3GPP TSG RAN WG1 #101 R1-200xxxx

e-Meeting, May 25th – June 5th, 2020

Source: Moderator (OPPO)

Title: FL summary for Multi-TRP/Panel Transmission

Agenda Item: 7.2.6.2

Document for: Discussion and Decision

1. Introduction

Rel-16 enhancement on MIMO WID includes objectives of enhancing multi-TRP/Panel transmission with ideal and non-ideal backhaul. During the work of rel-16, designs for multiple-PDCCH based and single-PDCCH based multi-TRP/Panel transmission were discussed and specified. Enhancements of multi-TRP transmission for URLLC were also specified. In this contribution, we summarize the remaining issues for multi-TRP transmission that are raised by companies in contributions [1~19].

The issues are summarized with following structures: issues for multi-PDCCH based transmission, issues for single-PDCCH based or URLLC and editorial changes proposed by companies.

1. Issues for Multi-PDCCH based Transmission
   1. Issue #a-1: The issue on PDCCH used to schedule for initial/re-transmission in Multi-DCI based M-TRP

Companies [3] and [14] discussed the issue of scheduling initial transmission and re-transmission in multi-DCI based M-TRP:

* [3] proposed that the initial and re-transmission of one TB shall be associated with the same *CORESETPoolIndex* value. The argument is to avoid additional complexity at both gNB and UE
* In contrast, [14] suggested that restricting the initial transmission and retransmission of a TB to the same TRP (associated with the same CORESETPoolIndex) is not required.

Based on the proposals in the contributions, offline proposal is:

Offline Proposal #a-1: In Multi-DCI based Multi-TRP, for PDCCHs scheduling the initial transmission and re-transmission of a TB, down-select from

* Alt1: They are associated with CORESETs having the same value of *CORESETPoolIndex*.
* Alt2: no restriction on the PDCCHs.
  1. Issue #a-2: whether configuring multi-DCI based and single-DCI based M-TRP simultaneously

Companies [4] [10] [12] [13] [17] discussed if configuring multi-DCI based and single-DCI based M-TRP simultaneously is allowed in rel15.

* Companies [4] [10][12] [13] proposed that multi-DCI based and single-DCI based M-TRP can not by configured simultaneously.
* But [17] suggest to conclude that no restriction to prevent single-DCI + multi-DCI mixed mode multi-TRP operation and supporting single-DCI based + multi-DCI based is per UE capability.

Furthermore, RAN2 made an agreement in RAN2 #109 e-meeting and it is not clear to RAN2 if simultaneous configuration of single-DCI based and multi-DCI based M-TRP is supported or not and RAN2 is waiting for RAN1’s decision:

*Agreements online:*

1. *eLCID values are assigned only for UL MAC CEs with four-octet variants for Rel-16 eMIMO (MAC CEs for Rel-15 are not changed)*
2. *Consider to re-design PUSCH Pathloss Reference RS Activation/Deactivation MAC CE. Discuss further implication offline, including whether we need to consult with RAN1*
3. *Re-design the SP SRS Activation/Deactivation MAC CE to support 192 NZP CSI-RS resource(s). FFS whether this new MAC CE includes Aperiodic SRS case or not.*
4. *From RAN2 point of view it's unclear whether simultaneous configuration of single-DCI based and multi-DCI based M-TRP is supported. We wait for RAN1 decision before working on this.*

Thus, we need to make a conclusion on this issue.

**Offline Proposal #a-2: Regarding configuration of multi-TRP transmission, down-select from:**

* **Alt 1: Simultaneous configuration of single-DCI based and multi-DCI based M-TRP is not supported.**
* **Alt 2: Conclude that no restriction to prevent configuring multi-DCI and single-DCI based M-TRP simultaneously and it is per UE capability to support that.** 
  1. Issue#a-3: Active BWP operation in multi-DCI based M-TRP system

Companies [2] [7] [8] [10] [12] [14] [15] [16] discussed the issues of active BWP operation in multi-DCI based M-TRP system and explained that current spec does not capture the condition correctly. For the reference, we made the following agreement on active BWP in RAN1#96:

|  |
| --- |
| **Agreement**  For a UE supporting multiple-PDCCH based multi-TRP/panel transmission and each PDCCH schedules one PDSCH, at least for eMBB with non-ideal backhaul, support following restrictions:   * The UE may be scheduled with fully/partially/non-overlapped PDSCHs at time and frequency domain by multiple PDCCHs with following restrictions:   + …   + The UE is expected to be scheduled with the same active BWP bandwidth and the same SCS if the UE is expected to receive multiple PDSCHs simultaneously at given symbols.   + The number of active BWPs for a UE is 1 per CC   + … |

Companies made the following proposal on active BWP issue:

* [2][7][10][12][15][16] suggests that current text has some issue and they proposed TPs to update TS 38.214 for more precise description:
  + [2] suggest that the condition of “if the UE is expected to receive multiple PDSCHs simultaneously at given symbols” in the agreement is not captured in TS 38.214 yet and propose TP
  + [7] propose that if a UE detects two DCIs indicating a same active DL BWP change in a same slot, the UE is not required to receive or transmit in the cell during a time duration from the end of the third symbol of a slot where the UE receives the DCI until the beginning of a slot indicated by the smaller slot offset value of the time domain resource assignment fields in the two DCI.
  + [10] proposed when UE is scheduled with different active BWPs through multi-PDCCHs, only one PDCCH is applied and the other PDCCH is dropped
  + [12] proposed for a PDCCH associated to *ControlResourceSet* having value of *CORESETpoolIndex* equal to 1, the UE doesn’t expect the bandwidth part indicator field in a DCI of the PDCCH indicates a different BWP from the active BWP.
  + [15] proposed that BWP switching is only indicated from the PDCCH associated with CORESET provided CORESETPoolIndex with a value of 0.
  + [16] proposed a TP to capture the agreement more precisely.
* In contrast, [8] and [14] suggested that current specification is ok.

Based on the proposals in the contributions, offline proposal is:

**Offline Proposal #a-3: Regarding active BWP operation in multi-DCI based M-TRP, discuss on whether and how to update the current specification to capture agreement precisely.**

* 1. Issue#a-4: CSI/SR UCI overlapping with two HARQ-ACK PUCCH /PUSCH of two different TRPs

Companies [1] [12] and [14] discussed the issues when other UL transmission, for example CSI or SR in PUCCH, overlaps with two PUCCHs being sent to different TRPs. [12] explained that in multi-DCI based M-TRP system, CSI or SR transmission might overlap with two PUCCHs or PUSCH that are transmitted to two different TRPs within one slot, as shown in Figure shown below. The UE behavior is not clear in current specification.



They make the following proposals for this issue:

* [1] proposed that the UE does not expect a PUCCH with CSI/SR/LRR overlap with more than one PUCCH with HARQ-ACK information.
* [12] proposed UE doesn’t expect two PUCCHs with separate HARQ-ACK or two PUSCHs within a slot associated with different values of *CORESETPoolIndex* to be simultaneously overlapped with another UL signal.
* [14] suggested that the case PUCCH used for CSI or SR is overlapping with other PUCCH/PUSCH transmissions which are associated with a CORESETPoolIndex, is avoided by both network and UE implementation. No additional specification impact in Rel-16.

Based on the proposals in the contributions, offline proposal is:

Offline Proposal #a-4: For the issue of two PUCCH of different TRPs overlapping with other UL signal not associated with *CORESETPoolindex*, down-select from:

* Alt1: the UE does not expect two PUCCH/PUSCH of different TRPs overlap with other UL signal
* Alt2: Conclude the case of that UL transmission not associated a CORESETPoolIndex value overlaps with a PUCCH/PUSCH associated with a *CORESETPoolIndex* value does not happen in rel16.
  1. Issue#a-5: Sub-slot based HARQ-ACK feedback in multi-DCI based multi-TRP

Companies [1] and [14] discussed the issue of sub-slot based HARQ-ACK feedback vs multi-TRP transmission.

* [1] proposed to clarify that the UE can transmit up to two PUCCH of HARQ-ACK in one slot **only when** separate feedback is configured and sub-slot HARQ ACK feedback is not configured.
* [14] proposed to clarify that, if the separate HARQ-ACK feedback mode is configured, the UE is allowed to transmit to TDMed PUCCH within a slot, not within a sub-slot

Based on the proposals in the contributions, offline proposal is:

Offline Proposal #a-5: discuss how to update TS 38.213 to clarify that up to two PUCCHs are in one slot when separate feedback is configured.

* 1. Issue#a-6: Default QCL for AP CSI-RS in multi-DCI based M-TRP

Companies [1][2][5][8][12][13][14][16][18] discussed the default QCL for AP CSI-RS when the scheduling offset is less than threshold in multi-DCI based M-TRP system:

* [1] proposed that
  + If the UE supports the feature of default QCL assumption per CORESETPoolIndex:
    - If there is one PDSCH in the same symbols as the AP CSI-RS and the PDSCH is associated with the same CORESETPoolIndex value as that of the PDCCH triggering the AP CSI-RS, the UE applies the QCL assumption of the PDSCH when receiving the AP CSI-RS
    - Otherwise, it is the default QCL for PDSCH in multi-DCI based M-TRP
  + If the UE does not support the feature of default QCL assumption per CORESETPoolIndex, Rel-15 behavior is reused regardless of CORESETPoolIndex.
* [2] proposed that
  + If there is any other known DL signal in the same symbol and the known DL signal is associated with same TRP or is a SPS-CSI-RS or P-CSI-RS, the QCL assumption for the AP CSI-RS is the QCL assumption of that known DL signal
  + Otherwise, the UE applies the QCL assumption used for the CORESET associated with a monitored search space with the lowest ID among all the CORESETs with the same value of CORESETPoolIndex as the PDCCH triggering the AP CSI-RS, in the latest slot in which one or more CORESETs associated with the same CORESETPoolIndex as the PDCCH triggering the AP CSI-RS within the active BWP of the serving cell are monitored
* [5] proposed that if the UE does not support the feature of default TCI state per CORESETPoolIndex, release 15 behavior is used, and if the UE supports the feature of default TCI state per CORESETPoolIndex:
  + if there is any other DL signal with the same CORESETPoolIndex as the PDCCH triggering the aperiodic CSI-RS, the UE applies the QCL assumption of the other DL signal. The other DL signal refers to PDSCH scheduled with offset larger than or equal to the threshold timeDurationForQCL and aperiodic CSI-RS scheduled with offset larger than or equal to the UE reported threshold min{beamSwitchTiming, 48};
  + else if there is semi-persistent CSI-RS or periodic CSI-RS, the UE applies the QCL assumption of the semi-persistent CSI-RS or periodic CSI-RS;
  + else, the UE applies the QCL assumption used for the CORESET associated with a monitored search space with the lowest controlResourceSetId among all the CORESETs with the same value of CORESETPoolIndex as the PDCCH triggering the aperiodic CSI-RS, in the latest slot in which one or more CORESETs within the active BWP of the serving cell are monitored.
* [8] proposed that, if the UE does not support the capability of M-TRP default TCI-state, rel15 is used, and if the UE supports the capability of M-TRP default TCI-state:
  + If there is any other DL signals:
    - When AP-CSI-RS is overlapped with a DL signal associated with the same CORESETPoolIndex, apply QCL assumption of the DL signal in receiving the AP-CSI-RS
    - When AP-CSI-RS is overlapped with a DL signal associated with different CORESETPoolIndex, apply default beam associated with the AP-CSI-RS
    - When AP-CSI-RS is overlapped with DL signal with no CORESETPoolIndex association, reuse Rel-15 rule
  + If there is no any other DL signals, default beam of the CORESETPoolIndex associated with the triggering DCI
* [12] proposed that:
  + UE doesn’t expect to receive the CSI-RS if the UE is scheduled with other DL signal(s) associated with multiple TCI states in the symbol.
* [13] proposed that:
  + for multi-TRP operation, the default aperiodic CSI-RS beam should be the same as the default PDSCH beam, since UE is not able to use different default beams to buffer downlink signals.
* [14] proposed that if a UE does not support capability of default TCI-state of M-TRP, rel-15 behavior is used and if a UE supports the capability of default TCI-state of M-TRP:
  + When there is one or two PDSCH(s) with an indicated TCI state in the same symbols as the AP CSI-RS,
    - If there is a PDSCH associated with the same *CORESETPoolIndex* value as that of the PDCCH triggering the AP CSI-RS, the UE applies the QCL assumption of that PDSCH when receiving the AP CSI-RS.
    - If there is no PDSCH associated with the same *CORESETPoolIndex* value as that of the PDCCH triggering the AP CSI-RS, the UE applies the QCL assumption used for the CORESET associated with a monitored search space with the lowest ID among all the CORESETs with the same value of *CORESETPoolIndex* as the PDCCH triggering the AP CSI-RS, in the latest slot in which one or more CORESETs within the active BWP of the serving cell are monitored.
* [16] proposed that
  + If there is any other DL signal(s) with indicated TCI state(s) and at least one of the other DL signal(s) is associated with a same CORESETPoolIndex value as the PDCCH triggering the AP CSI-RS, the UE assumes the TCI state of the other DL signal that is associated with a same CORESETPoolIndex value as the PDCCH triggering the AP CSI-RS is applied for AP CSI-RS processing;
  + Otherwise, the UE assumed the TCI state of CORESET associated with a monitored search space with the lowest ID among all the CORESETs with the same value of CORESETPoolIndex as the PDCCH triggering the AP CSI-RS in the latest slot is applied for AP CSI-RS processing
* [18] proposed that
  + If there is no known DL signal in the symbols of the AP CSI-RS, UE processes the AP CSI-RS via the default PDSCH beam associated with the *CORESETPoolIndex* for the AP CSI-RS;
  + If there are two known PDSCHs associated with different *CORESETPoolIndex* in the symbols of the AP CSI-RS, UE process the AP CSI-RS via the known PDSCH beam associated with the *CORESETPoolIndex* for the AP CSI-RS.

Based on the proposals in the contributions, offline proposal is:

Offline Proposal #a-6: Discuss and determine the default TCI state for AP CSI-RS with scheduling offset < threshold in multi-DCI based M-TRP.

* 1. Issue#a-7: Clarify the case of UE incapable of supporting default TCI state of M-TRP

Companies [4][5][8] and [9] discussed to clarify the UE behavior of default PDSCH TCI-state for UE not supporting the capability of TCI-state of M-TRP.

* [4] and [5] proposed to clarify in TS 38.214 that for a UE incapable of default TCI state of M-TRP (single-DCI based or multi-DCI based), the UE shall follow rel15 behavior.
* [8] proposed to Introduce new RRC parameters indicating UE to enable enhanced default beam for multi-DCI and single-DCI, respectively and proposed TP to include the newly introduced RRC parameters.
* [9] also proposed to clarify in TS 38.214 for the UE not supporting default TCI-state of multi-DCI based M-TRP.

Based on the proposals in the contributions, offline proposal is:

Offline Proposal #a-7: update TS 38.214 to capture that if the UE does not support the feature of default TCI state of M-TRP, rel-15 behavior is used.

* 1. Issue#a-8: the issues of uplink power control in multi-DCI based M-TRP

Companies [2] [7] [12][13] and [14] discussed couple of issues of uplink power control on PUSCH and/or PUCCH in multi-DCI based M-TRP system:

* [2] propose that the closed-loop power control shall be independent for PUSCH transmission scheduled by different TRP (i.e., CORESETs with different CORESETPoolIndex) regardless of the configured close loop index.
* [7] proposed:
  + In multi-DCI based M-TRP, at least two pathloss RSs shall be configured and default pathloss reference signal for PUCCH shall be determined according to the CORESETPoolIndex of the PDCCH;
  + TPC command in DCI format 2\_2 only applies to PUCCH resource associated with the same CORESETPoolIndex.
* [12] proposed for multi-DCI based M-TRP
  + Support TRP specific pathloss RS for PUSCH and PUCCH and clarify the default pathloss reference signal for PUSCH or PUCCH.
  + Define different values for default close loop indexes for PUSCH/PUCCH targeting to different TRPs.
* [13] proposed that the PUSCH/PUCCH associated with different CORESET-poolIndex should be configured with different closed-loop power control process index
* [14] suggested that no further specification support is introduced for PUSCH and PUCCH power control in Rel-16.

Based on the proposals in the contributions, offline proposal is:

Offline Proposal #a-8: Discuss if uplink power control enhancement for M-TRP is needed in rel-16 by considering the following aspects:

* **In multi-DCI based M-TRP, the uplink power control on PUCCH and PUSCH, down-select:**
  + **Alt1: the closed loop power control is independent between PUSCH or PUCCH associated with different CORESETPoolIndex values regardless of the configured close loop index.**
  + **Alt2: the PUSCH/PUCCH associated with different CORESET-poolIndex are configured with different/separate closed-loop power control process index**
* **Support TRP-specific pathloss RS and clarify the default TRP-specific pathloss RS for PUSCH and PUCCH.**
* **TPC command in DCI format 2\_2 only applied to PUCCH resource associated with the same TRP**
  1. Issue #a-9: default HARQ-ACK feedback mode if RRC parameter of ACK feedback mode is not configured

RRC parameter *ackNackFeedbackMode-r16* is used to configure HARQ-ACK feedback mode for multi-DCI based M-TRP transmission. Companies [3] and [14] discussed what shall be the default mode if the parameter *ackNackFeedbackMode-r16* is not provided.

* [3] proposed to specify in TS 38.213 that if RRC parameter ackNackFeedbackMode-r16 is not provided, the mode is separate feedback.
* [14] proposed that when RRC parameter ackNackFeedbackMode-r16 is not provided, additional specification support is not required. The feedback mode is inter-slot TDM HARQ feedback (Rel-15).

Based on the proposals, offline proposal is made:

Offline proposal #a-9: When RRC parameter *ackNackFeedbackMode-r16* is not provided, down-select from:

* Alt1: the feedback mode is separate feedback and update the TS 38.213 accordingly.
* Alt2: no change in the TS 38.213 and the feedback mode is inter-slot TDM.
  1. Issue #a-10: Out-of-order operation on PDSCH to HARQ-ACK PUCCHs within a slot

[4] and [5] explained that in the description of current specification, out-of-order operation for PDSCH to HARQ-ACK can be supported only in slot-level granularity, but according to the agreement on TDMed PUCCHs within a slot, it is natural to support out-of-order operation for PDSCH to TDMed HARQ-ACK within a slot.

Both [4] and [5] proposed TP to update section 5.1 of TS 38.214 to allow out-of-order operation for two HARQ-ACK PUCCH in symbol level within a slot:

|  |  |
| --- | --- |
| TP by [4] | ----------------------------------------------------- Start of text proposal for 5.1 of TS38.214 ----------------------------------<Unchanged parts are omitted>  If a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*, the UE may expect to receive multiple PDCCHs scheduling fully/partially/non-overlapped PDSCHs in time and frequency domain. The UE may expect the reception of full/partially-overlapped PDSCHs in time only when PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *CORESETPoolIndex*. For a *ControlResourceSet* without *CORESETPoolIndex*, the UE may assume that the *ControlResourceSet* is assigned with *CORESETPoolIndex* as 0. When the UE is scheduled with full/partially/non-overlapped PDSCHs in time and frequency domain, the full scheduling information for receiving a PDSCH is indicated and carried only by the corresponding PDCCH, the UE is expected to be scheduled with the same active BWP and the same SCS. When the UE is scheduled with full/partially-overlapped PDSCHs in time and frequency domain, the UE can be scheduled with at most two codewords simultaneously. When PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *CORESETPoolIndex,* the following operations are allowed:  - For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol *j* by a PDCCH associated with a value of *CORESETpoolIndex* ending in symbol *i*, the UE can be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH associated with a different value of *CORESETpoolIndex* that ends later than symbol *i*.  - In a given scheduled cell, the UE can receive a first PDSCH in slot *i*, with the corresponding HARQ-ACK assigned to be transmitted in slot *j*, and a second PDSCH associated with a value of *CORESETpoolindex* different from that of the first PDSCH starting later than the first PDSCH with its corresponding HARQ-ACK assigned to be transmitted in a slot before slot *j* or in the symbols before the start of HARQ-ACK for the first PDSCH in slot *j*.  ------------------------------------------------------- End of text proposal ------------------------------------------------------ |
| TP by [5] | 5.1 UE procedure for receiving the physical downlink shared channel  < Unchanged parts are omitted >  A UE shall upon detection of a PDCCH with a configured DCI format 1\_0, 1\_1 or 1\_2 decode the corresponding PDSCHs as indicated by that DCI. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to receive a PDSCH that overlaps in time with another PDSCH. The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6]. In a given scheduled cell, the UE is not expected to receive a first PDSCH, with the corresponding HARQ-ACK assigned to be transmitted in a first PUCCH or a first PUSCH ending in symbol *j*, and a second PDSCH starting later than the first PDSCH with its corresponding HARQ-ACK assigned to be transmitted in a second PUCCH or a second PUSCH ending earlier than symbol *j*. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH that ends later than symbol *i*. In a given scheduled cell, for any PDSCH corresponding to SI-RNTI, the UE is not expected to decode a re-transmission of an earlier PDSCH with a starting symbol less than *N* symbols after the last symbol of that PDSCH, where the value of *N* depends on the PDSCH subcarrier spacing configuration *μ,* with *N*=13 for *μ*=0, *N*=13 for *μ*=1, *N*=20 for *μ*=2, and *N*=24 for *μ*=3.  < Unchanged parts are omitted > |

Based on the proposals, offline proposal is made:

Offline proposal #a-10: Discuss whether need to and how to update TS 38.214 to allow out-of-order operation for PDSCH to HARQ-ACK within a slot based on the above TPs.

* 1. Issue#a-11: PDCCH monitoring priority based on QCL-Type D in multi-DCI based M-TRP

Companies [6] [8] [14] and [18] discussed the issues on PCCH monitoring priority based on QCL-TypeD in multi-DCI based M-TRP systems:

* [6] proposed to remove the applicability of current PDCCH priority based on QCL-typeD for multi-DCI based M-TRP, and extend the applicability of PDCCH priority based on QCL-typeD to multi-DCI based M-TRP
* [8] propose to NOT support simultaneous reception of PDCCHs with multiple different QCL-TypeDs.
* [14] propose that for a UE capable reception of two different QCL-TypeD, the PDCCH monitoring priority rule based QCL-TypeD apply within CORESETs with the same CORESETPoolIndex
* [18] propose to apply the QCL-typeD priority rule on first and second CORESETs with same CORESETPoolIndex values separately for UE capable of receiving two QCL-TypeD simultaneously.

Based on the proposals in [6][8][14][18], offline proposal is:

Offline proposal a-11: For the PDCCH monitoring priority rule based QCL-TypeD in multi-DCI based M-TRP, down-select from:

* Alt1: do not support simultaneous reception of PDCCHs with different QCL-TypeDs and no Spec change
* Alt2: for UE capable of two simultaneous QCL-TypeD, apply the priority rule within CORESETs with same CORESETPoolIndex.
  1. Issue#a-12: SPS transmission in multi-DCI based M-TRP

Companies [8] [14] and [18] discussed the issue of SPS transmission in multi-DCI based M-TRP.

* [8] proposed to associate SPS PDSCH associated with a TRP according to the value of CORESETPoolIndex in a CORESET in which the activation DCI of the SPS configuration is received and allow two SPS PDSCHs associated to two different TRPs according to the value of CORESETPoolIndex to overlap in time domain.
* [14] proposed that in multi-DCI based M-TRP, additional enhancements on supporting SPS PDSCH is not supported in Rel-16.
* [18] proposed to define the association of a SPS PDSCH with a CORESETPoolIndex value and SPS PDSCH association with *CORESETPoolIndex* is based on the DCI that activates the SPS configuration.

Based on the proposals in [8][14][18], offline proposal is:

Offline proposal a-11: For the SPS transmission in multi-DCI based M-TRP, down-select from the following:

* Alt1: no extra enhancement for SPS PDSCH transmission in multi-DCI based M-TRP in rel-16
* Alt2: the association between SPS PDSCH and a CORESETPoolIndex value is based on the DCI activating the SRS configuration and allow two SPS PDSCH associated with different TRP to overlap in time domain
  1. Issue#a-13: Radio link monitoring in multi-DCI based M-TRP

Companies [13] [14] [16] discussed the issue of radio link monitoring in multi-DCI based M-TRP system:

* [13] proposed that for multi-DCI based system, UE only needs to monitor the CORESET(s) with CORESETPoolIndex configured to be 0 for RLM
* [14] proposed that no additional specification support is required in Rel-16 to handle radio link monitoring in multi-DCI based multi-TRP operation.
* [16] propose to monitor only the CORESET with index = 0 in multi-DCI based system;

Based on the proposals in [13], [14] and [18], offline proposal is:

Proposal #a-13: For radio link monitoring in multi-DCI based M-TRP system, down-select from the following:

* Alt 1: the UE only monitors the RS in active TCI-state for PDCCH reception in CORESETs associated with *CORESETPoolIndex* value 0.
* Alt 2: no additional spec support.

## Issue #a-14 Specify the BD/CCE for the case when both NR-DC and multi-DCI based M-TRP are configured

[18] discussed the BD/CCE issue for the case when a UE is configured with NR-DC and multi-DCI based M-TRP in at least CC. As explained by [20], In rel15, for NR-DC operation, UE can indicate the capability values of pdcch-BlindDetectionMCG-UE and pdcch-BlindDetectionSCG-UE, respective maximum values for pdcch-BlindDetection for the MCG and pdcch-BlindDetection for the SCG. The network then should configure the UE with pdcch-BlindDetection for the MCG and pdcch-BlindDetection for the SCG. [18] propose to apply the same principles as agreed for case of CA on the case of NR-DC + multi-DCI based M-TRP, when calculating the values of  and  for describing the above two conditions:

*  should be replaced with the maximum value of that the UE can be configured with, where is the number of DL serving cells without multi-DCI based multi-TRP in both MCG and SCG, and  is the number of DL serving cells with multi-DCI based multi-TRP in both MCG and SCG.
*  should be replaced with , where is the number of configured downlink serving cells.

[18] also provided a TP for TS 38.213 on this issue.

Offline Proposal#a-14: For BD/CCEs when NR-DC and multi-DCI based M-TRP are configured at the same time, support to apply same principle as agreed for CA + multi-DCI based M-TRP and adopt the TP for TS 38.213.

* 1. Issue#a-15: Default TCI-state for PDSCH of cross-carrier scheduling in multi-DCI based M-TRP

Companies [1] [7] [14] [18] discussed the issue of default TCI state for PDSCH in cross-carrier scheduling case in multi-TRP systems.

* [1] propose the default TCI state for PDSCH of cross-carrier scheduling is:
  + In multi-DCI based system, the UE obtains its QCL assumption for the scheduled PDSCH from the activated TCI state with the lowest ID applicable to PDSCH corresponding to the CORESETPoolIndex, which is same as the CORESETPoolIndex of PDCCH scheduling that PDSCH in the active BWP of the scheduled cell.
* [7] proposed in multi-DCI based M-TRP that the UE obtains its QCL assumption for the scheduled PDSCH from the activated TCI state with the lowest ID applicable to PDSCH associated with the same CORESETPoolIndex as that configured for the CORESET transmitting the DL DCI in the active BWP of the scheduled cell.
* [14] proposed that for PDSCH with cross-carrier scheduling, a different default QCL assumption for PDSCH considering multi-TRP operations is not required.
* [18] proposed that
* For Case 1, clarify the CORESETPoolIndex association of a CC without CORESETs that is cross-carrier scheduled by another CC.
* For Case 2 and Case 3, cross-carrier configurations should determine whether the scheduled CC is associated with CORESETPoolIndex=0, CORESETPoolIndex=1, or both.

Furthermore, [18] presented five different scenarios for cross-carrier scheduling of PDSCH in multi-DCI based M-TRP system:

* Case 1: Cross carrier scheduling is used among the CCs that are not configured with multi-DCI based multi-TRP (for both scheduling CCs and scheduled CCs).
* Case 2: A CC that is configured with multi-DCI based mTRP schedules one or more other CCs, but the scheduled CCs are not multi-DCI based multi-TRP CCs.
* Case 3: A CC that is configured with multi-DCI based mTRP schedules another CC, and the scheduled CC operates in a multi-DCI based multi-TRP mode (i.e. wrt the features defined for multi-DCI based multi-TRP such as different PDSCH scrambling, partial/full overlap PDSCHs, CRS rate matching, etc.)
* Case 4: A CC that is not configured with multi-DCI based multi-TRP schedules another CC, and the scheduled CC operates in a multi-DCI based multi-TRP mode.
* Case 5: Two CCs that are not configured with multi-DCI based multi-TRP schedule another CC, and the scheduled CC operates in a multi-DCI based multi-TRP mode.

Offline Proposal#a-15: For cross-carrier PDSCH scheduling in multi-DCI based M-TRP systems:

* Discuss and determine which case(s) cross-carrier scheduling PDSCH in multi-DCI based M-TRP systems should be supported.
* Discuss and determine the default TCI state of PDSCH of cross-carrier scheduling in multi-DCI based M-TRP system for the supported case(s)
  1. Issue#a-16: TPs on PDCCH monitoring in multi-DCI based M-TRP

[11] suggested that in TS 38.213, in section 10, the CORESETs without CORESETPoolIndex are not included in the description of a second set of serving cells. Furthermore, [11] suggested that the highlight part in following agreement is not fully captured in the specification yet.

|  |
| --- |
| **Agreement**  If a UE can support and report R>1 for M-DCI based M-TRP/panel transmission,   * The value of r for a downlink cell configured with M-DCI based M-TRP is determined as   + If UE reports pdcch-BlindDetectionCA, the value of r to be applied is optionally configured by RRC, either r=1 or reported value r=R     - Note that when network configures r=1, it does not imply that UE has to support more CCs beyond the UE reported capability   + If UE does not report pdcch-BlindDetectionCA or the value of r is not configured by RRC, r=R. * UE indicates pdcch-BlindDetectionCA when it is possible to configure A+B DL cells to the UE with A>= 0 DL serving cells without multi-DCI based multi-TRP and B >=0 DL serving cells with multi-DCI based multi-TRP such that A+R∙B>4, whereas R is reported by UE capability signaling. * If the UE does not report pdcch-BlindDetectionCA, the UE does not expect to be configured with DL cells to the UE such that A+ R∙B>4 with A>= 0 DL serving cells without multi-DCI based multi-TRP and B >=0 DL serving cells with multi-DCI based multi-TRP, whereas R is reported by UE capability signaling. * The value range of R is [1, 2], and is indicated through UE capability signalling. * Note that this agreement does not preclude a UE from reporting multiple R values and corresponding A and B pairs depending on UE capability * Note that how to capture above into the spec can be up to the editor. |

[11] proposed TPs to correct those two.

Offline proposal #a-16: adopt the following TP for TS 38.213

|  |
| --- |
| 10 UE procedure for receiving control information --------------------------------------------------Unchanged text omitted---------------------------------------------  If a UE can support  - a first set of serving cells where the UE is either not provided *CORESETPoolIndex* or is provided *CORESETPoolIndex* with a single value for all CORESETs on all DL BWPs of each serving cell from the first set of serving cells, and  - a second set of serving cells where the UE is not provided *CORESETPoolIndex* or is provided *CORESETPoolIndex* with a value 0 for a first CORESET and with a value 1 for a second CORESET on any DL BWP of each serving cell from the second set of serving cells  ---------------------------------------------------Unchanged text omitted-------------------------------------------  If a UE indicates in *UE-NR-Capability* a carrier aggregation capability larger than 4 serving cells and the UE is not provided *PDCCHMonitoringCapabilityConfig* for any downlink cell or if the UE is provided *PDCCHMonitoringCapabilityConfig* = *R15 PDCCH monitoring capability* for all downlink cells where the UE monitors PDCCH, the UE includes in *UE-NR-Capability* an indication for a maximum number of PDCCH candidates and for a maximum number of non-overlapped CCEs the UE can monitor per slot when the UE is configured for carrier aggregation operation over more than 4 cells. When a UE is not configured for NR-DC operation, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per slot that corresponds to  downlink cells, where  -  is if the UE does not provide *pdcch-BlindDetectionCA* where is the number of configured downlink serving cells, and the UE does not expect > 4  - otherwise,  is the value of *pdcch-BlindDetectionCA* |

## Issue#a-17: Type 2 HARQ-ACK DAI for multi-DCI based multi-TRP operation

[5] found in the description of type 2 HARQ-ACK codebook, for the equation of , we need to update the condition of  and  because the first bullet only corresponds to  and single TRP case.  and Multiple TRP should be moved to the second bullet. [5] proposed a TP for that.

Offline Proposal#a-17: Discuss how to update the text on Type-2 HARQ-ACK codebook determination based on the following TP:

|  |
| --- |
| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel  < Unchanged parts are omitted >  If a UE is not provided *PDSCH-CodeBlockGroupTransmission* for each of the  serving cells, or for PDSCH receptions scheduled by a DCI format that does not support CBG-based PDSCH receptions, or for SPS PDSCH reception, or for SPS PDSCH release, and if , the UE determines a number of HARQ-ACK information bits  for obtaining a transmission power for a PUCCH, as described in Clause 7.2.1, as    where  - if  and the UE is not configured by higher layer parameter *PDCCH-Config* that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*,  is the value of the counter DAI in the last DCI format scheduling PDSCH reception or indicating SPS PDSCH release for any serving cell  that the UE detects within the  PDCCH monitoring occasions;  - otherwise,  - if the UE does not detect any DCI format that includes a total DAI field in a last PDCCH monitoring occasion within the  PDCCH monitoring occasions where the UE detects at least one DCI format scheduling PDSCH reception or indicating SPS PDSCH release for any serving cell ,  is the value of the counter DAI in a last DCI format the UE detects in the last PDCCH monitoring occasion  - if the UE detects at least one DCI format that includes a total DAI field in a last PDCCH monitoring occasion within the  PDCCH monitoring occasions where the UE detects at least one DCI format scheduling PDSCH reception or indicating SPS PDSCH release for any serving cell ,  is the value of the total DAI in the at least one DCI format that includes a total DAI field  < Unchanged parts are omitted >  If , the UE also determines  for obtaining a PUCCH transmission power, as described in Clause 7.2.1, with    where  - if  and the UE is not configured by higher layer parameter *PDCCH-Config* that contains two different values of *CORESETPoolIndex* in *ControlResourceSet*,  is the value of the counter DAI in the last DCI format scheduling CBG-based PDSCH reception for any serving cell  that the UE detects within the  PDCCH monitoring occasions  - otherwise,  is the value of the total DAI in the last DCI format scheduling CBG-based PDSCH reception for any serving cell  that the UE detects within the  PDCCH monitoring occasions  < Unchanged parts are omitted > |

1. Issues for single-PDCCH based Transmission & URLLC Enhancement
   1. Issue#b-1: PDSCH processing time in Scheme 3

Companies [3] and [18] discussed the issue on PDSCH processing time for scheme 3

* [3] explained that we agreed only mapping type B can be assumed for Scheme 3 and thus the definition of d1,1 is unclear for URLLC scheme 3 in current spec. [3] proposed to clarify that the number of PDSCH symbols is 2ⅹL to determine d1,1.
* [19] also propose to specify the PDSCH processing time for Scheme 3 in TS 38.214

|  |  |
| --- | --- |
| TP by [3] | < Start of the text proposal >  5.3 UE PDSCH processing procedure time  If the first uplink symbol of the PUCCH which carries the HARQ-ACK information, as defined by the assigned HARQ-ACK timing *K1* and the PUCCH resource to be used and including the effect of the timing advance, starts no earlier than at symbol *L1*, where *L1* is defined as the next uplink symbol with its CP starting after  after the end of the last symbol of the PDSCH carrying the TB being acknowledged, then the UE shall provide a valid HARQ-ACK message.  < Unchanged parts are omitted >  - For the PDSCH mapping type A as given in clause 7.4.1.1 of [4, TS 38.211]: if the last symbol of PDSCH is on the *i-*th symbol of the slot where *i* < 7, then *d1,1 = 7 - i*, otherwise *d1,1 = 0*  - The number of PDSCH symbols allocated is 2ⅹL to determine *d1,1* when a UE is configured by higher layer parameter *RepSchemeEnabler* set to *'TDMSchemeA'*, and the UE is indicated with two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication*' and DM-RS port(s) within one CDM group in the DCI field "*Antenna Port(s)*".  - For UE processing capability 1: If the PDSCH is mapping type B as given in clause 7.4.1.1 of [4, TS 38.211], and  < End of the text proposal > |
| TP by [18] | ============TP for 38.214 Section 5.3====================================  - For a PDSCH that consists of two PDSCH transmission occasions in one slot, , where  - is determined by considering the first PDSCH transmission occasion in the slot, and as described above.  - is determined by considering the second PDSCH transmission occasion in the slot, and as described above.  - is the higher layer parameter *StartingSymbolOffsetK,* if configured; else = 0. |

Based on the proposal in [3] and [18], offline proposal is:

Offline proposal #b-1: Specify in TS 38.214 the UE processing time for Scheme 3 based on the TPs proposed by [3] and [18].

* 1. Issue#b-2: Clarify the relationship between *RepetitionNumber-r16/RepSchemeEnabler* and *pdsch-AggregationFactor*

Companies [4] [12] [17] [18] [20] discussed the issue of relationship between RepetitionNumber-r16/RepSchemeEnabler and pdsch-AggregationFactor.

* [4] proposed that Rel-15 repetition number *pdsch-AggregationFactor* should be overwritten whenever Rel-16 repetition number RepetitionNumber-r16 is indicated by DCI.
* [12] proposed *pdsch-AggregationFactor* should be ignored when scheme 4 is configured.
* [17] observed that *pdsch-AggregationFactor* can be overridden when RepNumR16 is indicated
* [18] proposed
  + To disallow simultaneous configuration of *pdsch-AggregationFactor* and *RepNumR16*
  + And that simultaneous configurations of pdsch-AggregationFactor and RepSchemeEnabler should be disallowed.
  + [18] also propose to clarify that PDSCH transmission occasions for scheme 4 are in consecutive slots
  + [18] also proposed that simultaneous configurations of *pdsch-AggregationFactor* and *RepSchemeEnabler* should be disallowed
* [17] and [20] proposed to clarify that PDSCH is repeated in RepNumR16 consecutive slots.

Based on the proposal in contributions, offline proposal is:

Offline proposal #b-2:

* Clarify in TS 38.214 that PDSCH of scheme 4 is repeated in RepNumR16 consecutive slots.
* For pdsch-AggregationFactor vs repNumR16, down-select:
  + Alt1: when scheme 4 is configured, *pdsch-AggregationFactor* is ignored.
  + Alt2: when a RepNumR16 is indicated by DCI, *pdsch-AggregationFactor* is ignored.
  + Alt3: when scheme 4 is configured, the UE does not expect to be configured with *pdsch-AggregationFactor.*
* When the UE is configured with *RepSchemeEnabler*, down-select from:
  + the UE does not expect to be configured with *pdsch-AggregationFactor*.
  + The UE ignores the *pdsch-AggregationFactor* if it is configured*.*
  1. Issue#b-3: Default TCI-state for PDSCH when DCI has no TCI field

Companies [1][7][11] discussed the issue of default TCI-state for PDSCH in the case that the DCI does not have TCI field. Their proposals are:

* [1] proposed that if the offset is less than timeDurationForQCL, the UE assumes the default TCI state of the PDSCH is the first TCI state of the two default different TCI states of PDSCH in single-DCI M-TRP system.
* [7] proposed the QCL parameter(s) is the first TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states.
* [11] proposed that
  + if tci-*PresentInDCI* is not configured for the CORESET scheduling the PDSCH, not support multi-TRP transmission scheduled by PDCCH in the CORESET
  + When the offset between the reception of the PDCCH and the corresponding PDSCH is less than timeDurationForQCL, and at least one TCI codepoint indicates two TCI states, follow Rel-15 default TCI state for the case when TCI field is not present in DCI

Based on the proposals by companies [1][7][11], the following offline proposal is made:

Offline proposal #b-3: discuss and determine the default TCI state of PDSCH in the case of DCI without TCI field.

* 1. Issue#b-4: Default TCI-state for PDSCH when DCI indicates one TCI-state

Companies [1] [2] discussed the issue of default TCI-state of PDSCH when DCI indicates one TCI-state and their proposals are:

* [1] proposed to consider two cases:
  + If the indicated TCI state is one of those two default TCI-states for PDSCH, the UE assume the default TCI-state is the indicated one.
  + Otherwise, the UE assumes the default TCI-state is the first one of those two default TCI-states for PDSCH.
* [2] propose in this case, single-TRP or TDM scheme 4 may be scheduled. The indicated TCI state can be replaced by the first of two default TCI states. The mapping among the first one of default TCI states, DMRS ports and the allocated time/frequency resources can still follow the case when the offset between PDCCH and the corresponding PDSCH is larger than the threshold.

Based on the proposals by companies, the following offline proposal is made:

Proposal #b-4: discuss and determine the default TCI state of PDSCH when DCI indicates one TCI state

* 1. Issue#b-5: Default TCI-state for PDSCH when DCI indicates two TCI-states

Companies [2] [7] discussed the issue of default TCI-state of PDSCH when DCI indicates two TCI-states and their proposals are:

* [2] propose that if the TCI codepoint indicates two TCI states, one of SDM, FDM scheme 2a, FDM scheme 2b, TDM scheme 3 and TDM scheme 4 may be scheduled. Two indicated TCI states can be replaced by the two default TCI states. The mapping among the default TCI states, DMRS ports and the allocated time/frequency resources can follow the case when the offset between PDCCH and the corresponding PDSCH is larger than the threshold.
* [7] proposed that the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) associated with the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states

Based on the proposals by companies [2][7], the following offline proposal is made:

Offline proposal #b-5: discuss and determine the default TCI state of PDSCH when DCI indicates two TCI states

* 1. Issue #b-6: Default TCI-state for PDSCH of Scheme 3 and Scheme 4

Companies [1][7] [8] [11] [13] [14] [15] [16] [17] discussed the issues of default TCI state for PDSCH in URLLC scheme 3 and 4.

* [1] propose to differentiate the PDSCH transmission occasions with offset less than the threshold and occasions with offset >= the threshold:
  + For PDSCH occasions with offset < threshold, two default TCI-states are applied respectively.
  + For PDSCH occasions with offset >= threshold, two indicated TCI-states are applied respectively.
* [7] proposed to specify the case when the indicated RepNumR16 is > 2 and CycMapping or SeqMapping is configured for scheme 4:
  + When RepNumR16 is > 2 and CycMapping is configured:
    - if the scheduling offset between the reception of the DL DCI and the first PDSCH is less than the threshold timeDurationForQCL, while the scheduling offset between the reception of the DL DCI and the second PDSCH equal to or greater than the threshold timeDurationForQCL, the first TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states and the second indicated TCI state by the TCI field in the scheduling DCI are applied to the first and second PDSCH transmission occasions, respectively, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.
    - Otherwise, if the scheduling offset between the reception of the DL DCI and the second PDSCH is less than the threshold timeDurationForQCL(the scheduling offset between the reception of the DL DCI and the first PDSCH is also less than the threshold timeDurationForQCL), the first TCI states and the second TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states are applied to the first and second PDSCH transmission occasions, respectively, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.
  + When RepNumR16 is > 2 and SeqMapping is configured:
    - if the scheduling offset between the reception of the DL DCI and the first PDSCH is less than the threshold timeDurationForQCL, and the scheduling offset between the reception of the DL DCI and the third PDSCH is larger than the threshold timeDurationForQCL, while the scheduling offset between the reception of the DL DCI and the second PDSCH equal to or greater than the threshold timeDurationForQCL, the first TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is applied to the first and second PDSCH transmissions occasions, and the second indicated TCI state by the TCI field in the scheduling DCI is applied to the third and fourth PDSCH transmissions, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.
    - Otherwise, if the scheduling offset between the reception of the DL DCI and the third PDSCH is less than the threshold timeDurationForQCL, the first TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is applied to the first and second PDSCH transmissions occasions, and the second TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is applied to the third and fourth PDSCH transmissions occasions, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.
* [8] proposed that for scheme3 and scheme 4:
  + For UE supporting the enhanced default beam, when the time offset between the DCI and at least one PDSCH transmission occasion among all PDSCHs is less than the threshold, the enhanced default TCI states are applied on the reception of all PDSCH transmission occasions. The mapping between enhanced default TCI states and PDSCH transmission occasions follows the mapping specified in Section 5.1.2.1 in TS 38.214.
  + For UE not supporting the enhanced default beam, when the time offset between the DCI and at least one PDSCH transmission occasion among all PDSCHs is less than the threshold, the Rel-15 default TCI state is applied on the reception of all PDSCH transmission occasions.
* [11] proposed that for single-DCI based multi-TRP case, the default TCI states for PDSCH in URLLC scheme 3 and scheme 4, support Alt2, and the default TCI states are based on the first PDSCH transmission occasion.
  + When the time offset between the DCI and the 1st PDSCH transmission occasion is less than the threshold, the two default TCI-states are applied to PDSCH transmission occasions, respectively. The mapping between default TCI states and PDSCH transmission occasions follows the mapping specified in Section 5.1.2.1 in TS 38.214
* [13] proposed that rel-15 default TCI-state is applied to scheme 3 and scheme 4.
* [14] proposed that: for default TCI-state for PDSCH of Scheme 3 and Scheme 4, when the time offset between the DCI and the 1st PDSCH transmission occasion is less than the threshold, the two default TCI-states are applied to PDSCH transmission occasions, respectively. The mapping between default TCI states and PDSCH transmission occasions follows the mapping specified in Section 5.1.2.1 in TS 38.214
* [15] proposed that if the offset between DCI and PDSCH is less than threshold:
  + For scheme 3: two transmission occasions are assumed, and one of the two TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is associated to one PDSCH transmission occasion
  + For scheme 4: one of the two TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is associated to one PDSCH transmission occasion following current rule.
* [16] proposed that for scheme 3 and scheme 4, when the time offset between the DCI and the 1st PDSCH transmission occasion is less than the threshold, the two default TCI-states are applied to PDSCH transmission occasions, respectively. The mapping between default TCI states and PDSCH transmission occasions follows the mapping specified in Section 5.1.2.1 in TS 38.214.
* [17] suggests that UE applies default TCI-state on the n-th transmission with offset of n-th transmisison < threshold, and the UE applies the indicated TCI-state on n-th transmission with offet of n-th transmsision >= threshold

Based on the proposals by companies [1][7] [8] [11] [13] [14] [15] [16] [17], the following offline proposal are made:

Proposal #b-5: discuss and determine the default TCI state for the Scheme 3 and Scheme 4.

* 1. Issue#b-7: Default QCL for AP CSI-RS in single-DCI based M-TRP

Companies [1][2][5] [8] [12] [13] [14] [16] [17] [18] discussed the default QCL for AP CSI-RS when the scheduling offset is less than threshold in single-DCI based M-TRP system:

* [1] proposed to differentiate the cases with known other DL signal and without other DL signal and also differentiate the buffering and measuring:
  + If there is any known other DL signal, the UE apply the QCL-TypeD(s) of known DL signal to buffer the symbol and the UE measures the CSI-RS as follows: If the indicated TCI state of the AP CSI-RS is same as one of the one or two TCI states of the PDSCH, the UE uses the AP CSI-RS buffered with the QCL-TypeD of the indicated TCI state to measure the CSI. Otherwise, the UE uses the AP CSI-RS buffered with the QCL-TypeD of the first default TCI state to measure the CSI.
  + If there is no any known other DL signal, the UE applies the QCL-TypeDs of the default TCI-states for PDSCH and for measuring the CSI-RS: If the indicated TCI state of the AP CSI-RS is same as one of the two default TCI states, the UE uses the AP CSI-RS buffered with the QCL-TypeD of the TCI-state that is same as the indicated TCI state to measure the CSI. Otherwise, the UE uses the AP CSI-RS buffered with the QCL-TypeD of the first default TCI state to measure the CSI.
* [2] proposed that
  + If there is any other DL signal in the same symbols as AP CSI-RS,
    - the UE applies QCL assumption of the other signal to receive the AP CSI-RS.
    - When other DL signal refers to PDSCH scheduled with two TCI states (with the offset larger than or equal to the threshold timeDurationForQCL), the UE applies first QCL assumption of the other signal to receive the AP CSI-RS.
  + If there is no known DL signal in the symbols of AP CSI-RS:
    - If the indicated TCI state for the AP-CSI-RS is the same with one of the default TCI-states for PDSCH, the UE applies the TCI state indicated by the DCI;
    - Otherwise, the UE apply the first one of default TCI-states for PDSCH, i.e., the two TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states.
* [5] proposed that:
  + if there is any PDSCH with two indicated TCI states in the same symbols as the CSI-RS, the UE applies the TCI state indicated by the triggering UL DCI, which shall be identical to one of those two TCI states for PDSCH;
  + if there is any DL signal with one indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal;
  + if there is no other DL signal, the UE applies the TCI state indicated by the triggering UL DCI, which shall be identical to one of those two default TCI states for PDSCH.
  + If the UE does not support two default TCI states, the default QCL assumption of aperiodic CSI-RS follows the Release-15 behavior.

[8] proposed that:

* + If there is any other DL signals:
    - When AP-CSI-RS is overlapped with a DL signal having two TCI states, apply the first indicated TCI state of the DL signal in receiving the AP-CSI-RS
    - When AP-CSI-RS is overlapped with a DL signal having single TCI state, reuse Rel-15 rule
  + If there is no any other DL signals, use the first among the two default beams.
  + If the UE does not support the capability, Rel-15 default beam is used.
* [12] proposed that for AP CSI-RS, UE doesn’t expect to receive the CSI-RS if the UE is scheduled with other DL signal(s) associated with multiple TCI states in the symbol.
* [13] proposed that for multi-TRP operation, the default aperiodic CSI-RS beam should be the same as the default PDSCH beam, since UE is not able to use different default beams to buffer downlink signals.
* [14] proposed that:
  + When there is known PDSCH with two indicated TCI state in the same symbols as the AP CSI-RS,
    - The UE applies the first QCL assumption of the other signal to receive the AP CSI-RS.
  + When there is no known PDSCH in the same symbols as the AP CSI-RS,
    - The UE applies the first one of default TCI-states for PDSCH, i.e., the two TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states, when receiving the AP CSI-RS.
* [16] proposed to specify the way to buffer and the way to measure the AP CSI-RS:
  + To buffer the AP CSI-RS:
    - If there is PDSCH scheduled with offset larger than or equal to the threshold timeDurationForQCL in the same symbols as AP CSI-RS, The UE applies the QCL-TypeD(s) of the TCI-state(s) of the PDSCH to buffer the symbols of the AP CS-RS.
    - Otherwise, if there is any CSI-RS with indicated TCI-states or there is no known DL signal in the same symbols of AP CSI-RS: The UE apply the QCL-TypeDs of the default TCI-states for PDSCH i.e., the two TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states, to buffer the symbol of AP CSI-RS.
  + To measure the AP CSI-RS:
    - If the TCI-state of the indicated AP CSI-RS is the same as one of the default TCI-state(s) for AP CSI-RS buffering, the UE use the AP CSI-RS buffered with the QCL-TypeD of the TCI-state that is same to the indicated TCI-state to measure the CSI; if the TCI-state of the indicated AP CSI-RS is not the same as any of the default TCI-state(s), the UE uses the AP CSI-RS buffered with the QCL-TypeD of the first default TCI state to measure the CSI.
* [17] proposed that
  + If there is any other DL signal in the same symbols as AP CSI-RS, the UE applies QCL assumption of the other signal to receive the AP CSI-RS.
    - When other DL signal refers to PDSCH scheduled with two TCI states (with the offset larger than or equal to the threshold timeDurationForQCL), the UE applies first QCL assumption of the other signal to receive the AP CSI-RS.
      * if the PDSCH is scheduled with single-DCI based NC-JT, ‘FDMSchemeA’, or ‘FDMSchemeB’, the UE applies Nth QCL assumption of the other signal to receive the AP CSI-RS, where N=1 if the resource id of AP CSI-RS is odd, and N=2 if the resource id of AP CSI-RS is even.
      * if the PDSCH is scheduled with ‘TDMSchemeA’ or Scheme 4, the UE applies the QCL assumption of the overlapping PDSCH transmission occasion to receive the AP CSI-RS.
  + If there is no known DL signal in the symbols of AP CSI-RS:
    - The UE applies the Nth one among the default TCI-states for PDSCH, i.e., the two TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states, where N=1 if the resource id of AP CSI-RS is odd, and N=2 if the resource id of AP CSI-RS is even.
* [18] proposed that if there is no known DL signal in the symbols of the AP CSI-RS, UE processes the AP CSI-RS via the default PDSCH beam whose TCI state is identical to the indicated TCI state of the AP CSI-RS.

Based on the proposals by companies [1][2][5][8][12][13][14][16][17][18], the following offline proposal is made:

Proposal #b-7: discuss and determine the default TCI state for AP CSI-RS in single-DCI based M-TRP.

* 1. Issue#b-8: Default TCI-state for PDSCH of cross-carrier scheduling in single-DCI M-TRP

Companies [1] [8] [14] discussed the issue of default TCI state for PDSCH in cross-carrier scheduling case in multi-TRP systems.

* [1] propose the default TCI state for PDSCH of cross-carrier scheduling is:
  + In single-DCI based system, the UE obtains its QCL assumption for the scheduled PDSCH from the activated TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states applicable to PDSCH in the active BWP of the scheduled cell.
* [8] propose the default TCI-state for PDSCH cross-carrier scheduling in single-DCI based M-TRP is the TCI states corresponding to the lowest codepoint among codepoints containing two different TCI states of the scheduled cell.
* [14] proposed that for PDSCH with cross-carrier scheduling, a different default QCL assumption for PDSCH considering multi-TRP operations is not required.

Based on the proposals by companies [1] [8][14], the following offline proposal is made:

Offline proposal #b-8: discuss and determine the default TCI state for PDCSH of cross-carrier scheduling in single-DCI based M-TRP.

* 1. Issue#b-9: Clarify the time-domain position of DMRS and number of symbols for TBS determination in Scheme 3

[2] discussed the time-domain position of DMRS in scheme 3 and proposed to clarify in TS 38.211 that the time-domain position of PDSCH DMRS is based on the duration of PDSCH transmission occasion corresponding to one TCI-state and make the following TP:

|  |
| --- |
| **7.4.1.1.2 Mapping to physical resources**  <Unchanged parts are omitted>  The position(s) of the DM-RS symbols is given by  and duration where  - for PDSCH mapping type A, is the duration between the first OFDM symbol of the slot and the last OFDM symbol of the scheduled PDSCH resources in the slot  - for PDSCH mapping type B, is the duration of the scheduled PDSCH resources except PDSCH is associated with two TCI states and the higher layer parameter *RepSchemeEnabler* is set to ‘*TDMSchemeA’*,for which is the duration of the scheduled PDSCH resources corresponding to one TCI state in a slot |

Based on the proposal by [2], the following offline proposal is made:

Offline proposal #b-9-1: Adopt the above TP for 38.211.

[5] suggested that the description of TBS determination in current specification does not apply to the case of Scheme 3 and propose a TP to update that. [5] propose to use a unified description by specifying that is given by the number of symbols indicated in SLIV of DL DCI.

Based on the proposal by [5], the following offline proposal is made:

Offline proposal #b-9-2: Adopt the following TP for 38.214

|  |
| --- |
| **5.1.3.2 Transport block size determination**  < Unchanged parts are omitted >  For the PDSCH assigned by a PDCCH with DCI format 1\_0, format 1\_1 or format 1\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, or SI-RNTI, if Table 5.1.3.1-2 is used and *,* or a table other than Table 5.1.3.1-2 is usedand *,* the UE shall, except if the transport block is disabled in DCI format 1\_1, first determine the TBS as specified below:  1) The UE shall first determine the number of REs (*NRE*) within the slot.  - A UE first determines the number of REs allocated for PDSCH within a PRB () by , where is the number of subcarriers in a physical resource block,  is the number of symbols *L* of the PDSCH allocation ~~within the slot~~ according to Clause 5.1.2.1,  is the number of REs for DM-RS per PRB in the scheduled duration including the overhead of the DM-RS CDM groups without data, as indicated by DCI format 1\_1 or format 1\_2 or as described for format 1\_0 in Clause 5.1.6.2, and  is the overhead configured by higher layer parameter *xOverhead* in *PDSCH-ServingCellConfig*. If the *xOverhead* in *PDSCH-ServingCellconfig* is not configured (a value from 0, 6, 12, or 18), the  is set to 0. If the PDSCH is scheduled by PDCCH with a CRC scrambled by SI-RNTI, RA-RNTI, MsgB-RNTI or P-RNTI,  is assumed to be 0.  < Unchanged parts are omitted > |

* 1. Issue#b-10: Description on QCL of DMRS ports of M-TRP PDSCH in 38.211

[4] [12] discussed that description that all DMRS ports of one PDSCH are QCLed cannot be applied to PDSCH associated with two TCI-states in M-TRP and suggest to fix it.

|  |  |
| --- | --- |
| TP by [4] | ----------------------------------------Start of text proposal for 7.4.1.1.2 of TS 38.214 -----------------------------------------  <Unchanged parts are omitted>  In absence of CSI-RS configuration, and unless otherwise configured, the UE may assume PDSCH DM-RS and SS/PBCH block to be quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and, when applicable, spatial Rx parameters. The UE may assume that the PDSCH DM-RS within the same CDM group are quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and spatial Rx(when applicable).  The UE may assume that no DM-RS collides with the SS/PBCH block.  ------------------------------------------------------- End of text proposal ------------------------------------------------------ |
| TP by [12] | 7.4.1.1.2 Mapping to physical resources  In absence of CSI-RS configuration, and unless otherwise configured, the UE may assume PDSCH DM-RS and SS/PBCH block to be quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and, when applicable, spatial Rx parameters. The UE may assume that the PDSCH DM-RS within the same CDM group are quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and spatial Rx. Except for a PDSCH associated with two TCI states, the UE may assume that DMRS ports associated with a PDSCH are QCL with QCL Type A, Type D (when applicable) and average gain.  The UE may assume that no DM-RS collides with the SS/PBCH block. |

Based on the proposal by [4] and [14], the following offline proposal is made:

Offline proposal #b-10: update the TS 38.211 based on TPs proposed by [4] and [12].

* 1. TP #b-11 capturing the missing conditions for scheme 4 and scheme 2a/2b/3 in TS 38.214

[1][2][4] [9] [14]discussed the issue that in current specification TS 38.214, condition 4, i.e., none of entry in TDRA contains RepNumR16, is missing for identifying Scheme 2a (FDMSchemeA)/2b (FDMSchemeB)/c (TDMSchemeA); The condition of “RepSchemeEnabler is not configured” is missing for Scheme 4.

In RAN1#100bis-3 meeting, a reply LS to RAN2 [4] was agreed as follows:

*From RAN1 perspective, schemes 2a/2b/3 and scheme 4 are mutually exclusive, which will be captured (with text proposal to be finalized) in TS38.214, Section 5.1.*

They make the following proposals:

* [1],[2],[4],[9] proposed to capture the condition 4 for Scheme 2a/2b/3 and the condition of “RepSchemeEnabler is not configured” for Scheme 4. And proposed TP for that.
* While [14] proposed to support dynamic switching between scheme 2a/2b/3 and 4.

Since this issue was discussed in last meeting and we made agreement that scheme 2a/2b/3 and scheme 4 are mutually exclusive and that should be captured in TS 38.214. Therefore, the offline proposal is:

Offline proposal #b-11: update the TS 38.214 to capture the missing condition for scheme 2a/2b/3 and for scheme 4.

* 1. Issue#b-12: Type-1 HARQ-ACK codebook determination for Scheme 3

Company [14][16] discussed the issue of Type-1 HARQ-ACK codebook determination for Scheme 3. [16] explained the problem with the following two figures:



Fig.1 Time domain resource allocation for TDM scheme A



Fig.2 PDSCH time domain resource allocation table configuration

Both [14] and [16] proposed that for TDM scheme A, the HARQ-ACK bit location in type-1 HARQ-ACK codebook is determined based on the 1st PDSCH reception occasion.

Offline proposal #b-12: For TDM scheme A, the HARQ-ACK bit location in type-1 HARQ-ACK codebook is determined based on the 1st PDSCH reception occasion

* 1. Issue#b-13: RV values for DL SPS based multi-TRP repetition transmission

[17] and [18] discussed the issues of DL SPS transmission in single-DCI based M-TRP.

* [17] proposed to re-use a similar approach adopted for Rel-15 based DL SPS PDSCH repetition for indicating RV values for DL SPS based multi-TRP PDSCH repetition schemes.
* [18] proposed:
  + To clarify that the RV sequence used across multiple repetitions in schemes 2b, 3, and 4 is based on setting rvid=0
  + To clarify clarified that the in the case of scheme 4 with SPS, *RepNumR16* repetitions should not be larger than the periodicity P of the corresponding *sps-config*

Offline proposal #b-13: for SPS in single-DCI based M-TRP,

* discuss how to clarify the RV values
* clarify that for SPS with scheme 4, the value *RepNumR16* shall not be larger than the periodicity of SPS.

Summary on Priority of the Issues

Table 1 summarizes the views of interested companies on the priority of the Issues/Proposals for the discussion in RAN1#101 e-meeting:

**Table 1 Summary on the Priority of the Issues/Proposals for RAN1#100 e-meeting discussion**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Issue#** | **Description of Issues** | **Company Inputs** | | |
| **Companies who think it is essential issue** | **Companies who think it is NOT essential issue** | **Additional Comments** |
| #a-1 | PDCCH used to schedule for initial/re-transmission in Multi-DCI based M-TRP |  | QC, Apple, ZTE, MediaTek, Ericsson | QC: Not clear why such a restriction is needed.  Apple: This is an optimization.  MediaTek: further per-TRP based restriction is not required |
| #a-2 | whether configuring multi-DCI based and single-DCI based M-TRP simultaneously | FL, Apple, ZTE, MediaTek | Ericsson (no need to introduce any further restrictions into 38.214) | FL: we need a clear conclusion on if multi-DCI and single-DCI can be configured at the same time and RAN2 is waiting for RAN1 conclusion on this issue.  ZTE: RAN2 has discussed this issue and is waiting for RAN1’s decision..  MediaTek: Agree with FL’s suggestion and we should conclude in this meeting. Support Alt 1. Use case for S-DCI and M-DCI together is not clear.  Ericsson: Note that current RAN1 specs allows the possibility for simultaneous configuration of multi-DCI and single-DCI. So, the scheduling restriction proposed by companies [10], [12], [17] is not needed in our view. We propose to conclude that current RAN1 specs allows simultaneous configuration of single-DCI and multi-DCI, and this should be sufficient for RAN2 to continue their discussion. |
| #a-3 | Active BWP operation in multi-DCI based M-TRP system | Apple, ZTE | Ericsson | Apple: It is good to implement agreement correctly.  ZTE: Current spec does not align with the agreement and causes restriction that two PDSCHs even in different slots should have the same BWP for both single-TRP and MTRP transmission. This is not right. |
| #a-4 | CSI/SR UCI overlapping with two HARQ-ACK PUCCH /PUSCH of two different TRPs | Apple |  | Apple: There is indeed an ambiguity for this case. We recommend to define a default value for CSI without any associated CORESETpoolIndex as 0. |
| #a-5 | Sub-slot based HARQ-ACK feedback in multi-DCI based multi-TRP |  | ZTE |  |
| #a-6 | Default QCL for AP CSI-RS in multi-DCI based M-TRP | Apple, ZTE, MediaTek, Ericsson |  | QC: We think this is an essential issue, but ok to postpone given that no consensus could be reached in the previous meeting. We prefer to focus on more basic issues in this meeting.  Apple: This is a remaining issue from last meeting. We think we should try to reach a consensus. |
| #a-7 | Clarify the case of UE incapable of supporting default TCI state of M-TRP | QC, Apple, MediaTek, Ericsson |  | Apple: It is good to implement agreement correctly. |
| #a-8 | the issues of uplink power control in multi-DCI based M-TRP | Apple，ZTE | MediaTek | QC: We prefer to handle this issue as part of UE capability instead of specification change in 213.  Apple: One possible way to implement mDCI is to utilize CA framework, but when a common power control loop is configured for multiple TRPs, it would be difficult to use CA framework.  MediaTek: No more spec enhancement in Rel-16 |
| #a-9 | default HARQ-ACK feedback mode if RRC parameter of ACK feedback mode is not configured |  | QC, ZTE, MediaTek, Ericsson | QC: Specification works as expected. If neither joint nor separate feedback is configured, Rel. 15 procedures are followed. |
| #a-10 | Out-of-order operation on PDSCH to HARQ-ACK PUCCHs within a slot | MediaTek | Apple | Apple: This seems to be an optimization  MediaTek: Without this change of TP in [5], out-of-order of PDSCH to HARQ is allowed in symbol level even for the UE not supporting out-of-order. TP in [4] is not necessary because it is already allowed in Rel-15. |
| #a-11 | PDCCH monitoring priority based on QCL-Type D in multi-DCI based M-TRP | QC, ZTE, Ericsson | Apple | QC: It is important to support this case. Otherwise, the benefit of multi-DCI based mTRP is reduced not only in one CC but also across CCs.  Apple: This seems to be an optimization  ZTE: It is weird to support two receive beams for PDSCH but not for PDCCH. |
| #a-12 | SPS transmission in multi-DCI based M-TRP | QC, Ericsson | Apple, MediaTek | QC: Currently SPS cannot be configured / activated even from only one of the TRPs as the scrambling, HARQ-Ack, etc. for SPS is not specified given that association with a CORESETPoolIndex is not defined.  Apple: This seems to be an optimization  MediaTek: No more spec enhancement for SPS in Rel-16 |
| #a-13 | Radio link monitoring in multi-DCI based M-TRP | Apple |  | Apple: at least when 5 CORESETs are configured and L\_max=8, current spec is broken. We need to handle this issue. |
| #a-14 | Specify the BD/CCE for the case when both NR-DC and multi-DCI based M-TRP are configured | QC | Apple | QC: This issue is an FFS point from an agreement in October 2019. The issue should be concluded as specification is currently broken for the case of NR-DC.  Apple: This can be discussed later after we finalize non-DC case. |
| #a-15 | Default TCI-state for PDSCH of cross-carrier scheduling in multi-DCI based M-TRP | QC, ZTE | Apple | QC: For cross carrier scheduling in the presence of CORESETPoolIndex **in general**, it should be discussed which cases are supported.  Apple: This can be discussed after all default beam related issue for intra-CC scheduling is finished. |
| #a-16 | TPs on PDCCH monitoring in multi-DCI based M-TRP |  |  |  |
| #a-17 | Type 2 HARQ-ACK DAI for multi-DCI based multi-TRP operation | MediaTek | QC | QC: It is already mentioned in the spec that for , a multi-DCI based mTRP cell is counted as two times. Hence, there is no issue.  MediaTek: The definitions of counter DAI and total DAI updated in RAN1#100bis-e have already considered multi-DCI, so  should not be counted two times there. The behavior of counting two times as a local variable should be restricted within the pseudo code. |
| #b-1 | PDSCH processing time in Scheme 3 | QC | Apple, MediaTek | QC: This issue should be clarified as soon as possible due to UE implementation impact.  Apple: This should be handled in URLLC session  MediaTek: No ambiguity from the current spec |
| #b-2 | Clarify the relationship between *RepetitionNumber-r16/ RepSchemeEnabler*  and *pdsch-AggregationFactor* | FL, QC, Apple, ZTE, MediaTek, Ericsson |  | FL: the relationship between RepNum16 and *AggregationFactor* is ambiguous now and a clear conclusion is necessary for the operation of scheme 4.  Ericsson: we think it is important to clarify that for scheme 4, the repetitions are in RepNum16 **consecutive** slots. |
| #b-3 | Default TCI-state for PDSCH when DCI has no TCI field | ZTE | Apple, MediaTek | Apple: Default beam has nothing to do with indicated TCI, which is the principle in Rel-15. |
| #b-4 | Default TCI-state for PDSCH when DCI indicates one TCI-state | ZTE | Apple | Apple: Default beam has nothing to do with indicated TCI, which is the principle in Rel-15.  ZTE: issue b-3 to b-8 can be discussed under one email thread. We prefer to finish the default TCI issues as soon as possible. Otherwise, the scheduling latency will be impacted for those URLLC schemes. |
| #b-5 | Default TCI-state for PDSCH when DCI indicates two TCI-states | ZTE, MediaTek | Apple | Apple: Default beam has nothing to do with indicated TCI, which is the principle in Rel-15.  MediaTek: It should be clarified in the spec how default TCI states are applied to DMRS ports for different single-DCI based schemes. |
| #b-6 | Default TCI-state for PDSCH of Scheme 3 and Scheme 4 | Apple, ZTE, Ericsson | MediaTek | QC: Similar to our comments for Issue#a-6, we think this is an essential issue, but ok to postpone.  Apple: This is a remaining issue from last meeting. We think we should try to reach a consensus.  MediaTek: No optimization should be considered in maintenance stage. The ambiguity of TCI state association can be resolved in Issue #b-5. |
| #b-7 | Default QCL for AP CSI-RS in single-DCI based M-TRP | Apple, ZTE, MediaTek, Ericsson |  | QC: Similar to our comments for Issue#a-6, we think this is an essential issue, but ok to postpone.  Apple: This is a remaining issue from last meeting. We think we should try to reach a consensus. |
| #b-8 | Default TCI-state for PDSCH of cross-carrier scheduling in single-DCI M-TRP | ZTE | Apple | Apple: This can be discussed after all default beam related issue for intra-CC scheduling is finished. |
| #b-9 | Clarify the time-domain position of DMRS and number of symbols for TBS determination in Scheme 3 | ZTE, MediaTek |  | MediaTek: editorial change for clarification |
| #b-10 | Description on QCL of DMRS ports of M-TRP PDSCH in 38.211 | FL, QC, Apple, ZTE, MediaTek, Ericsson |  | FL: the description in TS 38.211 is not correct for single-DCI based M-TRP and thus a correction is necessary |
| #b-11 | capturing the missing conditions for scheme 4 and scheme 2a/2b/3 in TS 38.214 | FL, QC, Apple, ZTE, MediaTek, Ericsson |  | FL: the agreed conditions are missing in TS 38.214, which are necessary for configuring the URLLC schemes scheme2a/2b/3 and scheme 4.  ZTE: The reply LS has been agreed. This TP will be easy to be agreed. |
| #b-12 | Type-1 HARQ-ACK codebook determination for Scheme 3 | QC, MediaTek |  |  |
| #b-13 | RV values for DL SPS based multi-TRP repetition transmission | QC, ZTE, Ericsson |  |  |

1. List of contributions
2. R1-2003397 On remaining issues on M-TRP vivo
3. R1-2003469 Maintenance of multi-TRP enhancements ZTE
4. R1-2003531 Remaining issues on multi-TRP in R16 Huawei, HiSilicon
5. R1-2003627 Discussion on remaining issues of multi-TRP/panel transmission CATT
6. R1-2003660 Remaining issues on multi-TRP transmission MediaTek Inc.
7. R1-2003742 Corrections to multi-TRP Intel Corporation
8. R1-2003819 Remaining issues on multi-TRP/panel transmission Lenovo, Motorola Mobility
9. R1-2003881 On Rel.16 multi-TRP/panel transmission Samsung
10. R1-2003928 Text proposals on enhancements on multi-TRP/panel transmission LG Electronics
11. R1-2003954 Remaining issues on multi-TRP/panel transmission CMCC
12. R1-2003987 Discussion on remaining issues of multi-TRP operation Spreadtrum Communications
13. R1-2004047 Text proposals for enhancements on multi-TRP and panel Transmission OPPO
14. R1-2004229 Remaining issues for Multi-TRP enhancement Apple
15. R1-2004265 Maintenance of Rel-16 Multi-TRP operation Nokia, Nokia Shanghai Bell
16. R1-2004311 Remaining issues on multi-TRP transmission NEC
17. R1-2004395 Remaining issues on multi-TRP/panel transmission NTT DOCOMO, INC
18. R1-2004432 Remaining issues on Multi-TRP/Panel Transmission Ericsson
19. R1-2004463 Multi-TRP Enhancements Qualcomm Incorporated
20. R1-2004592 Clarification on Multi-TRP URLLC Scheme 4 Convida Wireless