3GPP TSG RAN WG1 Meeting #94b **R1-1810751**
Chengdu, China, October 8th – 12th, 2018

Source: **Intel Corporation**
Title: **Remaining Issues on Beam Management**
Agenda item: **7.1.2.3**
Document for: **Discussion and Decision**

1. Introduction

In this contribution, we provide some corrections for beam management and beam failure recovery.

2. Beam Management

2.1 CSI-RS beam indication

For aperiodic CSI-RS, currently two ways are agreed for TRS and CSI-RS for CSI acquisition. For CSI acquisition, a default beam should be used when scheduling offset is before UE reported threshold. For TRS, the scheduling offset shall not be less than UE reported threshold. Then how to decide the QCL for CSI-RS for BM could be one remaining issue. Different from CSI acquisition, CSI-RS for BM can be used to discover new gNB and UE beams. So it is better that the UE can have enough QCL information to decide the Rx beam for CSI-RS for BM. Then the scheduling offset for CSI-RS for BM should be above the threshold UE reported.

Further there are currently two thresholds defined in UE capability, one is the threshold for PDSCH reception, which is also applied to aperiodic TRS; the other is the threshold for CSI-RS reception. For CSI-RS for CSI acquisition, a UE may need to prepare multiple Rx beams to receive one CSI-RS resource set, so additional processing latency should be considered compared to PDSCH and TRS reception. Therefore the threshold for CSI-RS acquisition should reuse the threshold for CSI-RS for BM. In addition, since CSI-RS for CSI acquisition can also be used to measure CSI for PDSCH with default beam, it is better that the default beam of CSI-RS is one of PDSCH default beam, which follows the TCI state in monitoring CORESET in active BWP in latest slot with lowest CORESET ID when multiple CORESETs are configured.

Proposal 1: For aperiodic CSI-RS for beam management, UE shall expect its scheduling offset is above threshold UE reported.

Proposal 2: The threshold for CSI-RS for CSI acquisition should be the same as that for CSI-RS for beam management.

Proposal 3: The default beam for CSI-RS for CSI acquisition follows the TCI state in monitoring CORESET in active BWP in latest slot with lowest CORESET ID when multiple CORESETs are configured.

2.2 PDSCH beam indication

It has been agreed that when the scheduling offset is below a threshold, the PDSCH beam should use the default beam which is the same as beam of the lowest CORESET-ID in the latest slot in which one or more CORESETs are configured for the UE. However there may be some issues if the CORSET-BFR is considered as shown in Figure 1. In that case, the UE should follow the beam for CORESET-BFR. However the beam for CORESET-BFR is not clear if it is not in beam failure recovery procedure. So the CORSET-BFR should be excluded for default PDSCH beam assumption, and only the CORESET the UE is monitoring should be considered.

Further there may be two different understandings for the wording for current spec on default PDSCH QCL assumption as follows:

- Interpretation 1: default PDSCH beam always follows beam of CORESET with lowest ID
- Interpretation 2: default PDSCH beam follows beam of CORESET in latest slot, if there are multiple CORESETs in the slot, the one with lowest CORESET ID should be applied.

For both the cases when tci-PresentInDCI is set to 'enabled' and tci-PresentInDCI is not configured in RRC connected mode, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold Threshold-Sched-Offset, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the lowest CORESET-ID in the latest slot in which one or more CORESETs within the active BWP of the serving cell are configured for the UE.

Interpretation 2 seems to be aligned with previous agreements. So based on the discussion above, a TP is proposed.

Proposal 4: Adopt the following TP for 38.214.

5.1.5 Antenna ports quasi co-location

<unrelated part omitted>

For both the cases when *tci-PresentInDCI* is set to 'enabled' and *tci-PresentInDCI* is not configured in RRC connected mode, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *Threshold-Sched-Offset*, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the **monitoring CORESET** ~~lowest *CORESET-ID*~~ in the latest slot in which **the CORESET with lowest *CORESET-ID* is applied** when one or more **monitoring** CORESETs within the active BWP of the serving cell are configured for the UE. If none of configured TCI states contains 'QCL-TypeD', the UE shall obtain the other QCL assumptions from the indicated TCI states for its scheduled PDSCH irrespective of the time offset between the reception of the DL DCI and the corresponding PDSCH.

In addition, when scheduling offset is below threshold, the PDSCH beam should follow one CORESET beam, but if there is no CORESET configured with TCI state in that bandwidth part (BWP), it is not clear how to determine the PDSCH beam. According to current 38.331 as follows, TCI state is not allowed to be configured for CORESET 0.

controlResourceSetId

Corresponds to L1 parameter 'CORESET-ID'. Value 0 identifies the common CORESET configured in MIB and in ServingCellConfigCommon (controlResourceSetZero) and is hence not used here in the ControlResourceSet IE. Values 1..maxNrofControlResourceSets-1 identify CORESETs configured by dedicated signalling or in SIB1. The controlResourceSetId is unique among the BWPs of a ServingCell.

Then if a UE is configured with CORESET 0 only in active BWP. It cannot identify one CORESET with TCI state. Therefore one simple way is to configure at least one CORESET with TCI state configured in active BWP for FR2.

Proposal 5: To identify default PDSCH QCL, UE shall expect that gNB should not schedule PDSCH with scheduling offset within threshold when there is no CORESET with TCI state configured in active BWP in FR2.

Further for cross-carrier scheduling, when TCI state is not present in scheduling DCI and scheduling offset is above threshold, how to determine the PDSCH QCL could be one issue. Based on current spec, the UE would apply the same beam to receive scheduling PDCCH and PDSCH in that case. But the cross-CC QCL may not always be guaranteed, if the scheduling PDCCH and scheduled PDSCH are in different band, e.g. PDCCH in FR1 and PDSCH in FR2 as shown in Figure 1.

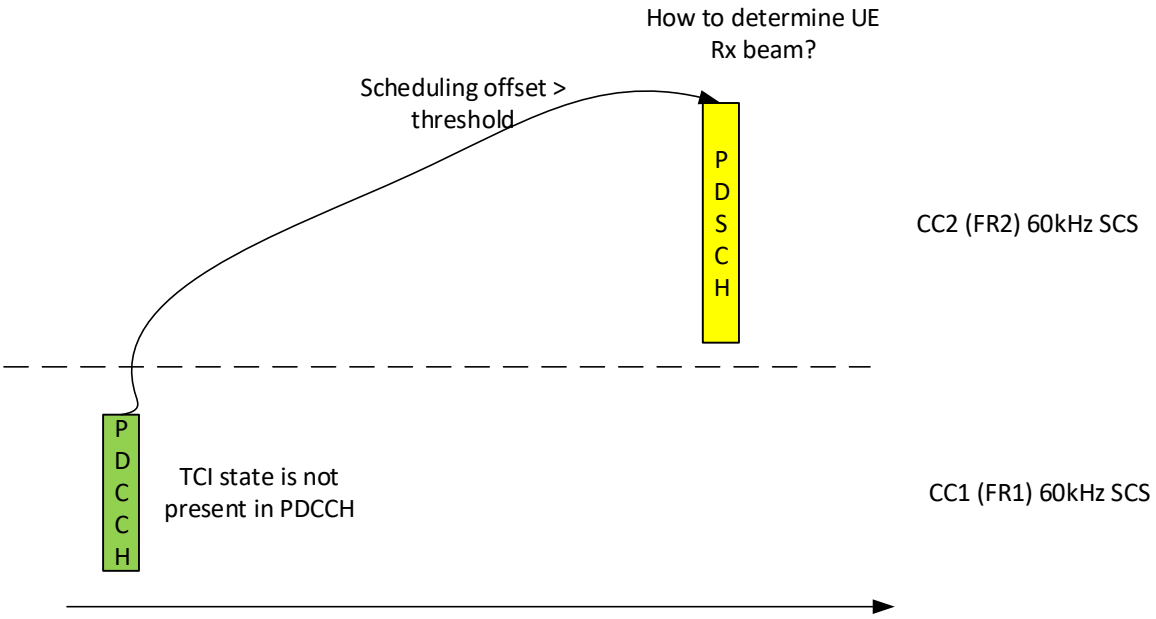

Figure 1: one issue for cross-carrier scheduling

Therefore one possible way is that for cross-carrier scheduling when TCI state is not present and scheduling offset is above threshold, the UE can also use the default PDSCH beam to receive the scheduled PDSCH.

Proposal 6: For cross-carrier scheduling, if TCI is not present in DCI, UE can use the default PDSCH QCL assumption to receive the scheduled PDSCH regardless of the scheduling offset, and the default PDSCH QCL assumption is based on the TCI state for CORESET in the latest slot with the lowest ID if multiple CORESETs are configured.

In last meeting, it has been agreed that the TCI state is selected from the candidate TCI states in PDSCH slot for single-slot PDSCH case. For multi-slot PDSCH, this is still an open issue. To simplify the UE assumption, one possible way is to determine the TCI state based on the candidate TCI states in the first PDSCH slot for multi-slot PDSCH case.

Proposal 7: For multi-slot PDSCH, the indicated TCI should be based on the active TCI states in the first PDSCH slot.

It has been agreed that UE can report it supports only 1 active TCI states for PDSCH and PDCCH as FG2-4 in the table below. In that case, only 1 TCI state could be configured by MAC CE. Such a UE may need to support 1 additional TCI state for PDCCH according to FG2-4a. Therefore for such a UE, if two CORESETs with different TCIs are configured, gNB has to schedule the PDSCH with scheduling offset larger than threshold and TCI should be present in DCI, although only 1 candidate TCI state is selected by MAC CE, otherwise UE has to monitor an additional active TCI state for PDSCH since in some case PDSCH beam is based on PDCCH beam. To support such a UE capability, when only 1 TCI state for PDSCH is indicated by MAC CE, UE shall use this TCI state to derive PDSCH QCL information regardless whether TCI is present in DCI or whether scheduling offset is below threshold.

2-4	TCI states for PDSCH	1. Support number of active TCI states per BWP per CC, including control and data 2. maximum number of configured TCI states per CC for PDSCH	2-1	Yes	Only one TCI state can be supported	Type 1	N.A.	N.A.				Component-1: Candidate value set: {1, 2, 4, 8 } Component-2: candidate value set: {4, 8, 16, 32, 64} FFS: mandatory values for component-2	
2-4a (new FG)	Additional active TCI state for PDCCH	Support one additional active TCI state for control in addition to the supported number of active TCI states for PDSCH	2-1	Yes	No additional TCI state for control	Type 1	N.A.	N.A.		Note: Only applicable if Component-1 of 2-4 is set to 1		Mandatory with capability signalling	Mandatory with capability signalling

Proposal 8: To support UE reporting its capability of 1 active TCI state, when only 1 TCI state for PDSCH is indicated by MAC CE, UE shall use this TCI state to derive PDSCH QCL information regardless whether TCI is present in DCI or whether scheduling offset is below threshold.

2.3 PDCCH beam indication

It has been agreed that PDCCH beam indication is based on RRC or RRC+MAC CE. The beam indication is per CORESET basis. Then one remaining issue is whether/how to indicate the beam for CORESET 0 and CORESET-BFR.

For COREST 0, to configure TCI state by RRC is precluded according to 38.331, and it has been agreed that the no new RRC signaling or MAC CE is defined. Then there could be the following remaining options to for CORESET 0 beam indication:

- Option 1: Reuse MAC CE for CORESET TCI indication for CORESET 0 beam indication, where the TCI field can be an SSB index.
- Option 2: CORESET 0 beam is based on the SSB index with strongest L1-RSRP reported in latest beam reporting
- Option 3: PDCCH ordered PRACH to update CORESET 0 beam

Table 1 illustrates study on the pros and cons for the three options.

Table 1: Pros and Cons for the options for CORESET 0 beam indication

Options	Pros	Cons
Option 1: Reuse MAC CE for CORESET TCI indication	Clean solution	unclear
Option 2: Beam reporting based	Faster than MAC CE based scheme	UE has to report one SSB beam status
Option 3: PDCCH ordered PRACH based	unclear	Large overhead and potential misunderstanding between gNB and UE

In addition, for CORESET-BFR, it has been agreed that it can only be tied to search space used for BFR. During BFR, its beam is based on the newly identified beam and after BFR UE would not monitor CORESET-BFR, so it is not necessary to configure TCI state for CORESET-BFR. If TCI state is configured, it would be confused for UE what the QCL assumption for CORESET-BFR should be when it starts to monitor it.

Proposal 9: For CORESET 0, support to reuse MAC CE for CORESET TCI indication to maintain the same understanding of SSB between gNB and UE, where the TCI state ID field should be based on an SSB index.

Proposal 10: For CORESET-BFR, UE shall expect TCI state should not be configured.

2.4 PUSCH beam indication

It has been specified that "The UE shall not expect PUSCH scheduled by DCI format 0_0 in a component carrier without configured PUCCH resource with *PUCCH-SpatialRelationInfo* in frequency range 2". But this restriction should only be applied to UE in RRC connected mode. For idle mode UE, PUSCH beam should follow Msg3 beam and gNB cannot configure a PUCCH resource.

Hence a TP is proposed as follows:

Proposal 11: Adopt the following TP for PUSCH beam indication for 38.214.

6.1.1 Transmission schemes

Two transmission schemes are supported for PUSCH: codebook based transmission and non-codebook based transmission. The UE is configured with codebook based transmission when the higher layer parameter *txConfig* in *PUSCH-Config* is set to 'codebook', the UE is configured non-codebook based transmission when the higher layer parameter *txConfig* is set to 'nonCodebook'. If the higher layer parameter *txConfig* is not configured, the UE is not expected to be scheduled by DCI format 0_1. If PUSCH is scheduled by DCI format 0_0, the PUSCH transmission is based on a single antenna port. The UE shall not expect PUSCH scheduled by DCI format 0_0 in a component carrier without configured PUCCH resource with *PUCCH-SpatialRelationInfo* in frequency range 2 **after RRC connection**.

Further for PUSCH beam indication, currently it is based on the beam indication for SRS for current transmission scheme, e.g. codebook or non-codebook. It is specified that the indicated SRI in DCI is associated with the most recent transmitted SRS before PDCCH. Then it is unclear whether the UE should apply new Tx beam for PUSCH after beam indication for SRS or after transmission of the SRS by new beam as shown in Figure 2.

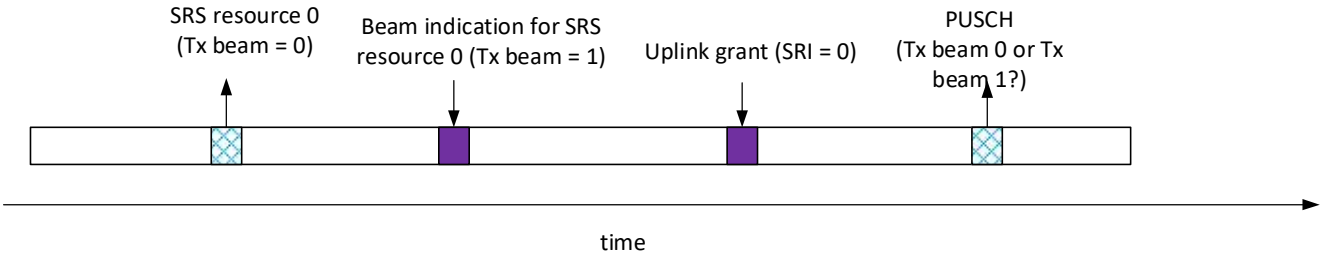

Figure 2: one issue for PUSCH beam indication

To reduce overhead and latency, it is better that the UE can apply beam after the beam indication for corresponding SRS.

Proposal 12: PUSCH should use the same spatial domain filter as configured for indicated SRS in DCI instead of the spatial domain filter applied in latest transmission of the indicated SRS.

2.5 SRS for beam management

SRS for beam management can be used for UE beam refinement, where UE can apply different beams in different time instances. Then when SRS is configured in spatial relation info, it should be identified which time instance of the SRS is indicated. Further, if the UE changes spatial domain filter for SRS, whether the corresponding beam for indicated channel should change or not is one issue. As shown in Figure 3, there could be different options to determine the spatial domain transmission filter for PUCCH. To reflect the latest beam status, it is better that the PUCCH can follow the latest Tx beam for corresponding SRS, as shown in option 1.

	Tx beam index			
PUCCH instance	option 1	option 2	option 3	option 4
0	2	2	0	1
1	3	2	0	1

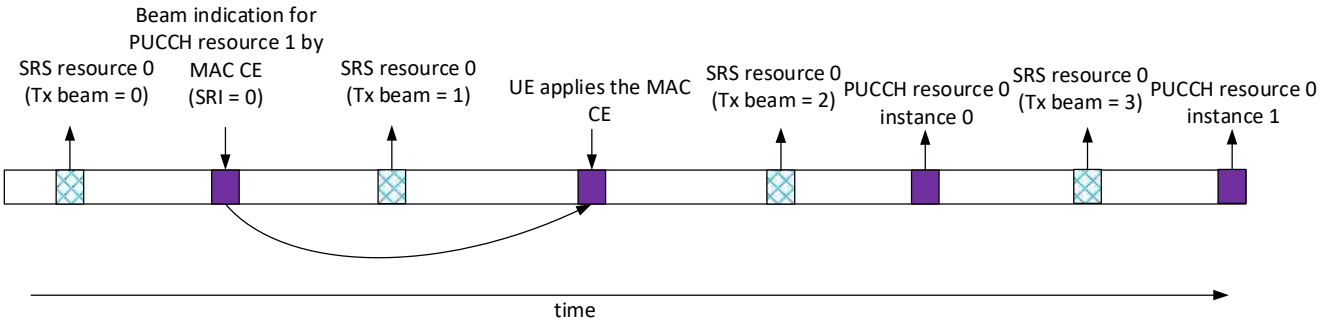

Figure 3: one issue for SRS based beam indication

Proposal 13: When SRS is configured in spatial relation info, for each transmission of the corresponding uplink channel, i.e. SRS for other purpose, PUCCH, it should follow the spatial domain transmission filter for latest SRS transmission.

2.6 Beam reporting

It has been specified that when repetition is 'ON", gNB can configure UE to report CRI/RSRP, but UE would report RSRP only. Such behavior is not clear to gNB since whether the RSRP is averaging from all or some of the CSI-RS resources or based on a single CSI-RS resource is unknown. This is also not easy for RAN4 test case design. Further there seems to be no agreement for such UE behavior. Therefore it is better that when repetition is "ON', gNB shall not configure UE to report CRI/RSRP.

Proposal 14: Adopt the following TP on beam reporting for 38.214.

5.2.1.4 Reporting configurations

<Unrelated part omitted>

When the UE is configured with higher layer parameter *NZP-CSI-RS-ResourceSet* and when the higher layer parameter *repetition* is set to 'off', the UE shall determine a CRI from the supported set of CRI values as defined in Subclause 6.3.1.1.2 of [5, TS 38.212] and report the number in each CRI report. When the higher layer parameter *repetition* is set to 'on', **UE shall expect to be configured with a *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'none'** ~~CRI is not reported~~. CRI reporting is not supported when the higher layer parameter *codebookType* is set to 'typeII' or to 'typeII-PortSelection'.

<Unrelated part omitted>

3. Beam Failure Recovery

3.1 BFD RS

Currently SSB cannot be configured for BFD explicitly or implicitly. Therefore some wording for SSB for BFD should be removed.

Proposal 15: Adopt the following TP on BFD RS for 38.213.

6 Link recovery procedures

<unrelated part omitted>

The physical layer in the UE assesses the radio link quality according to the set $\overline{q}_0$ of resource configurations against the threshold $Q_{out,LR}$. For the set $\overline{q}_0$, the UE assesses the radio link quality only according to periodic CSI-RS resource configurations ~~or SS/PBCH blocks~~ that are quasi co-located, as described in [6, TS 38.214], with the DM-RS of PDCCH receptions monitored by the UE. The UE applies the $Q_{in,LR}$ threshold to the L1-RSRP measurement obtained from a SS/PBCH block. The UE applies the $Q_{in,LR}$ threshold to the L1-RSRP measurement obtained for a CSI-RS resource after scaling a respective CSI-RS reception power with a value provided by higher layer parameter *powerControlOffsetSS*.

The physical layer in the UE provides an indication to higher layers when the radio link quality for all corresponding resource configurations in the set $\overline{q}_0$ that the UE uses to assess the radio link quality is worse than the threshold $Q_{out,LR}$. The physical layer informs the higher layers when the radio link quality is worse than the threshold $Q_{out,LR}$ with a periodicity determined by the maximum between the shortest periodicity among the periodic CSI-RS configurations ~~and/or SS/PBCH blocks~~ in the set $\overline{q}_0$ that the UE uses to assess the radio link quality and 2 msec.

3.2 BFD during DRX

It has been agreed that indication of beam failure instance to higher layer is periodic, and the beam failure indication interval is determined by the shortest periodicity of BFD RS, which is also lower bounded by 2ms. However, the UE could be configured with DRX operation. During the inactive time of one DRX cycle, the UE could go to sleep to reduce power consumption. During the inactive time, the UE doesn't perform measurement on the BFD RS, and consequently the UE can't assess the radio link quality whether it is better or worse than the threshold. So during the inactive time of one DRX cycle, the UE physical layer should not send beam failure indication to MAC layer.

Proposal 16: If DRX operation is configured, the UE physical layer shall not be mandated to send beam failure indication to MAC layer during the inactive time.

3.3 BFR over contention based PRACH

The contention based PRACH based BFR has been agreed. However the CB-PRACH may have some other functions, e.g. SR. Then it should be necessary to differentiate beam failure recovery request with other purpose of PRACH. There could be the following two options.

Option A: beam failure recovery request is identified in Msg1.

Option B: beam failure recovery request is identified in Msg3.

With option A, since the PRACH is contention based, it means there should be a separate PRACH resource pool for beam failure recovery request. UEs sending beam failure recovery request should share the resource pool and collision could happen. Thus although the gNB could know the PRACH is for BFR in Msg1, the gNB still needs to wait for Msg3 to identify the UE.

With option B, the UE could include information identifying beam failure recovery request in Msg3. Compared with option B, Option A is more complicated since a separate resource pool should be created.

Proposal 17: For BFR over CB-PRACH, whether CB-PRACH is used for BFR or other purpose should be identified in Msg3.

3.4 PDCCH and PDSCH QCL during BFR

In current spec, it is specified that "For the PDCCH monitoring and for the corresponding PDSCH reception, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with index q_{new} until the UE receives by higher layers an activation for a TCI state or any of the parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*.". However UE shall monitor previous CORESET after transmitting BFRQ. So the PDCCH monitoring should indicate the PDCCH in SS-BFR, and corresponding PDSCH means the PDSCH scheduled by PDCCH. It has been specified that when scheduling offset is below a threshold, UE shall use default beam. So only when scheduling offset is above threshold, UE can use new beam to monitor PDSCH. Therefore one TP is proposed as follows.

Proposal 18: Adopt the following TP for PDCCH/PDSCH QCL during BFR in 38.213.

6 Link recovery procedures

<unrelated part omitted>

The UE may receive by higher layer parameter *PRACH-ResourceDedicatedBFR*, a configuration for PRACH transmission as described in Subclause 8.1. For PRACH transmission in slot n and according to antenna port quasi co-location parameters associated with periodic CSI-RS resource configuration or with SS/PBCH block associated with index q_{new} provided by higher layers [11, TS 38.321], the UE monitors PDCCH in a search space set provided by higher layer parameter *recoverySearchSpaceId* for detection of a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI starting from slot $n+4$ within a window configured by higher layer parameter *BeamFailureRecoveryConfig*. For the PDCCH monitoring, **which is in a search space set provided by higher layer parameter *recoverySearchSpaceId,*** and for the corresponding PDSCH reception **with scheduling offset equal to or larger than *Threshold-Sched-Offset***, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with index q_{new} until the UE receives by higher layers an activation for a TCI state or any of the parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the UE continues to monitor PDCCH candidates in the search space set provided by *recoverySearchSpaceId* until the UE receives a MAC CE activation command for a TCI state or higher layer parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList.*

3.5 PUCCH spatial relation info after BFR

PUCCH spatial relation info may be configured either by downlink RS, e.g. SSB/CSI-RS, or SRS. If PUCCH beam is not the same as PDCCH beam, it is not necessary to update PUCCH spatial relation info. Therefore after BFR, UE should reset the Tx beam for only the PUCCH resources with the spatial relation info configured by SSB/CSI-RS that is the same as that configured in TCI state for a CORESET.

Further, when to start to reset the Tx beam could be an issue. Currently BFR response is carried by PDCCH in SS-BFR. The PDCCH can schedule either a PDSCH or a PUSCH. Then it could be possible that PDCCH is not received by UE. Then if spatial relation info reset starts right after the PDCCH slot, there could be mismatch between gNB and UE. If PDCCH is used to schedule a PDSCH, K1 slots should be needed to report ACK for the PDSCH. Then gNB can know whether PDCCH is received or not by UE after detecting ACK. If PDCCH is used to schedule PUSCH, K2 slots should be needed to transmit PUSCH. After receiving PUSCH, gNB can identify whether PDCCH

is received or not. To detect ACK/PUSCH, similar to BFRQ, 4 slots can be reserved for gNB processing. Therefore the PUCCH spatial relation info should be reset K1+4 slot after PDCCH slot if PDCCH is used to schedule PDSCH, or K2+4 slots after PDCCH slot if PDCCH is used to schedule PUSCH as shown in Figure 4.

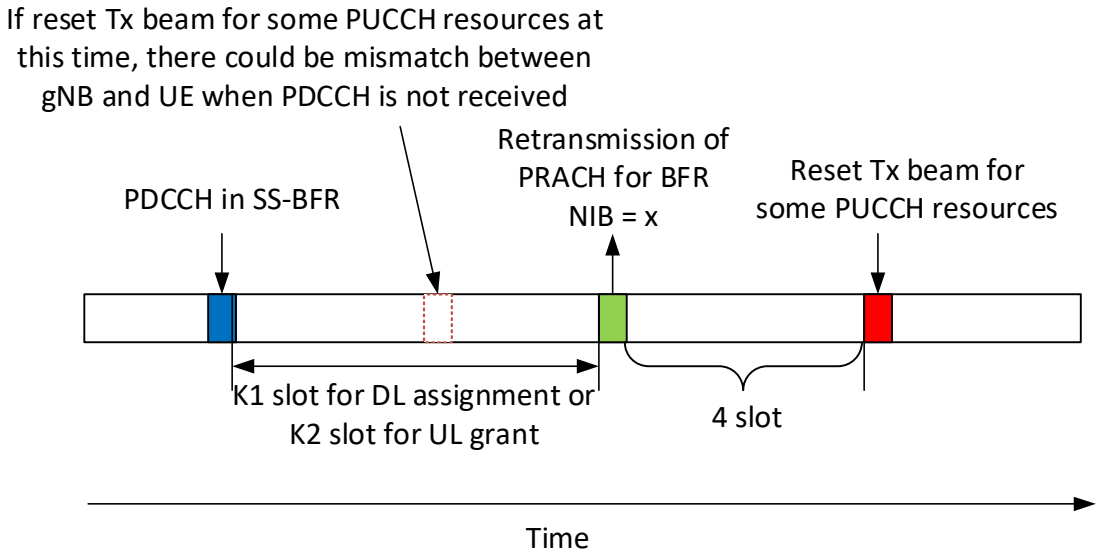

Figure 4: Timeline for PUCCH beam reset

Proposal 19: K slots after receiving PDCCH in SS-BFR, UE should use the spatial domain filter for CF-PRACH for BFR to transmit some PUCCH resources.

- ***K is K1+4 if PDCCH is downlink assignment or K is K2+4 if PDCCH is uplink grant***
- ***Some PUCCH resources indicates the PUCCH resources with the spatial relation info configured by the SSB/CSI-RS that is the same as TCI state for one CORESET in active BWP***

3.6 Reply on RAN2 LS

In last meeting, RAN2 sent an LS R2-1813493 to RAN1 asking whether the power ramping counter should be increased or not for the following cases:

(C) the CSI-RS is selected and the CSI-RS is same as the last RA preamble transmission.

(D) the CSI-RS is selected but the CSI-RS is not same as the last RA preamble transmission.

(E) the SSB is selected but the CSI-RS was selected in the last RA preamble transmission.

(F) the CSI-RS is selected but the SSB was selected in the last RA preamble transmission.

When PRACH is associated with the same new beam, the counter should be increased. So if the same resource is associated with PRACH in different time instances, the power ramping counter should be incremented. For the other cases, from current spec, UE cannot guarantee that the same spatial domain transmission filter is applied for different reference signal resources. Therefore the counter should not be incremented. Moreover regarding the overhead, a normal gNB should not configure different resources with the same beam that is associated with different PRACH resources. Therefore for case C, power ramping counter should be incremented, and for case D-F, power ramping counter should not be incremented.

Moreover, it can be observed that UE can select a different PRACH resources in each BFRQ opportunity. Hence in current spec, it should be defined the q_{new} can be different in each PRACH instance.

Proposal 20: Reply RAN2 LS R2-1813493 with the following response: for case C, power ramping counter should be incremented, and for case D-F, power ramping counter should not be incremented.

Proposal 21: Adopt the following TP to reflect q_{new} can be different in different PRACH instances.

6 Link recovery procedures

The UE may receive by higher layer parameter *PRACH-ResourceDedicatedBFR*, a configuration for PRACH transmission as described in Subclause 8.1. For PRACH transmission in slot n and according to antenna port quasi co-location parameters associated with periodic CSI-RS resource configuration or with SS/PBCH block associated with index q_{new} **for current PRACH transmission** provided by higher layers [11, TS 38.321], the UE monitors PDCCH in a search space set provided by higher layer parameter *recoverySearchSpaceId* for detection of a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI starting from slot $n+4$ within a window configured by higher layer parameter *BeamFailureRecoveryConfig*. For the PDCCH monitoring and for the corresponding PDSCH reception, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with **latest** index q_{new} until the UE receives by higher layers an activation for a TCI state or any of the parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the UE continues to monitor PDCCH candidates in the search space set provided by *recoverySearchSpaceId* until the UE receives a MAC CE activation command for a TCI state or higher layer parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList.*

3.7 BFD for CORESET 0

Currently there are two ways for UE to determine the DL RS for BFD: the first way is to use the explicitly configured CSI-RS for BFD; the second way is to use the RS indicated in the TCI state for CORESET(s) when there is no CSI-RS explicitly configured. According to current RRC signaling, TCI state cannot be configured for CORESET 0. So the second way is not feasible. Then if BFD for CORESET 0 is required, it means gNB should configure CSI-RS for BFD and the second way with lower overhead cannot be used any more. Since CORESET 0 is mainly used for broadcast signal, it is not necessary to mandate gNB to configure explicit CSI-RS for CORESET 0 for BFD. Thus UE shall not be mandated to do beam failure detection for CORESET 0.

Proposal 22: Beam failure detection should not be applied for CORESET 0.

4. Conclusion

In this contribution we have provided some discussion on beam management and beam failure recovery. From the discussion, we have achieved the following proposals for beam management.

Proposal 1: For aperiodic CSI-RS for beam management, UE shall expect its scheduling offset is above threshold UE reported.

Proposal 2: The threshold for CSI-RS for CSI acquisition should be the same as that for CSI-RS for beam management.

Proposal 3: The default beam for CSI-RS for CSI acquisition follows the TCI state in monitoring CORESET in active BWP in latest slot with lowest CORESET ID when multiple CORESETs are configured.

Proposal 4: Adopt the following TP for 38.214.

5.1.5 Antenna ports quasi co-location

<unrelated part omitted>

For both the cases when *tci-PresentInDCI* is set to 'enabled' and *tci-PresentInDCI* is not configured in RRC connected mode, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *Threshold-Sched-Offset*, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the **monitoring CORESET** ~~lowest *CORESET-ID*~~ in the latest slot in which **the CORESET with lowest *CORESET-ID* is applied** when one or more **monitoring** CORESETs within the active BWP of the serving cell are configured for the UE. If none of configured TCI states contains 'QCL-TypeD', the UE shall obtain the other QCL assumptions from the indicated TCI states for its scheduled PDSCH irrespective of the time offset between the reception of the DL DCI and the corresponding PDSCH.

Proposal 5: To identify default PDSCH QCL, UE shall expect that gNB should not schedule PDSCH with scheduling offset within threshold when there is no CORESET with TCI state configured in active BWP in FR2.

Proposal 6: For cross-carrier scheduling, if TCI is not present in DCI, UE can use the default PDSCH QCL assumption to receive the scheduled PDSCH regardless of the scheduling offset, and the default PDSCH QCL assumption is based on the TCI state for CORESET in the latest slot with the lowest ID if multiple CORESETs are configured.

Proposal 7: For multi-slot PDSCH, the indicated TCI should be based on the active TCI states in the first PDSCH slot.

Proposal 8: To support UE reporting its capability of 1 active TCI state, when only 1 TCI state for PDSCH is indicated by MAC CE, UE shall use this TCI state to derive PDSCH QCL information regardless whether TCI is present in DCI or whether scheduling offset is below threshold.

Proposal 9: For CORESET 0, support to reuse MAC CE for CORESET TCI indication to maintain the same understanding of SSB between gNB and UE, where the TCI state ID field should be based on an SSB index.

Proposal 10: For CORESET-BFR, UE shall expect TCI state should not be configured.

Proposal 11: Adopt the following TP for PUSCH beam indication for 38.214.

6.1.1 Transmission schemes

Two transmission schemes are supported for PUSCH: codebook based transmission and non-codebook based transmission. The UE is configured with codebook based transmission when the higher layer parameter *txConfig* in *PUSCH-Config* is set to 'codebook', the UE is configured non-codebook based transmission when the higher layer parameter *txConfig* is set to 'nonCodebook'. If the higher layer parameter *txConfig* is not configured, the UE is not expected to be scheduled by DCI format 0_1. If PUSCH is scheduled by DCI format 0_0, the PUSCH transmission is based on a single antenna port. The UE shall not expect PUSCH scheduled by DCI format 0_0 in a component carrier without configured PUCCH resource with *PUCCH-SpatialRelationInfo* in frequency range 2 **after RRC connection**.

Proposal 12: PUSCH should use the same spatial domain filter as configured for indicated SRS in DCI instead of the spatial domain filter applied in latest transmission of the indicated SRS.

Proposal 13: When SRS is configured in spatial relation info, for each transmission of the corresponding uplink channel, i.e. SRS for other purpose, PUCCH, it should follow the spatial domain transmission filter for latest SRS transmission.

Proposal 14: Adopt the following TP on beam reporting for 38.214.

> 5.2.1.4 Reporting configurations
>
> <Unrelated part omitted>
>
> When the UE is configured with higher layer parameter *NZP-CSI-RS-ResourceSet* and when the higher layer parameter *repetition* is set to 'off', the UE shall determine a CRI from the supported set of CRI values as defined in Subclause 6.3.1.1.2 of [5, TS 38.212] and report the number in each CRI report. When the higher layer parameter *repetition* is set to 'on', **UE shall expect to be configured with a *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'none'** ~~CRI is not reported~~. CRI reporting is not supported when the higher layer parameter *codebookType* is set to 'typeII' or to 'typeII-PortSelection'.
>
> <Unrelated part omitted>

From the discussion, we have achieved the following proposals for beam failure recovery.

Proposal 15: Adopt the following TP on BFD RS for 38.213.

> # 6 Link recovery procedures
>
> <unrelated part omitted>
>
> The physical layer in the UE assesses the radio link quality according to the set $\overline{q}_0$ of resource configurations against the threshold $Q_{out,LR}$. For the set $\overline{q}_0$, the UE assesses the radio link quality only according to periodic CSI-RS resource configurations ~~or SS/PBCH blocks~~ that are quasi co-located, as described in [6, TS 38.214], with the DM-RS of PDCCH receptions monitored by the UE. The UE applies the $Q_{in,LR}$ threshold to the L1-RSRP measurement obtained from a SS/PBCH block. The UE applies the $Q_{in,LR}$ threshold to the L1-RSRP measurement obtained for a CSI-RS resource after scaling a respective CSI-RS reception power with a value provided by higher layer parameter *powerControlOffsetSS*.
>
> The physical layer in the UE provides an indication to higher layers when the radio link quality for all corresponding resource configurations in the set $\overline{q}_0$ that the UE uses to assess the radio link quality is worse than the threshold $Q_{out,LR}$. The physical layer informs the higher layers when the radio link quality is worse than the threshold $Q_{out,LR}$ with a periodicity determined by the maximum between the shortest periodicity among the periodic CSI-RS configurations ~~and/or SS/PBCH blocks~~ in the set $\overline{q}_0$ that the UE uses to assess the radio link quality and 2 msec.

Proposal 16: If DRX operation is configured, the UE physical layer shall not be mandated to send beam failure indication to MAC layer during the inactive time.

Proposal 17: For BFR over CB-PRACH, whether CB-PRACH is used for BFR or other purpose should be identified in Msg3.

Proposal 18: Adopt the following TP for PDCCH/PDSCH QCL during BFR in 38.213.

6 Link recovery procedures

<unrelated part omitted>

The UE may receive by higher layer parameter *PRACH-ResourceDedicatedBFR*, a configuration for PRACH transmission as described in Subclause 8.1. For PRACH transmission in slot n and according to antenna port quasi co-location parameters associated with periodic CSI-RS resource configuration or with SS/PBCH block associated with index q_{new} provided by higher layers [11, TS 38.321], the UE monitors PDCCH in a search space set provided by higher layer parameter *recoverySearchSpaceId* for detection of a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI starting from slot $n+4$ within a window configured by higher layer parameter *BeamFailureRecoveryConfig*. For the PDCCH monitoring, **which is in a search space set provided by higher layer parameter *recoverySearchSpaceId,*** and for the corresponding PDSCH reception **with scheduling offset equal to or larger than *Threshold-Sched-Offset***, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with index q_{new} until the UE receives by higher layers an activation for a TCI state or any of the parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the UE continues to monitor PDCCH candidates in the search space set provided by *recoverySearchSpaceId* until the UE receives a MAC CE activation command for a TCI state or higher layer parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList.*

Proposal 19: K slots after receiving PDCCH in SS-BFR, UE should use the spatial domain filter for CF-PRACH for BFR to transmit some PUCCH resources.

- ***K is K1+4 if PDCCH is downlink assignment or K is K2+4 if PDCCH is uplink grant***
- ***Some PUCCH resources indicates the PUCCH resources with the spatial relation info configured by the SSB/CSI-RS that is the same as TCI state for one CORESET in active BWP***

Proposal 20: Reply RAN2 LS R2-1813493 with the following response: for case C, power ramping counter should be incremented, and for case D-F, power ramping counter should not be incremented.

Proposal 21: Adopt the following TP to reflect q_{new} can be different in different PRACH instances.

Proposal 22: Beam failure detection should not be applied for CORESET 0.

6 Link recovery procedures

The UE may receive by higher layer parameter *PRACH-ResourceDedicatedBFR*, a configuration for PRACH transmission as described in Subclause 8.1. For PRACH transmission in slot n and according to antenna port quasi co-location parameters associated with periodic CSI-RS resource configuration or with SS/PBCH block associated with index q_{new} **for current PRACH transmission** provided by higher layers [11, TS 38.321], the UE monitors PDCCH in a search space set provided by higher layer parameter *recoverySearchSpaceId* for detection of a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI starting from slot $n+4$ within a window configured by higher layer parameter *BeamFailureRecoveryConfig*. For the PDCCH monitoring and for the corresponding PDSCH reception, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with **latest** index q_{new} until the UE receives by higher layers an activation for a TCI state or any of the parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the UE continues to monitor PDCCH candidates in the search space set provided by *recoverySearchSpaceId* until the UE receives a MAC CE activation command for a TCI state or higher layer parameters *TCI-StatesPDCCH-ToAddlist* and/or *TCI-StatesPDCCH-ToReleaseList.*

References

[1] 3GPP TS 38.213 v15.2.0

[2] 3GPP TS 38.214 v15.2.0