**3GPP TSG-RAN WG1 #103-e R1-200xxxx**

**e-Meeting, October 26th – November 13th, 2020**

**Source: Moderator (Apple Inc.)**

**Title: Feature lead summary #8 on reduced PDCCH monitoring**

**Agenda item:** **8.6.2**

**Document for:** **Discussion and Decision**

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# 1 Introduction

Contributions made under the “reduced PDCCH monitoring” agenda item of the Rel-17 study item on “Study on support of reduced capability NR devices” as well as initial evaluation results in [29] were summarized in FL summary #1 (FLS1) in R1-2008471.

This document captures the following RAN1#103e RedCap email discussion.

|  |
| --- |
| [103-e-NR-RedCap-03] Email discussion for reduced PDCCH monitoring– Hong (Apple)* 1st check point: 10/29
* 2nd check point: 11/4
* 3rd check point: 11/10
* Last check point 11/12
 |

This summary was organized based on the structure of latest TR 38.875 [1] to document the evaluation results of reduced PDCCH monitoring provided in Phase-2 post-102-e-meeting email thread [102-e-Post-NR-RedCap-01] into section 2. In addition, section 3 intends to discuss potential conclusions for this study item based on the finding in section 2.

Follow the naming convention in this example:

* RedCapPDCCHFLS2-v000.docx
* RedCapPDCCHFLS2-v001-CompanyA.docx
* RedCapPDCCHFLS2-v002-CompanyA-CompanyB.docx
* RedCapPDCCHFLS2-v003-CompanyB-CompanyC.docx

This version of document contains updated proposal tagged FL8.

# 8.2 Reduced PDCCH monitoring

## 8.2.1 Description of feature

In the Wednesday GTW session, the following was agreed for capturing the feature description

|  |
| --- |
| Agreements:* To include description of the evaluated schemes #1/#2/#3 as in R1-2009370 to the TR
	+ Further discussion the detailed text proposal for these schemes
	+ Note: the description for scheme #1 is taken as a higher priority than #2/#3
 |

**[FL6]** **Proposal 8.2.1-1: Capture the following feature description for Scheme #1 in the TR:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot in connected mode** In Rel-15 and Rel-16 NR, the limits on maximum number of BDs per slot are defined for different SCS configurations, as summarized in Table 1. Scheme #1 is to reduce the maximum number of BDs in a slot. In Rel-15 and Rel-16 specifications, the total number of different DCI sizes configured to monitor is up to 4 with up to 3 different DCI sizes with C-RNTI. Two alternatives were studied under Scheme #1, which includes reduced maximum number of BDs per slot with additionally reduced DCI size budget (Alt.1a) and reduced maximum number of BDs per slot without reduced DCI size budget (Alt.1b). Table 1: Blind decoding limits in NR.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCS [kHz]** | **15** | **30** | **60** | **120** |
| **Max # BD per slot (in NR)** | 44 | 36 | 22 | 20 |

 |

**When commenting, please provide details about what modification is needed in order to add it into TR to make progress, instead of only raising your concerns. Thanks!!**

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| vivo | Y | We prefer not to explicitly separate alt.1a/1b, but can accept if there is majority view to separate them.  |
| Qualcomm | Y |  |
| Intel | Y | We are Ok to accept this for sake of progress if there is majority support/interest. In our view, Scheme 1 just targets to achieve a reduced maximum number of BDs per slot which can be obtained either with Rel15 DCI format size budget (a.k.a without reduced DCI format size budget) or with a reduced DCI format size budget, but we can accept this version in light of the fact that reducing DCI format size budget would be helpful in reducing *the need for larger numbers of BDs*, in addition to reducing UE complexity. |
| Samsung | Y | Although we think reduced DCI size budget helps mitigating PDCCH blocking, and the benefit is common to Scheme #1, #2, and #3, we are fine if the majority prefer to capture it under Scheme #1.  |
| Futurewei | Y | Minor editorial comment: “Scheme #1 reduces the maximum number of BDs in a slot.” |
| InterDigital | Y |  |
| Ericsson | With modifications | We are fine with capturing the above description, if the following sentence is added at the end: “These two alternatives can be enabled by using existing Rel-15/16 mechanisms, for instance, by configuration of the number of PDCCH candidates per aggregation level and/or the number of DCI sizes to monitor”. |
| Lenovo, Motorola Mobility | Y | Fine with the proposal. |
| CATT | Y |  |
| LG | Y with modifications | We think Scheme #1 should not be separated into Alt.1a and Alt.1b, however, we are okay if the majority prefer to separate them. We agreed with Ericsson’s modification. |
| Huawei, HiSilicon | Y | We are fine with the description. |
| Spreadtrum | Y |  |
| OPPO | Y (conditionally) | OK for that. We understand that we do not going to the detail of alt 1a and 1b. It seem they can be implemented by setting a UE capability or by other means. At this stage it seems general enough, by we may need further discussion the details options in later stage. |
| Nokia, NSB | Y |  |
| ZTE,sanechips | Y | The number of PDCCH candidates per aggregation level can be configured for a searchspace, which can not used to reduce maximum limit of PDCCH candidates (fixed in current mechanism) for all the searchspaces or just for USS.So the modification from Ericsson is not needed here. |

Summary of 6th round email discussion.

All responses indicate to accept FL proposals for progress and very appreciated by FL. One response indicates to add note that it can be implemented by Rel-15 configuration. However, the core part of this scheme is reduced the ‘maximum’ number of BDs, which is hard encoded in specification and is not configurable. We can further discuss this perspective in conclusion section anyhow. Let’s focus on the description itself, instead of specification impact.

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had, especially considering that this is just to make the scheme 1 clear for reader and nothing related to recommend it or not.**

**[FL7]** **Proposal 8.2.1-1: Capture the following feature description for Scheme #1 in the TR:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot in connected mode** In Rel-15 and Rel-16 NR, the limits on maximum number of BDs per slot are defined for different SCS configurations, as summarized in Table 1. Scheme #1 reduces the maximum number of BDs in a slot. In Rel-15 and Rel-16 specifications, the total number of different DCI sizes configured to monitor is up to 4 with up to 3 different DCI sizes with C-RNTI. Two alternatives were studied under Scheme #1, which includes reduced maximum number of BDs per slot with additionally reduced DCI size budget (Alt.1a) and reduced maximum number of BDs per slot without reduced DCI size budget (Alt.1b). Table 1: Blind decoding limits in NR.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCS [kHz]** | **15** | **30** | **60** | **120** |
| **Max # BD per slot (in NR)** | 44 | 36 | 22 | 20 |

 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Y |  |
| vivo | Y | We suggest to not mention (Alt.1a) and (Alt.1b), if possible |
| Futurewei | Y |  |
| Samsung  | Y |  |
| Nokia, NSB | Y |  |
| InterDigital | Y |  |
| Ericsson | With modifications | We are fine if the description is updated as follows to accurately describe the Rel-15/16 behavior.In Rel-15 and Rel-16 NR, the ~~limits on maximum~~ number of BDs per slot is configurable up to the limits ~~are~~ defined for different SCS configurations, as summarized in Table 1. Scheme #1 reduces the maximum number of BDs in a slot. In Rel-15 and Rel-16 specifications, the total number of different DCI sizes ~~configured~~ to monitor is configurable up to 4 with up to 3 different DCI sizes with C-RNTI. Two alternatives were studied under Scheme #1, which includes reduced maximum number of BDs per slot with additionally reduced DCI size budget (Alt.1a) and reduced maximum number of BDs per slot without reduced DCI size budget (Alt.1b).  |
| Intel | Y | Fine with FL’s version |
| Huawei, HiSilicon | Y |  |
| Qualcomm | Y |  |
| LG | Y (with modifications) | We suggest not to explicitly split Alt.1a and Alt.1b. And we prefer the modifications from Ericsson. |
| OPPO | Y | Fine for the version as it is try to describe schemes not to recommend. |

#### **<GTW#4>**

**[FL7]** Updated **Proposal 8.2.1-1: Capture the following feature description for Scheme #1 in the TR:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot in connected mode** In Rel-15 and Rel-16 NR, the ~~limits on maximum~~ number of BDs per slot is configurable up to the limits ~~are~~ defined for different SCS configurations, as summarized in Table 1. Scheme #1 reduces the maximum number of BDs in a slot. In Rel-15 and Rel-16 specifications, the total number of different DCI sizes configured to monitor is up to 4 with up to 3 different DCI sizes with C-RNTI. Two alternatives were studied under Scheme #1, which includes reduced maximum number of BDs per slot with additionally reduced DCI size budget (Alt.1a) and reduced maximum number of BDs per slot without reduced DCI size budget (Alt.1b). Table 1: Blind decoding limits in NR.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCS [kHz]** | **15** | **30** | **60** | **120** |
| **Max # BD per slot (in NR)** | 44 | 36 | 22 | 20 |

 |

**[FL6]** **Proposal 8.2.1-2: Capture the following feature description for Scheme #2 in the TR:**

|  |
| --- |
| **Scheme #2: Extending the PDCCH monitoring gap to X slots (X>1) in connected mode*** In Rel-15/16 NR, the range of PDCCH monitoring periodicity is configurable, which is in a range of a few symbol (s) to 2560 slots subject to UE capability. Scheme#2 is to increase the minimum configurable gap (i.e. the minimum separation between two consecutive PDCCH monitoring occasions) to be X slots, where . The maximum capable number of BDs in a PDCCH monitoring occasion on average is reduced in X slots compared to Rel-15.
 |

**When commenting, please provide details about what modification is needed in order to add it into TR to make progress, instead of only raising your concerns. Thanks!!**

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| vivo | Y with modifications | For the last sentence, we think there is no need to mention PDCCH monitoring occasion, we agree with the comment from Ericsson and FL before about the interpretation of scheme#2. A hopefully clearer version for the last sentence is suggested as below for consideration:On top of Rel-15 BD limit M per slot, a maximum capable number of BDs per X slot is defined as N, and N<M\*X to achieve average BD reduction across X slots.   |
| Qualcomm | Y | This essentially configures a sparse PDCCH monitoring. Whether additional BD limit per multiple slots is defined should be FFS and hence should not be captured in TR. Our preference is not to define the additional BD limit per multiple slots. |
| Intel |  | The current last sentence is not clear. Vivo’s version for the last sentence seems clearer, although the phrase “capable number of BDs” does not seem very appropriate. If we pursue this scheme, the requirements will be updated accordingly, and thus, what is implied by use of “capable” is not clear. This could simply say “max number of BDs per X > 1 slots”. |
| Samsung | Y with modification | We think “minimum configurable gap” is not needed. For some example, the minimum gap could be UE reported PDCCH monitoring capability, which is not configurable. Also, it’s better to use “extend” instead of “increase”, to keep same wording as the title. So, we suggest the following modifications. In Rel-15/16 NR, the range of PDCCH monitoring periodicity is configurable, which is in a range of a few symbol (s) to 2560 slots subject to UE capability. Scheme#2 is to increase extend the minimum configurable gap (i.e. the minimum separation between two consecutive PDCCH monitoring occasions) to be X slots, |
| Futurewei | Y | Same minor editorial as first comment: “Scheme#2 increases…” Capture in a note that scheme#2 may not be within the scope of WID |
| InterDigital | Y |  |
| Ericsson | With modifications | In our view, the following statement should be captured: “Extending the PDCCH monitoring gap to X slots can be achieved by using existing Rel-15/16 mechanisms”. |
| CATT | Y with modifications | The last sentence is not clear to us. The maximum number of BD is defined within the basic time-domain transmission unit, i.e. per slot or per span. The proposed sentence seems to introduce a more advanced capability for UE which is against the objectives in SID, which is shown below:Reduced PDCCH monitoring by smaller numbers of blind decodes and CCE limitsIt should be noted that the blind decodes and CCE limits are well defined in the current specification. The last sentence has the risk that the BD and CCE limit in a slot can be larger than the existing ones.From this perspective, we think the wording proposed by HW in the last round discussion is more suitable, i.e. ‘The maximum capable number of BDs **in a slot keeps the same maximum number of BDs in a slot as that in Rel-15/16**’  |
| Sharp | Y | Agree with vivo. |
| LG | Y with modifications | We suggest a note that scheme#2 may not be in the scope and can be achieved by using existing Rel-15/16 mechanisms. |
| Huawei, HiSilicon | Y with modification | Share similar view with Qualcomm and CATT.  |
| Fraunhofer | Y with modifications | In principle we are fine with vivo’s proposed last sentence. However, as Intel mentioned the term “maximum capable” for N seems unclear to us and should be replaced by a more appropriate solution. |
| OPPO | Y | We understand the intention is per X slot based and the X can be 1. Not per monitoring occasion based. |
| Nokia, NSB | Y with modifications | Would like the Ericsson suggested Note added. |
| ZTE,sanechips | Y with modifications | From our understanding, scheme2 is to define the maximum number of BD on multiple slots or per span, instead of PDCCH monitoring occasion. And whether the PDCCH occasion is defined on multiple slots can be discussed in WI stage.Additionally, maximum capable number of BDs can be referred to UE capability based maximum number of BDs. However, whether it is based on the UE capability should be discussed in the WI stage. So the word “capable” is not appropriate here. So we suggest to make a modification for the last sentence. The maximum number of BDs is reduced in X slots compared to Rel-15 |

Summary of 6th round email discussion.

Almost all responses indicate to support FL proposal with some modification on the last sentence. One response indicates to not explicitly capture new BD limit definition per X slot in TR and should keep it FFS to work item phase. Again, let’s not discuss whether or not it in scope at least on this section. We can discuss it in conclusion section. One response indicates to capture a note that it can be achieved by using existing mechanisms. However, it should be noted the scheme #2 is to further limit the minimum periodicity for PDCCH monitoring, which maybe hard-encoded in specification and is not configurable. One response indicates that the maximum BD should be still up bounded by the Rel-15 limit. To avoid this confusion, it was suggested to add one sentence to make this clear.

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had, especially considering that this is just to make the scheme 2 clear for reader and nothing related to recommend it or not.**

**[FL7]** **Proposal 8.2.1-2: Capture the following feature description for Scheme #2 in the TR:**

|  |
| --- |
| **Scheme #2: Extending the PDCCH monitoring gap to X slots (X>1) in connected mode**In Rel-15/16 NR, the range of PDCCH monitoring periodicity is configurable, which is in a range of a few symbol (s) to 2560 slots subject to UE capability. Scheme#2 is to extend the minimum configurable gap (i.e. the minimum separation between two consecutive PDCCH monitoring occasions) to be X slots, where X . Using ‘M’ to denote Rel-15 BD limit per slot and ‘N’ to denote maximum number of BDs per X slot with Scheme #2, N<M\*X to achieve average BD reduction across X slots. For scheme #2, the maximum number of BDs in a slot keeps the same as that in Rel-15.  |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Partially Y | For each slot, the intention is to reduce the maximum number of BDs. So, a gap is defined on X slots to achieve that on average. However, for the last sentence, the maximum number of BDs in a slot keeps the same as that in Rel-15, seems to conflict with the intention. Maybe a modification may be needed to make it clearer. |
| vivo | Y |  |
| Futurewei |  | Whiile our preference would be to capture that not within scope, we understand FL’s preference of having it in the conclusion |
| Samsung  | Y with modifications | 1. The minimum separation may not be configurable. Minimum configurable gap is confusing and redundant, thus can be removed.
* In Rel-15/16 NR, the range of PDCCH monitoring periodicity is configurable, which is in a range of a few symbol (s) to 2560 slots subject to UE capability. Scheme#2 is to extend the ~~minimum configurable gap (i.e.~~ the minimum separation between two consecutive PDCCH monitoring occasions~~)~~ to be X slots, where X .
1. Last sentence is not needed to achieve N < M\*X. The BD limit defined per PDCCH monitoring occasion in a slot with Scheme #2 can be further discussed during WI phase. Thus, we suggest to remove it.
* Using ‘M’ to denote Rel-15 BD limit per slot and ‘N’ to denote maximum number of BDs per X slot with Scheme #2, N<M\*X to achieve average BD reduction across X slots. ~~For scheme #2, the maximum number of BDs in a slot keeps the same as that in Rel-15.~~
 |
| Nokia, NSB |  | Share the same observation as ZTE |
| Ericsson | Y |  |
| Intel |  | We think by “Average BD reduction across X slots” it is intended that number of BDs per slot is reduced on average. So that part maybe revised such as “to achieve reduced ~~average~~ BD numbers per slot on average across X slots”. Moreover, limit on maximum number of BDs per slot need not be touched for the scheme.  |
| Huawei, HiSilicon | Partially Y | We share similar view with ZTE that the two sentences conflict:* Using ‘M’ to denote Rel-15 BD limit per slot and ‘N’ to denote maximum number of BDs per X slot with Scheme #2, N<M\*X to achieve average BD reduction across X slots.
* For scheme #2, the maximum number of BDs in a slot keeps the same as that in Rel-15.

We have concerns on the first sentence above, and we just need the second one.  |
| Qualcomm | Y with modifications | The following modifications are made to keep the flexibility for further WI discussion* extend the minimum configurable gap (~~i.e.~~ e.g., the minimum separation between two consecutive PDCCH monitoring occasions, PDCCH spans or slots with configured PDCCH candidates)

There is no strong motivation to define a multi-slot BD limit given the sparse PDCCH monitoring can already achieve reduced PDCCH monitoring. Suggest to remove the following sentence * Using ‘M’ to denote Rel-15 BD limit per slot and ‘N’ to denote maximum number of BDs per X slot with Scheme #2, N<M\*X to achieve average BD reduction across X slots.
 |
| LG |  | We share a view with ZTE. How the scheme is intended to achieve the reduced PDCCH monitoring needs to be further clarified. |
| OPPO | Y (mostly without the latest change) | We this reduced capability should not keep the same as for 1 slot case. This is not the reduction.The last sentence should be removed. |
| Sharp | Y | The last sentence is not necessary, because with N<M\*X, the average BD number per slot has already been reduced, for the purpose of power saving.  |

#### **<GTW#5>**

**[FL7]** Updated **Proposal 8.2.1-2: Capture the following feature description for Scheme #2 in the TR:**

|  |
| --- |
| **Scheme #2: Extending the PDCCH monitoring gap to X slots (X>1) in connected mode**In Rel-15/16 NR, the range of PDCCH monitoring periodicity is configurable, which is in a range of a few symbol (s) to 2560 slots subject to UE capability. Scheme#2 is to extend the minimum separation between two consecutive PDCCH monitoring occasions to be X slots, where X .  |

**[FL6]** **Proposal 8.2.1-3: Capture the following feature description for Scheme #3 in the TR:**

|  |
| --- |
| **Scheme #3**: **Dynamic adaptation of PDCCH ~~monitoring parameters~~ Blind Decoding (BD) in connected mode**In Rel-15/16, the parameters of PDCCH monitoring is configured by RRC signaling on a per search space set basis. Scheme #3 is to dynamically adapt PDCCH ~~monitoring~~ BD parameters e.g. maximum number of PDCCH candidates per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions. For example, to address real-time traffic variations on a cell or for a UE while accounting for blocking, a gNB can indicate reduced/full PDCCH BD on the cell to the UE when traffic is low/high.  |

**When commenting, please provide details about what modification is needed in order to add it into TR to make progress, instead of only raising your concerns. Thanks!!**

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| Qualcomm | Y | Note that in TS 38.213, a monitored PDCCH candidate is equivalent to a blind decode per email discussion in PDCCH session (in “[92b-NR-02-213] draft CR to 38.213 - update 1” in May 2018). It is better to clarify whether the PDCCH candidate in this FL refers to the number of PDCCH candidates configured in search space set configuration or refers to BD in this sentence “adapt PDCCH ~~monitoring~~ BD parameters e.g. maximum number of PDCCH candidates per PDCCH monitoring occasion”.  |
| Intel |  | We are generally fine to capture the description, however, the last sentence seems more of an observation or motivation, and not quite suitable as part of feature description. Suggest to delete this sentence. |
| Samsung | Y |  |
| Futurewei | Y | Capture in a note that it may not be within scope of SID |
| InterDigital | Y |  |
| Ericsson | Y | We suggest adding “-related parameters”:**Dynamic adaptation of PDCCH Blind Decoding (BD)-related parameters in connected mode**Although we are not convinced on the potential power saving benefits of the above scheme (on top of other schemes), we are okay to capturing the above description for the sake of making progress. |
| Lenovo, Motorola Mobility | Y |  |
| CATT |  | Share same views as Intel. |
| LG | Y | We suggest a note that Scheme#3 may not be in the scope.  |
| Nokia, NSB |  | Share same view as Intel |
| Huawei, HiSilicon | Y | Generally fine. We are also OK with Ericsson’s revision.Regarding the last added example, we share similar view with Intel and CATT. However, as compromise, if we decide to capture it, we don’t think we should capture the purpose and suggest just capture the gNB indication part.“For example, ~~to address real-time traffic variations on a cell or for a UE while accounting for blocking,~~ a gNB can indicate reduced/full PDCCH BD per slot on the cell to the UE when traffic is low/high.” |
| Fraunhofer | Y |  |
| OPPO | Y | OK for limited to DB parameter.  |
| ZTE,sanechips | Y | We are generally fine with the FL proposal. |

Summary of 6th round email discussion.

All responses indicate that proposal from FL is general acceptable. Two responses indicate to add ‘note’ about ‘out of scope’. Again, let’s not discuss it here, instead of focusing on how to make the description clear, which can help reader to understand the evaluation results associated with it. We will discuss whether it is in scope or not at the conclusion/recommendation section. Three responses indicate to delete the last sentence as typically scheme description focuses on the key information without example description. The example is provided by proponents based on comments for more detailed information. We can remove it now as it seems companies understand the scheme better.

#### **<GTW#3>**

**[FL7]** **Proposal 8.2.1-3: Capture the following feature description for Scheme #3 in the TR:**

|  |
| --- |
| **Scheme #3**: **Dynamic adaptation of PDCCH Blind Decoding (BD) parameters in connected mode**In Rel-15/16, the parameters of PDCCH monitoring is configured by RRC signaling on a per search space set basis. Scheme #3 is to dynamically adapt PDCCH BD parameters e.g. maximum number of PDCCH candidates per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions. ~~For example, to address real-time traffic variations on a cell or for a UE while accounting for blocking, a gNB can indicate reduced/full PDCCH BD on the cell to the UE when traffic is low/high.~~  |

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had, especially considering that this is just to make the scheme 3 clear for reader and nothing related to recommend it or not.**

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Y |  |
| vivo | Y |  |
| Futurewei | Y |  |
| Samsung | Y |  |
| Nokia, NSB |  Y |  |
| InterDigital | Y |  |
| Ericsson | Y |  |
| Intel | Y |  |
| Huawei, HiSilicon | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |

## 8.2.2 Analysis of UE power saving

**[FL5] Q 8.2.2-1: In addition to observations agreed in GTW session, what other observations need to be added into TR 38.875 for power saving gain for FR1 and FR2? Please briefly explain why, if propose to add new observations. Companies views on the following two observations proposed by one response [Ericsson] can be provided in ‘Comments’ column.**

|  |
| --- |
| * Most sources only considered only DL-only traffic in their evaluations. One source has also considered 50% DL and 50% UL traffic for VoIP. The power saving gains in this case were observed to be less than that of the DL-only case.
* Scheme #1 can already be achieved by proper configuration by the network using existing Rel-15/16 configuration parameters.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| OPPO | N | The results already give individual case. |
| Samsung  | N |  |
| Intel | N | Scheme # 1 is particularly about reduced BD/CCE limits compared to those in Rel15/16. We do not see the relevance of the second bullet here. |
| vivo | N | For bullet #1, all the results have already been captured in the table with several Notes clarifying the key different assumptions. There is no need to additionally draw observation according to the results from individual source, otherwise, there will be endless proposals and discussions. For bullet #2, the scheme#1 is to reduce the BD budget that UE is able to support, which is hardcoded in Rel-15/16 specifications and cannot be adapted by the network.  |
| Huawei, HiSilicon | N | * For the first observation, we see some companies also provide results with different UL and DL configurations. We don’t think we need a separate observation based on each UL/DL configurations.
* We provide the observations regarding the power saving gain due to the BD reduction. We think the second observation is not relevant here.
 |
| LG | N |  |
| ZTE,sanechips | N |  |
| Qualcomm | N | In bullet 1, there is no need to highlight the DL vs. DL-UL hybrid as DL-UL hybrid is not mandatory evaluation and it is already captured in evaluation result tables.Bullet 2 is misleading. As long as BD limit is reduced or other PDCCH adaptation is adopted, it has to be enabled by network configuration. The key point is whether network can guarantee to do it.Both bullets should be removed. |
| Futurewei | N |  |
| Ericsson | Y | The UL state has a considerable impact on the power saving gain and, hence, it should not be ignored. Therefore, we believe the first bullet is an important observation to capture in the TR in order to make a fair determination of the power saving benefits of Scheme #1.Minor edit: “Most sources only considered DL-only traffic in their evaluations”. |

## 8.2.3 Analysis of performance impacts

The performance impacts study evaluation includes impacts of PDCCH blocking probability, latency and scheduling flexibility.

### 8.2.3.1 PDCCH Blocking probability

**[FL8]** **Proposal 8.2.3.1-1: Capture the following note into TR 38.875 clause 8.2.3:**

|  |
| --- |
| * For the cases where number of PDCCH candidates per AL is more than 8, assumption includes configurations where multiple overlapping search space sets may exist.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| OPPO | Y | Seems this is in line with depdeep’s comment online.We can include that text. |
| vivo |  | We don’t see the need for the text but will not object |
| Sharp | Y | The expression is quite confusing. If our understanding is correct, it can be modified as:For the cases where the number of PDCCH candidates per AL is more than 8, the following configuration should be assumed, i.e., multiple overlapping search space sets are allowed. |
| MediaTek | Y |  |
| Ericsson | Y |  |
| ZTE,sanechips | Y |  |
| Nokia, NSB | Y |  |

### 8.2.3.2 Latency and Scheduling flexibility

**[FL6]** **Proposal 8.2.3.2-1: Capturing the following into TR 38.875 for section 8.2.3 for latency impact:**

* Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be scheduled. If BD reduction with a same DCI size budget like in Rel-15, it increases latency. However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices. If BD reduction with reducing DCI size budget, there is no impact on the latency performance.

**If no, what needs to be modified to add it into TR 38.875?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N | We propose the following modifications. Basically keep the observation simple and not coupled with detailed schemes. * Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be scheduled. ~~If BD reduction with a same DCI size budget like in Rel-15, it increases latency.~~ However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices. ~~If BD reduction with reducing DCI size budget, there is no impact on the latency performance.~~

  |
| Qualcomm | Y with modifications | Flexibility impact by BD reduction also depends on SCS. |
| Intel | N | Fine with Vivo’s version, with minor revision* Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be simultaneously scheduled. ~~If BD reduction with a same DCI size budget like in Rel-15, it increases latency. However, the~~ Overall impact to latency due to BD reduction is negligible in typical scenarios when a long DRX cycle may be configured to Redcap devices. ~~If BD reduction with reducing DCI size budget, there is no impact on the latency performance.~~

The deleted sentences on DCI format size budget are not correct simply since a higher DCI size budget requirement for the UE (a more capable UE) can never worsen performance (latency here). |
| Samsung | Y with modifications | DCI size budget reduction is just one out many potential enhancements to provide more scheduling flexibility. So, we suggest to capture all studied schemes as below.* Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be scheduled~~. If BD reduction with a same DCI size budget like in Rel-15, it increases latency.~~ However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices. Enhancements relative to Rel-15/16 can be considered to provide more scheduling flexibility if necessary. The enhancements studied include reduced DCI size budget, UE-grouping scheduling, modification to PDCCH candidates dropping rule. ~~If BD reduction with reducing DCI size budget, there is no impact on the latency performance.~~
 |
| Futurewei |  | In our view, this sentence should be removed: “. However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices” |
| Ericsson | N | We suggest the following updates to the text:Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be scheduled. However, in general, reduction of BDs restricts scheduling flexibility and efficient multiplexing for scheduling multiple UEs. If BD reduction is done with a same DCI size budget like in Rel-15, it increases latency~~.~~ However, the increased latency due to BD reduction is ~~negligible~~ smaller when a longer DRX cycle is configured for Redcap devices. If BD reduction is done with reducing DCI size budget, there is no significant impact on the latency performance. However, DCI size budget reduction requires DCI size alignment (e.g., padding) of several DCI formats, which impacts resource utilization (due to additional overhead) and scheduling flexibility. This, in turn, may impact blocking rate and consequently latency.It should also be clarified if the above text is for Scheme #1.  |
| Lenovo, Motorola Mobility | Y |  |
| Huawei, HiSilicon | Y with modification | RedCap can be used for wearable device, which have VoIP traffic. In this case, a long DRX cycle is not acceptable. The largest DRX cycle length for VoIP is 40ms. We have observed by evaluations that the increment of PDCCH blocking and latency shall impact the number of UEs out of service.We propose to remove the following sentence and we are OK for other part.*~~However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices.~~* |
| Fraunhofer | Y with modifications | Agree with Samsung. |
| ZTE,sanechips | Y with modifications | We think the scheduling flexibility and latency can be described as 2 sub-bullets which can be clearer. As Huawei mentioned, the DCI size budget still has an impact on the scheduling flexibility due to the DCI alignment. Therefore, We suggest the following:* Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, AL distribution, channel condition, number of ALs per UE,number of candidates per AL per UE, number of UEs that need to be scheduled simultaneously, DCI size budget.

 * If BD reduction with a same DCI size budget like in Rel-15, it increases latency. However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices. If BD reduction with reducing DCI size budget, there is no significant impact on the latency performance.
 |

**Summary of 6th round email discussion:**

In general, this section should keep it simple without coupling with specific solution as commented by one response. In addition, it should focus on latency impact, instead of enhanced solutions since they supposed to be captured in specification impact section, instead of here.

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had.**

**[FL7]** **Proposal 8.2.3.2-1: Capturing the following into TR 38.875 for section 8.2.3 for latency impact:**

|  |
| --- |
| * Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, Subcarrier Spacing (SCS) AL distribution, channel condition, number of ALs per UE, number of UEs that need to be simultaneously scheduled.
* The latency impact due to BD reduction may largely depend on PDCCH blocking rate performance impact. If the PDCCH blocking rate is increased by BD reduction, the latency performance is expected to be increased; Otherwise, BD reduction has no impact on the latency.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Y |  |
| vivo |  | We would like to keep the following sentence as it is the fact that DRX contributes to the most of the latency while the potential additional latency increase due to PDCCH blocking is marginal.*However, the increased latency due to BD reduction is negligible when a long DRX cycle is configured for Redcap devices.* |
| Futurewei | Y |  |
| Samsung  | Y |  |
| Nokia, NSB | Y |  |
| InterDigital | Y |  |
| Ericsson | With modifications | We suggest the following update to the first bullet:Reduction of BDs reduces scheduling flexibility when scheduling multiple UEs. The ~~Scheduling~~ impact ~~by BD reduction~~ depends on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be simultaneously scheduled.  |
| Intel | Y with modifications | Agree with suggestion from Vivo. We suggest following versionThe latency impact due to BD reduction may largely depend on PDCCH blocking rate performance impact. If the PDCCH blocking rate is increased by BD reduction, the latency may increase; Otherwise, BD reduction has no impact on the latencyNote that *,* the increased latency due to BD reduction is expected to be negligible for RedCap use-cases, e.g., it would be negligible when a long DRX cycle is configured for Redcap devices. |
| Huawei, HiSilicon | Y |  |
| Qualcomm | Y | A minor update: to add “,” after Subcarrier Spacing (SCS) |
| LG | Y |  |

#### **<GTW#6>**

**[FL7]** **Proposal 8.2.3.2-1: Capturing the following into TR 38.875 for section 8.2.3 for latency impact:**

|  |
| --- |
| * Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution, channel condition, number of ALs per UE, number of UEs that need to be simultaneously scheduled.
* The latency impact due to BD reduction may largely depend on PDCCH blocking rate performance impact. If the PDCCH blocking rate is increased by BD reduction, the latency performance is expected to be increased; Otherwise, BD reduction has no impact on the latency.
 |

## 8.2.4 Analysis of coexistence with legacy UEs

**[FL6]** **Q 8.2.4-1: Which of the listed options can be captured into TR 38.875 for section 8.2.4? Please provide details if you think other option is not needed? Or, if possible, please modify the favored Option to reflect the other option.**

* Option 1: The potential impacts on legacy UEs, in terms of PDCCH blocking probability, when coexisting with RedCap UEs in a shared CORESET depend on the scheduling strategy and system parameters. If legacy UEs are prioritized over RedCap UEs by network implementation choice, there is no any coexistence impact on the legacy UEs at the cost of increased latency at the Redcap device side.
* Option 2: Reduced PDCCH monitoring for Redcap devices has no impacts on legacy UEs.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | We are fine with either option 1 or 2.  |
| Qualcomm | Option 1 seems more understandable.  |
| Intel | Option 1 seems more appropriate; as an editorial comment, suggest to replace “there is no any …” with “there may not be any”. |
| Samsung | Both seem to be okay. |
| Futurewei | In a sense, it depends which scheme is used. For instance, with scheme 1, option 1a is applicable, whereas with scheme 1b, option 2 is better. In order to keep the observations at a relatively high level, suggest the following rewording of option 2: “Reduced PDCCH monitoring for Redcap devices has limited impacts on legacy UEs. For some schemes, there is no impact” |
| Ericsson | Option 1 |
| Lenovo, Motorola Mobility | Option 2. Alternatively, option 1 with the following modification (since there is no or negligible latency increase for RedCap UE).Option 1: The potential impacts on legacy UEs, in terms of PDCCH blocking probability, when coexisting with RedCap UEs in a shared CORESET depend on the scheduling strategy and system parameters. If legacy UEs are prioritized over RedCap UEs by network implementation choice, there is no any coexistence impact on the legacy UEs ~~at the cost of increased latency at the Redcap device side~~.  |
| Sharp | Option 1 |
| LG | Option 1 |
| HW | We don’t think we should assume legacy UEs are prioritized over RedCap UEs by network implementation. We should at least remove: If legacy UEs are prioritized over RedCap UEs by network implementation choice, there is no any coexistence impact on the legacy UEs at the cost of increased latency at the Redcap device side.We don’t agree with Option2. |
| Fraunhofer | Option 1 |
| Nokia, NSB | Option 1 |
| ZTE,sanechips | Option 1 with modification. From our opinion, the co-existence issue only happens in the case that both legacy UE and RedCap UE share the same CORESET.* Option 1: The potential impacts on legacy UEs, in terms of PDCCH blocking probability, when coexisting with RedCap UEs in a shared CORESET depend on the scheduling strategy and system parameters. If legacy UEs and RedCap UEs share the same CORESET, there is no significant coexistence impact on the legacy UEs when the legacy UEs are prioritized over RedCap UEs by network implementation choice. Otherwise, reduced PDCCH monitoring for Redcap devices has no impacts on legacy UEs
 |

Summary of 6th round email discussions:

Companies positions were summarized in the Table below:

|  |  |  |
| --- | --- | --- |
|  | Companies | #of companies |
| Option 1 | Qualcomm, Intel, Ericsson, Sharp, LG, Fraunhofer, Nokia, NSB, HW/HiSilicon (with modification), ZTE (with modification) | 11 |
| Option 2 | Lenovo, Motorola Mobility,  | 2 |
| Either | Vivo, Samsung | 2 |

Option 1 is clearly preferred by majority companies and FL therefore suggest going with it. One response indicates to modify the last sentence to avoid implication of de-prioritizing Redcap device. One response indicates to remove the ‘at the cost of increased latency at the Redcap device side’. However, this sentence was requested by at least four responses before to capture impacts on Redcap UE. Hence, FL suggests keeping it to avoid repeating discussions.

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had.**

#### **<GTW#2>**

**[FL7] Proposal 8.2.4-1 Captured the following into TR 38.875 for section 8.2.4**

|  |
| --- |
| * The potential impacts on legacy UEs, in terms of PDCCH blocking probability, when coexisting with RedCap UEs in a shared CORESET depend on the scheduling strategy and system parameters. Depending on the network implementation, if legacy UEs are prioritized over RedCap UEs, there is no any coexistence impact on the legacy UEs at the cost of increased latency at the Redcap device side.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Y |  |
| vivo | Y |  |
| Futurewei | Y |  |
| Samsung | Y |  |
| Nokia, NSB | Y |  |
| InterDigital | Y |  |
| Ericsson | Y |  |
| Intel | Y |  |
| Huawei, HiSilicon | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |
| OPPO | Y |  |

## 8.2.5 Analysis of specification impacts

**[FL6]** **Proposal 8.2.5-1: Capturing the following into TR 38.875 for section 8.2.5 for Scheme 1**

* Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include the reduced maximum number of PDCCH candidates, the reduced DCI size budget and DCI format design for multiple PDSCHs scheduling to minimize the PDCCH blocking rate impact.

**If not, what modification is needed to add into TR 38.875?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | We think the DCI size alignment maybe impacted as well if reduced size budget is reduced, suggest to revise as following. * Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include the reduced maximum number of PDCCH candidates, the reduced DCI size budget, modification to DCI size alignment rule and DCI format design for multiple PDSCHs scheduling to minimize the PDCCH blocking rate impact.
 |
| Qualcomm | Fine with the proposal. |
| Intel | Fine with modified version from Vivo. |
| Samsung | We think PDCCH candidates dropping rule maybe impacted as well if maximum number of PDCCH candidates is reduced. So, we suggest following modification. * Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include the reduced maximum number of PDCCH candidates, the reduced DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact.
 |
| Futurewei | Ok in principle. We suggest to reword as “specification impact may including reducing the maximum number of PDCCH candidates, or reducing the DCI size budget and DCI format design for multiple PDSCHs scheduling to minimize the PDCCH blocking rate impact.  |
| Ericsson | Although we understand FL’s point of view, in our view, it is very important to capture S1. This captures that the potential power saving can be achieved by existing network configuration, i.e., without specification impact. * S1 [2]: If the network assist BD reduction and UE power saving using existing configurations without any specified restriction for RedCap, specification changes are not required.
 |
| Lenovo, Motorola Mobility | Fine with the proposal |
| LG | We suggest to capture that the potential power saving may be achieved by existing network configuration, i.e., without specification impact. |
| Huawei and HiSilicon | Generally fine, with the following revision:* Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include the reduced maximum number of PDCCH candidates, the reduced DCI size budget and DCI format design ~~for multiple PDSCHs scheduling~~ to minimize the PDCCH blocking rate impact.
 |
| Fraunhofer | Fine with Samsung’s version. |
| Spreadtrum | Agree to the modification of HW and Samsung. |
| ZTE | Fine with Samsung’s version |

**Summary of 6th round email discussions**

Almost all responses agree FL proposal regarding specification impacts. Two responses indicate to add S1 that it can be achieved by current signaling. Again, please note that the scheme 1 is to reduce the maximum number of BDs i.e. upper boundary, which is hard encoded in TS 38.213 and cannot be achieved by configuration.

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had.**

**[FL7]** **Proposal 8.2.5-1: Capturing the following into TR 38.875 for section 8.2.5 for Scheme 1**

|  |
| --- |
| * Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the maximum number of PDCCH candidates, or reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Y |  |
| vivo | Y with small changes | We think the “or” should be deletedDepending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the maximum number of PDCCH candidates, ~~or~~ reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact.  |
| Futurewei | Y with change | The “modification to DCI size alignment rule” is part of DCI format overall, thus is not needed in the observation |
| Samsung | Y |  |
| Nokia, NSB | Y | Agree with Vivo “or” comment |
| InterDigital | Y |  |
| Ericsson | N | As we mentioned in our response to this proposal in FLS6, it is important to capture the finding from the SI that the estimated power saving from BD reduction can be achieved by existing network configuration, i.e., without specification impact. So, we should capture S1 in the text.“If the network assist BD reduction and UE power saving using existing Rel-15/16 configurations without any specified restriction for RedCap, specification changes are not required.” We note here that in the coexistence impacts section, the FL’s proposal is to capture how potential coexistence impacts can be avoided depending on network the implementation. A similar statement is needed in the specification impacts section, which is what is captured above.Also, note that there will be specification impact if the BD limits need to be specified for RedCap (i.e., updating BD limits table in TS 38.213). |
| Intel | Y with small changes | It is important the explicitly capture ‘limit’ in the description. Following revision is suggested.Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the limit on maximum number of PDCCH candidates, or reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact.  |

|  |  |  |
| --- | --- | --- |
| Huawei, HiSilicon | Y with modifications | As network vendor, we have strong concern on the specification changes which would cause network restriction. Specification impact that introduces no restriction or just marginal network restriction can be further considered. We would like to capture this in the specification impact analysis. Secondly, we have never discussed the modification to PDCCH candidates dropping rule during these three weeks. Therefore, it is difficult to understand the mechanism of this specification impact, and how it can bring power saving benefit. Therefore, we propose to remove the “modification to PDCCH candidates dropping rule”.There is one unnecessary ‘or’, which we also propose to delete it.Our suggested change is:Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the maximum number of PDCCH candidates, ~~or~~ reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, ~~modification to PDCCH candidates dropping rule,~~ to minimize the PDCCH blocking rate impact and avoid any network restriction e.g. restriction on scheduling flexibility.  |
| Qualcomm | Y |  |
| LG | N | We suggest to capture that BD reduction and power saving can be achieved by existing network configuration, i.e., without specification impact. |
| OPPO | Y | We are ok with the text, those are potential specification impact. |

**[FL6]** **Proposal 8.2.5-2: Capturing the following into TR 38.875 for section 8.2.5 for Scheme 2**

* For Extending the PDCCH monitoring gap to X slots (X), the minimum configurable gap (i.e. the minimum separation between two consecutive PDCCH monitoring occasion) is increased from 1 slot to X>1 slots and X needs to be specified. The maximum number of configurable BDs in X slots are reduced compared to Rel-15, which is required to be specified.

**If not, what modification is needed to add into TR 38.875? Kindly note that please focus on the specification impact wording, instead of commenting the need of capturing scheme #2 impact, as we already agreed to capture all schemes including scheme 2 already.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| vivo | Suggest modification to the last sentenceFor Extending the PDCCH monitoring gap to X slots (X), the minimum configurable gap (i.e. the minimum separation between two consecutive PDCCH monitoring occasion) is increased from 1 slot to X>1 slots and X needs to be specified. The maximum number of configurable BDs in X slots ~~are reduced compared to Rel-15, which~~ is required to be specified.  |
| Qualcomm | The last sentence should be removed. We do not think it is necessary to define such a new multi-slot BD limit. It is not preferred for UE to implement another or additional counting procedure other than what we have from Rel-15.* ~~The maximum number of configurable BDs in X slots are reduced compared to Rel-15, which is required to be specified.~~
 |
| Samsung | We think PDCCH candidates dropping rule maybe impacted as well if the gap is extended to be X>1 slot. Also, we think the enhancements for minimizing PDCCH blocking rate also applies to Scheme #2. So, we suggest following modification. For Extending the PDCCH monitoring gap to X slots (X), ~~the minimum configurable gap (i.e.~~ the minimum separation between two consecutive PDCCH monitoring occasion~~)~~ is increased from 1 slot to X>1 slots and X needs to be specified. The maximum number of configurable BDs in X slots are reduced compared to Rel-15, which is required to be specified. Enhancement, such as the reduced DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, may be needed to minimize the PDCCH blocking rate impact.  |
| Futurewei | Include a note that scheme 2 may not be within scope of SID |
| Ericsson | The following statement should be added to the text.“If extending the PDCCH monitoring gap to X slots is achieved using existing configurations without any specified restriction for RedCap, specification changes are not required.”Also, in our understanding, “the maximum number of configurable BDs in X slots are reduced compared to Rel-15, which is required to be specified” may not be necessary, since the maximum number of BDs in a slot can be the same as in Rel-15/16. The average number of BDs per slots is reduced with extended gap.  |
| Lenovo, Motorola Mobility | The maximum number of BDs for RedCap UEs can still be specified per slot-basis, while the minimum separation between two consecutive PDCCH monitoring occasions is specified to be X slots (X>1). Thus, we suggest modifying the proposal as follows:For Extending the PDCCH monitoring gap to X slots (X), the minimum configurable gap (i.e. the minimum separation between two consecutive PDCCH monitoring occasion) is increased from 1 slot to X>1 slots and X needs to be specified. The maximum number of configurable BDs per slot ~~in X slots~~ are reduced compared to Rel-15, which is required to be specified.  |
| Sharp | Agree with vivo. But it is better to keep consistency of the wording for either “configurable” or “capable”.  |
| Huawei, HiSilicon | We have concerns on: “The maximum number of configurable BDs in X slots are reduced compared to Rel-15, which is required to be specified.”. |
| Fraunhofer | Agree with vivo’s version. |
| Nokia, NSB | Agree with Ericsson’s suggestion. |
| ZTE,sanechips | We are OK with Samsung’s version with a modification: The maximum number of configurable BDs in X slots ~~are reduced compared to Rel-15, which~~ is required to be specified.  |

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had.**

**[FL7]** **Proposal 8.2.5-2: Capturing the following into TR 38.875 for section 8.2.5 for Scheme 2**

|  |
| --- |
| * For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two consecutive PDCCH monitoring occasion is increased from 1 slot to X>1 slots and X needs to be specified.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Partially Y | After X is specified, how to specify the maximum number of configurable BDs in X slots seems to be unclear. So, we suggest to add that and make it clearer. For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two consecutive PDCCH monitoring occasion is increased from 1 slot to X>1 slots. X and the maximum number of configurable BDs in X slots needs to be specified.  |
| vivo |  | We are fine with ZTE’s modification |
| Futurewei |  | While we are okay having results for scheme 2 captured, we have concerns with this observation since we do not have a mandate in the WID to increase X |
| Samsung  | Y with modifications | We support ZTE’s modification.In addition, scheme #2 has impact on PDCCH blocking, too. Enhancements to minimize the PDCCH blocking rate for Scheme #1 also applies to Scheme #2. Thus, we think it’s necessary to include those potential specification impact.* For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two consecutive PDCCH monitoring occasion is increased from 1 slot to X>1 slots X and the maximum number of configurable BDs in X slots needs to be specified. Additional specification impact may include reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact.
 |
| Ericsson | N | We have a similar response as in **Proposal 8.2.5-1**. How the specification impact could be avoided should also be captured. Therefore, we suggest adding the following sentence (which is analogous to S1) to the above text:“If the extension of the PDCCH monitoring gap to X slots is carried out using existing configurations without any specified restriction for RedCap, specification changes are not required.” |
| Intel | Y | Fine with FL’s version.  |
| Huawei, HiSilicon | Y | We are not OK to add back the definition of maximum BD over X slots in the specification. |
| Qualcomm | Y | To keep flexibility for WI discussion, the following modifications are made:* the minimum configurable gap (~~i.e.~~ e.g., the minimum separation between two consecutive PDCCH monitoring occasion, PDCCH spans or slots with configured PDCCH candidates)

We do not think defining another X slot BD limit is necessary given the sparse PDCCH monitoring with minimum separation of X slots can already achieve reduced PDCCH monitoring. So we support to remove the last sentence as it is in FL’s proposal. |
| LG | N | There is a way to avoid the specification impact of scheme 2, therefore, we should capture it. We support Ericsson’s modification. |
| OPPO |  | Seems the minimum would be problematic. If the minimum for a UE is X slot and X >1. Does that means UE can not support 1 slot, even in the initial access?Should remove ‘minimum’. |
| Sharp | Y | Agree with the modification of ZTE. |

**[FL6]** **Proposal 8.2.5-3: Capturing the following into TR 38.875 for section 8.2.5 for Scheme #3**

* For dynamic adaptation of PDCCH monitoring parameters scheme, specification impacts may include mechanisms used to dynamically adapt PDCCH monitoring parameters e.g. maximum number of PDCCH candidates per PDCCH per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions.

**If not, what modification is needed to add into TR 38.875? Kindly note that please focus on the specification impact wording, instead of commenting the need of capturing scheme #3 impact, as we already agreed to capture all schemes including scheme #3 already.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Similar to comments to scheme 3, the definition and differentiation between PDCCH candidate and BD needs to be clarified. The yellow highlighted text below is not clear.* For dynamic adaptation of PDCCH monitoring parameters scheme, specification impacts may include mechanisms used to dynamically adapt PDCCH monitoring parameters e.g. maximum number of PDCCH candidates per PDCCH per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions.
 |
| Samsung | The adaptation should be limited to PDCCH blind decoding related parameters as specified in feature description. Also, we think the enhancements for minimizing PDCCH blocking rate also applies to Scheme #3. So, we suggest following modification. For dynamic adaptation of PDCCH BD ~~monitoring~~ parameters ~~scheme~~, specification impacts may include mechanisms used to dynamically adapt PDCCH BD ~~monitoring~~ parameters e.g. maximum number of PDCCH candidates per PDCCH per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions. Enhancement, such as the reduced DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, may be needed to minimize the PDCCH blocking rate impact.  |
| Futurewei | Include a note that scheme 3 may not be within scope of SID |
| Lenovo, Motorola Mobility | Fine with the proposal. |
| Huawei, HiSilicon | Generally fine. |
| Fraunhofer | Fine with the proposal. |
| Nokia, NSB | Support the Futurewei comment |
| ZTE,sanechips | Agree with replacing the “ PDCCH monitoring parameters” as “PDCCH BD parameters”. |

**Since we are approaching the end of meeting and we have not start discussing conclusion section yet, FL strongly stresses that please try to avoid repeating comments/discussion we already had.**

**[FL7]** **Proposal 8.2.5-3: Capturing the following into TR 38.875 for section 8.2.5 for Scheme #3**

|  |
| --- |
| * For dynamic adaptation of PDCCH BD parameters, specification impacts may include mechanisms used to dynamically adapt PDCCH BD parameters e.g. maximum number of BDs per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions. The specification impact may include reducing DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact.
 |

|  |  |  |
| --- | --- | --- |
| **Company** |  **Y/N** | **Comments** |
| ZTE,sanechips | Y |  |
| Futurewei | N | Same concern as for scheme 2 |
| Samsung | Y with editorial | The impact regarding minimizing the PDCCH blocking rate is addition to the dynamic adaptation on BD parameters. ~~-The~~ Additional specification impact may include reducing DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact |
| Nokia, NSB | N | Same concern as Futurewei regarding WID scope  |
| InterDigital | Y |  |
| Ericsson |  | We agree with Futurewei and Nokia |
| Intel |  | No strong view. Some rewording may be necessary. Specification impact may include ….mentioned twice. List of possibilities may be collected in one sentence. |
| Huawei, HiSilicon | Y with modifications | Similar comments for Scheme#1. Also we think the dynamic adaption should only apply to connected mode. We propose the following revision:For dynamic adaptation of PDCCH BD parameters in connected mode, specification impacts may include mechanisms used to dynamically adapt PDCCH BD parameters e.g. maximum number of BDs per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions. The specification impact may include reducing DCI size budget, DCI format design for multiple PDSCHs scheduling, ~~modification to PDCCH candidates dropping rule,~~ to minimize the PDCCH blocking rate impact and avoid any network restriction e.g. restriction on scheduling flexibility. |
| Qualcomm | Y | Current BD limit is defined per slot. There is no strong motivation to define a new BD limit per PDCCH monitoring occasion. Then the modification is suggested.* specification impacts may include mechanisms used to dynamically adapt PDCCH BD parameters e.g. maximum number of BDs per ~~PDCCH monitoring occasion~~ slot

Also the following modifications are made to leave enough flexibility for WI discussion* minimum time separation between two consecutive PDCCH monitoring occasions, PDCCH spans or slots with configured PDCCH candidates etc.
 |
| LG |  | We have same concern as Futurewei, Nokia and Ericsson.  |
| OPPO | Y | We can accept QC’s modification. |
| Sharp | Y |  |

#### **<GTW#7>**

**[FL7]** **Proposal 8.2.5-1: Capturing the following into TR 38.875 for section 8.2.5**

|  |
| --- |
| * Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the limit on maximum number of PDCCH candidates, reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, to minimize the PDCCH blocking rate impact.
* For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two consecutive PDCCH monitoring occasion is increased from 1 slot to X>1 slots and X needs to be specified.
* For dynamic adaptation of PDCCH BD parameters in connected mode, specification impacts may include mechanisms used to dynamically adapt PDCCH BD parameters e.g. maximum number of BDs per PDCCH monitoring occasion and minimum time separation between two consecutive PDCCH monitoring occasions.
* Additional specification impacts may include reducing DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact and avoid network restriction.
 |

# 12. Conclusion

The following table summarizes companies’ proposals to further study the power saving scheme(s) to reduce PDCCH power consumption:

|  |  |  |
| --- | --- | --- |
| Scheme Index | Supportive Companies  | # of companies  |
| 1 | Huawei&HiSilicon [4], vivo [6], ZTE [7], Intel [10], Spreadtrum [15], NEC[16] , Samsung[17], OPPO [18], Lenovo [19], Sharp[20], Apple [21], Qualcomm [24], InterDigital[25], WILUS [27], Sequans [28], CATT[8], Fraunhofer [26], CMCC[11] | 19 |
| 2 | vivo[6] | 1 |
| 3 | NEC[16] ,Samsung[17], Lenovo [19] CATT[8], InterDigital, Fraunhofer [26], Qualcomm[24] | 7 |
| 4 (Remain same as in Rel-15/16) | Futurewei [3], Nokia [13], MTK [22], LG[12], Ericsson [2], DOCOMO [23] | 6 |

Given the majority companies interest and study on power saving gain and PDCCH blocking rate, the following survey was initiated.

**[FL8] Q 12-1: Can we agree the following conclusion for reduced PDCCH monitoring Study to be captured in TR 38.875? if not, what other aspects need to be added or what modification is needed?**

|  |
| --- |
| The PDCCH monitoring reduction for RedCap UEs has been studied. The study includes the evaluation of power saving benefit, system performance impact, potential schemes and the corresponding specification impacts. The power saving benefit by PDCCH monitoring reduction for RedCap UEs has been evaluated based on the agreed power model and traffic model, with the results and observations captured in section 8.2.2. The system performance impact has been evaluated using PDCCH blocking rate as the metric, with the results and observations captured in section 8.2.3. Three candidate schemes for PDCCH monitoring reduction have been identified with the corresponding specification impact captured in section 8.2.5. Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme in Rel-17.   |

**Since we are approaching the end of meeting and this is the last GTW session, please provide if you tempted to answer ‘No’ to the proposal, please also please also consider proposing a way forward that you realistically think has a good chance of being agreed by the group. Please do not enter ‘No’ without justification.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | N | We have problem to understand why we need to jump into the conclusion to recommend all the 3 schemes. It’s been comment during the meeting that some of them may not need to be support in the WI.We should say: “Based on the study, it is recommended by RAN1 to specify PDCCH DB reduction, e.g. Scheme #1&#2， in Rel-17.”   |
| vivo | Y |  |
| Sharp | Y |  |
| MediaTek | N | We don’t support the recommendation of Schemes #1 & #2, the power saving by Schemes #1 & #2 can be achieved with existing configurations.* The number of BDs per slot is RRC configured (i.e. scheme#1 can be achieved with existing configurations)
* The monitoring periodicity is configured by RRC (i.e. scheme#2 can be achieved with existing configurations as well)

The conducted power saving evaluations for Schemes #1 & #2 assumed that the baseline UE is configured with the maximum BDs for PDCCH monitoring defined in Rel-15/Rel-16. So, if the baseline UE is configured with 50% of the maximum BDs for PDCCH monitoring defined in Rel-15/Rel-16, there will be no power saving by adopting Schemes #1.On the other hand, Scheme #3 will add very useful functionality (i.e. dynamically adapt PDCCH monitoring parameters) that is not supported in R15/R16. This approach is more superior to the Schemes #1 & #2 that is based on UE capability.Thus, Schemes #3 should be recommended. |
| Ericsson | N | We do not agree to capture the recommendation in the 5th paragraph due to the following reasons: * From the observations to be captured in Section 8.2.2 of the TR that there is no considerable power savings benefit that can achieved. The power saving gain, even with 50% BD reduction, is only ~1 - 6% for most cases in FR1. For 25% BD reduction, the power saving gain is roughly half of this value. It is also important to note that:
	+ Almost all power saving results reported by the companies are based on DL-only traffic. From our results available [here](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.6/EvaluationResults/RedCapPower/RedCapPower-v023-Ericsson-IDCC2.xlsx), it can be seen that the power saving gain is considerably lower when we consider a mix of DL and UL traffic, which is a more realistic scenario.
	+ Furthermore, (as already agreed) the BD reduction for 1 Rx case (which is what most RedCap UEs may likely support) is less than that of the 2 Rx case.
	+ If we consider that other power savings schemes (e.g., cross-slot scheduling) is configured for the UE, then the power saving gain is even lower.
* It is important to note that the equivalent power saving due to BD reduction can already be achieved using existing Rel-15/16 configuration parameters (e.g., number of PDCCH candidates and number of DCI sizes to monitor) without any new specified restriction for RedCap UEs.
* On the other hand, we can see from the observations to be captured in Clause 8.2.3.1 of the TR that that increase in PDCCH blocking probability is significant in many cases.
* Other performance impacts include reduction of scheduling flexibility when multiple UEs need to be scheduled simultaneously.
* From the SID, it can be seen that the battery life requirements are vastly different for different RedCap use cases. Therefore, the network should be able to configure the RedCap UEs with appropriate power saving features (including Rel-16/17 power saving features), rather than permanently reducing the BD limit for a generic RedCap UE.
* There are substantially more promising power saving features that are being studied in the RedCap SI (Extended DRX for RRC Inactive and/or Idle, RRM relaxation for stationary devices). We do not want to make any recommendations to introduce new BD restriction before the results for these more promising features become available.
* If it becomes mandatory for the network to implement the new BD restriction in order to support RedCap UEs, this would hamper the successful timely deployment of RedCap UEs in the networks.

Therefore, the recommendation in the 5th paragraph should be removed. We have also the following comments on other paragraphs of the TP:1st paragraph:In our view, Scheme #2 and Scheme #3 should not be considered in conclusion section, as it is out-of-scope of SID. Therefore, we propose the following update:“The PDCCH monitoring reduction by smaller numbers of blind decoding limits for RedCap UEs has been studied. The study includes the evaluation of power saving benefit, system performance impacts, coexistence impacts ~~potential schemes~~ and ~~the corresponding~~ specification impacts.” 3rd paragraph:“The system performance impact has been evaluated using PDCCH blocking rate as the metric, with the results and observations captured in section 8.2.3. In addition, scheduling flexibility and latency impacts have also been studied in Section 8.2.3.”4th paragraph:  “Reduced PDCCH monitoring by smaller numbers of blind decoding limits ~~Three candidate schemes for PDCCH monitoring reduction~~ have been studied ~~identified~~ with the corresponding coexistence and specification impacts captured in Sections 8.2.4 and 8.2.5, respectively.” |
| ZTE,sanechips | Y |  |
| Nokia, NSB |  N | Similar view as Ericsson. Remove final recommendation, for the reasons below:* Power saving given more realistic conditions are likely to be significantly less than 6%
* These small power saving gains come at a high cost in terms of the blocking probability
* There are other power saving features (e.g. WUS DCI) that can achieve significant power savings without the drawback of increasing the blocking probability
* These power savings can already be achieved through the existing specifications that allow the PDCCH candidates to be configured.
* The additional impacts to the network/rollout, to manage REDCAP UEs with new hard-coded lower BD limits.
 |

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# Annex: Previous Agreements

## **RAN1 #101 e-meeting**

*Agreements:*

* Study the impact of BD and CCE limits reduction on power saving and PDCCH blocking probability (quantitatively) and impacts on latency and scheduling flexibility (at least qualitatively).

*Agreements:*

* Study the impact of BD and CCE limits reduction on power saving and PDCCH blocking probability (quantitatively) and resulting impacts on latency and scheduling flexibility (at least qualitatively).
* Reuse the power consumption models and scaling factors for FR1 and FR2 provided in TR 38.840 (sections 8.1.1, 8.1.2, 8.1.3) as appropriate.
* For evaluation of UE power saving, for wearables, use the traffic models FTP model 3 and VoIP from TR 38.840 to characterize the wearables service types including IM, VoIP, heartbeat, etc. with proper modification of at least packet size and mean inter-arrival time. Values are FFS.
* For evaluation of UE power saving, for industrial wireless sensor use cases, use a traffic model based on the service performance requirements for the process monitoring use case in TS 22.104 Table 5.2-2. At least 64 bytes UL message (plus headers, e.g. MAC, RLC, etc.) transmitted periodically with a periodicity 100 ms should be considered (other values are encouraged).

## **RAN1 #102 e-meeting**

Agreements:

* Use the VoIP traffic model from TR 38.840 as baseline. Other VoIP traffic models are not precluded and companies to report if other VoIP traffic models are assumed in evaluation.

Agreements:

For power saving evaluation of RedCap UEs:

* Reuse the Instant message traffic model from TR 38.840 as baseline. Other ~~Instant~~ traffic models based on FTP model 3 are not precluded and companies to report the mean inter-arrival time and packet size if other ~~instant~~ traffic models are assumed in evaluation.
* FFS: ‘heartbeat’ traffic model

Agreements:

* The scaling factor ‘0.7’ is used for 2 Rx to 1Rx power scaling for power reduction related evaluation.
* For evaluation, the power scaling for PDCCH candidate reduction defined in TR 38.840 is reused for Redcap UEs.
* For power consumption evaluation, the DRX configurations of Instant message and VoIP in TR 38.840 are reused.
* Discussion on reduced maximum number of configurable CORESET technique for power saving is deprioritized in the Redcap power saving sub-agenda
* For power consumption evaluation, use FTP-3 model with 100 Bytes packet size and 60s mean inter-arrival time as baseline for ‘heartbeat’ traffic.
* For power consumption evaluation, reuse the following DRX configuration defined in TS 38.840 for ‘heartbeat’ traffic model:
* C-DRX cycle 640 msec, inactivity timer {200, 80} msec
* FR1 On duration: 10 msec
* FR2 On duration: 5 msec

Agreements: For the PDCCH blocking rate evaluation, at least the following parameters are assumed as baseline:

|  |  |
| --- | --- |
| Parameters | Assumptions |
| Number of candidates for each AL | Each company to report. |
| SCS/BW   | FR1: 30KHz/20MHz* 15kHz/20MHz is optional

FR2: 120KHz/[100]MHz |
| CORESET duration  | 2 symbols, with 3 symbols optional |
| Delay toleration (Slot) | 1 (1: implies that PDCCH is blocked if it can’t be scheduled in the given slot), with 2 optional |
| Aggregation level Distribution  | Companies to report (including the necessary UE channel conditions and deployment scenario(s) for the aggregation level distribution) |

Agreements: For Redcap power consumption evaluation:

* Note that 2RX is assumed

|  |  |
| --- | --- |
| Power State | Alt.4a  |
| Deep Sleep (PDS) | 0.8 |
| Light Sleep (PLS) | 18 |
| Micro sleep (PMS) | 31 |
| PDCCH-only (PPDCCH) | 50 for same-slot scheduling, 40 for cross-slot scheduling |
| PDCCH + PDSCH (PPDCCH+PDSCH) | 120 |
| PDSCH-only (PPDSCH) | 112 |
| SSB/CSI-RS proc. (PSSB) | 50 |
| Intra-frequency RRM measurement (Pintra) | ·        [60]Note4 (synchronous case, N=8, measurement only)·        [80]Note4 (combined measurement and search) |
| Inter-frequency RRM measurement (Pinter) | [60]Note4 (neighbor cell search power per freq. layer)·       [~~150~~80] Note4 (measurement only per freq. layer)·        Micro sleep power assumed for switch in/out a freq. layer |

Working assumption:

Adopting the following rule for power determination

* Rule 1: ‘Micro sleep’ power of 1 Rx is [0.8]x2 Rx ‘Micro sleep’ power
* Rule 2: For both 1 Rx and 2 Rx configuration,
* P(α) = max (Micro-sleep, α ∙ Pt + (1 – α) ∙ 0.7Pt))
* Pt is the PDCCH-only power for same slot and cross-slot scheduling cases.

**Conclusion**: It is up to each company to report the power consumption modeling for 3-symbols CORESET configuration and reduced number of non-overlapped CCEs.