3GPP TSG RAN WG1 #104-e R1-21xxxxx

e-Meeting, Janurary 25th – Feburary 5th, 2021

**Source: Moderator (Sharp)**

**Title: FL Summary#1 on Enhancements on PUSCH repetition type A**

**Agenda Item: 8.8.1.1**

**Document for: Discussion** **and Decision**

# Introduction

This document is intended to facilitate view exchange and discussions for the following assigned email discussion.

[104-e-NR-CovEnh-01] Email discussion on enhancements on PUSCH repetition type A – Toshi (Sharp)

* 1st check point: Jan 28
* 2nd check point: Feb 2
* 3rd check point: Feb 4

# Increasing the maximum number of repetitions

The discussions in this section are based on the following objective in the Coverage Enhancement WID.

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| The detailed objectives of the work item are as follows:   * Specification of PUSCH enhancements [RAN1, RAN4]   + Specify the following mechanisms for enhancements on PUSCH repetition type A [RAN1]     - **Increasing the maximum number of repetitions up to a number to be determined during the course of the work.**     - The number of repetitions counted on the basis of available UL slots. |

# The maximum number of repetitions

In Rel-15/16, RRC parameter *pusch-AggregationFactor* configures the number of repetitions for PUSCH, where the candidate value set of *pusch-AggregationFactor* = {2, 4, 8}. TRDA based dynamic repetition number indication introduced in Rel-16 is applied when configured, where the candidate value set of *numberOfRepetitions-r16* = {1, 2, 3, 4, 7, 8, 12, 16}.

13 companies (ZTE, OPPO, CATT, vivo, Intel, China Telecom, NEC, Panasonic, Xiaomi, Sierra Wireless, Apple, Qualcomm, NTT DOCOMO) provided their views that the maximum number of repetitions should be increased to 32. One major reason is it enables 8 actual repetitions in DDDDDDDSUU slot structure. Two companies (CMCC, Samsung) also accepted increasing it to 32.

2 companies (Huawei, HiSilicon) mentioned that the currently supported maximum number of repetition being 16 is sufficient to meet the coverage requirement.

1 company (Sharp) proposed considering the maximum number of repetitions of 36 which enables 8 actual repetitions in DDDSU slot structure.

1 company (IITH) preferred increasing of the maximum number of repetitions to 128.

1 company (Ericsson) proposed that assuming FDD for determination of the maximum number of repetitions without postponement justifies an increase to 20. Values greater than 20 needs confirmation that the corresponding data rates support vocoder operation with sufficient quality and low enough higher layer overhead.

2 companies (Nokia, Nokia Shanghai Bell) provided their views that specification changes on TDRA should be avoided for the Rel-17 enhancements on PUSCH repetition type A.

1st round discussion

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| **FL observation 1-1:**  Clear majority supports 32 as the maximum number of repetitions.  **Question 1-1:**  Companies are invited to provide technical reasoning / technical concern to the majority’s view. | |
| **Company** | **Comment** |
| Samsung | If a number larger than 16 is agreed, the maximum size of the TDRA table remains unchanged (64 rows, 6 bits in DCI for the indication) as a UE’s coverage condition is slowly varying and the TDRA table can be adjusted by RRC. |
| Qualcomm | Support increasing maximum number of repetitions to 32 for both RRC configured PUSCH and dynamic TDRA-based PUSCH grants. This aids VoIP traffic where one aggregated packet is generated every 40 ms and the resulting packet can be repeated a large number of times. Allowing large number of repetitions is also useful from an NTN perspective where retransmissions may not be feasible due to large time delays. |
| Apple | We supports 32 as the maximum repetition number, other values and indication can discuss later. |
| Intel | We are fine with the proposal to support 32 as maximum number of repetitions. |
| China Telecom | Support the proposal to increase the maximum number of repetitions to 32. The feature is independent of the number of repetitions counted on the basis of available UL slots. Even the maximum number of repetitions is increased to 32, the actual number of repetitions is still very limited for TDD. |
| NTT DOCOMO | We supports 32 as the maximum number for the repetition. |
| ZTE | Agree to support a maximum of 32 repetitions.  Considering TDD configuration, increasing the number of repetitions is desirable to make sure the actual number of repetitions transmitted. In addition, from UE capability point of view, increasing the number of repetitions with may be easier for coverage enhancement compared to the number of slots counted by available slots. |
| Panasonic | We support 32 as the maximum repetition number, since for Rel.15/16 PUSCH repetition Type A mechanism, supporting 32 as the maximum number of repetitions seems reasonable considering the actual number of repetitions and slot structure. |
| CATT | We support 32 as the maximum repetition number. Besides, the gNB does not always have to configure/indicate 32, if it thinks 32 is rather too large. |
| Sharp | We also think 32 repetitions should be supported. In addition, we suggest considering 36 as well, which enable 8 actual repetitions in DDDSU slot structre. |
| NEC | We support 32 as the maximum number for the repetition. |
| CMCC | From our view, 16 repetitions are sufficient for the coverage enhancement.  Our understanding is that, after the discussion of available slot, the 16 or 32 repetition should work under the definition of available slots. In this condition, the actual repetition should be more close to the ‘nominal’ repetition, not the poor 8 repetitions mentioned before.  For the RRC configured *AggregationFactor*, we do not see much motivation to extend the repetition number, since TDRA based repetition indication have provided sufficient flexibility. Please clarify the motivation and using scenarios. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | We understand the motivation for 32 for VOIP scenarios. But for eMBB, the coverage gap is around 7dB. In our simulations we showed that without 128 actual repetitions, the coverage gap cannot be overcome. So, we would like to understand the motivation behind 32 for all scenarios. |
| OPPO | Agree to support 32 as the maximum repetition number and this is also FDD 20 slot aggregation.  We think there should be clarification on how to introduce the 32 slots, Via numberOfRepetitions-r16 or Aggregation factor. If we add the 32 into numberOfRepetitions-r16 it will also applicable to Repetition type B. Thus, we consider to add 16 and 32 to aggregation factor. |
| vivo | Maximum number of repetitions can be extended to 32. |
| Sierra Wireless | Support but when making the agreement, we need to clarify that 32 repetitions is only supported when TBoMS (TB over multi-slots) is NOT used and how repetitions with TBoMS is FFS. The concern is that if TBoMS support coding over e.g. 4 slots, then the transmission time could be as long as 4\*32 =128 slots. Alternatively, we could specify as maximum slots of transmission. |
| Ericsson | There’re 2 options to enhance Type A PUSCH repetition according to the WID. And there seem to be two possible ways of specifying Options 1 and 2, which will affect how to determine the maximum number of repetitions for option 1 and option 2:  1) There are two UE capabilities for the two options  2) There is one UE capability.    If there are two capabilities, then they should be able to be configured differently, and there should be two different maximum numbers of repetitions for 2 options (option 1 has the increased maximum number of repetitions, while option 2 has legacy repetition factors).  If there is one UE capability, then the operation would likely be unified, and the maximum number of repetitions should be determined according to Option 2, which may not need as large a number of repetitions, i.e. same as legacy and there’s no need to increase number of repetitions.  Another point is that Options 1 and 2 are not equally useful for FDD and TDD. Increasing the maximum number of repetitions directly increases the repetitions for FDD, but less so for TDD. So we can consider different use cases when determining the maximum values for Options 1.  Assuming two UE capabilities is the least restrictive at this stage, and so we’re fine to further discuss a maximum number of repetitions for option 1 based on the use cases and data rates agreed for the study. However, we do not think it necessary to optimize the number of repetitions for option 2. |

# Other candidate values for configured number of repetitions

3 companies (CATT, vivo, China Telecom) discussed that, on top of adding 32, additional values for a value set of the number of repetitions (e.g. also adding {20, 24, 28}) with finer granularity improve performance. 1 company (ZTE) discussed increasing of the number of candidate repetition factors from 8 to 16.

1st round discussion

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| **FL proposal 1-2:**  Additional candidate values for configured number of repetitions are discussed after concluding the discussion on the maximum number of repetitions. This is also affected by outcomes from Question 1-4.  **Question 1-2:**  Any views on the above suggestion? | |
| **Company** | **Comment** |
| Qualcomm | Candidate repetition factors can include {20,24,28,32}. |
| Intel | We are fine with the suggestions |
| NTT DOCOMO | We support FL proposal. |
| ZTE | Fine with the proposal. |
| CATT | Fine with the proposal. We think additional candidate value can provide flexibility for gNB. {20, 24, 28} is linear between 16 and 32, and fine for us. |
| Sharp | We are fine with FL proposal. |
| NEC | Support FL proposal. |
| CMCC | Considering the transmission latency caused by large number repetitions, additional candidate value between 16 and 32 is acceptable to us, if the 32 is agreed. |
| OPPO | We can consider {16, 20}, assuming AggregationFactor, as elaborated in the question 1-2. |
| vivo | Fine with the proposal. Candidate values like {20, 24, 28} can provide flexibility and finer granularity for gNB scheduling. |
| Sierra Wireless | For VoIP, repetition factors which are multiples of 10ms could be considered. |
| Ericsson | The exact values of each candidate repetition factor can be further discussed. Note that a separate TDRA list for R17 is needed for backward combability. At least we do not want to increase the number of rows of the TDRA table which may increase the number of bits of TDRA indication in DCI. |

# Repetitions for configured grant

In Rel-15/16, RRC parameter *repK* applies to both Type 1 and Type 2 configured grant transmissions, where the candidate value set of *repK* = {1, 2, 4, 8}. TRDA based dynamic repetition number indication introduced in Rel-16 is applicable to Type 2 configured grant transmission, where the candidate value set of *numberOfRepetitions-r16* = {1, 2, 3, 4, 7, 8, 12, 16}.

2 companies (ZTE, Apple) discussed that the maximum repetition number for PUSCH transmission with configured grant is currently 8, and it should be increased, too.

1st round discussion

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| **FL observation 1-3:**  Only few companies have explicitly shown their views on increase of the maximum number of repetitions for configured grant.  **Question 1-3:**  Any views on increasing the maximum number of repetitions for configured grant? | |
| **Company** | **Comment** |
| Samsung | Apply same conclusion as for DG-PUSCH. |
| Qualcomm | Apply same maximum for both DG and CG PUSCH. |
| Apple | Agree with Samsung and Qualcomm. In addition, to align the objective of this WI, the proposal should clarify for PUSCH repetition type A with a configured grant. |
| Intel | We think new maximum number of repetitions should also apply to CG-PUSCH. |
| NTT DOCOMO | We support to apply the same maximum number or repetitions for configured grand. |
| ZTE | We should aim for the same conclusion for DG and CG. |
| Panasonic | It is desirable to apply same maximum number of repetitions for both DG and CG PUSCH. |
| CATT | Fine to apply same maximum number for DG and CG PUSCH. |
| Sharp | Same number specified for PUSCH with dynamic grant should be supported for PUSCH with configured grant. |
| NEC | Apply same conclusion as for DG-PUSCH. |
| CMCC | Need more clarification for the use cases and scenarios to extend the repetition number of configured grant transmission, which is not covered during the study item. Configured grant transmission is targeted for the URLLC traffic which have a high requirement about the latency. The increase of repetition number would induce a larger latency |
| OPPO | Yes. Repetition in configured grant is more important than DG. Gains for the repetition is higher in VoIP services. |
| vivo | Apply the same maximum number of repetitions for both CG-PUSCH and DG-PUSCH. |
| Ericsson | For the enhancement of Type A PUSCH repetitions in R17, we assume we’re only doing enhancement based on the enhanced R16 Type A PUSCH repetition.  For Type 2 CG PUSCH, the enhanced R17 TDRA list with increase number of repetitions can be used by CG PUSCH as well.  For Type 1 CG PUSCH repetition, we do not see the need to enhance the R15 *repK* value. |

# RRC parameters to be extended

In GTW session, there was a discussion on which RRC parameters should be extended to support more repetitions.

1st round discussion

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| **FL observation 1-4:**  There are 3 RRC parameters which are possibly extended so as to increase the maximum number of repetitions.   * *pusch-AggregationFactor* * *numberOfRepetitions* * *repK*   **Question 1-4:**  Companies are invited to provide their views on which RRC parameter(s) is extended to increase the maximum number of repetitions. | |
| **Company** | **Comment** |
| Samsung | If the maximum number of repetitions in the TDRA table is increased above 16, *pusch-AggregationFactor* and *repK* should also be increased. |
| Qualcomm | All three parameters can be extended to accommodate up to 32 repetitions. |
| Apple | Which parameter needs to extend the value is related to indication the repetition number semi-statically or dynamically. If we agree repetition number is 32 or more. Semi-statically indication is less the flexibility and resource utilization is not so efficient. From this point, parameter *numberOfRepetitions* and *repK* can be increased. |
| Intel | We think all three parameters should be included. |
| China Telecom | All three parameters should be extended to support maximum number of 32. |
| NTT DOCOMO | Three parameters needs to be extended. |
| ZTE | It seems introducing only one new parameter for *numberOfRepetitions* with Rel-17 suffix included in TDRA table is sufficient. If this new parameter is not configured, then the number of repetitions is determined by legacy rules. |
| Panasonic | All three parameters can be extended if the maximum number of repetitions to be supported is increased from that supported in current specification. |
| CATT | Fine to increase the maximum repetition number for all three parameters. |
| Sharp | At least *numberOfRepetitions* should be extended. Extension of the other two parameters can be also considered. |
| NEC | *numberOfRepetitions* could overwrite *pusch-AggregationFactor*, so no need to extend *pusch-AggregationFactor* as in Rel-16. |
| CMCC | Currently, increase the repetition number of *numberOfRepetitions* is sufficient. As mentioned in the replies above, the other two parameters need justifications. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | At least one of these parameters should be extended. |
| OPPO | * pusch-AggregationFactor * repK   As evaluated in the Qestion 1-1, it seems numberOfRepetitions should not be increase since it is also for Type B repetition. |
| Ericsson | First of all, we do not think it necessary to enhance R15 repetition factors (i.e. *repK, pusch-AggregationFactor*) and we should focus on the enhancement of R16 repetition factors (up to 16).  Furthermore, this increased *numberOfRepetitions* in a R17 TDRA list is only needed for Option 1 and there’s no need of separate TDRA list for Option 2 since the repetition factors in the existing R16 TDRA list will be treated as actual repetitions if a Type A PUSCH option 2 is configured. |

# The number of repetitions counted on the basis of available slots for the PUSCH transmissions

The discussions in this section are based on the following objective in the Coverage Enhancement WID.

1st round discussion

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| The detailed objectives of the work item are as follows:   * Specification of PUSCH enhancements [RAN1, RAN4]   + Specify the following mechanisms for enhancements on PUSCH repetition type A [RAN1]     - Increasing the maximum number of repetitions up to a number to be determined during the course of the work.     - **The number of repetitions counted on the basis of available UL slots.** |

# Basic postponement mechanism

In Rel-15/16 the number of repetitions for a PUSCH repetition type A is counted at every slot regardless of whether the slot has sufficient available resources for UL transmissions or not.

4 companies (CATT, Panasonic, Qualcomm, NTT DOCOMO) mentioned that the number of repetitions counted on the basis of available resources for UL transmissions is already supported by Rel-15/16 PUCCH repetition and it can be reused for Rel-17 PUSCH repetition.

2 companies (ZTE, Ericsson) mentioned that definition of “available UL resource” can follow Rel-15/16 rules (i.e. reuse of legacy PUSCH omitting rules).

2 companies (OPPO, vivo) discussed that UE should postpone the transmission in a slot if the slot cannot transmit the repetition of a TB, where the postponing applies until the configured number of the repetition is achieved.

1st round discussion

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| **FL observation 2-1:**  Most of the companies share the views on postponement mechanism as the following:   * If a slot is determined as available for a scheduled PUSCH, the slot is counted in the PUSCH repetition. Otherwise, the slot is not counted in the PUSCH repetition and the repetition is postponed to the next slot. * Adopt one of the following:   + Alt 1: The above step is repeated until the count reaches the configured/indicated number of repetitions.   + Alt 2: The above step is repeated until the count reaches the configured/indicated number of repetitions N, or until the duration of the PUSCH transmission is K slots and the count is not larger than N.   + Note: additional dropping on the actual repetitions is not precluded (See FL proposal 2-2a).   **Question 2-1:**  Any views on the above observation? | |
| **Company** | **Comment** |
| Samsung | Postponing has the drawback of increasing latency (and resources), and complicating the gNB scheduler as resources are reserved in advance. How much postponing can be done by a UE needs to be controlled by the gNB. We suggest the following change in red:   * The above step is repeated until the count reaches the configured/indicated number of repetitions N, or until the duration of the PUSCH transmission is K slots and the count is not larger than N. |
| Qualcomm | Postponing and on-the-fly determination of slots available for repetition can lead to unpredictable latency and scheduling complications.  We prefer to reuse methodology used for PUCCH repetitions. No postponements are allowed. All slots for repetition are identified **right at the beginning** of the transmission and not revised later on.    This framework is also critical to enabling DMRS bundling, which is being studied in a separate sub-agenda. UE and gNB need to plan in advance for DMRS bundling/joint channel estimation.  Note further that typically PUSCH repetitions may be slightly over-provisioned to account for the fact that some repetitions may get dropped. It is therefore not necessary to specify a complicated mechanism of identifying slots for repetition.  Request FL to add an alternative to not allow postponing before discussing Alt 1 or Alt 2:  **Alt A:** If a slot is determined as available for a scheduled PUSCH prior to the beginning of the first transmission, the slot is counted in the PUSCH repetition. Otherwise, the slot is not counted in the PUSCH repetition. Once slots for repetition are identified they are not revised.  **Alt B:** If a slot is determined as available for a scheduled PUSCH, the slot is counted in the PUSCH repetition. Otherwise, the slot is not counted in the PUSCH repetition and the repetition is postponed to the next slot.  Adopt one of the following:   * + Alt 1: The above step is repeated until the count reaches the configured/indicated number of repetitions.   + Alt 2: The above step is repeated until the count reaches the configured/indicated number of repetitions N, or until the duration of the PUSCH transmission is K slots and the count is not larger than N.   + Note: additional dropping on the actual repetitions is not precluded (See FL proposal 2-2a). |
| Apple | Alt. 1 seems straightforward, gNB could control the repetition and delay if the PUSCH is scheduling. |
| Intel | We think we may need to further discuss the meaning of postponement or deferral. In our view, PUCCH repetition mechanism as defined in Rel-15 for TDD can also be viewed as postponement/deferral, i.e., if UE cannot transmit PUCCH in the next slot due to collision with semi-static UL/DL configuration, UE will defer the PUCCH transmission to the next available UL slots.  Certainly, the determination of available UL slots is performed before the actual first transmission. Note that it is possible that the PUCCH transmission on the available UL slots can be further cancelled due to other factors, including dynamic SFI/UL CI, or different priorities, but it should not be part of procedure on the determination of available UL slots for PUSCH repetition. |
| ZTE | Support Alt 1. gNB could properly handle this, e.g. indicating a proper number of repetitions based on TDD configuration. In addition, we suggest to the note. We can first discuss the issues in 3.2, and then come back to see whether a note is needed. |
| Panasonic | We think part of Alt.2 behaviour “until the duration of the PUSCH transmission is K slots and the count is not larger than N” could be achieved by Rel.15/16 PUSCH repetition Type A. If PUSCH repetition mode configuration/indication can allow to select either Rel.15/16 PUSCH repetition Type A and Rel.17 PUSCH repetition Type A, Alt.1 seems sufficient. |
| CATT | We share the same view with Intel that PUCCH repetition mechanism is a kind of postponement (though described as slot determination). In this regard, we are open to any description as long as the inner meaning is the same.  We also agree with Qualcomm and Intel that the determination of available UL slots is performed before the actual first transmission, i.e., based on semi-static RRC configuration. Possible SFI/CI may still lead to dropping of slots but does not change the already determined slot set, and no more additional postpone, as illustrated in the following figure.    We are OK with both Alt.1 and Alt.2. |
| Sharp | We prefer Alt.1. These alternatives are somehow correlated to alternatives in FL proposal 2-2a. If SFI/CI are not used for determination of the counting, excessive delay does not occur. |
| NEC | We are OK with the principle of both Alt.1 and Alt.2. Meanwhile, PUCCH mechanism can be baseline but some difference between PUSCH and PUCCH should be noticed. For example, when a UE is configured with multiple serving cells and is provided half-duplex-behavior = 'enable', and is not capable of simultaneous transmission and reception on any cell from the multiple serving cells, and indicates support of capability for half-duplex operation in CA with unpaired spectrum, some extra omission rules are adopted based on TS38.213 which is not used for PUCCH. |
| CMCC | Alt 1 is preferred. For the alternative 2, the relation between scheduled PUSCH slots and the repetition number should be clarified. According to the definition of PUSCH repetition type A, the repetition number N should be aligned with scheduled slots K in preconditions that the K slots are the available slots.  We share the similar view that the determination of available UL slots should be performed before the actual first transmission. Any dynamic change of the counting number of available slots will induce misalignments between gNB and UE.  The naming of this section, the postponement, may induce misunderstandings, though we understand that the intention is to describe the counting procedure of available slots for PUSCH repetitions or transmissions. Of course the long delay due to the unexpected postponement of PUSCH is not preferred. |
| OPPO | Alt 1 seems would be simple and controllable. As the PUCCH also not have another limit of repetition, it should be feasible.  Note, the most relevant case is for semi-static UL/DL configuration and the number of available UL slot is predictable by gNB |
| vivo | Alt. 1 is preferred. Since the available slots to be counted is not expected to be changed even if considering the dynamic indication like SFI, CI. |
| Sierra Wireless | We prefer Alt 1 as it is simpler and gNB can still control the total length of transmission. |
| Ericsson | We prefer to discuss the definition of the available slots first. |

# Definition of available slots for PUSCH repetitions

Several companies (vivo, Apple) discussed that dynamic SFI, CI and higher priority transmissions can lead to repetition transmission resource to be unavailable and not to be counted for determination of relevant repetitions, so that “available UL slots” should correspond to the slots where UL repetition is actually transmitted.

7 companies (Intel, Panasonic, Qualcomm, Ericsson, WILUS, Nokia, Nokia Shanghai Bell) discussed that a slot is determined for a PUSCH transmission if the allocated symbols for the PUSCH according to TDRA do not partly or fully overlap with DL symbols or invalid symbols (e.g. SS/PBCH block symbols). In other words, the same number of PUSCH symbols should be kept in every repetition.

7 companies (Intel, China Telecom, NEC, CMCC, Qualcomm, Sharp, WILUS) discussed that only semi-static configuration is referred to for determination of relevant repetitions, and dynamic signaling (e.g. dynamic SFI, CI) is not referred to.

2 companies (OPPO, Sharp) proposed that only symbols semi-statically configured as UL are used for determination of slots for PUSCH repetition.

1 company (CMCC) mentioned that confliction between PUSCH repetitions and other UL transmission (e.g. SRS) should be further clarified. One company (WILUS) mentioned that PUSCH repetition should be postponed when conflicting with a PUCCH repetition.

In current specification, UE does not expect to detect a DCI, indicating a PUCCH resource for HARQ-ACK in a later slot, if UE detects a DCI scheduling a PUSCH transmission in a previous slot and the HARQ-ACK information be multiplexed on the PUSCH transmission. 1 company (vivo) discussed that this timeline restriction should be removed by allowing puncturing of some PUSCH symbols.

1 company (Qualcomm) proposed that all slots for a PUSCH repetition shall be identified prior to the start of the first PUSCH transmission.

1 company (Intel) discussed that a time window can/limitation of postponing can be configured so that an excessive postponement is avoided. For the same purpose, several companies (Lenovo, Motorola Mobility) discussed that a repetition span can be configured in TDRA table so that an excessive postponement is avoided. One company (Samsung) also discussed that limitation on the number of postponing can be configured separately from TDRA.

1 company (LG) discussed adopting early stop of PUSCH repetition mechanism such as indication in DCI (e.g. New Data Indication and HARQ process ID), introduction of maximum time duration for PUSCH repetition, and dynamic indication of number of PUSCH repetition in addition to semi-static configuration.

2 companies (Panasonic, Xiaomi) discussed that early termination of the repetition should be considered, and DFI mechanism as in Rel-16 NR-U can be a starting point.

1 company (InterDigital) proposed supporting enhancement to enable fixed number of repetitions for a TB over one or more bundles.

1st round discussion

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| **FL observation 2-2:**  There seems to be several views on how to determine a given slot as available for PUSCH repetitions. E.g.,   * Only semi-static configurations are referred to for determination of whether or not a given slot as available for PUSCH repetitions for a postpone mechanism, * Dynamic signaling is also referred to for determination of whether or not a given slot as available for PUSCH repetitions for a postpone mechanism.   **FL proposal 2-2:**  For further discussions on definition of available slots for PUSCH repetitions for the postpone mechanism, the following terminology is used   * *Counted repetitions for a PUSCH repetition*: A set of the slots which are considered as available and counted according to the postpone mechanism. The number of counted repetitions is configured/indicated by gNB. * *Actual repetitions for a PUSCH repetition*: Transmission occasions with actual transmissions the UE performs for the PUSCH repetition.   + If there are transmission occasions without actual transmissions, the number of actual repetitions is smaller than the number of the transmission occasions.   **Question 2-2:**  Any views on the above proposal 2-2? | |
| **Company** | **Comment** |
| Samsung | The proposed definitions seem not to be needed. “Counted” or “Actual” is independent on how a slot is determined to be available.  We only need to decide whether a slot is considered available for UL transmission based on the tdd\_ul\_dl configuration or can be also adapted by SFI.  We support adaptation by SFI. It is a Rel-15 feature. Rel-16 already supports a similar functionality through the UL CI and even Rel-17 URLLC considers operation in conjunction with SFI despite the much higher reliability requirements. |
| Qualcomm | It may further help to identify at what point a slot is deemed to be available and when a repetition counter is incremented. |
| Apple | Try to understand the proposal, *counted repetitions for a PUSCH repe*tition just precludes the DL slots for unpaired spectrum case, and *actual repetitions* precludes some of UL slots which could not be used for transmission. |
| Intel | We are not sure whether we need to define actual repetition as in PUSCH repetition type B. In our view, for enhancement on PUSCH repetition type A, the available UL slots are only determined based on semi-static RRC configuration as dynamic indication may introduce misalignment between UE and gNB, which should be avoided. The introduction of actual repetition is unnecessary. |
| ZTE | In our view, if a slot is available, a repetition will be transmitted and counted, as long as it doesn’t exceed the number of configured/indicated number of repetitions. If one repetition would collide with some invalid symbols in a slot, the slot would be not an available slot. Thus, our understanding is Alt 2 below. |
| Panasonic | We support to use the terminology of “counted repetitions for a PUSCH repetition” and “actual repetitions for a PUSCH repetition”. The actual repetitions for a PUSCH repetition can be different from counted repetitions for a PUSCH repetition according to dynamic signalling such as SFI, CI, etc. |
| CATT | Seems like the 2nd and 4th line in our figure in Question 3.1.  At this stage, we are fine with the terminology of ‘Actual repetition’ since it helps understanding during the discussion. But it may not need to define ‘actual repetition’ at the end. Simple description should be enough, like (1) determine the UL available slots by semi-static RRC configuration. (2) Within these UL available slots, drop any slot if conflicted with dynamic indication. |
| OPPO | It is general problem of counting; we see it count only for the real transmission. |
| vivo | Agree FL that the counted repetition and the actual repetition number may be different. And even if some slots are not used for PUSCH repetition, e.g. due to SFI, CI, there are still counted in the repetition numbers. |
| Ericsson | In our view, we do not think it necessary to discuss the detail omission/cancellation rules in R16 for Type A PUSCH repetition.  As a start point, the available slot can be defined based on the rules to determine the subset of slots that is not omitted for actual PUSCH type A repetition transmission in R16, i.e. the following omission rules:  For PUSCH repetition Type A, a PUSCH transmission in a slot of a multi-slot PUSCH transmission is omitted according to the conditions in Clause 9, Clause 11.1 and Clause 11.2A of [6, TS38.213].  If addition rules are needed, we are open to further discuss. |

With the above terminology, companies’ preferences can be classified as follows:

Alt 1: Counted repetitions for a PUSCH repetition are determined by semi-static configuration (e.g. TDD configuration). Actual repetitions for a PUSCH repetition are determined as remaining counted repetitions after dropping according to dynamic signaling (e.g. SFI, CI, etc).

Alt 2: Counted repetitions for a PUSCH repetition are determined by semi-static configuration (e.g. TDD configuration) and dynamic signaling (e.g. SFI, CI, etc). Actual repetitions are the same as the counted repetitions.

1st round discussion

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| **FL proposal 2-2a:**  Adopt one of the following:   * Alt1: Whether or not a slot is considered as available for UL transmissions depends on tdd\_ul\_dl configuration and does not depend on SFI. * Alt2: Whether or not a slot is considered as available for UL transmissions depends on tdd\_ul\_dl configuration and also depends on SFI.   **Question 2-2a:**  Any views on the above proposal 2-2a? | |
| **Company** | **Comment** |
| Samsung | We support adaptation by SFI. It is a Rel-15 feature. Rel-16 already supports a similar functionality through the UL CI and even Rel-17 URLLC considers operation in conjunction with SFI despite the much higher reliability requirements. |
| Qualcomm | Support Alt 1. Please see response to Question 2-1 for justification. This is for eMBB/Voice traffic, and the latency considerations for URLLC are not required here. Its best to keep this specification straightforward. |
| Apple | Some cases are not considered by the proposal, such as UE specific UL/DL configuration, CI, PUSCH priority for URLLC.  From our side, the available slot simply means the slot with actual transmission. This is compliant what we agreed up to Rel.16. |
| Intel | We support Alt. 1. The issue of using dynamic SFI or CI to determine the available UL slot is that if UE mis-detects the DCI carrying dynamic indication, UE may have different understanding from gNB on which slots to be used for PUSCH repetitions. If we further consider postponement mechanism, this would introduce undesirable interference or even cross-link interference in the network.  We would also like to include “invalid UL symbols” as defined in Rel-16, which is also semi-statically configured, to determine the available UL slots. |
| China Telecom | Support Alt.1. In our view, the available UL slots semi-statically configured based on TDD frame structure is more robust. |
| NTT DOCOMO | We support Alt.1, since we have the same concern with Intel that if UE can’t detect DCI for SFI, UE and gNB may have different understanding for the PUSCH slots for repetition. |
| ZTE | Support Alt 2.  In our view, even dynamic SFI is configured, there would be no ambiguity on the number of repetitions among gNB and UE. Because, for DG PUSCH, no conflict between dynamic grant and SFI is expected in Rel-15. For CG PUSCH, the UE will not transmit on flexible symbols. So, there is no conflicts with SFI.  The Rel-15 collision handling rule is well summarized in R1-1913519, “Summary #4 of PUSCH enhancements for NR eURLLC (AI 7.2.6.3). Companies can further check whether dynamic SFI could cause problem based on the summary. |
| Panasonic | We support Alt.1. It is similar functionality to available slot determination in Rel.15/16 PUCCH repetition. |
| CATT | We support Alt.1 in principle.  However, tdd\_ul\_dl configuration may not be the only RRC parameter that should be considered when determining the UL available slot. Other semi-static RRC parameter should also be included. |
| Sharp | Support Alt. 1.  The other dynamic signaling/scheduling based factors, such as CI and PUSCH priority, should be treated in the same way as SFI. |
| NEC | Support Alt. 1. |
| WILUS | Support Alt. 1. Ambiguity between UE and gNB can occur when UE mis-detects DCI format 2\_0 with CRC scrambled by SFI-RNTI. |
| CMCC | Alt 1 is preferred.  As mentioned in our contribution, the available uplink slots should be determined based on semi-static RRC configurations, i.e. tdd-UL-DL-ConfigurationCommon and tdd-UL-DL-ConfigurationDedicated. The SFI indication may induce different understanding of the available uplink slots between gNB and UE and increase the complexity of the specification.  We are open to further consideration of the limitations induced by other semi-static RRC parameter. |
| OPPO | Alt 1. The SFI and other dynamic one should be carefully used, since it have implication of flexibility. |
| vivo | Support Alt. 1.  Since gNB is not aware of whether UE has correctly detected dynamic SFI, UE and NW may have different understandings on PUSCH transmission occasions and RV index of each PUSCH repetitions. |
| Ericsson | In our view, we do not think it necessary to discuss the detail omission/cancellation rules in R16 for Type A PUSCH repetition.  As a start point, the available slot can be defined based on the rules to determine the subset of slots that is not omitted for actual PUSCH type A repetition transmission in R16, i.e. the following omission rules:  For PUSCH repetition Type A, a PUSCH transmission in a slot of a multi-slot PUSCH transmission is omitted according to the conditions in Clause 9, Clause 11.1 and Clause 11.2A of [6, TS38.213].  If addition rules are needed, we are open to further discuss. |

# Special slot handling

4 companies (OPPO, Huawei, HiSilicon, Samsung) discussed that a slot can be identified as an available UL slot if it consists of sufficient number of consecutive uplink symbols, e.g. number of consecutive uplink symbols is larger than a predefined or configurable threshold. 1 company (China Telecom) discussed symbol allocation in a special slot can be different from the one for UL slots.

2 companies (OPPO, China Telecom) discussed that utilizing of special slot(s) improves performance especially in low SNR case.

2 companies (Huawei, HiSilicon) discussed that new rate matching is performed if the number of UL symbols in a special slot is smaller than the scheduled number of symbols for the PUSCH.

1st round discussion

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| **FL observation 2-3:**  There seems to be several views on how to handle special slots. In general, some companies discussed some special handling on the special slots while some other companies discussed it together with definition of available slots for PUSCH repetitions.  **FL proposal 2-3:**  Discuss further how to handle special slots:  Alt 1: Discuss special slots together with section 3.2. Definition of available slots for PUSCH repetitions.  Alt 2: Discuss special slots separately from section 3.2. Definition of available slots for PUSCH repetitions.  **Question 2-3:**  Any views on the above proposal 2-3? | |
| **Company** | **Comment** |
| Samsung | Alt. 1 |
| Qualcomm | Alt. 1 |
| Apple | We are fine with both alternatives. |
| Intel | Alt. 1 |
| China Telecom | Either way is OK. In our view, for coverage enhancement, one of the principles is to maximize the amount of time a UE can transmit continuously at maximum power. In this sense, it is necessary to include any UL resource in time domain for PUSCH transmission, especially for TDD. |
| ZTE | Alt. 1  Whether special slot can be decided as available slot belong to the definition of available slot. |
| Panasonic | Alt.1. |
| CATT | Fine with both alternatives. |
| Sharp | Alt. 1 |
| NEC | Alt. 1. |
| CMCC | Share similar view with China telecom that fully use of the uplink resource is more important and encouraged for the TDD system.  From the view of unified design, Alt 1 is slightly preferred. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Alt 1 |
| OPPO | Alt.1. Separation will bring more complexity. |
| vivo | Support Alt 1. And the same S and L within a slot is expected for enhanced type-A PUSCH repetition. Otherwise, type-B PUSCH repetition can be used. |
| Ericsson | Alt2.  More evaluations are needed on the benefit of using special slot. |

# PUSCH repetition mode configuration/indication

2 companies (China Telecom, Ericsson) discussed that Network should be able to configure one of two modes: Mode 1) the number of repetitions is counted on the basis of contiguous slots; and Mode 2) the number of repetitions is counted on the basis of available UL slots; by RRC. 3 companies (Panasonic, Lenovo, Motorola Mobility)) mentioned either RRC configuration or use of TDRA table can be considered for the mode indication.

1st round discussion

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| **FL observation 2-4:**  So far, only a few companies provided their views on configuration/indication of PUSCH repetition mode between:   * the number of repetitions counted on the basis of contiguous slots (i.e. legacy PUSCH repetition) * the number of repetitions counted on the basis of available slots for the PUSCH transmissions (i.e. enhanced PUSCH repetition)   There seems to be two options:   * Alt 1: Whether the counting is based on contiguous slots or available slots is configured by higher-layer configuration. * Alt 2: Whether the counting is based on contiguous slots or available slots is indicated by dynamic signaling.   **Question 2-4:**  Companies are invited to provide their views on PUSCH repetition mode configuration/indication. | |
| **Company** | **Comment** |
| Samsung | No need to discuss. In case of no postponing, the counting is based on contiguous slots. In case of postponing, the counting is based on available slots. |
| Qualcomm | Motivation to maintain two modes of counting is not clear. Needs sufficient justification. Else, prefer to go with the new mode that is being discussed currently.  @Samsung, a case of no postponing but based on available slots (using semi-static tdd ul-dl configurations) is also a possibility. |
| Apple | According to the WID, the counting is only based on available slot. So the proposal seems beyond the objective of this WI. |
| Intel | In our view, for FDD or TDD without semi-static UL/DL configuration, the number of repetitions is counted on the basis of contiguous slots. For TDD with semi-static UL/DL configuration, it can be either based on available UL slots or contiguous slots, which also depend on the UL/DL configurations. |
| China Telecom | For Rel-17, there are two kinds of UE behaviours: on the basis of contiguous slots (maximum number of repetitions increased to 32) and on the basis of available slots. Rel-17 UE may support only one of them or support both. If both of them is supported by Rel-17 UE, UE need to be indicated which one is configured. Otherwise, how can UE distinguish which should it follow? The signalling can be explicit or implicit. |
| ZTE | If a new RRC parameter is introduced for the enhancements, it could be automatically used for indication of using the enhancements. We don’t see a need to discuss this issue now. |
| Panasonic | Firstly, whether Rel.17 CE UEs support both modes (Rel.15/16 PUSCH repetition Type A and Rel.17 enhanced PUSCH repetition Type A) or not should be discussed and concluded. |
| CATT | We can discuss this later. |
| Sharp | According to WID, two modes are supported.   * Mode 1: Counting based on contiguous slots with increased maximum number of repetitions * Mode 2; Counting based on available slots with maximum number of repetitions = 16 |
| NEC | We support Alt.1. |
| CMCC | We do not see any motivation to maintain two modes and change the mode during the procedure. The new defined mode could work in both TDD and FDD system. If a UE is updated to Rel-17, it should support the new defined mode. |
| OPPO | No further configurability is needed. We can decide to how to define the available slots. |
| vivo | Alt. 1.  In our view, there is no need to support two modes on PUSCH repetition at the same time. |
| Ericsson | RRC signaling in *pusch-config* is needed to indicate whether a legacy, or an option 1 or an option2 PUSCH repetition Type A should be used when a Type A repetition is configured, in a similar way as the RRC configuration to indicate PUSCH repetition type in R16 (TypeA or Type B) in *pusch-config*. |

# Appendix

# References

1. R1-2100095 Discussion on enhanced PUSCH repetition type A ZTE
2. R1-2100172 Enhancements on PUSCH repetition type A OPPO
3. R1-2100196 Coverage enhancements for PUSCH repetition typeA Huawei, HiSilicon
4. R1-2100397 Discussion on enhancements on PUSCH repetition type A CATT
5. R1-2100457 Discussion on enhancement for PUSCH repetition type A vivo
6. R1-2100665 Enhancements on PUSCH repetition type A Intel Corporation
7. R1-2100712 Discussions on PUSCH repetition type A enhancements LG Electronics
8. R1-2100731 PUSCH repetition for coverage enhancements InterDigital, Inc.
9. R1-2100915 Enhancements on PUSCH repetition type A China Telecom
10. R1-2100942 Discussion on enhancements on PUSCH repetition type A NEC
11. R1-2101001 Enhancements on PUSCH repetition type A Lenovo, Motorola Mobility
12. R1-2101017 Discussion on enhancements on PUSCH repetition Type A Panasonic Corporation
13. R1-2101055 Discussion on enhancements on PUSCH repetition type A CMCC
14. R1-2101127 Enhancements on PUSCH repetiton type A Xiaomi
15. R1-2101221 Enhancements on PUSCH repetition type A Samsung
16. R1-2101327 Design Considerations for Enhancements on PUSCH repetition Sierra Wireless, S.A.
17. R1-2101395 Discussion on PUSCH repetition type A enhancement Apple
18. R1-2101407 PUSCH Repetitions for Coverage Enhancement Indian Institute of Tech (H)
19. R1-2101477 Enhancements on PUSCH repetition type A Qualcomm Incorporated
20. R1-2101520 PUSCH Repetition Type A Enhancement Ericsson
21. R1-2101545 Enhancements on PUSCH repetition type A Sharp
22. R1-2101641 Enhancements on PUSCH repetition type A NTT DOCOMO, INC.
23. R1-2101656 Enhancements on PUSCH repetiton type A Xiaomi
24. R1-2101679 Discussion on enhancements on PUSCH repetition type A WILUS Inc.
25. R1-2101710 Enhancements on PUSCH repetition type A Nokia, Nokia Shanghai Bell