**3GPP TSG-RAN WG1 Meeting #106-e R1-210xxxx**

**e-Meeting, August 16th – August 27th, 2021**

**Agenda item:** 8.1.2.1

**Source:** Moderator (Qualcomm)

**Title:** Summary #3 of email discussions [106-e-NR-feMIMO-03] for mTRP PDCCH enhancements

**Document for:** Discussion/Decision

# **The case that one linked candidate overlaps with an individual candidate**

The following was agreed in the previous meeting:

**Agreement**

When one of the linked PDCCH candidates uses the same set of CCEs as an individual (unlinked) PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, for the purpose of BD counting and interpretation of a detected DCI, select one option among the following in RAN1#105-e:

* Option 1: The individual candidate is not counted for monitoring
  + Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).
* Option 2: The candidate in a higher SS set ID is not counted for monitoring
  + Interpretation of the detected DCI depends on which candidate is not counted (either based on Rel. 15/16 rules or based on Rel. 17 PDCCH repetition rules).
  + FFS: Impact to the other linked PDCCH candidate
* Option 3: The candidate associated with SS set(s) with lower priority is not counted for monitoring, where for two linked SS sets, the priority is according to one of the two SS sets with a lower SS set ID
  + Interpretation of the detected DCI depends on which candidate is not counted (either based on Rel. 15/16 rules or based on Rel. 17 PDCCH repetition rules).
  + FFS: Impact to the other linked PDCCH candidate
* FFS: Whether a max limit on number of such overlaps is needed.

Additional specification support may be introduced for the purpose of resolving ambiguity (if any) for interpretation of the detected DCI. For example,

* Distinguished by different RNTIs defined for the linked candidate versus the individual candidate
* Distinguished by aggregation level restrictions that can be expected by the UE in the case of overlap

Views in the first round of discussions are summarized below:

* **Support the proposal, i.e., Option 1: NTT Docomo (depending on overbooking), MediaTek (if “not counted” is changed to “not monitored”), Apple, QC (if UE capability is added), Fujitsu, vivo, ZTE, Nokia/NSB, CMCC, NEC, Huawei/HiSilicon, Convida Wireless, FGI/APT, TCL**
* **Support Option 2: Lenovo/MotM, LG, OPPO, Samsung, InterDigital, CATT, Intel**
* **Support Option 3: NTT Docomo (depending on overbooking), LG, Fraunhofer IIS/HHI, Xiaomi, InterDigital, CATT, E///, Futurewei, Intel**

Option 1 has slight majority support. Also, a good number of companies support Option 3.

Docomo suggested to first decide on overbooking issue. From moderator perspective, this issue has been discussed for a long time now, and a decision may be needed in this meeting.

MediaTek suggested that “not counting for monitoring” should be replaced with “not monitored”. In my understanding, these two are not the same. This is also evident from the GTW agreement for the other issue (dropping or not monitoring does not impact the BD count). I think what we already agreed on is “not counting for monitoring” as copied below, which is same as Rel. 15 rule when CORESET/DCI size/CCEs/scrambling are the same. However, if there is a consensus to change the agreement, it can be discussed. A question is asked below regarding this point.

**Agreement**

When two SS sets are linked for PDCCH repetition, they do not contain individual PDCCH candidates.

* Note 1: For configuration of individual PDCCH candidates, a different SS set can be configured by network.
* Note 2: When one of the linked PDCCH candidates uses the same set of CCEs as an individual PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, Rel. 15 rule is followed wrt not counting an additional BD.

LG and a few other companies suggested to combine Option 2 and Option 3. This does not seem to help since these options are already identified and one needs to be selected. If needed, we can down-select between two options first (instead of first combining options and then separating them again). Given that we have been discussing this issue for multiple meetings now, it is preferred to directly select one option.

Also, the following have been mentioned by companies in the first round:

* Option 1: Simplest solution and less specification impact. Discussions on handling the other (non-overlapped) linked candidates would not be needed.
* Option 2: Reuses priority rule of Rel.15/16, and allows for prioritizing either the linked candidate or the individual candidate
* Option 3: Same priority for linked SS sets, and allows for more flexibility

**Question 1: Do you think “not counted for monitoring” should be changed to “not monitored” in the description of the options?**

**Question 2: Among Option 1 and Option 3, can you accept one option? If yes, which one?**

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| Company | Comments |
| Apple | Q1: Yes  Q2: Option 1, which is simple and seems to be majority’s view. |
| NTT Docomo | Q1: No  Q2: 1st preference is option3. |
| MediaTek | Q1: Yes  Q2: Option 1  @ Docomo  If we use “not counted for monitoring” here, the UE has to monitor both individual candidate and one of linked candidates anyway even if two candidates are overlapped. The BD is not counted but two candidates should be monitored by following the Rel-15/16 rule. Then why does it matter to support option 1 or option 3? There is no priority between two overlapped candidates in this case. Could you please share any technical concern to use “not monitored”? |
| LG | Q1: Yes  Q2: Our first preference is option 2 but option 3 is fine. |
| Lenovo/MotM | Q1: Slightly prefer not to change since this proposal focuses on discussing BD counting scheme.  Q2: Slightly prefer option 3 on account of flexibility. |
| QC | Q1: We would be ok with the change, but also realize the previous agreement.  @MediaTek: We do not think UE needs to perform 2 BDs in this case with separate decoding. Also with 3BDs, with Option 1, the candidate that is not counted is the individual one. At the same time, UE needs to pay some cost for duplicate candidate determination (the cost is less than performing an additional BD)  Q2: Option 1.  In the case of 3BDs, it is not clear what “not counted for monitoring” means in Option 3 (or Option 2) when the linked candidate is not counted toward the BD. |
| Xiaomi | Q1: Yes  Q2: prefer Option 3 |
| CMCC | Q1: No  Q2: Option 1 as it is a simple way to solve this issue. |
| Convida Wireless | Q1: ~~Slightly prefer not to change~~. Update: Given further discussion, we are ok with the change.  Q2: Prefer Option 1. |
| Samsung | Q1: Yes  Q2: Our preference is Option 2. It can reuse the existing Rel-15/16 rule, and based on proper configuration of SS set ID from gNB, Option 2 can have same functionality with Option 1. Moreover, Option 2 can be aligned with the agreement what we made in this meeting (i.e., UE still monitors the linked candidate that is not dropped). |
| Nokia/NSB | Q1: Yes  Q2: Option 1 |
| ZTE | Q1: Yes  Q2: Option 1 |
| Fraunhofer IIS/HHI | Q1: Fine with the change.  Q2: Option 3 |
| OPPO | Q1: Yes  Q2: Option 2. The reasons are as below   * Option 2 is more aligned with the existing R15/16 design principle * Option 2 provides more flexibility to gNB since Option 2 can achieve the same purpose of Option 1/3 by proper configuration * In this meeting, we have agreed that UE should monitoring one of the linked candidate when the other is dropped. Thus, as Samsung commented, Option 2 is more aligned with the new proposal |
| FGI/APT | Q1: Yes  Q2: Prefer option2 and option3 |
| Ericsson | Q1: yes  Q2: 1st preference is option3. 2nd preference option 1 |
| CATT | Q1: Yes  Q2: We support Option 3. Unified solutions for this issue and overbooking rule are expected. |
| NTT Docomo\_2 | Q1: @MediaTek: Thanks a lot for explanation. We don’t think with “not counted for monitoring” means UE has to monitor both individual candidate and one of linked candidates. But we can be OK with the change to “not monitored” to clarify. We would like to understand if it is changed to “not monitored”, whether the one “not monitored” will be counted or not?  Q2: 1st preference is option3. 2nd preference can be option1. |
| MediaTek2 | @ Docomo  Thanks for changing your position.  The definition of “not counted for monitoring” is as follows (confirmed by the editor Aris)   |  | | --- | | The UE still needs to monitor the candidate but it is just not counted for BD because it is a byproduct of the same decoding. In this case, the UE still parse both candidates following the associated search space set |   Thus, the UE has to monitor both candidates. That is why we are suggesting this wording shouldn’t be used here.    If we use “not monitored”, whether it is counted or not is an another issue.  We have several cases for PDCCH dropping or “Not monitored” or officially “is not required to monitor” in the spec. For example, like another proposal, the cases are overlap with SSB or overlap with ratematching pattern, etc. In Rel-15/16, the BD is not impacted (which means counted). Probably, it is because recalculating BD in every slot requires a lot of computation at the UE when some PDCCH candidates are dropped.  @ Lenovo, Convida wireless, CMCC  I hope you can change the position based on my explanation. |
| Vivo | This issue raised aims at resolving two problems.   1. only 1 BD counted in individual SS set or linked SS set for overbooking rule 2. interpretation of detected DCI belongs to individual SS set or linked SS set   Q1: we think the wording “not counted for monitoring” present two answers for two problems, that is only 1BD counted in linked SS set and DCI belongs to PDCCH repetition. If it is changed to “not monitored”, only 1BD counted in which SS set is unanswerable.  @ MTK and FL, if I miss your understanding, please correct .  Q2: Among option1 and option3, we prefer **Option1** since that is a simple and clear scheme, considering that more complicated cases exist, e.g. different individual PDCCH candidates overlaps with each PDCCH repetition candidates. Regarding Option3, if one of PDCCH repetition candidate is dropped due to issue 2.2 in round 0 or overbooking rule, we think it is strange that the priority is still according to one of the two SS sets with a lower SS set. |
| Lenovo&MotM\_2 | Q1: @MediaTek: Thanks a lot for detail explanation. It resolves our concern on the impact of current specification. We are fine to support your proposal. |
| MediaTek3 | @ Lenovo&MotM and Convida Wireless  Thanks for changing your position on Q1.  @ vivo  Please check the meaning of “not counted for monitoring” in MediaTek2.  For issue 1, in Rel-17, the point is that we have to count both BDs for individual candidate and one of linked candidates because two decodings are different unlike the overlapping of two individual candidates in Rel-15/16. That is why we shouldn’t use “not counted for monitoring”.  For issue 2, if we change the wording to “not monitored”, then detected DCI belongs to the other candidate which is not dropped. I am not following why you think detected DCI is unanswerable.  As I mentioned several times, if we use “not counted for monitoring”, the UE has to monitor both candidates (even if only 1 BD is counted for both candidates). Then, why do you think we need to decide option 1 or option 3? Both candidates are all monitored regardless of option 1 or option 3.  Considering almost all companies already support the wording change, please check this again. If you have further question, please let me know. |
| TCL | Q1: Yes.  Q2: Option 1 as it is a simple and clear scheme. |
| Huawei, HiSilicon | Q1: we are fine for the change. To be clear, should it be not monitored and not counted either?  Q2: We prefer option 1 for simplicity. |
| CMCC\_2 | Q1: @MTK Thanks a lot for the detailed explanation. Since it need different decoding for linked and individual candidates, we can accept the wording change.  Q2: Prefer Option 1 as it is a simple way to solve this issue. |
| Futurewei | Q1: Yes, which works fine and simplifies the UE behavior.  Q2: We support Option 3. For Option 1, if the individual candidate is in a CSS but not monitored, this may not be desirable. |
| Intel | Q1: No, we understood that the idea is to allow gNB to use this overlap to have individual and linked candidates without additional BD – this is already discussed in RAN1#104e as noted.  Q2: prefer Option 3, we would prefer to keep prioritization as in Rel-15/16 due to the latency issue in some cases as mentioned in our tdoc. |

## **Update**

It seems that all companies are ok with the change suggested by MediaTek. Hence, the updated wording is used, and a note is added to avoid further confusion. With respect to Option 1 versus Option 3, the views are

* **Option 1 (14): Apple, NTT Docomo (2nd), MediaTek, QC, CMCC, Convida Wireless, Nokia/NSB, ZTE, Ericsson (2nd), vivo, TCL, Huawei/HiSilicon**
* **Option 3 (13): NTT Docomo (1st), LG, Lenovo/MotM (slightly prefer), Xiaomi, Fraunhofer, IIS/HHI, FGI/APT, Ericsson (1st), CATT, Futurewei**
* **Still prefer option 2: Samsung, OPPO,**

The situation has not changed much, and there is slightly more support for Option 1. Some companies with first preference for Option 3 seem to be ok with Option 1 now. We have been discussing this issue for multiple meetings now, and from moderator perspective, it would be good if we can conclude.

@vivo: Yes, your understanding is correct on the original intention. However, MediaTek’s suggestion is that we need to still count toward BD as this case (one linked candidate overlaps with an individual candidate) depends on UE implementation (i.e., it may not be possible to do 1 BD only). This concern seems to be valid to me, and companies are ok to change it. A note is added below to clarify this.

***FL Proposal 3: When one of the linked PDCCH candidates uses the same set of CCEs as an individual (unlinked) PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, ~~for the purpose of BD counting and interpretation of a detected DCI~~:***

* ***Option 1: The individual candidate is not monitored ~~counted for monitoring~~*** 
  + ***Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).***
* ***Note: This does not impact the BD count, and the following note in the agreement in RAN1#104-e is replaced with this note.***
  + ***“Note 2: When one of the linked PDCCH candidates uses the same set of CCEs as an individual PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, Rel. 15 rule is followed wrt not counting an additional BD.”***

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| Company | Comments |
| ZTE | Support |
| LG | We are fine with “not monitoring” but still prefer Option 3 for flexibility. |
| Samsung | Still prefer Option 2. As we mentioned, Option 1 can be made by Option 2 based on appropriate gNB configuration for SS set ID. |
| NTT Docomo | Support  While we think replacing the previous note may not be needed. With current option1 “the individual candidate is not monitored”, Rel.15 rule wrt not counting an additional BD can still be followed. But we can also be fine if majority agree with it. |
| MediaTek | Support |
| NEC | Support |
| Intel | We have some concerns on this (see comment in previous table copied here):  Q1: No, we understood that the idea is to allow gNB to use this overlap to have individual and linked candidates without additional BD – this is already discussed in RAN1#104e as noted.  Q2: prefer Option 2or 3, we would prefer to keep prioritization as in Rel-15/16 due to the latency issue in some cases as mentioned in our tdoc. |
| MediaTek | @ Intel  Do you think it is reasonable to “not count BD” even if the UE has to perform the additional BD in order to monitor both candidates? This is totally different case from the overlapped of individual candidates in Rel-15/16. The reason we had agreement in RAN1#104e is that many of delegates including me and FL had a misunderstanding of the wording “not counted for monitoring”. We thought “not counted for monitoring” means “not counted and not monitored”. But after checking with the editor, it is actually “not counted but monitored”. Thus, this wording shouldn’t be used here. Could please elaborate how this works without additional BD when the UE uses soft combining?  Considering all companies already said yes for this change, I hope intel also can accept this change. |
| Huawei, HiSilicon | We support the main bullet and option1, but we don’t support the note.  If the individual candidate is not monitored, then UE doesn’t need to decode it, and thus no need to count it. As there’s no ambiguity on the overlapping of linked candidate and individual candidate, then our understanding is that the individual candidate is not counted either.  To be more clear, the option 1 should be as below from my understanding:   * ***Option 1: The individual candidate is not monitored and not counted***   + ***Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).*** |
| Xiaomi | Prefer Option 3 for flexibility. |
| Lenovo/MotM | Since both Opt.1 and Opt.3 can work and has their individual benefit, we can live with Opt. 1 and accept the proposal if it is the major review although our first priority is Opt.3 on account of flexibility. |
| OPPO | Considering the situation, we can compromise support the proposal. We also share similar views as some companies that the note is not needed. |
| Vivo | Support this proposal |
| Fraunhofer IIS/HHI | Option 3 is our first preference. If there is majority support for option 1, we are OK with it as second preference. |
| Nokia | Support |
| Convida Wireless | Support |
| QC | Support. We think the note is needed if “not counted for monitoring” is changed to “not monitored”.  With the current FL proposal, additional max limit on such number of overlaps is not needed as the BDs are already counted toward the BD limit.  However, in the absence of the note, a max limit is needed because otherwise there is practically no limit on how many candidates UE needs to check for duplicate detection (before performing BDs). This means that even though the UE performs up to 44 BDs per slot for 15 KHz SCS, it still may have to deal with 44\*10=440 candidates in theory if the network configurations result in 10 SS sets that are overlapping in a slot, and identify which ones do not require BD operation. This is a non-trivial amount of processing at the UE side especially in the presence of PDCCH repetition and since theses overlaps are not fixed (can change slot by slot).  This is obviously not reasonable, and there should be some limits (we prefer the limit to be UE capability, but ok with any other method that can ensure the scenario above does not happen) |
| Spreadtrum | Support |
| Intel | use-case: we expect SS-sets for sTRP (individual candidate) and mTRP (linked candidates) would typically overlap to allow dynamic switching of sTRP/mTRP PDCCH Tx as this is more efficient for CCE count and overlapping candidates are also efficient in terms of BD count.  In the following we explain why not monitoring individual candidate is a problem for PDCCH scheduling. We can assume option-1 that individual candidate is not counted/monitored (as in proposal 3) and analyze 4 combinations of monitoring/BD counting. The arguments below remain about the same for options-2/3.  Case -1: The individual candidate is monitored but not counted (Round-1 option-1)  (+) Rel-15/16 behavior  (+) can handle different DCI formats of same size (parsing done separately)  (+) Ok for UEs with individual decoding capability (e.g. UEs reporting BD=3 and may be some UEs reporting BD=2)  (+) Ok for dynamic switching of sTRP/mTRP PDCCH Tx  (-) soft-combining complexity concern (MTK)  Case -2: The individual candidate is not monitored but counted (Round-2 proposal)  (-) cannot handle different DCI formats of same size (parsing due to linked SS-set)  (-) no dynamic switching of sTRP/mTRP PDCCH Tx (its unclear how soft-combining will work with sTRP transmission), because gNB does not know if UE performs individual decoding  (-) 1 BD wasted per overlap (BD for individual is counted but not used)  Case -3: The individual candidate is not monitored and not counted  (-) cannot handle different DCI formats of same size (parsing due to linked SS-set)  (-) no dynamic switching of sTRP/mTRP PDCCH Tx (its unclear how soft-combining will work with sTRP transmission), as gNB may not know if UE performs individual decoding  Case -4: The individual candidate is monitored and counted  (+) can handle different DCI formats of same size (parsing done separately)  (+) Ok for UEs with soft-combining complexity  (+) Ok for dynamic switching of sTRP/mTRP PDCCH Tx  (+) can address soft-combining complexity issue  (-) Not needed for UEs with individual decoding capability (e.g. UEs reporting BD=3 and may be some UEs reporting BD=2), but such UEs can be excluded through UE capability  we think retaining Rel-15 behavior of monitoring individual candidate makes even more sense for mTRP repetition. The BD count for overlap can be adjusted, possibly based on UE capability to address UE complexity (for soft-combining and possibly for duplicate counting). This issue can be further discussed. |

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| CMCC | Support in principle and ok with Huawei’s version.  We think the note is not needed as many companies already said. If one candidate is not monitored, then there is no need to blind decode it and count it for BD. The candidate should not be monitored and not counted for monitoring too. |
| CATT | We still prefer Option 3. Agree with Intel’s analysis, dynamic switching between sTRP and mTRP will be restricted if Option 1 is adopted. |
| Futurewei | Support the proposal. Prefer Option 3 for its flexibility, but we can also accept Option 1 as expressed in the email discussion. |

## **Second Update**

With respect to Options, views are summarized below:

* **Option 1 (16): Apple, NTT Docomo (2nd), MediaTek, QC, CMCC, Convida Wireless, Nokia/NSB, ZTE, Ericsson (2nd), vivo, TCL, Huawei/HiSilicon, NEC, Spreadtrum**
* **Option 3 (13): NTT Docomo (1st), LG, Lenovo/MotM (slightly prefer), Xiaomi, Fraunhofer IIS/HHI (ok with Option 1), FGI/APT, Ericsson (1st), CATT, Futurewei (can accept Option 1)**
* **Still prefer option 2: Samsung, OPPO (can accept Option 1),**

@ All: With respect to Options, majority view is clear. However, based on the discussions above, it seems important to have a common understanding about “not monitoring” or “not counted for monitoring”.

@ Intel: For Case 1 and Case 4 (monitored), are Options 2 or 3 applicable? That is, when both candidates are monitored, shouldn’t we always follow Rel. 17 rules wrt reference candidate? Otherwise, if a DCI is decoded there, how does the UE know it corresponds to the individual candidate or the PDCCH repetition?

Also, for the use case you described (dynamic switching), why handling different DCI formats of same size is important, and how likely this case occurs across the two SS sets?

@ Huawei/HiSilicon: We have many different cases in Rel. 15 that a candidate is not monitored but is counted (e.g., overlap with SSB).

@ All: Before pursuing down-selection, let’s have some discussions on the points mentioned by Intel and others. Also, I would like to gather some views about the importance of optimizing this case given that other individual candidates can be used for dynamic switching. Overall, my suggestion is to focus on **Case 1** and **Case 2** since theses cases have been the main direction of discussions so far. Also, we should avoid ending up with multiple cases.

**Question 1: Which of the following cases do you support (first/second preference)? You can assume option 1 for simplicity and given the views above. If possible, please list pros / cons wrt flexibility / feasibility / complexity.**

* **Case 1: The individual candidate is monitored but not counted**
* **Case 2: The individual candidate is not monitored but counted**
* **Case 3: The individual candidate is not monitored and not counted**
* **Case 4: The individual candidate is monitored and counted**

**Question 2: Which of the cases above are possible with all decoding assumptions (since gNB does not know the decoding assumption based on the agreements so far)? Do you support more than one case for more than one decoding assumption?**

**Question 3: Which of the cases above may require additional UE capability and/or specification impacts beyond the FL Proposal 3?**

**Question 4: How important optimizing this issue is wrt Cases 1-4 given the conditions (same DCI size, same CCEs, same CORESET, same scrambling)?**

* **Can gNB still configure overlapped SS sets (individual and linked) such that some individual candidates do not have complete CCE overlap with linked candidates, and still perform dynamic switching with most CCEs being shared for efficient CCE count?**

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| Company | Comments |
| Intel | @FL: yes agree, there are now 3 issues for overlapping candidates a) BD counting b) monitoring c) reference timing. For reference timing I agree its better to follow Rel-17 rules.  Q1. We think Case 1 is sufficient which means no change to Rel-15/16 behavior. If some relaxation is needed as MTK commented we can add UE capability of reporting additional BD count per overlap of 2 candidates (default 0, otherwise 1). Prefer not to have case 2 or 3 because it does not allow gNB to send sTRP PDCCH on an overlapped candidate.  Q2. Possible does not mean desirable, the point is Case-1 is existing Rel-15/16 behavior and implemented in current schedulers. One issue for Case-1 is raised by MTK on a specific UE implementation that does soft-combining only. The way to handle such issue is UE capability. Case-2, Case-3 adds new scheduler restriction unconditionally (for all UEs and even when BD limit is not reached) – this is a poor design.  Q3. see above.  Q4. Good point. Firstly, fully overlapping candidates is the most efficient in terms of BD utilization allowed since Rel-15/16 – agree? Secondly, in FR2, max BD in a slot is 20, lets say 10 for each TRP, then we expect for AL8, and AL16 we would typically just have 1 or 2 candidates, e.g. M=[2,2,2,1,1] for [AL1, AL2, AL4, AL8, AL16]. Then we expect that full overlap would be the most efficient and quite common allocation. Lastly, we are not trying to optimize, we are just trying to not destroy a Rel-15 feature. |
| LG | Q1: answer depends on BD assumption. We think 3 BD implies two separate decoding and one combining based decoding and 2 BD implies two separate decoding. Therefore, BD for individual candidate is a byproduct of BD for linked candidates. In that sense, we prefer Case 1.  Q4: we have similar understanding with Intel. We don’t think this is optimized enhancement. Fully overlapping is already supported in legacy. |
| Apple | Q1: Case 2 (first choice) and 3 (second choice) for option 1  Q2: We think both case 2 and 3 should be possible for all decoding assumption. Case 1 and 4 may require additional complexity if soft-combining is used.  Q3: Case 1 and 4  Q4: We do not think it is important to optimize this issue. |
| QC | Q1: Our first preference is Case 2, which does not require additional complications (such as capability to address UEs with soft combining only, capability to address complexity associated with duplicate candidate identifications).  Our second preference is Case 1 but only if the number of such overlaps is limited by UE capability. The reason for this and why it is important for the case of PDCCH repetition is explained before.  In our view, Case 3 and Case 4 are new behaviors compared to Rel. 15/16 (but both Case 1 and Case 2 are Rel. 15 behaviors for different cases)  Q2: Case 2 and Case 4  Q3: Case 1, Case 3, and Case 4. For Case 1 and Case 4, especial handling (UE capability) for UEs performing soft combining only is required to select between them. For Case 1 and Case 3, a limit on max number of such overlaps would be needed due to complexity associated with duplicate candidate identification.  Q4: In our view, CCEs can still be shared, and dynamic switching between sTRP and PDCCH repetition can be achieved using candidates that are not completely overlapping. This is illustrated below as one example:    @Intel: I get the point on BD benefit (above can address CCE sharing to a good extend), but we have to consider the complexity and simplicity as well. In FR2 there will be more candidates per unit of time, and in addition, there is typically no shortage of BDs given that UEs need to be TDMed to some extend due to analog beamforming and gNB RF limitations. |
| NTT Docomo | Q1: our preference is case3 (1st) and case2 (2nd) for simplicity  Q2:   * we think case2/3 are possible for all decoding assumptions. And has less spec. impact * We think case1 is possible for 3BD decoding assumption. We don’t think case1 is possible for 2BD case with one individual decoding + one soft combining if the individual candidate is overlapped with the linked candidate where soft combining is performed. We think 2BD implies either induvial decoding or soft combing. * we think 4 is also possible for all decoding assumptions. But one additional BD seems only needed for the case when individual candidate is overlapped with a linked candidate where soft combing is performed in 2BD decoding assumption.   Q3: case1 and 3 and 4 may require further impact and discussion beyond pervious FL summary. But case1 and 4 requires more because they are related to whether soft combining is performed.  Q4: we can first identify and align understanding on feasibility and potential spec. impact of case1~4. |
| ZTE | Q1: We support Case 3 for simplicity. The situation is now different from Rel-15. We don’t need to care Rel-15 behavior anymore.  Q2: case2/3 are possible for all decoding assumptions, and have no extra spec effort  Q3: Case 1 and Case4 need further spec effort for UE capability with BD=2.   * For case 1, it is impossible for UE capability with BD=2 if we assume soft combining is used. If individual candidate is monitored, total BD should be 3 for linked PDCCH candidates and the individual candidate. * For case 2, we don’t understand why an extra BD should be counted if UE does not monitor it. It cause BD waste * For Case 4, it is not good for UE capability with BD =3. It cause BD waste since total BD = 3 is enough.   Q4: Not import issue from our side. Why do we have to support dynamic switching by overlapped CCEs. |
| OPPO | Q1: Case 2 is preferred since it has less impact on spec and less complexity at UE side. Case 2 can be the 2nd choice  Q2: Case 2 and 3 can be applicable to all decoding assumptions  Q3: Case 1 and Case 4 may require additional UE capability since UE needs to interpret the same DCI based on both R15 and R17 rules and Case 1 /4 are related to the decoding assumptions .  Q4: We think this use case is not important and it is not wise to spend much time for over-design. |
| Samsung | Thank you Intel and FL for your suitable guidance with questions.  Q1: If Option 1 is considered, our first preference is Case 3 which seems the simplest and the second preference is Case 2. Although Case 1 seems the legacy behavior (not counted for monitoring) but when soft combining is considered, it may need additional UE capability.  Q2: Case 2 and Case 3 can be solutions for all decoding assumptions since the individual candidate is not monitored.  Q3: At least Case 1 and 4 as both individual and linked candidates are monitored and this should need additional UE capability for UEs performing soft combining.  Q4: We agree with Intel that considering fully overlapped case can be efficient. |
| Lenovo/MotM | Q1: Our first preference is case 3 and second choice is case 2 on account of simplicity  Q2: Case 2 and 3 are possible for all decoding assumptions.  Q3: Case 1 and 4 may require additional UE capability if soft combining is used in case of UE reported BD number as 2.  Q4: Same view as NTT Docomo that more alignment is required on feasibility, necessity and spec. impact and typical application scenario, etc before conclusion. |
| Fraunhofer IIS/HHI | Q1: Case 3 (first preference), Case 2 (second preference). Not monitoring the individual candidate is simpler.  Q2: Cases 3 and 2 are applicable to all decoding assumptions.  Q3: Cases 1 and 4  Q4: Similar view as Docomo and Lenovo/MotM. Agree on spec impact of various cases before optimizing for them. |
| MediaTek | @ LG  2BD does not means selective decoding. UE can use 3 different decoding assumption 1-3 which we already discussed. The gNB cannot assume that UE will always perform selective decoding. Thus, we need to add additional BD.  Q1: Our first preference is case 2 which is the simplest solution. Second preference is case 3 with UE capability because UE needs to recalculation of BD even for dropped candidates. This is new behaviour.  Case 1 is the worst solution because BD is not correctly counted even if the UE has to perform additional BD which it uses soft combing.  Case 4 can be another solution because BD is correctly counted but we don’t think this dynamic switching with completely overlapped candidates is very useful configuration.  Q2: We think only case 1 is not applicable for all decoding assumptions because it cannot be used for soft combining. Other cases are possible with all decoding assumptions.  Q3: Case 1 and Case 3 requires UE capability because for case 1, UE needs additional BD which is not counted and for case 3, UE needs recalculation of BD for not monitored candidates.  Q4: As QC showed, the gNB can always use not fully overlapped candidates if they want dynamic switching. We cannot find very useful scenarios for the fully overlapped candidates with the same size between individual candidates and one of linked candidates. For the question, yes, gNB can configure overlapped SS sets (individual and linked) such that some individual candidates do not have complete CCE overlap with linked candidates, and still perform dynamic switching with most CCEs being shared for efficient CCE count. |
| Futurewei | Q1: Our first preference is Case 3 for its simplicity. Case 1 is also fine as it allows the S-TRP and M-TRP to be monitored at the same time.  Q2: Case 3 works fine for all decoding assumptions. Case 1 definitely works for 3BD, and should generally works for a reasonably implemented 2 BD (i.e., 2 individual BDs) but does not work if one of the 2 BDs has a soft combining.  Q3: Case 3 requires some minor spec changes of the new no-counting behavior. Case 1 with 3 BD is fine, but Case 1 with 2 BD may require an extra BD and new behavior.  Q4: Not critical. Ok to optimized with simple solutions. |
| **Nokia** | First we agree with the analysis provided by intel in the earlier round.  Q1: Case 1  Q2: We do not think that the UEs will only do soft combining decoding for linked candidates (BDs are 2 or 3. Not 1). The UE may have to support selective decoding as that seems to be necessary for situation of like this.  We would assume with 2 BDs and 3BDs, most of UEs will understand that and also use for selective decoding properly to overcome any concerns.  Q3: We prefer not to discuss additional UE capabilities on decoding assumptions associated with any case above.  Q4: Agree with Intel. gNB shall be able to support configure overlapped SS sets (individual and linked) such that some individual candidates have complete CCE overlap with linked candidates. There should not be any restriction on this. |
| InterDigital | Q1: Not sure, if the question should be about preference; rather whether about validity of the behavior considering different decoding assumptions. Then, the answer would depend on the UE decoding assumption. For example, for decoding assumption with BD=3 and 2(with selective), all cases may be considered. However, for the case with BD=2 (with combining), Case 1 may not be relevant.  Q2: Cases 2, 3 and 4 can be considered for all decoding assumptions  Q3: Case 1 and 4 where for a UE with BD=2 (with combining), UE behavior should ensure one of the blind decoding be performed on the individual candidate.  Q4: We don’t see a strong motivation in support of this scenario at this time. |
| CMCC | Q1: Our first preference is Case3 for its simplicity, our second preference is Case2.  Q2: We think Case 2 and Case 3 can work in all the BD assumptions.  Q3: Case 1 and Case 4 might need extra spec impact on UE capability since both individual candidate and linked candidate need be decoded.  Besides, for Case 1, if 2 BD is assumed and the soft combining just happens in the overlapping candidate, it is difficult for UE to decode the individual and linked candidate simultaneously; for Case 4, if 3 BD is assumed, it is a waste on BD, as the soft combining could happen in the third BD and the two overlapped candidates could just be counted as 1 BD, totally 3 BD is enough.  Q4: We do not think the dynamic switching using overlapping CCEs is very important. |
| Xiaomi | Q1: We think the individual candidate play two roles here. One is the candidate for sTRP and the other one is one of the two linked candidates for mTRP. If Option 1 is assumed, we prefer case 3 as the 1st preference and case 2 as the 2nd preference when taking the individual candidate as the PDCCH candidate for sTRP. But since the individual candidate is overlapped with one of the two linked candidate, when taking the individual candidate as the PDCCH candidate for mTRP, whether to monitor the individual candidate or not will depend on the BD assumption for two linked candidates. If 3 BDs is assumed, the individual candidate will be monitored and total 3 BDs will be counted for two linked candidates. If two individual decoding is used for 2 BDs assumption, the individual candidate will be monitored and counted. If only soft combining is used for 2 BDs assumption, the individual candidate will be not monitored. If one individual decoding and soft combining is used for 2 BDs assumption, the individual candidate will be monitored with some probability. |
| vivo | We think BD count and interpretation are decoupled. For instance, the following is the excerpt from 38.213, first PDCCH candidate can be associated with higher SS set ID, while second PDCCH candidate can be associated with lower SS set ID.    **For Q1**: Regarding overbooking rule in case of overlapping, BD count is related to the SS set ID in current spec, we think legacy rule can be reused here. We do not support these four cases since BD count only depend on lower SS set ID which has nothing to do with individual PDCCH candidate. we prefer Case5:  **Case5: BD count based on legacy rule,**   * **The individual candidate with USS is not monitored** * **The individual candidate with CSS with CORESET Index 0 is monitored**   **For Q2**: How to decode PDCCH candidate is up to UE implementation, e.g. UE can perform 1BD per PDCCH candidate without soft combining, even though UE report capability of 3 BD, just like the case of dropping rule that does not impact BD count of overbooking, so the waste of BD count is not of concern.  We only need to specify the overbooking rule and the priority of monitoring.  For example:   * **Case1**: In figure1, USS ID1 and USS ID2 fully overlaps with each PDCCH repetition candidate respectively. Based on legacy BD count, BD count is located in USS ID1 and USS ID2, but interpret PDCCH repetition. When UE report capability of 3BDs, how to count the third BD is another issue which should be discussed in the issue of overbooking.     Figure1   * **Case2-1**: In figure2, if CSS ID1 with CORESET zero and CSS ID2 with CORESET zero fully overlaps with each PDCCH repetition candidate respectively. And if USS ID1 and USS ID2 are all associated with CORESET zero.   Then UE interprets individual CSS PDCCH candidate per PDCCH candidate since CSS has highest priority, where UE perform individual BD count actually.    Figure2   * **Case2-2**: In figure2, if USS ID1 is associated with CORESET zero but USS ID1 is not.   Then UE interprets individual CSS PDCCH candidate at red PDCCH candidate since CSS has highest priority; while interprets individual CSS PDCCH candidate and PDCCH repetition at blue PDCCH candidate with 1+1 BDs is counted at blue PDCCH candidate.  **For Q3 and Q4:**  we prefer to take two questions as lower priority. |
| Huawei, HiSilicon | Q1: We prefer Case 3. If the individual candidate is not monitored, then the BD capability should not be wasted in counting. If companies have concern over the number of number of overlapping candidates, we failed the see the difference with R15/16 overlapping cases but would be open to discuss this. Note that the capability of BD and capability of counting should be two different capabilities, we don’t prefer to waste the BD capability due to the capability of candidate counting.  For Case 1, it needs additional UE decoding complexity since UE should be able to monitor individual candidate on the linked candidates while it’s not counted into BD number. So additional UE capability is needed, such as UE should report its decoding assumptions.  For Case 2, it is quite different from R15/16 behavior since that new behavior is introduced for “count one”. For example, UE needs to determine whether to perform “count one” according to the linkage configuration. In addition, as the individual candidate not monitored is still counted, then obviously, the UE’s BD capability is wasted, which would have impacts on flexibility and scheduling of PDCCH.  Q2: Case 3 can work for all cases.  Q3: Case 1 would need the UE to further decode the individual candidate, although it’s not counted in BD.  Q4: Not very important at this stage. |

## **Third Update**

@ OPPO: I interpreted “Case 2 can be the 2nd choice” as you meant Case 3 based on rest of your comment. Please let me know if that is not the case.

@ vivo: My understanding is that the discussed case is not related to the excerpt you mentioned above. Instead, it is related to the following:



First, the views on Cases 1-4 are summarized below

* **Case 1 (monitored, not counted):** 
  + **Intel, LG, QC (2nd if limit on number of overlaps), Futurewei (2nd), Nokia,**
* **Case 2 (not monitored, counted):** 
  + **Apple (1st), QC (1st), NTT Docomo (2nd), OPPO (1st), Samsung (2nd), Lenovo/MotM (2nd), Fraunhofer IIS/HHI (2nd), MediaTek (1st), CMCC (2nd), Xiaomi (2nd)**
* **Case 3 (not monitored, not counted):** 
  + **Apple (2nd), NTT Docomo (1st), ZTE, OPPO (2nd), Samsung (1st), Lenovo/MotM (1st), Fraunhofer IIS/HHI (1st), MediaTek (2nd with UE capability), Futurewei (1st), CMCC (1st), Xiaomi (1st), Huawei/HiSilicon**
* **~~Case 4 (monitored, counted):~~**
* **(Case 5):** 
  + **vivo**

Regarding Q2/Q3: Majority of companies believe that at least Case 2 and Case 3 (and Case 4) are possible for all decoding assumptions, and Case 1, Case 4 (and Case 3) may require additional specification impacts.

Regarding Q4, majority of companies think that optimizing this issue may not be very important, but some companies feel that Rel. 15/16 behavior should be kept.

Second, with respect to down-selection between Options 1-3, the views from the previous round are copied below:

* **Option 1 (16):** 
  + **Apple, NTT Docomo (2nd), MediaTek, QC, CMCC, Convida Wireless, Nokia/NSB, ZTE, Ericsson (2nd), vivo, TCL, Huawei/HiSilicon, NEC, Spreadtrum**
* **Option 3 (13):** 
  + **NTT Docomo (1st), LG, Lenovo/MotM (slightly prefer), Xiaomi, Fraunhofer IIS/HHI (ok with Option 1), FGI/APT, Ericsson (1st), CATT, Futurewei (can accept Option 1)**
* **Still prefer option 2:** 
  + **Samsung, OPPO (can accept Option 1),**

Given the above situation, moderator’s suggestion would be to go with Case 2 or Case 3 given the majority view, and simplifications. This corresponds to FL Proposal 3A. However, if companies supporting Case 1 cannot accept it, FL Proposal 3B can be considered in which the aspect related to UE capability is added to address the complexity concerns.

***FL Proposal 3A: (Case 2 or Case 3)***

***When one of the linked PDCCH candidates uses the same set of CCEs as an individual (unlinked) PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, ~~for the purpose of BD counting and interpretation of a detected DCI~~:***

* ***Option 1: The individual candidate is not monitored and [is counted / is not counted toward the BD limit]***
  + ***Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).***

***FL Proposal 3B: (Case 1)***

***When one of the linked PDCCH candidates uses the same set of CCEs as an individual (unlinked) PDCCH candidate, and they both are associated with the same DCI size, scrambling, and CORESET, ~~for the purpose of BD counting and interpretation of a detected DCI~~:***

* ***Option 1: The individual candidate is not counted toward the BD limit, but it is monitored***
  + ***Interpretation of the detected DCI is based on Rel. 17 PDCCH repetition rules (wrt reference PDCCH candidate).***
* ***Introduce a UE capability for maximum number of such overlaps***
  + ***Value of 0 is included as a candidate value for the UE capability***

# **GTW Agreements**

**Agreement**

If a PDSCH is scheduled by a DCI in PDCCH candidates (the first PDCCH candidate associated with a first CORESET and the second PDCCH candidate associated with a second CORESET) that are linked for repetition:

* Confirm the WA: The UE expects the same configuration for the first and second CORESETs wrt presence of TCI field in DCI.

**Agreement**

For the issues involving a timeline for/related to DCI decoding, the PDCCH candidate that ends later in time among the two linked PDCCH candidates is used as a reference. This includes at least the following issues

* For N timeline and the HARQ ACK slot offset in the case that DL DCI does not schedule PDSCH but requests HARQ-Ack: SPS release DCI, SCell dormancy indication, requesting Type-3 HARQ-Ack codebook
* For SPS PDSCH cancelation timeline (14 symbols)
* For PUCCH resource overriding timeline (N3)
* For starting drx-InacitivityTimer
* For timeline to send PRACH in response to PDCCH order
* For PDSCH / AP-CSI-RS reception preparation time with cross carrier scheduling with different SCS’s for PDCCH and PDSCH / AP-CSI-RS, i.e., minimum scheduling delay Npdsch and Ncsirs
* For PHR timeline conditions for virtual versus actual PHR
* For TPC application time window to determine whether a TPC command is applicable or not
* For CPU occupation duration for AP-CSI

For the following issue, the PDCCH candidate that starts earlier in time among the two linked PDCCH candidates is used as a reference:

* For determining the most recent transmission of SRS resource(s) identified by the SRI

**Agreement**

Among the two Alts in RAN1 #104b-e agreement on PDSCH mapping Type B, support Alt1 (The candidate that starts later in time).

**Agreement**

For PDCCH repetition with two linked candidates, if due to Rel. 15/16 procedures, one of the linked candidates is not monitored (is dropped)

* Option 1: UE still monitors the linked candidate that is not dropped and interprets the DCI based on Rel. 17 PDCCH rules (wrt reference PDCCH candidate)
* At least the following Rel. 15/16 rules are applicable for this purpose:
  + Case 1: Overlap with SSB
  + Case 2: Overlap with rate matching resources: RateMatchPattern, lte-CRS-ToMatchAround, or LTE-CRS-PatternList-r16, availableRB-SetPerCell-r16
  + Case 3: Due to TDD DL/UL related conflicts: Overlap with semi-static / dynamic UL symbols or overlap with PRACH
  + FFS: Case 4: QCL-TypeD prioritization rule among CORESETs result in one of the linked candidates not being monitored
  + FFS: Case 6: Overlap with reserved PRB(s) and OFDM symbol(s) indicated by DCI format 2\_1 where UE may assume no transmission intended for the UE
  + Other cases are not precluded
* This does not impact the BD count for both dropped and non-dropped PDCCH candidates

**Agreement**

For overbooking in the PCell for USS with two linked SS sets in the same slot/span, select one Alt for each of Case 1 and Case 2 in RAN1 #106-bis-e:

* Case 1: 2 BDs are counted for two linked candidates:
  + Alt1: No change (use existing spec)
  + Alt2: Consider the SS set pair together (both are kept or both are dropped), where the priority is based on lower SS set ID among the pair.
* Case 2: 3 BDs are counted for two linked candidates:
  + Alt1: Overbooking is per individual SS set as in Rel. 15/16
    - Alt1-1: The third BD is counted as a virtual SS set (i.e., the virtual SS set for the third BDs is dopped before dropping the linked SS sets).
    - Alt1-2: The third BD is counted as part of the SS set with higher ID.
  + Alt2: Consider the SS set pair together (both are kept or both are dropped), where the priority is based on lower SS set ID among the pair.
* FFS: Inter-span PDCCH repetition for r16monitoringcapablity.

**Agreement**

Study whether/how to handle UE complexity / memory requirements for linked PDCCH candidates

* The following cases can be considered:
  + Case 1: One pair of linked MO’s of one pair of linked SS sets in a given slot with large number of candidates.
  + Case 2: Multiple pairs of linked MO’s of one pair of linked SS sets in a given slot, where MO’s of the two SS sets are not interlaced
  + Case 3: For two pairs of linked SS sets (e.g. SS sets 1 and 2 are linked, and SS sets 3 and 4 are linked), a MO of any of the SS sets (e.g. SS set 3) is in between two linked MOs of another two SS sets (e.g. SS sets 1 and 2).
  + Other cases are not precluded.
* Examples of possible mechanisms to address the issue: Restrictions in the spec, UE capability, limit total number linked candidates in a slot, limit total number of linked candidates / CCEs at any given time (similar to CPU occupation)
* Whether the solution should also depend on AL of linked candidates
* The case of CA can also be considered

**Agreement**

SS set configured by *recoverySearchSpaceId* cannot be linked to another SS set for PDCCH repetition.

**Agreement**

For AP-CSI-RS scheduled by two PDCCH candidates that are linked for repetition, the UE does not expect that the AP-CSI-RS is transmitted before the first symbol of the PDCCH candidate that starts later in time.

**Working Assumption**

If a PDSCH with mapping Type B is scheduled by a DCI in PDCCH candidates that are linked for repetition, d1,1 for PDSCH processing time is determined

* Option 2: By considering the PDCCH candidate that results in larger d1,1 value
* Note: Above applies at least for UEs doing selective decoding

FFS: Relaxation of processing time for soft combining of linked PDCCH candidates including PUSCH processing, PDSCH processing for mapping Type A and B, AP CSI processing, DCI processing (N timeline), etc.

FFS: How above applies for UEs doing soft combining

**Agreement**

For a UE supporting reception with two different beams and configured with PDCCH repetitions, for determination of two QCL-TypeD properties for multiple overlapping CORESETs, down-select from the following Alts in RAN1 #106-bis-e:

* Alt1: Identify the two QCL-Type D properties based on legacy priority order.
* Alt2: Reuse legacy priority rule to identify the first QCL-TypeD property, and then, identify the second QCL-TypeD according to one of the SS sets that is linked with a SS set with the first QCL-TypeD (among the multiple overlapping CORESETs)
  + In the case of multiple such SS set pairs, Rel. 15 priority order is followed for the second QCL-TypeD determination
  + FFS: The case of no such SS set pair
* Alt3: Assign same priority for two linked search space sets for PDCCH transmission with overlapping monitoring occasions (the priority is according to one of the two SS sets with a lower SS set ID)
* Priority order: SS type (USS/CSS) > linkage of SS sets > cell index > associated SS set ID
  + Linked SS set has higher priority than individual SS set
* FFS: The case that the first QCL-TypeD is from unlinked CSS
* FFS: The case of no linked SS sets among the multiple overlapping CORESETs

**Agreement**

Support PDCCH repetition for Type3 CSS.

**Agreement**

For PDCCH repetition in Rel. 17, study the following aspects:

* Whether/how to support PDCCH repetition for Type0/0A/1/2 CSS
* Whether to support PDCCH order transmitted with PDCCH repetitions with different beams triggering CFRA for SpCell, and if it is supported how to determine the QCL assumption for the PDCCH that includes the DCI format 1\_0 with RA-RNTI and the corresponding scheduled PDSCH.

**Conclusion**

There is no consensus in RAN1 to support inter-slot PDCCH repetition in Rel. 17.