**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-03] (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-03] UCI multiplexing on PUSCH for PUSCH repetition Type B (Section 4 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 TP.

# 2 UCI multiplexing on PUSCH for PUSCH repetition Type B

In RAN1 #100bis-e, the following agreements were reached (see feature lead summary [R1-2003004](ftp://ftp.3gpp.org/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2003004.zip)):

***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*

What still remains open is how to determine the number of REs for UCI. In addition, there are a few contributions discussing the overlapping between PUSCH repetition Type B and PUCCH repetitions.

Before getting into the details of UCI multiplexing on PUSCH, there was one discussion point from RAN1#100bis-e that an actual repetition of a single symbol should not be considered for UCI multiplexing.

* Samsung[9], Sharp[16]: An actual repetition of a single symbol in case of L>1 is not considered for UCI multiplexing.
* QC[18]: An actual repetition of a single symbol PUSCH repetition Type B is not considered for UCI multiplexing.

In Rel-15, UCI is not multiplexed on a PUSCH with a single symbol. To follow the same principle, the following is proposed, which is generally applicable for any type of UCI (HARQ-ACK, P-CSI, A-CSI, SP-CSI) multiplexing on PUSCH repetition Type B.

### Proposal 1:

For PUSCH repetition Type B, an actual repetition of a single symbol is not considered for UCI multiplexing.

(Note that this means for PUCCH overlapping with multiple repetitions of PUSCH repetition Type B, UCI is multiplexed on the first overlapping actual repetition that is not a single symbol.)

**Companies please provide comments.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Agree with the proposal. |
| Nokia, NSB | Agree |
| QC | Agree |
| Panasonic | Agree |
| ZTE | Agree |
| DOCOMO | Agree |
| Huawei,  HiSilicon | Agree |
| Spreadtrum | Agree |
| vivo | Agree |
| Samsung | Agree |
| Fujitsu | Agree |
| OPPO | Agree with intention of proposal. However, for nominal repetition with L=1, UCI multiplexing procedure is not clear. There are two options at least:  Option 1: It is not expected that PUCCH overlaps with PUSCH repetition Type B with L=1  Option 2: If PUCCH overlaps with PUSCH repetition Type B with L=1, PUCCH transmits and the PUSCH drops.  [FL] my understanding of Rel-15 behavior is that the number of REs for UCI is zero if L=1. This means that PUSCH is transmitted but effectively UCI is not transmitted because the number of REs for UCI is 0. The intention is not to touch this part. Please correct me if this understanding is not correct. |
| LG | Agree. Maybe we can simply say “An actual repetition with a single symbol is omitted except for the case of L=1 before intra-UE multiplexing”  [FL] we probably need to think further how to capture this in the specs if this is agreeable. At this point, if you are fine with the proposal, we can agree on it first and discuss the best way to capture the agreements in the TP discussion. |
| Sony | Agree.  It should be noted in previous agreement, the UCI is mux to the 1st actual overlapping PUSCH. So if this 1st actual overlapping PUSCH is single symbol, then this agreement needs to be clarified somehow. |
| Apple | Agree |

### Proposal 1a:

For PUSCH repetition Type B, an actual repetition of a single symbol is not considered for UCI multiplexing.

* For PUCCH overlapping with multiple repetitions of PUSCH repetition Type B, UCI is multiplexed on the first overlapping actual repetition that is not a single symbol. (Note that this is an update of the RAN1#100bis-e agreements.)

Proposal 1a has been agreed on the Wednesday online session.

## 2.1 UCI resource determination

Regarding how to determine the number of Res for UCI when multiplexed on PUSCH repetition Type B, the discussions in previous meetings and in the RAN1#101-e contributions have been mainly focused on the case for PUSCH repetition Type B with UL-SCH. But the issue also exists for PUSCH repetition Type B without UL-SCH, and it also applied to all different types of UCI, including HARQ-ACK, P-CSI, A-CSI, SP-CSI.

### 2.1.1 UCI resource determination on PUSCH repetition Type B without UL-SCH

In Rel-15, for PUSCH without UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK, CSI part 1 and CSI part 2 is calculated according to

,



and

,

respectively, where is the number of available Res in the PUSCH piggybacking the UCI.

In addition, in Rel-15, CSI part 2 can be (partially) omitted according to the following:

|  |
| --- |
| When part 2 CSI is transmitted on PUSCH with no transport block, lower priority bits are omitted until Part 2 CSI code rate, which is given by where , , are given in clause 6.3.2.4 of [5, 38.212] before HARQ-ACK puncturing part 2 CSI if any, is below a threshold code rate lower than one, where    - is the CSI offset value from Table 9.3-2 of [6, TS 38.213]  - *R* is ignalled code rate in DCI |

The question is if the PUSCH is with repetition Type B, how the number of available Res should be calculated, i.e., whether it should be based on the nominal repetition or actual repetition.

Apple[15] proposed that in this case the calculation is based on actual repetition.

* “At least for CSI part 1 and CSI part 2,  should be calculated based on the actual repetition (if the actual repetition is different from the nominal repetition), because the formula intends to provide exactly how many Res are used for CSI transmission. It also dictates how the dropping of CSI part 2 should be performed based on the calculated code rate, which would only make sense when using the actual number of Res used for transmission. To be consistent, it would make sense to use the actual repetition to calculate the number of Res for HARQ-ACK as well.”

As this is the only company who had discussed this case, we use this proposal as the starting point for discussion.

### Proposal 2:

For UCI multiplexed on PUSCH repetition Type B without UL-SCH, the number of Res for HARQ-ACK, CSI part 1, and CSI part 2 is calculated based on the actual repetition.

(Note: whether the actual repetition is the same as nominal repetition depends on the outcome of email discussion [101-e-NR-L1enh-URLLC-PUSCH-03].)

**Companies please provide comments.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Agree with the proposal. |
| Nokia, NSB | Agree |
| QC | Postpone this discussion after decision is made in email thread PUSCH-02. This is indeed another reason we shall NOT support segmentation for CSI on PUSCH without UL-SCH. |
| Panasonic | Agree |
| ZTE | Agree |
| DOCOMO | Agree |
| Huawei,  HiSilicon | Agree |
| Spreadtrum | Agree |
| vivo | We agree with the proposal. |
| Samsung | Prefer to discuss after PUSCH-02. |
| Fujitsu | It is better to discuss this topic after the conclusion of the related discussion in [101-e-NR-L1enh-URLLC-PUSCH-02]. |
| OPPO | Agree with QC’s proposal. It depends on email thread PUSCH-02 outcome. |
| LG | Agree with the proposal. |
| Sony | Agree. |
| Apple | Agree |

### 2.1.2 UCI resource determination on PUSCH repetition Type B with UL-SCH

In Rel-15, for PUSCH with UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK, CSI part 1 and CSI part 2 is calculated according to

,

and

,

respectively, where is the number of available REs in the PUSCH piggybacking the UCI, and  is the TBS of the PUSCH.

In addition, in Rel-15, CSI part 2 can be (partially) omitted according to the following:

|  |
| --- |
| When the UE is scheduled to transmit a transport block on PUSCH multiplexed with a CSI report(s), Part 2 CSI is omitted only when  is larger than , where parameters , , , , , , , ,  and are defined in Clause 6.3.2.4 of [5, TS 38.212].  Part 2 CSI is omitted level by level, beginning with the lowest priority level until the lowest priority level is reached which causes the  to be less than or equal to . |

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
  + Huawei/HiSilicon
  + **Option 1a**: with the additional limit of no more than the resources available in the actual repetition
    - ZTE[1], Ericsson[3], Intel[7], Panasonic[8], OPPO[14], Docomo[17] (2nd preference)
  + **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[2], Samsung[9], LG[12], OPPO[14], Apple[15], QC[18]
* **Option 2**: The calculation is based on the actual repetition.
  + LG[12], WILUS[19]
* **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[5] (TP provided), CATT[6], Intel[7], Panasonic[8], Spreadtrum[11], Docomo[17] (1st preference)

Samsung[9]: Scale the value provided by RRC by the PUSCH repetition number *k* as = for the RE number calculation of UCI multiplexing on PUSCH for both Type B and Rel-16 Type A repetition with dynamic indication of the repetition number in the DCI format.

ETRI[10]: For actual repetition, more alpha scaling value is provided. (*not clear what this means exactly? One value for nominal repetition and one value for actual repetition?*) If any given alpha scaling does not give a meaningful bound, drop the actual PUSCH instance and transmit PUCCH.

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

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| --- | --- |
| **Option 1a (10)** | ZTE, Ericsson, Intel, Panasonic, OPPO, Docomo (2nd preference), Huawei/HiSilicon (1st preference), vivo, Sony |
| **Option 1b (7)** | vivo, Samsung, LG, OPPO, Apple, QC, Fujitsu |
| **Option 2 (2)** | LG, WILUS |
| **Option 3 (9)** | Nokia/NSB, CATT, Intel, Panasonic, Spreadtrum, Docomo (1st preference), Huawei/HiSilicon |
| **Other** |  |

**Companies please indicate if you have strong concerns on any of the options.**

|  |  |
| --- | --- |
| **Option 1a** |  |
| **Option 1b** |  |
| **Option 2** | Nokia/NSB (will give least available number of REs from all options) |
| **Option 3** |  |

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia, NSB | As stated, we prefer Option 3 but could be compromising if needed also to Option 1a.  Please note, that Option 1b seems to be not really working – as the requirement would include CSI-part 2 fully (and not allow partial CSI part 2 dropping). So would be nice if companies from the Option 1b camp could comment on Option 1b operation with relation to CSI (especially CSI part 2) |
| QC | Support 1b. And similar to all the other options, at the end of the day this is gNB who shall manage desired rates for each UCI part. If gNB is not able to provide, e.g., enough resources for CSI2, it could happen under any of these options as well. Note that here, where we have UL-SCH, the flexibility is more at gNB to provide nominal Res for UCIs. |
| Panasonic | Option 3 is the performance optimal way and our first preference. If the amount of specification impact is large, Option 1 with the handling to avoid exceeding the resource available in the actual repetition can also be acceptable. Option 1a seems to be almost the same as Option 3 since the additional limit is based on the resource available in the actual repetition. If the additional UE complexity to consider actual repetition for resource determination is big concern, Option 1b can also be considered as compromised solution. At least for DG PUSCH, gNB scheduler can properly handle the resource allocation. However, for CG PUSCH, gNB scheduling or TDD handling might be more complicated in Option 1b. |
| Huawei,  HiSilicon | We prefer either option 1a or option 3. For option 1b, it may bring some restriction at gNB side. Option 3 sounds reasonable also, especially if the PUSCH is for URLLC, providing some chance for gNB to ensure the limit for UCI is beneficial also. |
| Spreadtrum | We prefer Option 3. Option 1a has not much difference between Option 3, but Option 3 has higher scheduling flexibility by reserving some resources for PUSCH data. Option 1b has much higher implementation complexity, especially for CG PUSCH. |
| vivo | Our preference is option 1b from spec and UE implementation complexity perspectives. For UCI to be multiplexed on PUSCH with repetition type B, UCI performance should be guaranteed. Since gNB knows whether the nominal repetition is segmented or not, it can guarantee the UCI resources not exceed the available resources of the actual PUSCH repetition on which UCI would be multiplexed.  If scheduling restriction would be concerned for Option 1b, Option 1a could be compromise.  For option 3, the UCI performance may not be guaranteed due to the restriction of 2nd term, and additional calculation is required at the UE side. |
| Samsung | We prefer option 1b.  To answer Nokia’s question, with proper α and β, it still can drop CSI-part 2. If the proposal of option 1b is not clear, we suggest to update it to:  **Option 1b**: UE does not expect that the number of REs available for UCI is more than the number of available REs in the actual repetition on which the UCI is multiplexed.  For CG PUSCH, piggyback of UCI can be disabled.  For option 3, because segmentation or not is different in each scheduling, however, α is semi-statically configured to maintain the reliability of PUSCH. If the second part is changed based on actual repetition, it may not leave enough RE for PUSCH for segmentation cases.  For option 1a, if there is no restriction, we have concern about the reliability of UCI of A/N. |
| OPPO | Option 2 and option 3 leads more UCI dropping. UCI is prioritized in usual, so we prefer to option 1. |
| LG | We support Option 1b.  Option 1b exactly means same number of RE is used for UCI regardless of segmentation. So UE have same UCI performance. Even in option 1b and CSI-2, total available number of RE is limited by UCI scaling factor, there seems a lot of room to control UCI amount.  Option 2 is to use same code rate for UCI regardless of segmentation, it could maintain PUSCH performance and more aligned Rel-15 way to utilize beta-offset. |
| Sony | We prefer Option 1a. However, isn’t Option 1b also possible in Option 1a? Option 1b requires the gNb to guarantee the number of REs for UCI and it can be guaranteed in the form of beta portion of the equation or the alpha portion of the equation. |
| Apple | We prefer Option 1b for minimum specification and UE implementation impact. Agree with the comments by Samsung. |

## 2.2 Overlapping between PUSCH repetition Type B and PUCCH repetitions

A few contributions discussed the overlapping between PUSCH repetition Type B and PUCCH repetitions.

* ETRI[10]: Regarding HARQ-ACK repetition using long PUCCH formats, PUCCH is transmitted and overlapped PUSCH repetition(s) are dropped, provided that their priority index are the same.
* Fujitsu[13]: 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.
* ASUSTek[20]
  + There are two possible UE behaviors based on the current specification text, which should be clarified:
    - (1)The UE would drop all actual repetition(s) in the overlapping slot(s) and transmit the PUCCH
    - (2)The UE would only drop the actual repetition(s) that overlap with the PUCCH and transmit the remaining actual repetition(s). – preferred (TP provided)

Currently the overlapping between PUCCH with repetitions and PUSCH is specified as follows:

TS 38.213 Clause 9.2.6, **Paragraph 3**: “If a UE would transmit a PUCCH over a first number  of slots and the UE would transmit a PUSCH over a second number of slots, and the PUCCH transmission would overlap with the PUSCH transmission in one or more slots, and the conditions in Clause 9.2.5 for multiplexing the UCI in the PUSCH are satisfied in the overlapping slots, the UE transmits the PUCCH and does not transmit the PUSCH in the overlapping slots.”

This is intended to specify the behavior when PUCCH and PUSCH have the same priority index. The question is whether we keep Rel-15 behavior of dropping PUSCH in the overlapping slots, or just dropping the overlapping actual repetitions.

For PUCCH with repetitions overlapping with PUSCH repetition Type B, the UE transmits the PUCCH in the overlapping slots, and

* **Option 1**: the UE does not transmit all the actual PUSCH repetitions in the overlapping slots (reusing Rel-15 specifications)
* **Option 2**: the UE does not transmit the actual PUSCH repetitions that overlap with the PUCCH

**Companies please indicate which option you prefer.**

|  |  |
| --- | --- |
| **Option 1** |  |
| **Option 2** | CATT, Nokia/NSB, QC, Panasonic, ZTE, DOCOMO, Huawei/HiSilicon, vivo, Samsung, Fujitsu, OPPO, Sony |
| **Other** |  |

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia, NSB | Option 2 is less restrictive and will lead to less PUSCH (actual/nominal repetition) dropping (which for URLLC is not ‘nice’) |
| QC | We think Option 2 is still aligned with current specification, as even in Rel-15, PUSCHs that overlap with PUCCH are dropped, i.e. in a slot if a PUSCH does not overlap with PUCCH, that PUSCH is not dropped. |
| Panasonic | From URLLC performance perspective, Option 2 is preferred. We also have same understanding as Qualcomm on the current specification. |
| ZTE | Agree with QC |
| DOCOMO | Agree with QC and Panasonic. |
| Huawei,  HiSilicon | Don’t see the benefit to also drop the non-overlapping repetittions |
| Spreadtrum | We prefer Option 2. |
| vivo | We prefer Option 2. |
| Samsung | Option 2 follows same principle as in Rel-15 and other PUSCH omitting in Rel-16. |
| Fujitsu | We prefer Option 2. Option 2 follows the principle of the current spec. |
| OPPO | We prefer Option2. Option 2 is also aligned with current spec. |
| LG | Agree with QC. In addition, it should be maintained that overlapped PUSCH and PUCCH satisfy multiplexing timeline. |
| Sony | Prefer Option 2. Option 1 is over-dropping PUSCH for the sake of following the wordings in Rel-15 without any benefit. |
| Apple | Option 2 |

It seems that the following proposal is generally agreeable, but some companies think there is no need to change the specification because it is already supported by the current specification.

### Proposal 4:

For PUCCH with repetitions overlapping with PUSCH repetition Type B, the UE transmits the PUCCH in the overlapping slots, the UE does not transmit the actual PUSCH repetitions that overlap with the PUCCH.

Proposal 4 has been agreed on the Wednesday online session.

**Companies please indicate whether you think the Agreed proposal 4 requires specification change.**

|  |  |
| --- | --- |
| **Yes** | Apple, Nokia/NSB |
| **No** |  |

**Companies please provide comments on the corresponding specification change.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | The current specification may be taken as not transmitting all the PUSCH repetitions in the overlapping slots. Note that “PUSCH” or “PUSCH transmission” in this sentence does not really mean a single repetition. In the first part it actually refers to all the repetitions. We think it is always good to write the specification as clear as possible to avoid any potential confusion later on. Therefore, we suggest:  “If a UE would transmit a PUCCH over a first number  of slots and the UE would transmit a PUSCH over a second number of slots, and the PUCCH transmission would overlap with the PUSCH transmission in one or more slots, and the conditions in Clause 9.2.5 for multiplexing the UCI in the PUSCH are satisfied in the overlapping slots, the UE transmits the PUCCH and does not transmit the PUSCH in the overlapping slots. In case of PUSCH repetition Type B, the UE transmits the PUCCH and does not transmit the overlapping actual PUSCH repetitions (as defined in [6, TS 38.214]) in the overlapping slots.”  Of course, we are open to any TP as long as there is no ambiguity. |
| Nokia, NSB | TP will be needed, we can discuss the details next week |

# 3 Agreements

**Agreement**

For PUSCH repetition Type B, an actual repetition of a single symbol is not considered for UCI multiplexing.

* For PUCCH overlapping with multiple repetitions of PUSCH repetition Type B, UCI is multiplexed on the first overlapping actual repetition that is not a single symbol. (Note that this is an update of the RAN1#100bis-e agreements.)

**Agreement**

For PUCCH with repetitions overlapping with PUSCH repetition Type B, the UE transmits the PUCCH in the overlapping slots, the UE does not transmit the actual PUSCH repetitions that overlap with the PUCCH.

# 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:

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| **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:

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| **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:

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| **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:

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| 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:

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| 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:

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| --- |
| 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:

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| 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 > |