**3GPP TSG RAN WG1 #102-e R1-2005979**

**e-Meeting, August 17th – 28th, 2020**

Source: Moderator (OPPO)

Title: Summary for [102-e-NR-7.1CRs-08] QCL assumption for paging reception

Agenda Item: 7.1

Document for: Discussion and Decision

1. Introduction

This document is a summary for email discussion “[102-e-NR-7.1CRs-08] QCL assumption for paging reception”

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| [102-e-NR-7.1CRs-08] QCL assumption for paging reception – Zhihua (OPPO)* For Rel-16, Issue#21 in [R1-2006958](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2006958.zip)
* Discussion/Agreements by 8/19, TPs by 8/24
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The contribution R1-2006033 [1] raised the issue of QCL assumption for paging reception when paging PDCCH is monitored in CSS other than type0 CSS:

* When paging PDCCH is monitored in type0 CSS, TS 38.213 has specified the QCL assumption for paging reception.
* When paging PDCCH is monitored in CSS other than type0 CSS, TS 38.304 only defines the PDCCH monitoring occasion for paging in a PO corresponds to an SSB. However, no QCL assumption for such kind of paging reception is explicitly specified in current specifications.
1. Collection of Companies’ Views

## Q1

* Whether the following issue exists? And need to be fixed in spec?
	+ - When paging PDCCH is monitored in CSS other than type0 CSS, current spec lacks specification of QCL assumption for the paging reception.

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| **Company** | **View** |
| ZTE | Yes, the issue exists. According to the current spec, unfortunately, it seems that the QCL assumption for such kind of paging reception is based on the TCI state or QCL assumption applied to the CORESET by RRC/MAC-CE command. We wonder whether this issue of missing QCL assumption also exists for other type CSS(s) that is not in CORESET#0. |
| Ericsson | There is no problem. As noted in R1-2006033, if the UE has not been provided any TCI states, or no TCI state has been activated, the UE assumes the PDCCH DMRS is QCL with an SSB. It may be considered somewhat unfortunate that the SSB is described in 3 ways in 38.213: “associated SSB”, “SSB identified during initial access” and “same SS/PBCH block index as the one the UE uses to obtain MIB”. But it is clear that it is an SSB the UE chooses: since the choice is up to the UE anyway (there is no NW impact), there is no need to change the specification.We also have the following statements in 38.211:7.4.1.1.2: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.7.4.1.3.2In absence of CSI-RS configuration, and unless otherwise configured, the UE may assume PDCCH 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.Also in this case, it is clear that the UE may assume that the if no configuration exists, the UE may assume a QCL relationship with an SSB. |
| OPPO | Yes, the issue exists. For idle/inactive UE, when paging PDCCH is monitored in the type0 CSS, the UE can assume QCL properties between paging PDCCH, PDSCH and the corresponding SSB based on the following as specified in TS38213-f90:

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|  The UE may assume that the DM-RS antenna port associated with PDCCH receptions in the CORESET configured by pdcch-ConfigSIB1 in MIB, the DM-RS antenna port associated with corresponding PDSCH receptions, and the corresponding SS/PBCH block are quasi co-located with respect to average gain, QCL-TypeA, and QCL-TypeD properties, when applicable [6, TS 38.214], if the UE is not provided a TCI state indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in the CORESET. The value for the DM-RS scrambling sequence initialization is the cell ID. A SCS is provided by *subCarrierSpacingCommon* in *MIB* |

The following Figure 1 illustrates such QCL between CORESET 0 and the corresponding SSBs. Note that there is **one-to-one mapping between SSB and each PDCCH monitoring occasion**.Figure 1 QCL between CORESET 0 and the corresponding SSBsHowever, when paging search pace other than type-0 CSS is configured in RMSI, there is no similar description in the current specification on how the UE assume the QCL between SSB and the paging PDCCH in 38213. There is only the association between actually transmitted SSB and PMOs (paging PDCCH monitoring occasions) in this case as described 38.304. There is no QCL description on top of the association in the spec, as that for CORESET 0.

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| When *SearchSpaceId* other than 0 is configured for *pagingSearchSpace,*the UE monitors the (i\_s + 1)th PO. A PO is a set of 'S' consecutive PDCCH monitoring occasions where 'S'is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in*SIB1*. The Kth PDCCH monitoring occasion for paging in the PO corresponds to the Kth transmitted SSB. The PDCCH monitoring occasions for paging which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion for paging in the PF. When *firstPDCCH-MonitoringOccasionOfPO*is present, the starting PDCCH monitoring occasion number of (i\_s + 1)th PO is the (i\_s + 1)th value of the *firstPDCCH-MonitoringOccasionOfPO* parameter; otherwise, it is equal to i\_s \* S. |

During the discussion in previous meeting, and also as mentioned above by Ericssion, the sentence highlighted in yellow in the following paragraph can be applied in this case.

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| For a CORESET other than a CORESET with index 0, - if a UE has not been provided a configuration of TCI state(s) by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* for the CORESET, or has been provided initial configuration of more than one TCI states for the CORESET by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* but has not received a MAC CE activation command for one of the TCI states as described in [11, TS 38.321], the UE assumes that the DM-RS antenna port associated with PDCCH receptions is quasi co-located with the SS/PBCH block the UE identified during the initial access procedure; - if a UE has been provided a configuration of more than one TCI states by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* for the CORESET as part of Reconfiguration with sync procedure as described in [12, TS 38.331] but has not received a MAC CE activation command for one of the TCI states as described in [11, TS 38.321], the UE assumes that the DM-RS antenna port associated with PDCCH receptions is quasi co-located with the SS/PBCH block or the CSI-RS resource the UE identified during the random access procedure initiated by the Reconfiguration with sync procedure as described in [12, TS 38.331].For a CORESET with index 0, the UE assumes that a DM-RS antenna port for PDCCH receptions in the CORESET is quasi co-located with - the one or more DL RS configured by a TCI state, where the TCI state is indicated by a MAC CE activation command for the CORESET, if any, or- a SS/PBCH block the UE identified during a most recent random access procedure not initiated by a PDCCH order that triggers a contention-free random access procedure, if no MAC CE activation command indicating a TCI state for the CORESET is received after the most recent random access procedure. |

 But the above is applied for the UE that have completed initial access or in RRC connected states, who have not been configured the TCI states or have not been activated the TCI states. Please note that 2nd bullet highlighted in green is also for CORESET 0, for RRC idle UE, it can’t follow two different behaviors in the specification. Therefore, the above paragraph shall not be applied to RRC idle UEs. @Ericssion For the spec in 7.4.1.3.2 of 38211, the UE may assume PDCCH DM-RS and SS/PBCH block to be quasi co-located, it is consistent with our proposal, **the key point is for each PDCCH monitoring occasion, which SS/PBCH block shall be assumed to be quasi co-located by the UE.** Since paging is transmitted with beam sweeping manner, the gNB and the UE shall have consistent understanding which SSB is QCLed with which PDCCH monitoring occasion. With such mapping, the UE can receive paging at the PDCCH monitoring occasions corresponding to SSBs with good RSRP levels and skip the PDCCH blind detection at other PDCCH monitoring occasions. It is beneficial for the UE’s power saving, and it is why we have reached the following agreements during R-15 discussion. Agreements: * UE may assume QCL between SS Blocks, Paging DCIs and Paging Messages.
	+ UE is not required to soft combine multiple Paging DCIs within one PO.

Otherwise, without such mapping, if it is purely by UE’s implementation, the UE’s power would be wasted and also the UE may not get the right SSB for QCL assumption for each PDCCH monitoring occasion, the PDCCH detection performance may degrade.Therefore, we propose to solve this issue and complete the spec.  |
| Nokia | We are not fully sure if clarification is needed, but open to discuss about it. I.e. we have agreed that there is a QCL relation between broadcast monitoring and SSBs. Also for the case that non-zero SS ID is used, RAN2 specification captures the timing relation between the monitoring occasions and corresponding SSBs. In addition, for CORESET#0, as it is defined in 38.213 that:

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| The UE may assume that the DM-RS antenna port associated with PDCCH receptions in the CORESET configured by *pdcch-ConfigSIB1* in MIB and for corresponding PDSCH receptions, and the corresponding SS/PBCH block are quasi co-located with respect to average gain, QCL-TypeA, and QCL-TypeD properties, when applicable [6, TS 38.214], and if the UE is not provided a TCI state indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in the CORESET. |

Hence, when UE is not provided with TCI state for CORESET#0, it may assume QCL with the *corresponding SSB*. Evidently the QCL relation has not been very well captured (ref. ‘corresponding’) for CORESET#0, but the set relation between monitoring occasion and given SSB, combined with the statements in 38.211, as pointed by Ericsson, and in 38.213 above, would give desired end result. It is good to note also that there is no specification to determine how and which broadcast monitoring occasion UE should choose in IDLE/Inactive mode. Hence, it is not clear if we neeed anything for CORESET#0. Of course if SS ID ≠0, we can in SIB1 give alternative CORESET configuration (*commonControlResourceSet*, CORSET ID ≠0), thus, if seen necessary we can consider introducing similar statement as above covering the case that CORSET ID ≠0.In addition, if this is to be addressed in RAN1 specification, we should also address Type0A-PDCCH CSS. The monitoring occasions for OSI are defined in TS38.331 in a similar manner as for paging. So, if addressed for paging, we should also provide clarification in the case that when ‘*searchSpaceOtherSystemInformation*’ results non-zero value (for SS ID and CORESET ID) and TCI state has not been set. |
| Huawei | The current spec is not fully clear regarding the QCL assumption for paging receptions in particular when the search space for paging is non-zero and associated with a non-zero CORESET. Not that the QCL for CORESET #0 does not have any issue. On other hand, the PDCCH monitoring occasions for paging have been clearly specified in TR 38.304 where “The Kth PDCCH monitoring occasion for paging in the PO corresponds to the Kth transmitted SSB.” One may argue either way that the QCL assumption can/cannot be implicitly determined from this sentence. Overall, we have a slight preference to make some clarifications. However, it may be more important to confirm that whether UEs have already been implemented following the CR so that this does not results in NBC issues. We agree with Nokia that OSI has the same problem. It should be addressed together if deemed necessary.  |
| MediaTek | It seems not quite clear in the spec for such issue. Agreed with Nokia, this issue can be clarified for OSI as well if it should be clarified in the spec. If all companies share the same understanding on the QCL assumptions in this case (it seems so), it is better to make it clear in the spec or at least make the conclusion.  |
| CMCC | Yes, the issue exists. Although the association between Paging PDCCH monitoring occasions and SSB index when *pagingSearchSpace* is not search space#0 has been defined in TS38.304, there is no QCL assumption definition in TS 38.213.In addition, we agree with Nokia, Huawei and MTK, the QCL assumption for OSI has the similar issue and should be clarified. |
| CATT | When SearchSpaceId other than 0 is configured for pagingSearchSpace, TS 38.305 has defined the PDCCH monitoring occasion for paging in a PO corresponds to an SSB. However, it seems the QCL relation between PDCCHs/PDSCHs for paging and the corresponding SSBs are not explicitly defined in current specification with a non-zero CORESET. Thus, our preference is to have the clarification. About the similar issue exists in OSI as pointed out by Nokia, we think it might be better to fix the problem together to avoid repeating the same discussion. |
| Samsung | Agree with that the issue exists (however, this does not necessarily mean that it should be resolved by specification effort only). Absent All cases can be summarized as below:* Case 1) CORESET#0 + SS#0
	+ QCL assumption is clearly defined.
* Case 2) CORESET#X + SS#0
	+ This is invalid configuration since SS#0 cannot be associated with CORESET#X.
* Case 3) CORESET#0 + SS#Y
	+ QCL assumption is defined but there is some ambiguity between RAN1 and RAN2 specs for paging reception.
	+ For paging, as OPPO mentioned it, there are descriptions for relationship between PMOs and SSBs in 38.304. However, it is ambiguous whether the set of PMOs is selected from multiple CORESET#0s or from a single CORESET#0. If the set of PMOs are selected from the multiple CORESET#0s, then the UE will have different QCL assumption for each of PMO depending on which CORESET#0 is monitored. On the other hand, the set of PMOs are selected from a single CORESET#0, the UE will assume a single QCL for the set of PMOs based on RAN1 spec. Note that only a single QCL assumption is defined for a CORESET.
	+ For OSI, it is clear that CORESET#0 is associated with the corresponding SSB.
* Case 4) CORESET#X + SS#Y
	+ QCL assumption is not defined for CORESET#X for idle/inactive mode.
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| Futurewei | We don’t think there is an issue resulting in wrong implementation. If any, this is just for clarification. Specs are meant to be read in combination with RAN2 specs. TS38.304, Section 7.1 specifically stated as such: “A PO is a set of 'S' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1*. The Kth PDCCH monitoring occasion for paging in the PO corresponds to the Kth transmitted SSB….”Note that QCL is not a RAN2 terminology, so it should not be expected that the above is written in terms of QCL. Perhaps a question that we have for the proponents of this CR is that if the above texts don’t meant ‘QCL’, what does it mean to you when the RAN2 specs above says ‘..corresponds..”? |
| OPPO | Thanks for the discussion.@Nokia, Huawei, MTK,CMCC,CATT,Samsung. After check the current specification, we also noticed that when OSI using CSS other than type-0 CSS, the same QCL issue exits. So, we agree to clarify for OSI as well.@Futurewei, 38304 define the association between actually transmitted SSB and PMO, association is not equivalent to QCL. That is why for CORESET 0 case, we have defined the corresponding relationship in session 13 in 38.213 and further define the QCL in session 10.1 for this case, as in the following paragraph.

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| The UE may assume that the DM-RS antenna port associated with PDCCH receptions in the CORESET configured by pdcch-ConfigSIB1 in MIB, the DM-RS antenna port associated with corresponding PDSCH receptions, and the **corresponding** SS/PBCH block are quasi co-located with respect to average gain, QCL-TypeA, and QCL-TypeD properties, when applicable [6, TS 38.214], if the UE is not provided a TCI state indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in the CORESET. The value for the DM-RS scrambling sequence initialization is the cell ID. A SCS is provided by *subCarrierSpacingCommon* in *MIB* |

Furthermore, there may be different kind of QCL assumption as defined in 38.214, e.g., Type A, Type D.. The specification shall make it clear will kind of QCL shall be applied for this case. Therefore, we propose to clarify it in the spec. @Nokia, Samsung, thanks for the detailed analysis. For the case 3 as listed in Samsung’s feedback, we share similar view as Samsung, the QCL is not clear in this case, please note that for CORESET 0, there is no TCI configured, there shall be also one-to-one QCL mapping between SSB and PMO. We think the current spec only cover the Case 1) CORESET#0 + SS#0. Case 3 and Case 4 shall be handled together.  |
| Spreadtrum | Agree with that the issue exists, we prefer to clarify it in the spec to avoid any additional discussion later.We also share similar views as other companies on the QCL issue for OSI, it should be clarified together in the spec. |
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## Q2

* If yes for Q1, what’s the solution?

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| **Company** | **View** |
| ZTE | To reuse the default QCL assumption for monitoring paging PDCCH in type0 CSS in TS 38.213 |
| OPPO | Similar as the case where paging is monitored in type0 CSS, in the case paging is monitored in CSS other than type0, PDCCH in the PDCCH monitoring occasion is QCLed with the SSB associated with the PDCCH monitoring occasion. |
| Nokia | If clarification is deemed necessary it should cover both paging and OSI monitoring. Also, as discussed above, there does not appear to be problem if CORESET#0 is used for paging and OSI PDCCH monitoring. |
| Huawei | As discussed above, OSI should be addressed together. |
| MediaTek | Agreed with Nokia/Huawei, both paging and OSI should be clarified. |
| CMCC | Define the QCL assumption between PDCCH monitoring and SSB index.In addition, the QCL assumption of OSI PDCCH should also be defined. |
| Samsung | The issue is basically related to CORESET#X not SS#Y since QCL assumption is defined per CORESET not per SS. Therefore, we need to focus on how to define QCL assumption for CORESET#X in idle/inactive mode if we want to have clear QCL assumption. Then, it eventually covers both paging and OSI cases. There can be following three options for the potential solutions* Opt 1. Define clear QCL relationship
* Opt 2. Leave it to UE implementation
* Opt 3. Not allow to use CORESET#X for paging/OSI

We still think this issue can be handled by UE implementation. However, if companies have some concerns on it, we are open to discuss concrete solution.  |
| Spreadtrum | Shared similar views as Nokia/Huawei/MediaTek/CMCC, OSI should be handled together. |
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## TPs

Potential output depends on the above discussions. Companies are encouraged to input favorite CR to facilitate the second-stage discussion.

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| **Company** | **View / Proposed CR** |
| OPPO | The proposed CR is as following:\*\*\* Unchanged text is omitted \*\*\*The UE may assume that the DM-RS antenna port associated with PDCCH receptions in the CORESET configured by *pdcch-ConfigSIB1* in *MIB*, the DM-RS antenna port associated with corresponding PDSCH receptions, and the corresponding SS/PBCH block are quasi co-located with respect to average gain, QCL-TypeA, and QCL-TypeD properties, when applicable [6, TS 38.214], if the UE is not provided a TCI state indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in the CORESET. The value for the DM-RS scrambling sequence initialization is the cell ID. A SCS is provided by *subCarrierSpacingCommon* in *MIB*.If a UE is provided a non-zero value for *searchSpaceID* in *PDCCH-ConfigCommon*for a Type 2-PDCCH CSS set,  the UE may assume that the DM-RS antenna port associated with PDCCH receptions in the CORESET configured by pagingSearchSpace in *PDCCH-ConfigCommon*, the DM-RS antenna port associated with corresponding PDSCH receptions, and the corresponding SS/PBCH block are quasi co-located with respect to average gain, QCL-TypeA, and QCL-TypeD properties, when applicable [6, TS 38.214], if the UE is not provided a TCI state indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in the CORESET.\*\*\* Unchanged text is omitted \*\*\* |
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# Conclusions

To be added

# Reference

1. R1-2006033 Discussion on the QCL assumption for paging reception OPPO
2. R1-2006034 Draft CR on the QCL assumption for paging reception OPPO

# Appendix A: Views in the preparation phase email discussion

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| **Moderator / Session Chair's initial view** | Discuss over email in RAN1#102-eCarry over from Rel-15 maintenance. |
| **vivo** | Agree with Chairman's assessment |
| **Nokia** | Agree with the chairman, this was the conclusion in RAN1#101 |
| **CATT** | Agree to discuss in RAN1#102-e. When SearchSpaceId other than 0 is configured for pagingSearchSpace, TS 38.304 has clearly defined the PDCCH monitoring occasion for paging in a PO corresponds to an SSB. However, it seems the QCL relation between PDCCHs/PDSCHs for paging and the corresponding SSBs are not explicitly defined in current specification. |
| **Samsung** | OK to discuss over email. |
| **Huawei** | Ok to discuss. |
| **Apple** | Agree with chairman |
| **MediaTek** | OK to discuss |
| **Intel** | We support to discuss this CR. |
| **Ericsson** | OK to discuss |
| **OPPO** | Agree with Chairman |
| **ZTE** | We are okay to have further discussion on UE behavior for CORESET QCL assumption for CSS outside CORESET#0 after RACH procedure |
| **NTT DOCOMO** | OK to discuss in this meeting. |
| **QC** | OK to discuss over email in this meeting |

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