**3GPP TSG-RAN WG2 Meeting #124R2-2313673**

**Chicago, US, 13 – 17 November 2023**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *CR-Form-v12.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.300** | **CR** | **0742** | **rev** | **1** | **Current version:** | **17.6.0** |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
|  | | | | | | | | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Proposed change affects:*** | UICC apps |  | ME | **x** | Radio Access Network | **x** | Core Network |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | | | | |
| ***Title:*** | Introduction of MIMO evolution for Downlink and Uplink | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | NTT DOCOMO, INC. | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** |  | | | | |  | ***Date:*** | | | 2023-12-01 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | B |  | | | | | ***Release:*** | | | Rel-18 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18)*  *Rel-19 (Release 19)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Introduction of following features discussed in Rel-18 WI: MIMO Evolution for Downlink and Uplink: 2-TA enhancement for multi-DCI. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | [2-TA enhancement for multi-DCI]  Descriptions for 2-TA enhancement for multi-DCI agreed in RAN1 and RAN2 up to RAN1#114 and RAN2#123 are introduced.  1. In 6.12, descriptions for 2-TA multi-TRP operation are added based on following agreement in RAN1#113.   |  | | --- | | RAN1#113  Agreement  *For associating TAGs to target UL channels/signals for multi-DCI based multi-TRP operation, the baseline feature is revised as follows:*   * *UE expects that the ~~[activated]~~UL/joint TCI states ~~[~~of UL signals/channels~~]~~associated to one CORESET Pool Index correspond to one TAG* * *Association of TAG ID with UL/joint TCI state is via RRC configuration*    + *Above does not impact the association of the indicated TCI states and coresetPoolIndex values as agreed in previous meetings in 9.1.1.1.* |   2. In 9.2.6, descriptions for indication of TAG ID during RA procedure are added based on following agreements.   |  | | --- | | RAN1#114  **Agreement**  For intra-cell multi-DCI based Multi-TRP operation with two TA enhancement and PDCCH order CFRA, indicate a representation of the TAG ID with 1 bit (either the first TAG ID or the second TAG ID for the serving cell) as part of TA command in RAR  Note: For intra-cell multi-DCI based Multi-TRP operation, only a single *NTA,offset* is configured. | | RAN2#123   * The following is taken as baseline (for intra-cell case): for CBRA, we reuse the mechanism agreed for CFRA case, i.e. use the RA RAR to indicate the TAG. |   3. In 9.2.9, descriptions for 2-TA operation are added based on following agreements.   |  | | --- | | RAN2#123bis   * Confirmed: We will use the 2-PTAG model, i.e., both TAGs of SpCell are PTAGs; |   [SRI/TPMI enhancement for enabling 8 TX UL]  Added description in 5.3.1 based on LS from RAN1 (R2-2313911).  [Increased number of orthogonal DMRS ports]  Modified description in 5.2.1 and 5.3.1 based on LS from RAN1 (R2-2313911).  [UL precoding indication for multi-panel transmission]  Added description in 6.12 based on LS from RAN1 (R2-2313911). | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Stage 2 functions for following fatures discussed in Rel-18 WI: MIMO Evolution for Downlink and Uplink are not described in the specification.  - 2-TA enhancement for multiDCI  - SRI/TPMI enhancement for enabling 8 TX UL  - Increased number of orthogonal DMRS ports  - UL precoding indication for multi-panel transmission | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 5.2.1, 5.3.1, 6.12, 9.2.6, 9.2.9 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.306 CR 1015, TS 38.321 CR 1696, TS 38.331 CR 4406, TS 38.331 CR 4510 | | |
| ***affected:*** | |  | **x** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **x** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | | [Rev 0]  Endorsed in R2-2313417.  - Clause 6.12: added descriptions for 2-TA multi-TRP operation.  - Clause 9.2.6: added descriptions for indication of TAG ID during RA procedure.  - Clause 9.2.9: added descriptions for 2-TA operation.  [Rev 1]  - Clause 5.2.1: modified description to support Increased number of orthogonal DMRS ports based on LS from RAN1 (R2-2313911).  - Clause 5.3.1: modified description to support Increased number of orthogonal DMRS ports based on LS from RAN1 (R2-2313911).  - Clause 5.3.1: added description for SRI/TPMI enhancement for enabling 8 TX UL based on LS from RAN1 (R2-2313911).  - Clause 6.12: added description for UL precoding indication for multi-panel transmission based on LS from RAN1 (R2-2313911). | | | | | | | | |

\* \* \* Start of Change \* \* \*

### 5.2.1 Downlink transmission scheme

Demodulation Reference Signal (DMRS) based spatial multiplexing is supported for Physical Downlink Shared Channel (PDSCH). Up to 8, 12, 16 and 24 orthogonal DL DMRS ports are supported for type 1, type 2, enhanced type 1, and enhanced type 2 DMRS respectively. Up to 8 orthogonal DL DMRS ports per UE are supported for SU-MIMO and up to 4 orthogonal DL DMRS ports per UE are supported for MU-MIMO. The number of SU-MIMO code words is one for 1-4 layer transmissions and two for 5-8 layer transmissions.

The DMRS and corresponding PDSCH are transmitted using the same precoding matrix and the UE does not need to know the precoding matrix to demodulate the transmission. The transmitter may use different precoder matrix for different parts of the transmission bandwidth, resulting in frequency selective precoding. The UE may also assume that the same precoding matrix is used across a set of Physical Resource Blocks (PRBs) denoted Precoding Resource Block Group (PRG).

Transmission durations from 2 to 14 symbols in a slot is supported.

Aggregation of multiple slots with Transport Block (TB) repetition is supported.

\* \* \* Next Change \* \* \*

### 5.3.1 Uplink transmission scheme

Two transmission schemes are supported for PUSCH: codebook based transmission and non-codebook based transmission.

For codebook based transmission, the gNB provides the UE with a transmit precoding matrix indication in the DCI. The UE uses the indication to select the PUSCH transmit precoder from the codebook. For non-codebook based transmission, the UE determines its PUSCH precoder based on wideband SRI field from the DCI.

DMRS based spatial multiplexing is supported for PUSCH. Up to 8, 12, 16, and 24 orthogonal UL DMRS ports are supported for type 1, type 2, enhanced type 1, and enhanced type 2 DMRS respectively. For a given UE, up to 4 or up to 8 layer transmissions are supported. The number of code words is one for 1 to 4 layer transmission and two for 5 to 8 layer transmission. When transform precoding is used, only a single MIMO layer transmission is supported.

Transmission durations from 1 to 14 symbols in a slot is supported.

Aggregation of multiple slots with TB repetition is supported.

Two types of frequency hopping are supported, intra-slot frequency hopping, and in case of slot aggregation, inter-slot frequency hopping. Intra-slot and inter-slot frequency hopping are not supported when PRB interlace uplink transmission waveform is used.

PUSCH may be scheduled with DCI on PDCCH, or a semi-static configured grant may be provided over RRC, where two types of operation are supported:

- The first PUSCH is triggered with a DCI, with subsequent PUSCH transmissions following the RRC configuration and scheduling received on the DCI, or

- The PUSCH is triggered by data arrival to the UE's transmit buffer and the PUSCH transmissions follow the RRC configuration.

\* \* \* Next Change \* \* \*

## 6.12 Multiple Transmit/Receive Point Operation

In Multiple Transmit/Receive Point (multi-TRP) operation, a serving cell can schedule the UE from two TRPs, providing better coverage, reliability and/or data rates for PDSCH, PDCCH, PUSCH, and PUCCH.

There are two different operation modes to schedule multi-TRP PDSCH transmissions: single-DCI and multi-DCI. For both modes, control of uplink and downlink operation can be done by physical layer and MAC layer, within the configuration provided by the RRC layer. In single-DCI mode, the UE is scheduled by the same DCI for both TRPs and in multi-DCI mode, the UE is scheduled by independent DCIs from each TRP.

There are two different operation modes for multi-TRP PDCCH: PDCCH repetition as in Clause 5.2.3 and Single Frequency Network (SFN) based PDCCH transmission. In both modes, the UE can receive two PDCCH transmissions, one from each TRP, carrying the same DCI. In PDCCH repetition mode, the UE can receive the two PDCCH transmissions carrying the same DCI from two linked search spaces each associated with a different CORESET. In SFN based PDCCH transmission mode, the UE can receive the two PDCCH transmissions carrying the same DCI from a single search space/CORESET using different TCI states.

For multi-TRP PUSCH repetition, according to indications in a single DCI or in a semi-static configured grant provided over RRC, the UE performs PUSCH transmission of the same contents toward two TRPs with corresponding beam directions associated with different spatial relations. For multi-TRP PUCCH repetition, the UE performs PUCCH transmission of the same contents toward two TRPs with corresponding beam directions associated with different spatial relations.

For inter-cell multi-TRP operation, for multi-DCI PDSCH transmission, one or more TCI states can be associated with SSB with a PCI different from the serving cell PCI. The activated TCI states can be associated with at most one PCI different from the serving cell PCI at a time.

For inter-cell and intra-cell multi-DCI multi-TRP operation, up to two TAGs with associated TAG IDs can be configured per serving cell. Each UL/Joint TCI state is associated with a TAG ID and the UE applies the timing advance of the TAG ID associated with the UL/joint TCI state utilized for UL transmission.

For single-DCI multi-TRP Simultaneous Transmission with Multi-Panel (STxMP) Spatial Domain Multiplexing (SDM) PUSCH transmission, different layers of one PUSCH are separately transmitted towards two TRPs. For single-DCI multi-TRP STxMP SFN PUSCH transmission, same layers of one PUSCH are transmitted towards two TRPs. For multi-DCI based multi-TRP STxMP PUSCH+PUSCH transmission, two PUSCHs are transmitted towards two TRPs. For single-DCI multi-TRP STxMP SFN PUCCH transmission, one PUCCH is transmitted towards two TRPs.

\* \* \* Next Change \* \* \*

### 9.2.6 Random Access Procedure

The random access procedure is triggered by a number of events:

- Initial access from RRC\_IDLE;

- RRC Connection Re-establishment procedure;

- DL or UL data arrival, during RRC\_CONNECTED or during RRC\_INACTIVE while SDT procedure (see clause 18.0) is ongoing, when UL synchronisation status is "non-synchronised";

- UL data arrival, during RRC\_CONNECTED or during RRC\_INACTIVE while SDT procedure is ongoing, when there are no PUCCH resources for SR available;

- SR failure;

- Request by RRC upon synchronous reconfiguration (e.g. handover);

- RRC Connection Resume procedure from RRC\_INACTIVE;

- To establish time alignment for a primary or a secondary TAG;

- Request for Other SI (see clause 7.3);

- Beam failure recovery;

- Consistent UL LBT failure on SpCell;

- SDT in RRC\_INACTIVE (see clause 18);

- Positioning purpose during RRC\_CONNECTED requiring random access procedure, e.g., when timing advance is needed for UE positioning.

Two types of random access procedure are supported: 4-step RA type with MSG1 and 2-step RA type with MSGA. Both types of RA procedure support contention-based random access (CBRA) and contention-free random access (CFRA) as shown on Figure 9.2.6-1 below.

The UE selects the type of random access at initiation of the random access procedure based on network configuration:

- when CFRA resources are not configured, an RSRP threshold is used by the UE to select between 2-step RA type and 4-step RA type;

- when CFRA resources for 4-step RA type are configured, UE performs random access with 4-step RA type;

- when CFRA resources for 2-step RA type are configured, UE performs random access with 2-step RA type.

The network does not configure CFRA resources for 4-step and 2-step RA types at the same time for a Bandwidth Part (BWP). CFRA with 2-step RA type is only supported for handover.

The MSG1 of the 4-step RA type consists of a preamble on PRACH. After MSG1 transmission, the UE monitors for a response from the network within a configured window. For CFRA, dedicated preamble for MSG1 transmission is assigned by the network and upon receiving random access response from the network, the UE ends the random access procedure as shown in Figure 9.2.6-1(c). For CBRA, upon reception of the random access response, the UE sends MSG3 using the UL grant scheduled in the response and monitors contention resolution as shown in Figure 9.2.6-1(a). If contention resolution is not successful after MSG3 (re)transmission(s), the UE goes back to MSG1 transmission.

The MSGA of the 2-step RA type includes a preamble on PRACH and a payload on PUSCH. After MSGA transmission, the UE monitors for a response from the network within a configured window. For CFRA, dedicated preamble and PUSCH resource are configured for MSGA transmission and upon receiving the network response, the UE ends the random access procedure as shown in Figure 9.2.6-1(d). For CBRA, if contention resolution is successful upon receiving the network response, the UE ends the random access procedure as shown in Figure 9.2.6-1(b); while if fallback indication is received in MSGB, the UE performs MSG3 transmission using the UL grant scheduled in the fallback indication and monitors contention resolution as shown in Figure 9.2.6-2. If contention resolution is not successful after MSG3 (re)transmission(s), the UE goes back to MSGA transmission.

If the random access procedure with 2-step RA type is not completed after a number of MSGA transmissions, the UE can be configured to switch to CBRA with 4-step RA type.

 

(a) CBRA with 4-step RA type (b) CBRA with 2-step RA type

 

(c) CFRA with 4-step RA type (d) CFRA with 2-step RA type

Figure 9.2.6-1: Random Access Procedures



Figure 9.2.6-2: Fallback for CBRA with 2-step RA type

For random access in a cell configured with SUL, the network can explicitly signal which carrier to use (UL or SUL). Otherwise, the UE selects the SUL carrier if and only if the measured quality of the DL is lower than a broadcast threshold. UE performs carrier selection before selecting between 2-step and 4-step RA type. The RSRP threshold for selecting between 2-step and 4-step RA type can be configured separately for UL and SUL. Once started, all uplink transmissions of the random access procedure remain on the selected carrier.

The network can associate a set of RACH resources with feature(s) applicable to a Random Access procedure: Network Slicing (see clause 16.3), RedCap (see clause 16.13), SDT (see clause 18), and NR coverage enhancement (see clause 19). A set of RACH resources associated with a feature is only valid for random access procedures applicable to at least that feature; and a set of RACH resources associated with several features is only valid for random access procedures having at least all of these features. The UE selects the set(s) of applicable RACH resources, after uplink carrier (i.e. NUL or SUL) and BWP selection and before selecting the RA type.

When CA is configured, random access procedure with 2-step RA type is only performed on PCell while contention resolution can be cross-scheduled by the PCell.

When CA is configured, for random access procedure with 4-step RA type, the first three steps of CBRA always occur on the PCell while contention resolution (step 4) can be cross-scheduled by the PCell. The three steps of a CFRA started on the PCell remain on the PCell. CFRA on SCell can only be initiated by the gNB to establish timing advance for a secondary TAG: the procedure is initiated by the gNB with a PDCCH order (step 0) that is sent on an activated SCell of the secondary TAG, preamble transmission (step 1) takes place on the SCell, and Random Access Response (step 2) takes place on PCell.

When two TAG IDs are configured for the serving cell, the TAG for which the TA command is applied is indicated in Random Access Response message or in MSGB.

\* \* \* Next Change \* \* \*

### 9.2.9 Timing Advance

In RRC\_CONNECTED, the gNB is responsible for maintaining the timing advance to keep the L1 synchronised. Serving cells having UL to which the same timing advance applies and using the same timing reference cell are grouped in a TAG. Each TAG contains at least one serving cell with configured uplink, and the mapping of each serving cell to a TAG is configured by RRC.

For the primary TAG the UE uses the PCell as timing reference, except with shared spectrum channel access where an SCell can also be used in certain cases (see clause 7.1, TS 38.133 [13]). In a secondary TAG, the UE may use any of the activated SCells of this TAG as a timing reference cell, but should not change it unless necessary.

Timing advance updates are signalled by the gNB to the UE via MAC CE commands. Such commands restart a TAG-specific timer which indicates whether the L1 can be synchronised or not: when the timer is running, the L1 is considered synchronised, otherwise, the L1 is considered non-synchronised (in which case uplink transmission can only take place through MSG1/MSGA).

When two TAG IDs are configured for the PCell, both TAGs are regarded as primary TAG.

\* \* \* End of Change \* \* \*