSI report on another PUSCH without repetition such that latency for PUSCH transmission with type B repetitions will not be affected.  For option 3, similar as the timeline requirement defined for UCI multiplexing in PUSCH, the timeline shall be satisfied for all repetitions. Besides, if the PUSCH repetition for A-CSI multiplexing is determined by UE based on the timeline, there may be misalignment between gNB and UE due to the TA impact. Hence, additional optimization is not necessary in CR phase. |
| QC | We prefer Option 2, and share a similar view with Apple.  Proponents of Option 1 are aware of latency imposed to PUSCH data under option 1, but solutions to prevent such an unnecessary latency (like separate DCIs or relaxed PUSCH latency) does not really target to solve the problem but more ignore it. Obviously, it is gNB’s choice not to multiplex A-CSI on URLLC or use a separate DCI to prevent latency on data (at the cost of more PDCCH overhead and maybe more latency on CSI as mentioned by Apple). But the question still remains: for A-CSI on PUSCH type-B with UL-SCH (and say high priority UL-SCH), how to prevent latency on data or maybe define an error case that A-CSI on PUSCH with high priority is not expected)?  For Option 3, we agree with vivo that the multiplexing PUSCH occasion cannot be left to UE’s determination as this may result an ambiguity between gNB and UE, similar to UCI discussion, and nowhere in current spec such a thing is allowed to UE. |
| ZTE | We are fine with both Option 1 and Option 3. In our understanding, Option 1 is also more aligned with Rel-15 behavior. Option 3 is a further optimization to ensure latency for both CSI and PUSCH. As for the TA impact, it may not a big issue since gNB may know the value of TA. |
| Samsung | We support option 1.  We don’t see the motivation to trigger an A-CSI in URLLC PUSCH. And option 2 will introduce some unnecessary delay for A-CSI report for some other cases. The gain is not worthwhile comparing with the pain.  For option 3, we share similar concerns with other companies, that there may have different understanding on which repetition to multiplex on between UE and gNB. |
| Huawei,  HiSilicon | We support option 1  Transmitting CSI on the last actual PUSCH repetition for sure will result in unnecessary latency for gNB to get the channel quality in time, especially when there is larger number of repetitions. The main motivation for A-CSI is to get the channel quality in time.  In addition, we don’t agree with the ambiguity issue resulted from TA, which was raised in the last meeting to say we need to ensure timeline satisfied for all repetitions for UCI multiplexing, even in the end we accept the agreement but not because of the TA issue. If TA is a problem, then how gNB to ensure satisfying the timeline for all those repetitions. Therefore, option 3 can be considered also. |
| Spreadtrum | We prefer Option 1.  For Option 2, if a last actual repetition is cancelled due to some reason such as dynamic SFI, UE may not have opportunity to transmit CSI before the last occasion, and the CSI has to be dropped. For Option 3, there may be misalignment between gNB and UE, as mentioned by some other companies. |

# 3 Agreements

# References

1. R1-2003319 Remaining issues on PUSCH enhancements for NR URLLC ZTE
2. R1-2003389 PUSCH enhancements for URLLC vivo
3. R1-2003441 Remaining Issue of PUSCH Enhancements for NR URLLC Ericsson
4. R1-2003529 Corrections on PUSCH enhancement Huawei, HiSilicon
5. R1-2003579 Maintenance of PUSCH enhancements for Rel-16 NR URLLC Nokia, Nokia Shanghai Bell
6. R1-2003622 Remaining issues on PUSCH enhancements CATT
7. R1-2003739 Corrections on PUSCH enhancements for URLLC Intel Corporation
8. R1-2003815 Remaining issues on URLLC PUSCH enhancement Panasonic Corporation
9. R1-2003867 Remaining issues for PUSCH enhancements Samsung
10. R1-2003976 PUSCH enhancements ETRI
11. R1-2003986 Discussion on PUSCH enhancements for URLLC Spreadtrum Communications
12. R1-2004031 Remaining issues of PUSCH enhancements for NR URLLC LG Electronics
13. R1-2004046 Remaining issues on PUSCH enhancements for URLLC Fujitsu
14. R1-2004116 PUSCH enhancements for URLLC OPPO
15. R1-2004223 Remaining Issues on PUSCH enhancements for eURLLC Apple
16. R1-2004332 Remaining issues on PUSCH enhancements for NR URLLC Sharp
17. R1-2004391 Remaining issues for PUSCH enhancements for Rel.16 URLLC NTT DOCOMO, INC
18. R1-2004459 Remaining issues on PUSCH enhancements for URLLC Qualcomm Incorporated
19. R1-2004524 Remaining issues on PUSCH enhancement for NR URLLC WILUS Inc.
20. R1-2004572 Remaining issue of PUSCH enhancements for NR URLLC ASUSTeK

# 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. |

### RAN1#100bis-e (April. 2020)

**[100b-e-NR-L1enh-URLLC-PUSCH-01]**

**Agreements:**

Adopt the following TP to TS 38.213:

|  |
| --- |
| **TP to TS 38.213, Sec. 7**  7 Uplink Power control  Uplink power control determines a power for PUSCH, PUCCH, SRS, and PRACH transmissions.  A UE does not expect to simultaneously maintain more than four pathloss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions as described in Clauses 7.1.1, 7.2.1, and 7.3.1, except for SRS transmissions configured by IE *SRS-Positioning-Config* as described in Clause 7.3.1.  A PUSCH/PUCCH/SRS/PRACH transmission occasion  is defined by a slot index  within a frame with system frame number , a first symbol  within the slot, and a number of consecutive symbols . For PUSCH with repetition Type B, a PUSCH transmission occasion is a nominal repetition, as described in [6, TS 38.214 Clause 6.1.2].  7.1 Physical uplink shared channel  <omitted text>  7.1.1 UE behaviour  If a UE transmits a PUSCH on active UL BWP  of carrier  of serving cell  using parameter set configuration with index  and PUSCH power control adjustment state with index , the UE determines the PUSCH transmission power  in PUSCH transmission occasion  as  [dBm]  where,  <omitted text>  -  for  and  for  where  is provided by *deltaMCS* for each UL BWP  of each carrier  and serving cell . If the PUSCH transmission is over more than one layer [6, TS 38.214], .  and , for active UL BWP  of each carrier  and each serving cell , are computed as below  -  for PUSCH with UL-SCH data and  for CSI transmission in a PUSCH without UL-SCH data, where  -  is a number of transmitted code blocks,  is a size for code block , and  is a number of resource elements determined as , where  is a number of symbols for PUSCH transmission occasion on active UL BWP  of carrier  of serving cell,  is a number of subcarriers excluding DM-RS subcarriers and phase-tracking RS samples [4, TS 38.211] in PUSCH symbol  (assuming no segmentation for a nominal repetition in case of PUSCH repetition type B), , and ,  are defined in [5, TS 38.212]  <omitted text> |

**[100b-e-NR-L1enh-URLLC-PUSCH-02]**

**Agreements:**

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.

**Agreements:**

In case PUCCH overlaps with multiple repetitions of PUSCH repetition Type B that satisfy the multiplexing timeline conditions, UCI is multiplexed on only one actual repetition (including the case where a PUCCH overlaps with a PUSCH with repetition Type B in multiple slots). ~~To determine which actual repetition, down-select from the following 3 options:~~

* Option 1: the first overlapping actual repetition ~~in the first overlapping slot~~ that satisfies the multiplexing timeline

**Conclusion:**

The number of possible indices for beta offset that dynamic-ForDCIFormat0\_2 can indicate is not increased.

**[100b-e-NR-L1enh-URLLC-PUSCH-03]**

**Agreements:**

For operation in unpaired spectrum, 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.

**Agreements:**

For operation in unpaired spectrum, symbols indicated to a UE by *pdcch-ConfigSIB1*in *MIB*for a CORESET for Type0-PDCCH CSS are considered as invalid symbols for PUSCH repetition Type B, and segmentation occurs around these symbols.

**Agreements:**

For operation in unpaired spectrum, introduce a new RRC parameter *numberInvallidSymbolsForDL-UL-Switching* to indicate the number of symbols after the last semi-static DL symbol that are invalid symbols for PUSCH repetition Type B.

* The candidate values include {1, 2, 3, 4}.
* If not configured, it means no symbols are explicitly defined for DL-to-UL switching.

**Agreements:**

Adopt the following TP for TS 38.213:

|  |
| --- |
| TP for TS 38.213 Section 8.1  8.1 Random access preamble  < Unchanged parts are omitted >  For single cell operation or for operation with carrier aggregation in a same frequency band, a UE does not transmit PRACH and PUSCH/PUCCH/SRS in a same slot or when a gap between the first or last symbol of a PRACH transmission in a first slot is separated by less than  symbols from the last or first symbol, respectively, of a PUSCH/PUCCH/SRS transmission in a second slot where  for  or ,  for  or , and  is the SCS configuration for the active UL BWP. This applies to each actual repetition for PUSCH repetition Type B (as described in [6, TS 38.214 Clause 6.1.2])  < Unchanged parts are omitted > |

**[100b-e-NR-L1enh-URLLC-PUSCH-04]**

**Agreements:**

Adopt the following TP for TS 38.214:

|  |
| --- |
| TP for TS 38.214  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 > |

**Agreements:**

For PUSCH repetition Type B, S is from 0 to 11, and L is from 1 to 12 for extended cyclic prefix. Adopt the following TP for Section 6.1.2.1 in TS 38.214:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TP for TS 38.214  6.1.2.1 Resource allocation in time domain  < Unchanged parts are omitted >  - For PUSCH repetition Type B, the starting symbol *S* relative to the start of the slot, and the number of consecutive symbols *L* counting from the symbol *S* allocated for the PUSCH are provided by *startSymbol* and *length* of the indexed row of the resource allocation table, respectively.  - For PUSCH repetition Type A, the PUSCH mapping type is set to Type A or Type B as defined in Clause 6.4.1.1.3 of [4, TS 38.211] as given by the indexed row.  - For PUSCH repetition Type B, the PUSCH mapping type is set to Type B.  The UE shall consider the *S* and *L* combinations defined in table 6.1.2.1-1 as valid PUSCH allocations  **Table 6.1.2.1-1: Valid *S* and *L* combinations**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **PUSCH mapping type** | **Normal cyclic prefix** | | | **Extended cyclic prefix** | | | | ***S*** | ***L*** | ***S+L*** | ***S*** | ***L*** | ***S+L*** | | Type A | 0 | {4,…,14} | {4,…,14} (repetition\_Type A only) | 0 | {4,…,12} | {4,…,12} | | Type B | {0,…,13} | {1,…,14} | {1,…,14} for repetition Type A, {1,…,27} for repetition Type B | {0,…, 11} | {1,…  ,12} | {1,…,12} for repetition Type A, {1,...,23} for repetition Type B | |
| < Unchanged parts are omitted > |

**Agreements:**

Adopt the following TP for TS 38.214:

|  |
| --- |
| TP for TS 38.214  6.1.2.1 Resource allocation in time domain  < Unchanged parts are 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 all 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 *n*th actual repetition (with the counting including the actual repetitions that are omitted) is determined according to table 6.1.2.1-2.  < Unchanged parts are omitted > |

**Agreements:**

Adopt the following TP for TS 38.214:

|  |
| --- |
| TP for TS 38.214  6.1.4.2 Transport block size determination  < Unchanged parts are omitted >  The UE shall first determine the number of REs (*NRE*) within the slot:  - A UE first determines the number of REs allocated for PUSCH within a PRB  by  - , where is the number of subcarriers in the frequency domain in a physical resource block,  is the number of symbols *L* of the PUSCH allocation according to Clause 6.1.2.1 for scheduled PUSCH or Clause 6.1.2.3 for configured PUSCH,  is the number of REs for DM-RS per PRB in the allocated duration including the overhead of the DM-RS CDM groups without data, as described for PUSCH with a configured grant in Clause 6.1.2.3 or as indicated by DCI format 0\_1 or DCI format 0\_2 or as described for DCI format 0\_0 in Clause 6.2.2, and  is the overhead configured by higher layer parameter *xOverhead* in *PUSCH-ServingCellConfig*. If the  is not configured (a value from 6, 12, or 18), the  is assumed to be 0. For Msg3 transmission the  is always set to 0. In case of PUSCH repetition Type B,  is determined assuming a nominal repetition with the duration of *L* symbols without segmentation.  < Unchanged parts are omitted > |

# 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

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| --- |
| 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. |