3GPP TSG-RAN WG1 Meeting #101-e R1-20xxxxx

e-Meeting, May 25th – June 5th, 2020

Agenda Item: 6.2.1.3

Source: Moderator (Ericsson)

Title: Feature lead summary for Multi-TB scheduling for LTE-MTC

Document for: Discussion, Decision

# Introduction

This document provides a summary of the issues raised in contributions [1][2][3][4].

# Issue #1: TDD HARQ-ACK bundling mechanism

RAN1#100bis-e discussed the TDD HARQ-ACK bundling mechanism for multi-TB scheduling without reaching a conclusion. The background and discussion are documented in the section about Issue #5 in [5]. Qualcomm contribution [2] provides the 36.212/213 TPs below. For detailed discussion, see contribution [2].

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| **--------------------------------------------Start of Text Proposal for 36.212-----------------------------------------**5.3.3.1.12 Format 6-1A**<Unchanged parts are omitted>**- Downlink Assignment Index – number of bits as specified in Table 5.3.3.1.2-2. This field is reserved when *multi-TB-DL-config* is enabled and multiple TBs are scheduled, or when the configured maximum repetition number is larger than 1 for MPDCCH, and not present when the format 6-1A CRC is scrambled with G-RNTI, or when the higher layer parameter *csi-NumRepetitionCE-r13* indicates more than one subframe.**<Unchanged parts are omitted>****--------------------------------------------End of Text Proposal for 36.212-----------------------------------------****--------------------------------------------Start of Text Proposal for 36.213-----------------------------------------**7.3.2.1 TDD HARQ-ACK reporting procedure for same UL/DL configuration**<Unchanged parts are omitted>**For TDD and a BL/CE UE,- if the UE is configured with *multi-TB-DL-config*, and multiple TBs are scheduled by a single DCI- the UE is not expected to receive any other PDSCH transmission(s) or MPDCCH indicating downlink SPS releases, corresponding to which the UE shall report HARQ-ACK in any subframe(s) in which HARQ-ACKs are reported for the multiple TBs scheduled by the single DCI, according to subclause 10.2- The UE behaviour for HARQ-ACK reporting is the same as that of a BL/CE UE with FDD, except:- PUCCH resource(s) is (are) determined according to Subclause 10.1.3.1; and- PUCCH(s) is (are) transmitted in a set of BL/CE UL subframe(s) according to Subclause 10.2 for TDD and BL/CE UEs.- else if, the UE is configured with *csi-NumRepetitionCE* equal to 1 and *mPDCCH-NumRepetition* equal to 1,- the UE behaviour for HARQ-ACK reporting is the same as that of a non-BL/CE UE with TDD, except:- PDCCH/EPDCCH is replaced by MPDCCH; and- DCI format 1/1A/1B/1D/2/2A/2B/2C/2D is replaced by DCI format 6-1A; and- DCI format 0/4 is replaced by DCI format 6-0A; and- PUCCH is transmitted in a set of BL/CE UL subframe(s) according to Subclause 10.2 for TDD and BL/CE UEs;- else- the UE is not expected to receive more than one PDSCH transmission, or more than one of PDSCH and MPDCCH indicating downlink SPS releases, with transmission ending within subframe(s) , where  and  is defined in Table 10.1.3.1-1 intended for the UE; - The UE behavior for HARQ-ACK reporting is the same as that of a BL/CE UE with FDD, except:- PUCCH resource is determined according to Subclause 10.1.3.1; and- PUCCH is transmitted in a set of BL/CE UL subframe(s) according to Subclause 10.2 for TDD and BL/CE UEs.**<Unchanged parts are omitted>**10.1.3 TDD HARQ-ACK feedback procedures**<Unchanged parts are omitted>** For TDD and a BL/CE UE, - if the UE is configured with *csi-NumRepetitionCE* equal to 1 and *mPDCCH-NumRepetition* equal to 1,- the UE may be configured with HARQ-ACK bundling or HARQ-ACK multiplexing;- HARQ-ACK multiplexing can be configured only if *pucch-NumRepetitionCE-format1* equal 1 and HARQ-ACK multiplexing is performed according to the set of Tables 10.1.3-5/6/7- else- the UE is not expected to receive more than one PDSCH transmission, or more than one of PDSCH and MPDCCH indicating downlink SPS releases, with transmission ending within subframe(s) , where  and  is defined in Table 10.1.3.1-1 intended for the UE; For TDD and a BL/CE UE,- if multiple TBs are not scheduled by a single DCI- if the UE is configured with *csi-NumRepetitionCE* equal to 1 and *mPDCCH-NumRepetition* equal to 1,- the UE may be configured with HARQ-ACK bundling or HARQ-ACK multiplexing;- HARQ-ACK multiplexing can be configured only if *pucch-NumRepetitionCE-format1* equal 1 and HARQ-ACK multiplexing is performed according to the set of Tables 10.1.3-5/6/7- else- the UE is not expected to receive more than one PDSCH transmission, or more than one of PDSCH and MPDCCH indicating downlink SPS releases, with transmission ending within subframe(s) , where  and  is defined in Table 10.1.3.1-1 intended for the UE; **<Unchanged parts are omitted>****--------------------------------------------End of Text Proposal for 36.213-----------------------------------------** |

1. Consider the above 36.212/213 TPs for TDD HARQ-ACK bundling.

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| **Company** | **Comments on Proposal 1** |
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# Issue #2: Determination of number of TBs

Huawei/HiSilicon contribution [1] provides text proposals for clarification of the determination of the number of scheduled TBs has not been specified. For detailed discussion, see contribution [1].

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| **--------------------------------------------Start of Text Proposal for 36.212-----------------------------------------**5.3.3.1.10 Format 6-0A**<Unchanged parts are omitted>**- Scheduling TBs for Unicast – 12 bits. This field is only present if *multi-TB-UL-config* is enabled and the DCI is mapped onto the UE-specific search space given by C-RNTI as defined in [3]. The scheduled TB number is defined in clause 8 of [3].**<Unchanged parts are omitted>**5.3.3.1.11 Format 6-0B**<Unchanged parts are omitted>**- Scheduling TBs for Unicast – 10 bits. This field is only present if *multi-TB-UL-config* is enabled and the DCI is mapped onto the UE-specific search space given by C-RNTI as defined in [3]. The scheduled TB number is defined in clause 8 of [3].**<Unchanged parts are omitted>**5.3.3.1.12 Format 6-1A**<Unchanged parts are omitted>**- Scheduling TBs for Unicast – 12 bits. This field is only present if *multi-TB-DL-config* is enabled and the DCI is mapped onto the UE-specific search space given by C-RNTI as defined in [3]. The scheduled TB number is defined in clause 7 of [3].**<Unchanged parts are omitted>**5.3.3.1.13 Format 6-1B**<Unchanged parts are omitted>**- Scheduling TBs for Unicast – 10 bits. This field is only present if *multi-TB-DL-config* is enabled and the DCI is mapped onto the UE-specific search space given by C-RNTI as defined in [3]. The scheduled TB number is defined in clause 7 of [3].**<Unchanged parts are omitted>****-------------------------------------------End of Text Proposal for 36.212-------------------------------------------****-------------------------------------------Start of Text Proposal for 36.213-----------------------------------------**7 Physical downlink shared channel related procedures**<Unchanged parts are omitted>**A BL/CE UE configured with CEModeB is not expected to support more than 4 downlink HARQ processes if the UE is configured with higher layer parameter *multi-TB-DL-config,* 2 downlink HARQ processes otherwise. For TDD and a BL/CE configured with CEModeA, the maximum number of downlink HARQ processes for a serving cell shall be determined as indicated in Table 7-3.For a BL/CE UE configured in CEModeA, if the UE is configured with higher layer parameter *multi-TB-DL-config,* the scheduled TB number is determined from the value of the Scheduling TBs for Unicast field of the corresponding DCI of format 6-1A:- if the bit values of {*b0, b1, b2, b3, b4*} are set to all 0, ; - if the bit values of {*b0, b1, b2, b3, b4, b5, b6, b7*} range from 00001000 to 00100100, ;- if the bit values of {*b0, b1, b2, b3, b4, b5, b6, b7*} range from 00100101 to 01101011, ;- if the bit values of {*b0, b1, b2, b3, b4, b5*} range from 011011 to 110110, ;- if the bit values of {*b0, b1, b2*} are set to all 1, .For a BL/CE UE configured in CEModeB, if the UE is configured with higher layer parameter *multi-TB-DL-config,* the scheduled TB number is determined from the value of the Scheduling TBs for Unicast field of the corresponding DCI of format 6-1A:- if the bit values of {*b0, b1, b2, b3, b4, b5, b6*} range from 0000000 to 0001010, ; - if the bit values of {*b0, b1, b2, b3, b4*} range from 00011 to 01101, ;- if the bit values of {*b0, b1, b2, b3, b4*} range from 01111 to 11001, ;- if the bit values of {*b0, b1, b2, b3, b4, b5*} range from 110100 to 111110, .**<Unchanged parts are omitted>**8 Physical uplink shared channel related procedures**<Unchanged parts are omitted>**A BL/CE UE is not expected to be configured with simultaneous PUSCH and PUCCH transmission.For a BL/CE UE configured in CEModeA, if the UE is configured with higher layer parameter *multi-TB-UL-config,* the scheduled TB number is determined from the value of the Scheduling TBs for Unicast field of the corresponding DCI of format 6-0A:- if the bit values of {*b0, b1, b2, b3, b4*} are set to all 0, ; - if the bit values of {*b0, b1, b2, b3, b4, b5, b6, b7*} range from 00001000 to 00100100, ;- if the bit values of {*b0, b1, b2, b3, b4, b5, b6, b7*} range from 00100101 to 01101011, ;- if the bit values of {*b0, b1, b2, b3, b4, b5*} range from 011011 to 110110, ;- if the bit values of {*b0, b1, b2*} are set to all 1, .For a BL/CE UE configured in CEModeB, if the UE is configured with higher layer parameter *multi-TB-UL-config,* the scheduled TB number is determined from the value of the Scheduling TBs for Unicast field of the corresponding DCI of format 6-0B:- if the bit values of {*b0, b1, b2, b3, b4, b5, b6*} range from 0000000 to 0001010, ; - if the bit values of {*b0, b1, b2, b3, b4*} range from 00011 to 01101, ;- if the bit values of {*b0, b1, b2, b3, b4*} range from 01111 to 11001, ;- if the bit values of {*b0, b1, b2, b3, b4, b5*} range from 110100 to 111110, .**<Unchanged parts are omitted>****-------------------------------------------End of Text Proposal for 36.213-------------------------------------------** |

1. Consider the above 36.212/213 TPs for determination of number of TBs.

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| **Company** | **Comments on Proposal 2** |
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# Issue #3: Clarification of sub-PRB symbol counter reset

RAN1#100e agreed on a 36.211 clarification regarding symbol counter reset for NB-IoT. Huawei/HiSilicon contribution [1] proposes the following corresponding clarification for LTE-MTC.

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| 5.6A.2 Modulation scheme π/2-BPSK**<Unchanged parts are omitted>**where is the number of transport blocks defined in clause 8.0 of 3GPP TS 36.213 [4]. If >1 and interleaving between codewords is applied according to clause 8.0 of 3GPP TS 36.213 [4], then the symbol counter  is reset at the start of the first PUSCH codeword transmission and incremented for each symbol during the transmission of the PUSCH codewords . For other cases, the symbol counter  is reset at the start of each PUSCH codeword transmission and incremented for each symbol during the transmission of the PUSCH codeword.**<Unchanged parts are omitted>** |

1. Consider the above 36.211 TP for clarification of sub-PRB symbol counter reset.

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| **Company** | **Comments on Proposal 3** |
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# Issue #4: Clarification of SPS handling

During the RAN1#100bis-e email discussion “[100b-e-LTE-NB\_IoTenh3-Multi-TB-02]” for NB-IoT, it was noted that there may be a need to clarify e.g. the DCI encoding in case of simultaneous configuration of SPS and the multi-TB feature also for LTE-MTC. Qualcomm contribution [2] provides the 36.212 text proposal below.

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| 5.3.3.1.10 Format 6-0A**<Unchanged parts are omitted>**- Scheduling TBs for Unicast – 12 bits. This field is only present if *multi-TB-UL-config* is enabled and the DCI is mapped onto the UE-specific search space given by C-RNTI as defined in [3]. This field schedules one TB if the CRC of the DCI is scrambled by SPS C-RNTI.- If one TB is scheduled- 5 bits set to zero- HARQ process number – 3 bits- New data indicator – 1 bit- Redundancy version – 2 bits- Frequency hopping flag – 1 bit, where value 0 indicates frequency hopping is not enabled and value 1 indicates frequency hopping is enabled as defined in clause 5.3.4 of [2]. If frequency hopping is not enabled by higher layers, this field is set to 0.- If two TBs are scheduled- 2 bits set to zero- HARQ index with offset – 6 bits provide the HARQ index + offset, with an offset of +8 and HARQ index as defined in 8.0 of [3]- New data indicators – 2 bits, one for each scheduled TB in increasing order of HARQ process ID- Redundancy version for TB 1 – 1 bit- Redundancy version for TB 2 – 1 bit. If Repetition number is > 1 and frequency hopping is enabled by higher layers then this bit is a Frequency hopping flag for the TBs, and TB2 uses the redundancy version for TB1.- If four TBs are scheduled- 1 bit set to zero- HARQ index with offset – 7 bits provide the HARQ index + offset, with an offset of +36 and HARQ index as defined in 8.0 of [3]- New data indicators – 4 bits, one for each scheduled TB in increasing order of HARQ process ID- If six TBs are scheduled- HARQ index with offset – 6 bits provide the HARQ index + offset, with an offset of +27 and HARQ index as defined in 8.0 of [3]- New data indicators – 6 bits, one for each scheduled TB in increasing order of HARQ process ID- If eight TBs are scheduled- 3 bits set to one- New data indicators – 8 bits, one for each scheduled TB in increasing order of HARQ process ID- Redundancy version for all TBs – 1 bit. If Repetition number is > 1 and frequency hopping is enabled by higher layers then this bit is a Frequency hopping flag for the TBs, and the redundancy version for all TBs starts at 0.**<Unchanged parts are omitted>**5.3.3.1.12 Format 6-1A**<Unchanged parts are omitted>**- Scheduling TBs for Unicast – 12 bits. This field is only present if *multi-TB-DL-config* is enabled and the DCI is mapped onto the UE-specific search space given by C-RNTI as defined in [3]. This field schedules one TB if the CRC of the DCI is scrambled by SPS C-RNTI.- If one TB is scheduled- 5 bits set to zero- HARQ process number – 3 bits- New data indicator – 1 bit- Redundancy version – 2 bits- Frequency hopping flag – 1 bit, where value 0 indicates frequency hopping is not enabled and value 1 indicates frequency hopping is enabled as defined in clause 6.4.1 of [2]. If the UE is configured with 64QAM for PDSCH and the repetition number field indicates no PDSCH repetition, this field is the MSB bit of the extended Modulation and coding scheme field, as specified in Table 7.1.7.1-1 of [3]. If the UE is not configured with 64QAM for PDSCH and frequency hopping is not enabled by higher layers, this field is set to 0.- If two TBs are scheduled- 2 bits set to zero- HARQ index with offset – 6 bits provide the HARQ index + offset, with an offset of +8 and HARQ index as defined in 7.1.7.2 of [3]- New data indicators – 2 bits, one for each scheduled TB in increasing order of HARQ process ID- Redundancy version for TB 1 – 1 bit- Redundancy version for TB 2 – 1 bit. If the UE is configured with 64QAM for PDSCH and the repetition number field indicates no PDSCH repetition then this bit is the MSB bit of the extended Modulation and coding scheme field. If Repetition number is > 1 and frequency hopping is enabled by higher layers then this bit is a Frequency hopping flag for the TBs. In these cases TB2 uses the redundancy version for TB1.- If four TBs are scheduled- 1 bit set to zero- HARQ index with offset – 7 bits provide the HARQ index + offset, with an offset of +36 and HARQ index as defined in 7.1.7.2 of [3]- New data indicators – 4 bits, one for each scheduled TB in increasing order of HARQ process ID- If six TBs are scheduled- HARQ index with offset – 6 bits provide the HARQ index + offset, with an offset of +27 and HARQ index as defined in 7.1.7.2 of [3]- New data indicators – 6 bits, one for each scheduled TB in increasing order of HARQ process ID- If eight TBs are scheduled- 3 bits set to one- New data indicators – 8 bits, one for each scheduled TB in increasing order of HARQ process ID- Redundancy version for all TBs – 1 bit. If the UE is configured with 64QAM for PDSCH and the repetition number field indicates no PDSCH repetition then this bit is the MSB bit of the extended Modulation and coding scheme field. If Repetition number is > 1 and frequency hopping is enabled by higher layers then this bit is a Frequency hopping flag for the TBs. In these cases the redundancy version for all TBs starts at 0.**<Unchanged parts are omitted>** |

1. Consider the above 36.212 TP on SPS handling.

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| **Company** | **Comments on Proposal 4** |
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# Issue #5: No scheduling gap after last SC-MTCH TB

RAN1#100e agreed to eliminate the scheduling gap insertion after the last TB in a SC-MTCH multi-TB transmission for NB-IoT. ZTE contribution [3] provides a 36.213 TP for a similar change for LTE-MTC. For detailed discussion, see contribution [3].

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| 7.1.11 PDSCH subframe assignment for BL/CE UE**<Unchanged parts are omitted>**- for , - if the UE is configured with higher layer parameter *multi-TB-DL-Unicast-Interleaving-config*, and PDSCH corresponding to a MPDCCH with DCI CRC scrambled by C-RNTI and where  for BL/CE UE configured with CEModeA,  for BL/CE UE configured with CEModeB, - BL/CE DL subframes  with  are associated with TB*r+*1 ,- otherwise,- BL/CE DL subframes  with  are associated with TB*r+*1 ,.- for  and PDSCH corresponding to an MPDCCH with DCI CRC scrambled by G-RNTI,- If higher layer parameter *multiTB-Gap* is configured*,* a scheduling gap with a length equal to the indicated value of *multiTB-Gap* is inserted between TB*r* and TB*r+*1, *r=*0,2.*..,NTB*-2*.***<Unchanged parts are omitted>** |

1. Consider above 36.213 TP for removal of scheduling gap after last SC-MTCH TB.

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| **Company** | **Comments on Proposal 5** |
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# Issue #6: TDD DL HARQ process indication

ZTE contribution [3] proposes that the DCI size should be the same for all TDD UL/DL configurations when the multi-TB feature is configured. For detailed discussion, see contribution [3].

1. Discuss and decide whether to specify that the DCI size should be the same for all TDD UL/DL configurations when the multi-TB feature is configured.
* Note: No TP has been provided.

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| **Company** | **Comments on Proposal 6** |
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According to the current specification, the HARQ/NDI/HF/RV encoding in CE mode A uses joint encoding in FDD and in all TDD UL/DL configurations. ZTE contribution [3] proposes that the UL HARQ/NDI/FH/RV encoding uses bitmaps instead of joint encoding when the maximum number of UL HARQ processes is no larger than 4, i.e. for TDD UL/DL configurations 1-5. For detailed discussion, see contribution [3].

1. Discuss and decide whether to modify the UL HARQ/NDI/FH/RV encoding to use bitmaps instead of joint encoding when the maximum number of UL HARQ processes is no larger than 4, i.e. for TDD UL/DL configurations 1-5.
* If the answer is yes, the 36.212 TP in [3] can be used as a starting point.

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| **Company** | **Comments on Proposal 7** |
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According to the current specification for the DL HARQ processing grouping for HARQ-ACK bundling in TDD, the 1st group contains the first 8 processes and the 2nd group contains the remaining up to 8 processes. ZTE contribution [3] proposes that the DL HARQ process grouping in TDD is modified so that the 2nd group contains the last 8 HARQ processes, meaning that there can be an overlap between the 2 groups in case the total number of processes is less than 16. For detailed discussion, see contribution [3].

1. Discuss and decide whether to modify the DL HARQ process grouping so that the 2nd group always contains the last 8 HARQ processes.
* If the answer is yes, the 36.213 TP in [3] can be used as a starting point.

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| **Company** | **Comments on Proposal 8** |
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# Issue #7: Realization of UL early termination

ZTE [3] and Ericsson [4] discuss the realization of UL early termination. ZTE proposes to specify DCI support for indicating that individual HARQ process(es) should be terminated (rather than always all of them), whereas Ericsson proposes to check whether some updates in 36.213 are needed in order to ensure that the UE monitors the DL for DCI transmissions during the UL resource reservation gaps. For detailed discussion, see contributions [3] and [4].

1. Discuss and decide whether to specify DCI support for indicating that individual HARQ process(es) should be terminated.
* If the answer is yes, the 36.212/213 TPs in [3] can be used as a starting point.

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| **Company** | **Comments on Proposal 9** |
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1. Discuss and decide whether some updates in 36.213 are needed in order to ensure that the UE monitors the DL for DCI transmissions during the UL resource reservation gaps.
* Note: No TP has been provided.

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| **Company** | **Comments on Proposal 10** |
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# Issue #8: TB interleaving pattern with frequency hopping

Qualcomm contribution [2] points out that the currently specified interleaving pattern is the same irrespective of whether frequency hopping is enabled or not and notes that this means that some combinations do not enjoy frequency hopping gains and proposes to adopt the following tables for the TB interleaving patters with frequency hopping in CE mode A and B, respectively. For detailed discussion, see contribution [2].

Table FH-IL-CEModeA: TB interleaving pattern with frequency hopping for CE Mode A with 2 NBs. The cells highlighted in orange correspond to configurations where the interleaving pattern needs to be changed. In each orange cell, an entry of the type corresponds to an interleaving pattern that repeats with the unit across subframes.

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|  **(Number of narrowbands)** |  |  |  |  |  |
| **(Hopping Interval)** |  | *(cyclic shift = 1)* | *(cyclic shift = 1)* | *(cyclic shift = 1)* | *(cyclic shift = 1)* |
| **(Hopping Interval)** |  |  | *(cyclic shift = 2)* |  | *(cyclic shift = 2)* |
| **(Hopping Interval)** |  |  |  |  | *(cyclic shift = 4)* |
| **(Hopping Interval)** |  |  |  |  |  |

Table FH-IL-CEModeB: TB interleaving pattern with frequency hopping for CE Mode B with 2 NBs. Cells highlighted in orange correspond to configurations where the interleaving pattern needs to be changed.

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|  **(Number of narrowbands)** |  |  |  |  |
| **(Hopping Interval)** |  |  |  |  |
| **(Hopping Interval)** |  | *(cyclic shift = 1)* |  | *(cyclic shift = 1)* |
| **(Hopping Interval)** |  |  |  | *(cyclic shift = 2)* |
| **(Hopping Interval)** |  |  |  |  |

1. Consider the above tables for TB interleaving pattern with frequency hopping.
* Note: No TP has been provided.

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| **Company** | **Comments on Proposal 11** |
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# Issue #9: Clarification of CSI reporting

Ericsson contribution [4] proposes to discuss an issue with the CSI reporting that was originally brought up in an earlier ZTE contribution [6], where it is proposed that the CSI report is carried in the first TB and that other details are the same as in legacy operation.

1. Discuss and decide on the proposal that the CSI report is carried in the first TB and that other details are the same as in legacy.
* Note: No TP has been provided.

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| **Company** | **Comments on Proposal 12** |
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# References

1. [R1-2003540](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003540.zip), “Corrections on scheduling of multiple transport blocks”, Huawei, HiSilicon

1. [R1-2003782](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003782.zip), “Scheduling of multiple DL/UL transport blocks”, Qualcomm Incorporated

1. [R1-2003792](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2003792.zip), “Remaining issues on scheduling enhancement for MTC”, ZTE

1. [R1-2004656](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_101-e/Docs/R1-2004656.zip), “Corrections for Multi-TB scheduling for LTE-MTC”, Ericsson

1. [R1-2002796](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002796.zip), “Feature lead summary #2 for Multi-TB scheduling for LTE-MTC”

1. [R1-2001852](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2001852.zip), “Remaining issues on scheduling enhancement for MTC”, ZTE