**3GPP TSG RAN WG1 #111 R1-221XXXX**

**Toulouse, France, November 14th – 18th, 2022**

**Agenda Item:** 8.2

**Source:** Moderator (LG Electronics)

**Title:** Summary #1 of PDSCH/PUSCH enhancements (Scheduling/HARQ)

**Document for:** Discussion and decision

# Introduction

This is the summary document for 8.2 on PDSCH/PUSCH enhancements (especially for scheduling and HARQ) for NR above 52.6 GHz, based on the contributions listed in reference section.

# Issue#1: Last DCI determination for multi-PDSCH scheduling and single PDSCH scheduling in same MO

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| Company | Views |
| [1] ZTE | In Rel-16 CA/DC enhancements, cross carrier scheduling with different SCS for scheduling cell and scheduled cell was introduced. When the scheduling cell has smaller SCS than the scheduled cell, multiple DCIs for PDSCH scheduling for a scheduled cell can be transmitted in the same PDCCH monitoring occasion in the scheduling cell, depending on the UE capability. In legacy single PDSCH scheduling, a DCI can schedule only one PDSCH. When multi-PDSCH scheduling is configured for a scheduled cell, a DCI can schedule more than one PDSCHs in a scheduled cell. For Type-2 codebook, two sub-codebooks are included, where one is for the single PDSCH scheduling and the other one is for the multi-PDSCH scheduling. When the two sub-codebooks are indicated in the same slot, the two sub-codebooks are concatenated and transmitted in the PUCCH resource indicated by the last DCI. DAI counting is separate for the two sub-codebooks. It means that there are respective last DCIs for the two sub-codebooks, i.e., the last DCI for single PDSCH scheduling and the last DCI for multi-PDSCH scheduling. If the last DCI for single PDSCH scheduling and the last DCI for multi-PDSCH scheduling are transmitted in the different monitoring occasion, it is clear that the DCI transmitted in the later monitoring occasion is the last DCI for PUCCH resource determination. However, if last DCI for single PDSCH scheduling and the last DCI for multi-PDSCH scheduling are transmitted in the same monitoring occasion, which one is the last DCI for PUCCH resource determination is not clear.***Observation 1:*** *Which one is the last DCI for PUCCH resource determination is not clear when the last DCI for single PDSCH scheduling and the last DCI for multi-PDSCH scheduling are transmitted in the same monitoring occasion*In the current specification, the mechanism for counter DAI order for a sub-codebook is defined as below.

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| A value of the counter downlink assignment indicator (DAI) field in DCI formats denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pairs in which PDSCH receptions, excluding PDSCH receptions that provide only transport blocks for HARQ processes associated with disabled HARQ-ACK information if *downlinkHARQ-FeedbackDisabled* is provided, or HARQ-ACK information bits that are not in response for PDSCH receptions, associated with the DCI formats, excluding the SPS activation DCI, is present up to the current serving cell and current PDCCH monitoring occasion, - first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH reception on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair, - second in ascending order of serving cell index, and - third in ascending order of PDCCH monitoring occasion index $m$, where $0\leq m<M$.  |

In general, the DCI with the largest counter DAI is the last DCI for a sub-codebook. In our understanding, the mechanism of DAI order should be used to determine the last DCI and PUCCH resource across the two sub-codebooks. When the last DCI for single PDSCH scheduling and the last DCI for multi-PDSCH scheduling are transmitted on the same PDCCH monitoring occasion for a scheduled cell, the serving cell index can be reused to determine the last DCI and PUCCH resource. If the scheduled serving cell are the same, the PDSCH starting time can be reused to determine the last DCI and PUCCH resource. Among the multiple scheduled PDSCHs, the first PDSCH should be used. An example is shown in Figure 1. DCI 1 and DCI 2 are transmitted on the same PDCCH monitoring occasion. DCI 1 schedules PDSCH 1 and PDSCH 2, and PDSCH 3. DCI 2 schedules PDSCH 4. Among PDSCH 1, PDSCH 2, and PDSCH 3, the starting time of PDSCH 1 should be used to determine the last DCI. DCI 2 should be the last DCI since the PDSCH 4 has later starting time. Figure 1 An example of single PDSCH scheduling and multi-PDSCH scheduling***Proposal 1:*** *The mechanism of DAI order should be reused for last DCI determination across sub-codebooks.*9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel**<Unchanged parts are omitted>**A value of the counter downlink assignment indicator (DAI) field in DCI formats denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pairs in which PDSCH receptions, excluding PDSCH receptions that provide only transport blocks for HARQ processes associated with disabled HARQ-ACK information if *donwlinkHARQ-FeedbackDisabled* is provided, or HARQ-ACK information bits that are not in response for PDSCH receptions, associated with the DCI formats, excluding the SPS activation DCI, is present up to the current serving cell and current PDCCH monitoring occasion, - first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH reception on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair, - second in ascending order of serving cell index, and - third in ascending order of PDCCH monitoring occasion index $m$, where $0\leq m<M$. If a UE is provided *PDSCH-TimeDomainResourceAllocationListForMultiPDSCH* and multiple DCIs are transmitted in the same PDCCH monitoring occasion, the UE determines the PUCCH resource for transmission indicated by a DCI that schedules a PDSCH in a serving cell with the largest cell index, and schedules a PDSCH or multiple PDSCHs with the latest starting time for the first PDSCH if more than one DCIs schedule PDSCH on the serving cell with the largest cell index.**<Unchanged parts are omitted>** |

## [Moderator’s note] One company pointed out that the current specification for type-2 HARQ-ACK codebook generation can be ambiguous in terms of last DCI determination (to derive PUCCH resource) when multi-PDSCH scheduling DCI and single PDSCH scheduling DCI are detected in the same monitoring occasion.

# (E) Issue#2: Frequency hopping for PUSCH and SRS in FR2-2

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| Company | Views |
| [2] NTT DOCOMO | **Reason for change**:For both PUSCH and SRS, frequency hopping is supported. Meanwhile, as per the outcome Rel-16 NR-U, available frequency domain resources for each hop are restricted within a single RB set for operation with shared spectrum channel access, without any differentiation of frequency range. In Rel-17, NR supports FR2-2 (i.e., 52.6 – 71 GHz range), where there is unlicensed bands, while the concept of RB set is not essential. In this band, there is no need to restrict the frequency domain resource available for hops used for frequency hopping. **Summary of change**:Clarify that restriction of frequency domain resource for each hop in case of frequecy hopping within a RB set is applicable to FR1 only. |

## [Moderator’s note] TP (from [2]) that restricts hopping within a RB set to only FR1 unlicensed operation seems straight-forward.

# Reference

1. R1-2211635 Discussion on last DCI determination for multi-PDSCH scheduling and single PDSCH scheduling ZTE
2. R1-2211954 Draft CR on frequency hopping for PUSCH and SRS in FR2-2 NTT DOCOMO, INC.

# TPs

## TP#A (TBA)