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

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

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

**Title: Feature lead summary #4 on reduced PDCCH monitoring**

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

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

Table of Contents

[1 Introduction 1](#_Toc54733316)

[8.2 Reduced PDCCH monitoring 2](#_Toc54733317)

[8.2.1 Description of feature 2](#_Toc54733318)

[8.2.2 Analysis of UE power saving 3](#_Toc54733319)

[8.2.2.1 FR1 Results 4](#_Toc54733320)

[8.2.2.2 FR2 Results 15](#_Toc54733321)

[8.2.3 Analysis of performance impacts 20](#_Toc54733322)

[8.2.3.1 PDCCH Blocking probability 20](#_Toc54733323)

[8.2.3.2 Latency and Scheduling flexibility 39](#_Toc54733324)

[8.2.4 Analysis of coexistence with legacy UEs 41](#_Toc54733325)

[8.2.5 Analysis of specification impacts 43](#_Toc54733326)

[12. Conclusion 45](#_Toc54733327)

[References 46](#_Toc54733328)

[Annex: Previous Agreements 47](#_Toc54733329)

[RAN1 #101 e-meeting 47](#_Toc54733330)

[RAN1 #102 e-meeting 47](#_Toc54733331)

# 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 FL4.

# 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 |

One of concerns raised during GTW session is lack of the detail to achieve reduced maximum number of BD per slot by reducing the DCI size budget since the maximum number of BDs can still be configured even with reducing DCI size budget from ‘3+1’ to “2+1”. The revised proposals intend to address the concerns and to be added into TR for feature description.

**[FL4] Proposal 8.2.1-1**: **Capture the following feature descriptions into the TR 38.875**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| The following three reduced PDCCH monitoring schemes were studied and evaluated:  **Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot**   * 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 3 for DCI sizes with C-RNTI and 1 for other RNTIs. Two options were studied under Scheme #1 with reduced number of DCI size (Scheme #1a) and without reduced number of DCI size (Scheme #1b) to achieve a same reduced number of BDs per slot.   Table 1: Blind decoding limits in NR.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **SCS [kHz]** | **15** | **30** | **60** | **120** | | **Max # BD per slot (in NR)** | 44 | 36 | 22 | 20 |   **Scheme #2: Extending the PDCCH monitoring span gap to X slots (X>1)**   * 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 limit the minimum PDCCH monitoring periodicity value to be X slots, where and keep the same maximum number of BDs in a slot as that in Rel-15/16.   **Scheme #3**: **Dynamic adaptation of PDCCH monitoring parameters**   * 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 parameters e.g. number of PDCCH candidates and time separation between two consecutive spans. |

**Please comments “Yes or no” per Scheme e.g. Scheme 1 or Scheme 2, …, or simply ‘Yes’ means ‘all’. If a particular scheme is generally ok but need some modifications on the exact wording, please provide modified wording in the ‘comments’ column.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | OK in general | For scheme#1, we prefer not to further split into 1a and 1b, since both of them are targeting BD reduction. Suggest the following revisions  **Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot**   * 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 3 for DCI sizes with C-RNTI and 1 for other RNTIs. Two options were studied under Scheme #1, with reduced number of DCI sizes ~~(Scheme #1a)~~ and without reduced number of DCI sizes ~~(Scheme #1b)~~ to achieve a ~~same~~ reduced number of BDs per slot. |
| LG | Scheme #1 No  The others Yes | We don’t think it is essential to reduce the number of DCI sizes for the purpose of reducing the maximum number of BD per slot. There is no need to separate Scheme #1a and #1b. We think only Scheme #1b is Scheme #1 and there is no need to reduce the number of DCI sizes. |
| CATT | Y with some modification | For scheme#1, we are supportive to FL’s version except the wording ‘reduced number of DCI sizes’. It is a little bit confusing as the reduced number of DCI sizes can be put some restriction on the search space configuration, e.g. excluding some DCI formats or configure same payload size for different DCI formats. The intention here should be reduce the DCI budget. To be specific, we propose the following modification: Two options were studied under Scheme #1 with reduced ~~number of~~ DCI size budget (Scheme #1a) and without reduced ~~number of~~ DCI size budget (Scheme #1b) to achieve a same reduced number of BDs per slot.  For scheme#2, the corresponding description for scheme#2, i.e. the last sentence, is more like a restriction on the periodicity configuration. Furthermore, if URLLC PDCCH monitoring capability is supported, the total number of BD/CCE is defined per span. In the other words, the maximum number of BD/CCE per slot may be much larger than Rel-15. If the intention is to follow the per slot limit, Rel-15 limit is sufficient. |
| ZTE,sanechips | OK to scheme1  OK to scheme2  OK to scheme3 | Generally OK with scheme1. For scheme1, the total candidates under the AL distribution is an approximate value after 25% or 50% BDs reduction, which means the reduced number of BDs per slot may be different from each company,it is not the same. Therefore, we suggest to remove the “to achieve a same reduced number of BDs per slot” or adopt vivo’s modification.  Generally OK with scheme2, but we do think the  the maximum number of BDs should be defined in X slots instead of a slot. So, we suggest modify “and keep the same maximum number of BDs in a slot as that in Rel-15/16. ” as “and keep the same maximum number of BDs in X slots as that in Rel-15/16. ”  Generally OK with scheme3, but “time separation between two consecutive spans” is not clear and clarification is needed here. |
| Spreadtrum | OK in general | For scheme 1, there is no need to further split into Scheme1a and Scheme1b.  For scheme 3, it is more suitable for power saving WI. |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Huawei, HiSilicon | | Yes for Scheme#1;  Generally yes on Scheme#2 with slight revision;  Modification needed on Scheme#3; | | 1. Scheme#1: We are fine with VIVO’s revision on scheme#1. 2. Scheme#2: We are generally fine with the description of Scheme#2, but we don’t need to mention the concept of ‘span’ here. Actually, we are not sure whether RedCap UE needs to support the concept of ‘span’. Let’s remove the word of ‘span’. Also, we think the Scheme#2 should be semi-statically configure the X slots for monitoring. Therefore, we suggest the change of “Scheme#2 is to ~~limit~~ configure the minimum PDCCH monitoring periodicity value to be X slots”. 3. Scheme#3: As we agreed in the last week, it would be fine to capture the description of Scheme#3 proposed/evaluated by companies. However, the current description of Scheme#3 is too general and can cover almost all Rel-16/Rel-17 power saving adaptation enhancements, which may be even not relevant with BD reduction. We should give clear description of the solutions for the TP. | |
| Samsung | | Yes with modifications | | For scheme 1, we don’t think text regarding the two options are needed. For the evaluation results provided companies, the power saving gain is from BD scaling factor determined by PDCCH BD reduction rate only. It doesn’t matter how many DCI sizes are configured. The assumption of DCI sizes is just one configuration parameter, which is no different from the configured PDCCH candidates per AL.  Therefore, we suggest the following modification.  **Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot**   * 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 3 for DCI sizes with C-RNTI and 1 for other RNTIs. The number of PDCCH candidates per AL and number of DCI sizes to monitor are restricted by the maximum number of BD per slot. ~~Two options were studied under Scheme #1 with reduced number of DCI size (Scheme #1a) and without reduced number of DCI size (Scheme #1b) to achieve a same reduced number of BDs per slot.~~   For Scheme #2, the PDCCH monitoring span gap is the separation between two PDCCH monitoring occasions regardless of SS set configuration. But, PDCCH periodicity is configuration parameter per SS set. The PDCCH monitoring periodicity is restricted by UE capability of minimum span gap. In addition, it’s not necessary to keep the same maximum BD numbers as Rel15/16. The maximum BD numbers can be same as Rel-17 values from Scheme #1.  Therefore, we suggest the following modifications.  **Scheme #2: Extending the PDCCH monitoring span gap to X slots (X>1)**   * 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 limit the span gap, i.e. the minimum separation between two consecutive ~~of~~ PDCCH monitoring ~~periodicity value~~ occasions, to be X slots, where and determine ~~keep~~ the ~~same~~ maximum number of BDs in a span ~~in a slot as that in Rel-15/16.~~   For Scheme #3, similar as Scheme #1 and Scheme 3, we think it should be focus on explicit adaptation on BD limit. And it is also necessary to avoid overlapping with the Rel-17 PS enhancement agenda.  Therefore, we suggest to clarify the applicable adaptive parameter as following:  **Scheme #3**: **Dynamic adaptation of PDCCH monitoring parameters**   * 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 parameters e.g. maximum number of PDCCH candidates per PDCCH monitoring occasion and minimum time separation between two consecutive ~~spans~~ PDCCH monitoring occasions. | |
| Qualcomm | | Yes | | vivo and CAT’s modifications to scheme #1 make the wording more clear. | |
| Ericsson | Scheme #1: Yes (partially)  Schemes #2, #3: No | | Scheme #1 should be updated as follows:  **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 for different DCI sizes with C-RNTI ~~and 1 for other RNTIs~~. Two options were studied under Scheme #1 with reduced number of DCI size (Scheme #1a) and without reduced number of DCI size (Scheme #1b) to achieve a same reduced number of BDs per slot. Note that the BD reduction can already be achieved by using existing Rel-15/16 mechanisms, for instance, by configuration of the number of PDCCH candidates per aggregation level and the number of DCI sizes to monitor.   The last sentence can be common for both Scheme #1 and Scheme #2, if Scheme #2 were to be captured in the feature description.  We also support LG’s and Spreadtrum’s views on reduced number of DCI sizes for Scheme #1.  In our view, we should prioritize capturing Scheme #1, in line with the agreements during the GTW session. | |
| InterDigital | Y | | We prefer to keep Scheme 3 in RedCap SI. | |
| Nokia, NSB | Scheme #1: Yes Scheme #2: Yes  Scheme #3: No | | For scheme 1, we support the removal of the text regarding the two sub-options as suggested by Samsung.  Scheme 3 needs rewording to justify why it is studied here rather than the Power Savings WI. | |

## 8.2.2 Analysis of UE power saving

Most contributions have pointed out that reducing maximum number of BDs in a slot compared to Rel-15/16 reference NR UE enables reduced power consumption. The power saving gain has been extensively evaluated for both FR1 and FR2.

The power saving gain evaluation results reported by different source companies were provided in Table 2A,2B, 3A and 3B for 1 Rx and 2 Rx configurations, respectively. For a given traffic model, the evaluation results of power saving gain depend on the exact simulation assumption used by different companies including TDD UL/DL configuration, cross-slot scheduling etc.

For FR1 and FR2, the power saving gains of scheme 1~3 reported in post-meeting email discussion [102-e-Post-NR-RedCap-01] are provided in Table 2A/2B/3A/3B for different traffic models with assuming 30kHz SCS and 36 PDCCH blind decoding in the following cases:

* Case 1: Power saving gain at approximately 25% reduction in BDs.
* Case 2: Power saving gain at approximately 50% reduction in BDs.

### 8.2.2.1 FR1 Results

Table 2A: Power Saving gain, FR1, Same-Slot Scheduling, 1 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | VoIP traffic model | | Schemes  (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |
| 1 | vivo | 3.54% | 7.08% | 2.29% | 4.59% | 2.13% | 4.25% | 2.85% | 5.70% | S1 |  |
| - | 6.32% | - | 4.07% | - | 4.16% | - | - | S2 | Note 2 |
| - | 9.72% | - | 4.44% | - | 4.38% | - | - | S2 | Note 2, 3 |
| - |  | - | - | - | - | 3.80% | 5.70% | S1 | Note 4, 5 |
| 2 | Ericsson | 0.70% | 1.30% | 0.01% | 0.02% | 0.01% | 0.02% | 1.19% | 2.22% | S1 | Note 6 |
| 2.42% | 4.49% | 0.01% | 0.02% | 0.01% | 0.02% | 2.64% | 4.90% | S1 | Note 4 |
| 3 | Qualcomm | 3.22% | 6.44% | 0.96% | 1.92% | 0.65% | 1.30% | 1.53% | 3.06% | S1 | Note 7 |
| 4 | CATT | 1.83% | 3.67% | 1.10% | 2.20% | 1.04% | 2.08% | 0.90% | 1.82% | S1 |  |
| 5 | Spreadtrum | 5.70% | 11.40% | 3.40% | 6.80% | 3.20% | 6.40% | 3.10% | 6.00% | S1 |  |
| 6 | OPPO | 3.51% | 7.02% | 2.48% | 4.96% | 2.38% | 4.76% | - | - | S1 | Note 4 |
| 7 | Huawei, HiSilicon | 0.71% | 1.41% | 0.21% | 0.41% | 0.18% | 0.36% | 2.58% | 5.16% | S1 | Note 4, 8A,9A |
| 0.75% | 1.53% | 0.21% | 0.41% | 0.18% | 0.36% | 2.75% | 5.24% | S1 | Note 4, 8B, 9A |
| 2.57% | 5.14% | 2.11% | 4.06% | 1.96% | 3.91% | 3.71% | 6.23% | S1 | Note 4, 8A, 9B |
| 2.88% | 5.65% | 2.15% | 4.29% | 1.98% | 3.93% | 3.88% | 6.48% | S1 | Note 4, 8B, 9B |
| 8 | Apple | 4.46% | 8.92% | 2.66% | 5.33% | - | - | - | - | S1 | Note 4 |
| 3.38% | 6.77% | 0.65% | 1.32% | - | - | - | - | S1 | Note 4, 10 |
| 9 | Futurewei | 2.70% | 5.40% | 0.50% | 1.10% | 0.30% | 0.60% | 2.20% | 4.40% | S1 |  |
| ~~10~~ | ~~InterDigital~~ | ~~5%~~ | ~~10%~~ | ~~1.20%~~ | ~~2.40%~~ | ~~0.64%~~ | ~~1.28%~~ | ~~-~~ | ~~-~~ | ~~S1~~ | ~~Note 4~~ |
| 11 | Intel | 3.31% | 6.4% | 2.24% | 4.75% | 2.03% | 4.36% | - | - | S1 | Note 11, 12 |
| 3.2% | 6.2% | 2.1% | 4.16% | 1.76% | 3.81% | - | - | S1 | Note 13, 12 |
| 12 | ZTE | 4.15% | 8.29% | 2.60% | 5.21% | 2.29% | 4.57% | - | - | S1 | Note 4 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2:  Note 3: Multi-slot scheduling  Note 4: DL-only  Note 5: Size budget reduction by decoupling the configuration of DCI format 0\_1 and 1\_1, VOIP like DL only traffic  Note 6: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 7: slots "DDDU"  Note 8: The blocking rate in Table 9 is assumed for corresponding cases.  Note 8A: BD reduction with the same DCI size budget.  Note 8B: BD reduction by reducing DCI size budget.  Note 9A: UE can only transit to micro sleep in connected mode.  Note 9B: UE can transit to micro sleep, light sleep and deep sleep in connected mode according to the sleep duration.  Note 10 : Wake-Up Signal (WUS)  Note 11: TDD: DDDDDDDSUU  Note 12: TDD: DDDSUDDSUU  Note 13: 1 packet requires 1 PDSCH for Heartbeat traffic model; 1 packet requires 24 PDSCHs for IM model, assuming cell center UE. | | | | | | | | | | | |

Table 2B: Power Saving gain, FR1, Cross-Slot Scheduling, 1 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | VoIP traffic model | | Schemes (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |
| 1 | vivo | 3.13% | 4.77% | 1.95% | 2.98% | 1.80% | 2.75% | 2.47% | 3.76% | S1 |  |
| 2 | Ericsson | 0.66% | 0.81% | 0.01% | 0.01% | 0.01% | 0.01% | 1.14% | 1.39% | S1 | Note 2 |
| 2.39% | 2.91% | 0.01% | 0.02% | 0.01% | 0.02% | 2.62% | 3.19% | S1 | Note 3 |
| 3 | Samsung | 4.50% | 9% | 2.70% | 5.50% | 2.60% | 5.10% | 3.50% | 7% | S1, S2 | Note 3 |
| 4.50% | 9% | 2.70% | 5.50% | 2.60% | 5.10% | 4.50% | 3.5% | S3 |  |
| 4 | Qualcomm | 2.82% | 4.30% | 0.79% | 1.20% | 0.52% | 0.80% | 1.28% | 1.94% | S1 | Note 4 |
| 5 | OPPO | 2.77% | 5.54% | 2.13% | 4.25% | 2.04% | 4.07% | - | - | S1 | Note 3 |
| 6 | Apple | 4.05% | 6.17% | 2.29% | 3.50% | - | - | - | - | S1 | Note 3 |
| 2.98% | 4.53% | 0.54% | 0.82% | - | - | - | - | S1 | Note 3, 5 |
| 7 | ZTE | 3.7% | 7.4% | 2.28% | 4.57% | 2.03% | 4.05% | - | - | S1 | Note 3 |
| 8 | MediaTek | 2.43% | 4.45% |  |  |  |  | 2.72% | 5.41% | S1 | Note 6 |
| 0.84% | 1.68% |  |  |  |  | 0.87% | 1.74% | S1 | Note 7 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 3: DL-only  Note 4: slots "DDDU"  Note 5 : Wake-Up Signal (WUS)  Note 6: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 1 slot  Note 7: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 4 slots | | | | | | | | | | | |

Table 3A: Power Saving gain, FR1, Same-Slot Scheduling, 2 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | | VoIP traffic model | | Schemes (Note 1) | Notes |
| IAT = 200ms | | | IAT = 80ms | |
| Case 1 | Case 2 | | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |
| 1 | vivo | 4.22% | 8.44% | | 2.88% | 5.76% | 2.71% | 5.43% | 3.45% | 6.89% | S1 |  |
| - | 8.99% | | - | 7.02% | - | 6.87% | - | - | S2 | Note 2 |
| - | 9.58% | | - | 7.56% | - | 6.89% | - | - | S2 | Note 2, Note 3 |
| - | - | | - | - | - | - | 4.60% | 6.89% |  | Note 4, Note 5 |
| 2 | Ericsson | 0.95% | 1.76% | | 0.01% | 0.02% | 0.01% | 0.02% | 1.56% | 2.89% | S1 | Note 6 |
| 3.05% | 5.66% | | 0.22% | 0.42% | 0.20% | 0.38% | 3.33% | 6.17% | S1 | Note 4 |
| 3 | Qualcomm | 3.72% | 7.44% | | 1.25% | 2.50% | 0.86% | 1.71% | 1.98% | 3.96% |  | Note 7 |
| 4 | Nokia | - | 9.2% | | - | 6.8% | - | 6.1% | - | - | S1 | Note 4 |
| 5 | CATT | 2.16% | 4.12% | | 1.30% | 2.61% | 1.23% | 2.46% | 1.16% | 2.32% | S1 |  |
| 6 | Spreadtrum | 6.20% | 12.3% | | 4.10% | 8.20% | 3.90% | 7.80% | 3.70% | 7.20% | S1 |  |
| 7 | OPPO | 3.94% | 7.88% | | 2.81% | 5.61% | 2.70% | 5.40% | - | - | S1 | Note 4 |
| 8 | Huawei, HiSilicon | 0.64% | 1.55% | | 0.24% | 0.47% | 0.21% | 0.41% | 2.79% | 5.69% | S1 | Note 4, 8A, 9A |
| 0.82% | 1.63% | | 0.24% | 0.47% | 0.21% | 0.41% | 2.85% | 5.70% | S1 | Note 4, 8B, 9A |
| 1.47% | 4.92% | | 2.19% | 4.39% | 2.00% | 3.99% | 2.96% | 6.31% | S1 | Note 4, 8A, 9B |
| 2.83% | 5.65% | | 2.19% | 4.47% | 2.00% | 4.02% | 3.17% | 6.33% | S1 | Note 4, 8B, 9B |
| 9 | Apple | 5.10% | 10.1% | | 3.30% | 6.60% | - | - | - | - | S1 | Note 4 |
| 4.00% | 8.06% | | 0.90% | 1.80% | - | - | - | - | S1 | Note 4, 10 |
| 10 | Futurewei | 3.20% | 6.30% | | 0.70% | 1.30% | 0.40% | 0.80% | 2.70% | 5.50% | S1 |  |
| 11 | Intel | 3.46% | 6% | | 2% | 4.13% | 2.4% | 5.12% | - | - | S1 | Note 11,13 |
| 2.51% | 4.9% | | 1.9% | 4.04% | 2.3% | 4.43% | - | - | S1 | Note 12,13 |
| 12 | ZTE | 4.77% | 9.54% | | 3.03% | 6.06% | 2.94% | 5.87% | - | - | S1 | Note 4 |
| 13 | InterDigital | 5% | 10% | | 1.20% | 2.40% | 0.64% | 1.28% | - | - | S1 | Note 4 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2:  Note 3: Multi-slot scheduling  Note 4: DL-only  Note 5: Size budget reduction by decoupling the configuration of DCI format 0\_1 and 1\_1, VOIP like DL only traffic  Note 6: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 7: Slots "DDDU",  Note 8: The blocking rate in Table 9 is assumed for corresponding cases.  Note 8A: BD reduction with the same DCI size budget.  Note 8B: BD reduction by reducing DCI size budget.  Note 9A: UE can only transit to micro sleep in connected mode.  Note 9B: UE can transit to micro sleep, light sleep and deep sleep in connected mode according to the sleep duration.  Note 10: Wake-Up Signal (WUS)  Note 11: TDD: DDDDDDDSUU  Note 12: TDD: DDDSUDDSUU  Note 13: 1 packet requires 1 PDSCH for Heartbeat traffic model; 1 packet requires 24 PDSCHs for IM model, assuming cell center UE. | | | | | | | | | | | | |

Table 3B: Power Saving gain, FR1, Cross-Slot Scheduling, 2 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | VoIP traffic model | | Schemes (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |  |
| 1 | vivo | 3.80% | 7.61% | 2.50% | 4.99% | 2.34% | 4.68% | 3.04% | 6.07% | S1 |  |
| 2 | Ericsson | 0.77% | 1.44% | 0.01% | 0.02% | 0.01% | 0.02% | 1.30% | 2.41% | S1 | Note 2 |
| 2.46% | 4.57% | 0.64% | 0.78% | 0.58% | 0.71% | 2.71% | 5.02% | S1 | Note3 |
| 3 | Samsung | 4.50% | 6.90% | 2.80% | 4.20% | 2.50% | 3.90% | 3.50% | 5.30% | S1, S2 | Note 3 |
| 4.50% | 6.90% | 2.70% | 4.20% | 2.50% | 3.90% | 3.50% | 5.30% | S3 |  |
| 4 | Qualcomm | 3.31% | 6.61% | 1.03% | 2.07% | 0.71% | 1.40% | 1.67% | 3.34% | S1 | Note 4 |
| 5 | OPPO | 3.10% | 6.21% | 2.43% | 4.85% | 2.33% | 4.66% | - | - | S1 | Note 3 |
| 6 | Apple | 4.69% | 9.38% | 2.90% | 5.70% | - | - | - | - | S1 | Note 3 |
| 3.60% | 7.22% | 0.75% | 1.49% | - | - | - | - | S1 | Note 3, 5 |
| 7 | ZTE | 4.35% | 8.7% | 2.76% | 5.52% | 2.47% | 4.94% | - | - | S1 | Note 3 |
| 8 | MediaTek | 2.64% | 4.83% |  |  |  |  | 2.67% | 5.30% |  | Note 6 |
| 0.88% | 1.76% |  |  |  |  | 0.83% | 1.65% |  | Note 7 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 3: DL-only  Note 4: slots "DDDU",  Note 5 : Wake-Up Signal (WUS)  Note 6: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 1 slot  Note 7: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 4 slots | | | | | | | | | | | |

Based on the evaluations results in Table 2 and Table 3, the following observations are proposed to discuss for power saving gain for the text proposal to Redcap TP:

|  |
| --- |
| **Observation**  For the instant message traffic model, power saving gains by reducing 25% and 50% blind decoding (i.e. Scheme #1) are in the range of approximately [X1%~Y1%] and [X2%~Y2%] with same slot scheduling for the 1 Rx and 2 Rx cases, respectively. With cross-slot scheduling, the achievable power saving gains by reducing 25% and 50% BDs in Scheme #1 for instant message traffic model are varied between X3 to Y3 and between X4 to Y4 for the 1 Rx and 2 Rx cases, respectively.  For the VoIP traffic model, power saving gains by reducing 25% and 50% blind decoding (i.e. Scheme #1) are in the range of approximately [X5%~Y5%] and approximately [X6%~Y6%] with same slot scheduling for the 1 Rx and 2 Rx cases, respectively. With cross-slot scheduling, the achievable power saving gains by reducing 25% and 50% BDs in Scheme #1 for VoIP traffic model are varied between X7 to Y7 and between X8 to Y8 for the 1 Rx and 2 Rx cases, respectively.  For the Heartbeat traffic model, power saving gains by reducing 25% and 50% blind decoding (i.e. Scheme #1) are in the range of approximately [X9%~Y9%] and approximately [X10%~Y10%] with same slot scheduling for the 1 Rx and 2 Rx cases, respectively. With cross-slot scheduling, the achievable power saving gains by reducing 25% and 50% BDs in Scheme #1 for VoIP traffic model are varied between X11 to Y11 and between X12 to Y12 for the 1 Rx and 2 Rx cases, respectively. |

**Summary of 1st round email discussions**

All responses agree with the general template/framework of text proposal except one company comment to not differentiate the schemes when describing the power saving gain.

Methodology for <X, Y> values

* Value range

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Company | # of companies |
| Option 1 | The smallest value and largest value based on companies results. | All companies who provided replies. |  |

* Others
  + - Capturing the average value excluding the smallest and the largest values among companies can also be captured in the TR
      * CATT, Nokia, Qualcomm (mean or median can be captured to reflect the distribution of the results), Futurewei
    - Explicitly mention the result if it was provided by a few source companies e.g. 1 or 2
      * LG.
    - Highlighting the gain is compared to the UE with configuring the maximum blind decoding for PDCCH monitoring defined in Rel-15/Rel-16.
      * MediaTek, Ericsson
    - Separate observations for different DL/UL configuration
      * Ericsson (DL+UL, or DL only), Intel (TDD configuration)

The following was agreed in the Wednesday Moring GTW session in RAN1 #103 e-meeting:

|  |
| --- |
| Agreements:   * Determine the Xx (smallest power saving gain)-Yy (largest power saving gain) value based on the smallest and largest values reported by each company at least considering:   + Separate observations with corresponding Xx-Yy values are captured at least for cross-slot and same slot scheduling cases.   + Separate observations for FR1 & FR2   + Additional cases for separate observations * Capture average/mean value of Xx-Yy excluding the smallest and the largest values among companies. * Explicitly mention the result/observations if it was provided by a few source companies e.g. 1 or 2 with special setup or assumptions. * Highlighting the gain is compared to the UE with configuring the maximum blind decoding for PDCCH monitoring defined in Rel-15/Rel-16 |

**Q 8.2.2.1-1: Whether additional case(s) need to be considered for separate observations of power saving gains? If yes, please provide detailed information.**

* Note that it may result in reduced source companies for each case if the results are split too much.
* If additional separation is needed, each company needs to provide the corresponding evaluation assumptions. As one example, if power saving gains for different UL/DL configuration are separated, UL/DL configuration information needs to be collected to determine the Xx/Yy values**.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N | We think the it is sufficient to separate observations for cross-slot/same-slot and FR1/FR2. |
| OPPO | Y | We have agreements in the last GTW：   * Determine the Xx (smallest power saving gain)-Yy (largest power saving gain) value based on the smallest and largest values reported by each company at least considering:   + Separate observations with corresponding Xx-Yy values are captured at least for cross-slot and same slot scheduling cases.   + Separate observations for FR1 & FR2   To minimize the number of observations, we consider 2 more separation:  1. The Scheme #1a for power BD limit solutions Vs. Scheme #1b DCI size budget reduction.  2. The DL only power saving vs. DL + UL power saving.  Further for the separation no.1, to our understanding the most of companies evaluation is based on S1a. Essentially, the simulations are different. For S1a, you simply reduced the number of DB base on the power scaling of 38.840. For S1b, it should be further reported by companies that how to achieve 25% and 50% reduction by specific DCI budget reduction. How can a UE reduce 50 of BD by remove 1 DCI size budget. It should be based on some specific PDCCH candidate configuration. Then the corresponding traffic model generation can be done.  In short the S1b, is originally S1 with note 8a. Companies can further clarify if their results is S1b. Now seems HW and vivo have S1b. OPPO only provide S1a.  For the separation no.2, we are also fine to separate. But if there is too few samples, it may not be representative. Note, we mostly simulation DL only for power saving study.  Also related to the pending TP, we suggest to define S1b and S1a separated. They are different in terms of gains, complexity, spec. impact. |
| ZTE,sanechips |  | According to the agreement  Agreements:   * Determine the Xx (smallest power saving gain)-Yy (largest power saving gain) value based on the smallest and largest values reported by each company at least considering:   + Separate observations with corresponding Xx-Yy values are captured at least for cross-slot and same slot scheduling cases.   + Separate observations for FR1 & FR2   + Additonal cases for separate observations * Capture average/mean value of Xx-Yy excluding the smallest and the largest values among companies. * **Explicitly mention the result/observations if it was provided by a few source companies e.g. 1 or 2 with special setup or assumptions.** * Highlighting the gain is compared to the UE with configuring the maximum blind decoding for PDCCH monitoring defined in Rel-15/Rel-16   For the UL and DCI size budget simulation results, from our understanding, they should be mentioned explicitly and separately, since it is provided by a few source companies e.g. 1 or 2. Therefore, we do not need additional explanation for the UL and DCI size budget simulation results since they are included in the agreement. |
| Sharp | N | For power saving evaluation, we do not need to separate different approaches of BD reduction, but only need to know the ratio of BD reduction from the maximum limit. |
| Samsung | N | We already synced all the key factors in previous meetings, e.g. power model, traffic model. It’s OK the configuration from companies are not 100% aligned, that’s why we will provide a range Xx –Yy.  The observation that matters is the power saving gain with respect to different PDCCH BD reduction rate for particular traffic model. The details of how the BD reduction rate is achieved doesn’t matter. There is no need to separate observations by different schemes as well. |
| Spreadtrum | N | It is sufficient to separate observations for cross-slot/same-slot and FR1/FR2. |
| LG | N | We think that no additional case is needed.  By the way, we think that the agreement from the last GTW session needs to be clarified and updated. From our understanding, Xx-Yy values are determined separately based on each observation. However, the agreement itself may cause misunderstanding that only one Xx-Yy value is determined based on the overall observations. For clarification, we think Xx-Yy should be modified to Xn-Yn and some texts in the agreement can be additionally updated. |
| Huawei, HiSilicon | N | We think the current separation is enough. We don’t prefer to split too much to reduce the source companies.  BTW. We think OPPO’s separation of scheme 1 is actually incorrect. BD reduction with reduced DCI size budget is one way to achieve the BD reduction, not a replacement of BD reduction. |
| Nokia | N | We think the existing cases are sufficient. |
| Futurewei | N | No further splitting needed for power savings |
| Ericsson | N | No additional cases need to be considered for separate observations (assuming we have separate observations for 1 Rx and 2 Rx, as in the TP from the FL). |
| Intel | Y | In our view, observation should include assumption on DL/UL configurations. If this information is not available from results, companies should be asked to provide this information before including the result for consideration to the range to avoid inaccuracy. We understand observations would be split quite a bit if they are reflected based on each TDD configuration, however we think a range can be considered such as one observation for Xx – Yy % can be considered when DL to UL ratio is between 50% to 75%, another observation for Xx – Yy % can be considered for DL to UL ratio between 76% to 100% so as to avoid one general observation for any TDD configuration.  Also note that, we did not mean to remove Note 3 completely in the tables, only suggested to remove “1 layer transmission” from Note 3, as it may be redundant information since number of PDSCHs are already captured and this is enough to calculate power consumption. We think Huawei also commented on that part only, not Note 3 in general. |
| OPPO2 | Y | The scheme #1 in the summary is still a need to be further split to  1a: Reduced the arbitrary number of BDs in UE  1b: Reduced the DCI size budget  For the results Q 8.2.2.1-1 ask if the results can be separate. Even the results not separate in the end for simplicity, the 1a/1b can be still looked as different sub-scheme. This is two different questions.  Regarding HW’s comments on how to understand scheme #1, please note the TP for scheme1 also looks Size Budget as an alternatives of direct BD reduction.  “**Scheme #1: Reduced maximum number of Blind Decoding (BD) per slot**   * In Rel-15 and Rel-16 NR, the limits on maximum number of BDs and CCEs 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. The BD reduction maybe achieved by reducing the DCI size budget. The total number of different DCI sizes configured to monitor in Rel-15/16 is up to 4 with 3 for DCI sizes with C-RNTI and 1 for other RNTIs. One alternative of Scheme #1 is to reduce the maximum number of different DCI format sizes for C-RNTI to Y, where .   ”  The Schem#1 can simple define the 2 sub-scheme to solve the problem, even without further separate the results. |
| Qualcomm | N | There is no need to further fragment the scenarios. Otherwise, the results for each scenario are too sparse and not very representative. |

**Summary of 2nd round email discussions**

The following table summarized the response for Q 8.2.2.1-1 regarding the need of additional cases for separate observations

|  |  |  |  |
| --- | --- | --- | --- |
| Yes | | No | |
| Companies | # Companies | Companies | # Companies |
| OPPO (Two more separate, one is for reducing BDs limit and DCI size budget, the other is for DL-only vs ‘DL+UL’ power saving)  Intel: DL-only vs ‘DL+UL’ power saving | 2 | Vivo, Sharp, Samsung, Spreadtrum, LG, Huawei, HiSilicon, Nokia, Futurewei, Ericsson, Qualcomm | 11 |

The Table 2/3 were revised to reflect the following comments:

* Update with latest results or Notes. [Vivo, Huawei, Samsung, Intel, MediaTek, ZTE, Ericsson]
* Remove ‘1 layer transmission” from ‘Note’ for Intel result [Huawei, Intel, MediaTek]

**FL Proposals**

**[FL4] Proposal 8.2.2.1-1: Incorporate the revised Table 2A/2B and Table 3A/3B into Redcap TR 38.875**

* It is up to TR editor to use a separate excel sheet to include these Tables or directly capture these tables for inclusion in the TR.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y |  |
| LG | Partially yes | With regard to **[FL4] Proposal 8.2.1-1**, the tables should be captured excluding the results with reduced DCI size budget. Or, it is okay to capture the whole results with a note that explicitly mentions BD is reduced by reducing the DCI size budget. |
| CATT | Y |  |
| ZTE,sanechips | Y |  |
| Spreadtrum | Y |  |
| Huawei, HiSilicon | Y, but suggest to further clarify in the note for the simulated scheme of S3. | We are fine to capture the results from companies in the table.  However, it is not clear about which scheme of S3, e.g. dynamic BD reduction or something else, is evaluated considering there is no description about the evaluated scheme and no assumption for S3 in the table, e.g. how the BD reduction is dynamically adapted to 50%/25%. Some notes are needed in the column of ‘Notes’ to help people to understand the results captured in the TR. This comment may be also related with the comments of Scheme#3 description. |
| Samsung | Y |  |
| Futurewei | OK in principle | While it would be preferable to have only scheme 1, we can accept the FL proposal for the sake of compromise with the following note: “Schemes 2 and 3 are not necessarily within the scope of the SID” |
| Ericsson | Y, partially | Similar view as Futurewei |
| InterDigital | Y | We moved our results from table 2A to 3A because the number of Rx antennas used was 2. |
| Nokia, NSB | Y |  |

**[FL4] Proposal 8.2.2.1-2:**

Capture the following observations in the TR (editorial modifications by TR editor can be made for inclusion in the TR)

* 12 sources ([vivo], [Ericsson], [Qualcomm], [CATT], [Spreadtrum], [OPPO], [Huawei, HiSilicon], [Apple], [Futurewei], [InterDigital], [Intel], [ZTE]) reported the evaluation results of power saving gain for FR1 with same-slot scheduling for the 1 Rx antenna and 2 Rx antennas cases.

The following is observed for 1 Rx antenna case:

* + For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.7%~5.7%] and [1.3%~11.4%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 2.98% and 6.14%, respectively.
  + For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~3.40%] and [0.02%~6.80%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain by reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.56% and 3.27%, respectively.
  + For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~3.20%] and [0.02%~6.40%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.35% and 2.94%, respectively.
  + For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.90%~3.88%] and [1.82%~6.48%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 2.64% and 4.86%, respectively.

The following is observed for 2 Rx antennas case:

* For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.64%~6.20%] and [1.55%~12.30%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 3.08% and 6.68%.
* For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~4.10%] and [0.02%~8.20%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.68% and 4.00%, respectively.
* For the heartbeat traffic model with 80ms inactivity timer configuration maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~3.90%] and [0.02%~7.80%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.55% and 3.77%, respectively.
* For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.90%~3.88%] and [1.82%~6.48%]. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 2.85% and 5.63%, respectively.

**Assuming no additional cases for separate observations, can Proposal 8.2.2.1-2 be captured into Redcap TR 38.875 for FR1 with same-slot scheduling? If not, what needs to be modified?**

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

**[FL4] Proposal 8.2.2.1-3:**

Capture the following observations in the TR (editorial modifications by TR editor can be made for inclusion in the TR)

* 8 sources ([vivo], [Ericsson], [Samsung], [Qualcomm], [OPPO], [Apple], [ZTE], [MediaTek]) reported the evaluation results of power saving gain for FR1 with cross-slot scheduling for the 1 Rx antenna and 2 Rx antennas cases.

The following is observed for 1 Rx antenna case:

* + For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.66%~4.5%] and [0.81%~9%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 2.79% and 4.64%, respectively.
  + For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~2.7%] and [0.01%~5.5%], respectively With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing 36 PDCCH blind decoding by 25% and 50% are approximately 1.81% and 3.26%, respectively.
  + For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~2.6%] and [0.01%~5.1%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.8% and 3.35%, respectively.
  + For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.87%~4.5%] and [1.39%~7%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 2.29% and 3.20%, respectively.

The following is observed for 2 Rx antennas case:

* For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.77%~4.69%] and [1.44%~9.38%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 3.31% and 6.13%, respectively.
* For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~2.9%] and [0.02%~5.7%], respectively With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.95% and 3.51%, respectively.
* For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.01%~2.5%] and [0.02%~4.94%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 1.69% and 3.21%, respectively.
* For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50%, the power saving gains are in the range of approximately [0.83%~3.5%] and [1.65%~6.07%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 36) by 25% and 50% are approximately 2.28% and 4.45%, respectively.

**Assuming no additional cases for separate observations, can Proposal 8.2.2.1-3 be captured into Redcap TR 38.875 for FR1 with cross-slot scheduling? If not, what needs to be modified?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | Y |  |
| LG | Y |  |
| CATT | Y |  |
| ZTE,sanechips | Y |  |
| Spreadtrum | Y |  |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson | N | Based on the power consumption model, the power saving gain by BD reduction for cross-slot should be smaller than the same-slot case. Since different number of sources (8 and 12 companies) provided results for these two cases, the presented average value for cross slot is not always less than same slot. For example, for IM and 2 Rx:   * Gain with 25% BD reduction and same-slot: 3.08% * Gain with 25% BD reduction and cross-slot: 3.31%   This gives a wrong impression in the TR that power saving gain with BD reduction and cross-slot scheduling is higher than that with BD reduction and same-slot scheduling, which is not correct.  Therefore, we suggest including our observations in the ‘comments’ column of Q 8.2.2.1-2 to the text proposed by the FL. |
| InterDigital | Y |  |
| Nokia, NSB | Y |  |

**[FL4] Q 8.2.2.1-2: In addition to observations in Proposal 8.2.2.1-2 and Proposal 8.2.2.1-3 above, what other observations need to be added into TR 38.875 for power saving gain of FR1? Please briefly explain why, if propose to add new observations.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson |  | The following observations should be captured:   * In general, the power saving gain by BD reduction for cross-slot scheduling is less than that of the same-slot scheduling. * In general, the power saving gain by BD reduction for 1 Rx case is less than that of the 2 Rx case. * 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. * In our view, it is also very important to capture that the same power saving gain as Scheme #1 can already be achieved by proper configuration by the network using existing Rel-15/16 configuration parameters. |
| Nokia |  | We support the Ericsson comments, especially the latter 2 comments. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

### 8.2.2.2 FR2 Results

Table 4A: Power Saving gain, FR2, Same-Slot Scheduling, 1 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | | VoIP traffic model | | Scheme  (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | | Case 1 | Case 2 |
| 1 | Ericsson | 1.94% | 3.59% | 0.03% | 0.07% | 0.03% | | 0.06% | 2.52% | 4.66% | S1 | Note2 |
| 4.37% | 8.10% | 0.04% | 0.08% | 0.04% | | 0.07% | 4.66% | 8.64% | S1 | Note 3 |
| 2 | CATT | 4.53% | 9.07% | 2.97% | 5.93% | 2.75% | | 5.50% | 2.88% | 5.76% | S1 |  |
| 3 | Spreadtrum | 6.60% | 13.10% | 4.30% | 8.60% | 4.00% | | 7.90% | 5.00% | 9.40% | S1 |  |
| 4 | Futurewei | 4.40% | 8.70% | 2.00% | 1.00% | 0.50% | | 1.10% | 3.90% | 7.90% | S1 |  |
| 5 | Intel | 5.48% | 10.62% | 4.78% | 7.94% | 3.36% | | 6.6% |  |  | S1 | Note 4,5 |
| 6 | ZTE | 5.76% | 11.52% | 3.55% | 7.11% | 3.09% | | 6.18% | - | - | S1 | Note 3 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 3: DL-only  Note 4: TDD: DDDSUDDDSU  Note 5: 1 packet requires 1 PDSCH for Heartbeat traffic model; 1 packet requires 24 PDSCHs for IM model, assuming cell center UE. | | | | | | | | | | | | |

Table 4B: Power Saving gain, FR2, Cross-Slot Scheduling, 1 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | VoIP traffic model | | Scheme  (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |
| 1 | Ericsson | 1.40% | 2.70% | 0.02% | 0.04% | 0.02% | 0.04% | 1.94% | 3.60% | S1 | Note 2 |
| 3.65% | 6.76% | 0.03% | 0.06% | 0.03% | 0.05% | 3.94% | 7.31% | S1 | Note 3 |
| 2 | Samsung | 6.30% | 12.70% | 4.20% | 8.30% | 3.90% | 7.60% | 6.50% | 13.10% | S1, S2 | Note 3 |
| 6.30% | 12.70% | 4.20% | 8.30% | 3.90% | 7.60% | 6.50% | 13.10% | S3 | Note 3 |
| 3 | ZTE | 5.33% | 10.67% | 2.56% | 5.13% | 2.45% | 4.9% | - | - | S1 | Note 3 |
| 4 | MediaTek | 3.61% | 6.81% |  |  |  |  | 3.80% | 7.55% | S1 | Note 4 |
| 1.96% | 3.92% |  |  |  |  | 2.06% | 4.12% | S1 | Note 5 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 3: DL-only  Note 4: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 1 slot  Note 5: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 4 slots | | | | | | | | | | | |

Table 5A: Power Saving gain, FR2, Same-Slot Scheduling, 2 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | VoIP traffic model | | Scheme  (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |
| 1 | Ericsson | 2.45% | 4.54% | 0.04% | 0.10% | 0.04% | 0.09% | 3.10% | 5.74% | S1 | Note 2 |
| 4.84% | 8.96% | 0.06% | 0.11% | 0.05% | 0.10% | 5.13% | 9.51% | S1 | Note 3 |
| 2 | CATT | 4.81% | 9.61% | 3.34% | 6.68% | 3.12% | 6.06% | 3.19% | 6.39% | S1 |  |
| 3 | Spreadtrum | 6.80% | 13.6% | 4.90% | 11.9% | 4.6% | 9.2% | 5.5% | 10.5% | S1 |  |
| 4 | Futurewei | 4.60% | 9% | 1.10% | 2.10% | 0.50% | 1.00% | 4.50% | 8.90% | S1 |  |
| 5 | Intel | 4.43% | 9.73% | 4.2% | 7.80% | 4.57% | 8.74% | - | - | S1 | Note 4,5 |
| 6 | ZTE | 6.01% | 12.03% | 4.03% | 8.07% | 3.64% | 7.29% | - | - | S1 | Note 3 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 3: DL-only  Note 4: TDD: DDDSUDDDSU  Note 5: 1 packet requires 1 PDSCH for Heartbeat traffic model; 1 packet requires 24 PDSCHs for IM model, assuming cell center UE. | | | | | | | | | | | |

Table 5B: Power Saving gain, FR2, Cross-Slot Scheduling, 2 Rx antenna

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | IM traffic model | | Heartbeat traffic model | | | | VoIP traffic model | | Scheme  (Note 1) | Notes |
| IAT = 200ms | | IAT = 80ms | |
| Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 | Case 1 | Case 2 |
| 1 | Ericsson | 1.89% | 3.50% | 0.03% | 0.07% | 0.03% | 0.06% | 2.45% | 4.54% | S1 | Note 2 |
| 4.12% | 7.64% | 0.04% | 0.08% | 0.04% | 0.07% | 4.44% | 8.22% | S1 | Note 3 |
| 2 | Samsung | 6.60% | 13.20% | 4.90% | 9.60% | 4.60% | 8.90% | 6.80% | 13.7% | S1,S2 | Note 3 |
| 6.60% | 13.20% | 4.90% | 9.60% | 4.60% | 8.90% | 6.80% | 13.7% | S3 | Note 3 |
| 3 | ZTE | 5.53% | 11.05% | 3.08% | 6.17% | 2.7% | 5.4% | - | - | S1 | Note 3 |
| 4 | MediaTek | 3.63% | 6.86% |  |  |  |  | 3.72% | 7.39% | S1 | Note 4 |
| 1.96% | 3.91% |  |  |  |  | 1.97% | 3.95% | S1 | Note 5 |
| Note 1: ‘S1’ represents Scheme#1, ‘S2’ represents Scheme#2, ‘S3’ represents Scheme#3  Note 2: DL and UL (for VoIP, traffic is 50% in DL and 50% in UL)  Note 3: DL-only  Note 4: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 1 slot  Note 5: Baseline: static cross-slot scheduling (FR1: k0=2) + PDCCH monitoring periodicity of 4 slots | | | | | | | | | | | |

The Table 4A, 4B, 5A and 5B were revised to reflect the following comments:

* Update with latest results or Notes. [Samsung, Intel, MediaTek, ZTE, Ericsson]
* Remove ‘1 layer transmission” from ‘Note’ for Intel result. [Huawei, Intel, MediaTek]

**FL Proposals**

**[FL4] Proposal 8.2.2.2-1: Incorporate the revised Table 4A/4B and Table 5A/5B into Redcap TR 38.875.**

* It is up to TR editor to use a separate excel sheet to include these Tables or directly capture these tables for inclusion in the TR.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| LG | Y |  |
| ZTE,sanechips | Y |  |
| Spreadtrum | Y |  |
| Samsung | Y |  |
| Samsung | Y |  |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |

**[FL4] Proposal 8.2.2.2-2:**

Capture the following observations in the TR (editorial modifications by TR editor can be made for inclusion in the TR)

* 6 sources ([Ericsson], [CATT], [Spreadtrum], [Futurewei], [Intel], [ZTE]) reported the evaluation results of power saving gain for FR2 with same-slot scheduling for the 1 Rx antenna and 2 Rx antennas cases.

The following is observed for 1 Rx antenna case:

* + For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [1.94%~6.6%] and [3.59%~13.1%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 4.77% and 9.60%, respectively.
  + For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.03%~4.30%] and [0.07%~8.60%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain by reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 2.14% and 4.41%, respectively.
  + For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.03%~4%] and [0.06%~7.9%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 1.60% and 3.21%, respectively.
  + For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [2.52%~5%] and [4.66%~9.4%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 3.81% and 7.43%, respectively.

The following is observed for 2 Rx antennas case:

* + For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [2.45%~6.8%] and [4.54%~13.6%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 4.94% and 9.87%, respectively.
  + For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.04%~4.90%] and [0.10%~11.90%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain by reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 2.55% and 4.95%, respectively.
  + For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.04%~4.6%] and [0.09%~9.2%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 2.38% and 4.64%, respectively.
  + For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [3.10%~5.5%] and [5.74%~10.5%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 4.27% and 8.27%, respectively.

**Assuming no additional cases for separate observations, can Proposal 8.2.2.2-2 be captured into Redcap TR 38.875 for FR2 with same-slot scheduling? If not, what needs to be modified?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| LG | Y |  |
| CATT | Y |  |
| ZTE,sanechips | Y |  |
| Spreadtrum | Y |  |
| Samsung | Y |  |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson | Y |  |
| Nokia, NSB | Y |  |

**[FL4] Proposal 8.2.2.2-3:**

Capture the following observations in the TR (editorial modifications by TR editor can be made for inclusion in the TR)

* 4 sources ([Ericsson], [Samsung], [ZTE], [MediaTek]) reported the evaluation results of power saving gain for FR2 with cross-slot scheduling for the 1 Rx antenna and 2 Rx antennas cases.

The following is observed for 1 Rx antenna case:

* + For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [1.40%~6.30%] and [2.70%~12.7%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 3.64% and 7.04%, respectively.
  + For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.02%~4.20%] and [0.04%~8.30%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain by reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 1.30% and 2.60%, respectively.
  + For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.02%~3.9%] and [0.04%~7.6%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 1.24% and 2.48%, respectively.
  + For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [1.94%~6.5%] and [3.6%~13.1%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 3.27% and 6.33%, respectively.

The following is observed for 2 Rx antennas case:

* + For the instant message traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [1.89%~6.6%] and [3.50%~13.20%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 3.81% and 7.37%, respectively.
  + For the heartbeat traffic model with 200ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.03%~4.90%] and [0.07%~9.60%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain by reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 1.56% and 3.13%, respectively.
  + For the heartbeat traffic model with 80ms inactivity timer configuration, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [0.03%~4.6%] and [0.06%~8.9%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 1.37% and 2.74%, respectively.
  + For the VoIP traffic model, with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50%, the power saving gains are in the range of approximately [1.97%~6.8%] and [3.95%~13.7%], respectively. With excluding the smallest and the largest values among sources, the mean value of power saving gain with reducing maximum PDCCH blind decoding (i.e. 20) by 25% and 50% are approximately 3.38% and 6.52%, respectively.

**Assuming no additional cases for separate observations, can Proposal 8.2.2.2-3 be captured into Redcap TR 38.875 for FR2 with cross-slot scheduling? If not, what needs to be modified?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| LG | Y |  |
| CATT | Y |  |
| ZTE,sanechips | Y |  |
| Spreadtrum | Y |  |
| Samsung | Y |  |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson | Y, partially | Please also see our comments to **[FL4] Q 8.2.2.2-1** |
| Nokia, NSB | Y |  |

**[FL4] Q 8.2.2.2-1: In addition to observations in Proposal 8.2.2.2-2 and Proposal 8.2.2.2-3 above, what other observations need to be added into TR 38.875 for power saving gain of FR2? Please briefly explain why, if propose to add new observations.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson |  | The following observations should also be captured (same as for FR1):   * In general, the power saving gain by BD reduction for cross-slot scheduling is less than that of the same-slot scheduling. * In general, the power saving gain by BD reduction for 1 Rx case is less than that of the 2 Rx case. * 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. * In our view, it is also very important to capture that the same power saving gain as Scheme #1 can already be achieved by proper configuration by the network using existing Rel-15/16 configuration parameters. |
| Nokia, NSB |  | We support the capturing the Ericsson observation above. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

## 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

The PDCCH blocking probability is defined as the probability that all PDCCH candidates for a UE are blocked/overlapped with candidates used by other UEs, which is ratio between the number of the blocked UEs over the number of all UEs that need to be scheduled.

Many contributions pointed out that PDCCH blocking probability depends on various factors.

* CORESET size
* DCI format sizes
* Number of UEs needs to be scheduled simultaneously in a MO (this depends on traffic model)
* Aggregation Level (AL) distributions for AL [1,2,4,8,16].
* Number of PDCCH candidates

These factors should be carefully considered for PDCCH blocking probability analysis to ensure meaningful findings were used for Redcap devices study, taking into account the unique characteristic of Redcap devices e.g. light load, relaxed latency etc.

In the post email thread [102-e-Post-NR-RedCap-01], the following was agreed as evaluation assumptions for PDCCH blocking probability evaluation:

**Table 6 : Baseline parameters for the PDCCH blocking rate evaluation**

|  |  |
| --- | --- |
| **Parameters** | **Assumptions** |
| SCS/BW | FR1: 30KHz/20MHz; 15kHz/20MHz is optional FR2: 120KHz/[100]MHz |
| CORESET duration | 2 symbols, with 3 symbols optional |
| DCI size | 40 bits (Not including CRC) |
| Delay toleration (Slot) | 1 (1: implies that PDCCH is blocked if it can’t be scheduled in the given slot), with 2 optional |
| Note 1: “Number of users” represents the number of UEs that need to be scheduled simultaneously in a slot and and company can provide PDCCH blocking probabilities corresponding to a range of ‘number of users’ on different rows in Tab-7 | |

Contribution [6] studied the percentage of number of UE scheduled per slot for Uma (2.6GHz) scenario. The results were reported as follows. It was observed in [6] that the number of simultaneously scheduled UEs per slot is no more than 3 in nearly 99.6% cases, rarely 4 or 5 in the simulated case.

Table 7: Percentage of number of UE scheduled per slot for Uma (2.6GHz) scenario [6].

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Percentage of number of UE scheduled per slot** | **Number of scheduled UE per slot** | | | | | **System blocking probability**  **When the total CCE number is 16 (i.e. 30KHz and 2-symbol PDCCH) and 50% BD reduction** |
| 0 | 1 | 2 | 3 | 4 |
| Medium Loading (N=12, M=0), 1 Rx RedCap | 52.4% | 37.6% | 7.8% | 1.8% | 0.4% | 0.400% |
| Medium Loading (N=12, M=4), 1 Rx RedCap | 48.3% | 41.1% | 8.2% | 1.9% | 0.4% | 0.419% |
| Medium Loading (N=12, M=12), 1 Rx RedCap | 43.2% | 44.9% | 9.3% | 2.0% | 0.4% | 0.464% |
| Medium Loading (N=12, M=0), 2 Rx RedCap | 53.2% | 37.3% | 7.5% | 1.6% | 0.3% | 0.372% |
| Medium Loading (N=12, M=4), 2 Rx RedCap | 50.4% | 39.5% | 7.8% | 1.8% | 0.4% | 0.400% |
| Medium Loading (N=12, M=12), 2 Rx RedCap | 43.5% | 44.4% | 9.3% | 2.2% | 0.5% | 0.481% |

The following PDCCH AL distributions of AL [1,2,4,8,16] were evaluated by companies in Phase 2 of email thread [102-e-Post-NR-RedCap-01]:

Table 8: PDCCH AL distributions of AL [1,2,4,8,16], FR1 and FR2

|  |
| --- |
| PDCCH AL distributions of AL [1,2,4,8,16] |
| * Configuration 1 (C1): [0.5, 0.4, 0.05, 0.03, 0.02], assuming majority of the UEs are in is good coverage * Configuration 2 (C2): [0.1, 0.2, 0.4, 0.2, 0.1]: Majority of the UEs are in medium coverage * Configuration 3 (C3): [0.05, 0.05, 0.2, 0.3, 0.4]: Majority of the UEs are in poor coverage * Configuration 4 (C4): [0.3 0.5 0.1 0.06 0.04] * Configuration 5 (C5): [0.4 0.45 0.08 0.04 0.03] * Configuration 6 (C6): [0.2 0.55 0.14 0.06 0.05] * Configuration 7 (C7): [0.4 0.3 0.2 0.05 0.05] |

In addition, a set of number of PDCCH candidates for AL [1,2,4,8,16] were evaluated as summarized In Table 9:

Table 9: Number of PDCCH Candidates for AL [1,2,4,8,16]

|  |  |  |  |
| --- | --- | --- | --- |
|  | Without BD reduction | Approximately 25% reduction in BDs | Approximately 50% reduction in BDs |
| FR1 | * Configuration 1: [6, 6, 2, 2, 2] * Configuration 2: [6, 5, 4, 2, 1] * Configuration 3: [6, 4, 4, 2, 2] * Configuration 4: [18, 0, 0, 0, 0], [0, 9, 0, 0, 0], [0, 0, 4, 0, 0], [0, 0, 0, 2, 0], [0, 0, 0, 0, 1] * Configuration 5: [6, 6, 2, 2, 1] * Configuration 6: [16, 8, 4, 2, 1] * Configuration 7: [8, 6, 2, 2, 2] * Configuration 8: [2, 4, 8, 4, 2] * Configuration 9: [2, 2, 4, 6, 8] * Configuration 10 [16,14,8,4,2] | * Configuration 1: [5, 5, 1, 1, 1] * Configuration 2: [4, 3, 3, 2, 1] * Configuration 3: [6, 4, 1, 1, 1] * Configuration 4: [2, 4, 4, 2, 1] * Configuration 5: [1, 4, 4, 2, 2] * Configuration 6: [4, 4, 2, 2, 1] * Configuration 7: [13, 0, 0, 0, 0], [0, 9, 0, 0, 0], [0, 0, 4, 0, 0], [0, 0, 0, 2, 0], [0, 0, 0, 0, 1] * Configuration 8: [5,3,3,1,1] * Configuration 9: [11, 8, 2, 1, 1] * Configuration 10: [5, 4, 2, 2, 2] * Configuration 11: [1, 3, 7, 3, 1] * Configuration 12: [1,1,4,4,6] * Configuration 13: [13,11,6,2,1] * Configuration 14: [5 3 2 2 1] | * Configuration 1: [3, 3, 1, 1, 1] * Configuration 2: [3, 2, 2, 1, 1] * Configuration 3: [5, 1, 1, 1, 1] * Configuration 4: [1, 2, 4, 1, 1] * Configuration 5: [1, 1, 3, 2, 2] * Configuration 6: [9, 0, 0, 0, 0], [0, 9, 0, 0, 0], [0, 0, 4, 0, 0], [0, 0, 0, 2, 0], [0, 0, 0, 0, 1] * Configuration 7: [6 6 2 2 1] * Configuration 8: [8 4 1 1 1] * Configuration 9: [4,3,1,1,1] * Configuration 10: [1,1,5,2,1] * Configuration 11: [1,1,2,3,4] * Configuration 12: [9, 8, 3, 1, 1] * Configuration 13: [2 2 2 2 1] |
| FR2 | * Configuration 1: [4, 3, 1, 1, 1] * Configuration 2: [1,2,4,2,1] | * Configuration 1: [2, 2, 1, 1, 1] * Configuration 2: [3, 2, 0, 1, 1] * Configuration 3: [4, 3, 0, 0, 0] * Configuration 4: [1, 3, 1, 1, 1] * Configuration 5: [3, 2, 1, 1, 1] * Configuration 6: [1, 1, 3, 2, 1] | * Configuration 1: [1, 1, 1, 1, 1] * Configuration 2: [2, 2, 0, 0, 1] * Configuration 3: [4, 1, 0, 0, 0] * Configuration 4: [0, 3, 1, 1, 0] * Configuration 5: [0, 2, 1, 1, 1] |

Table 10 and Table 11A~11E summarized the evaluation results of PDCCH block probabilities on FR1 and FR2 for the following cases, which were provided in email thread [102-e-Post-NR-RedCap-01] or individual contribution for different number of UEs simultaneously scheduled by gNB in a slot:

* Case 1: Reference case with no reduction in BD limit.
* Case 2: Approximately 25% reduction in BD limit.
* Case 3: Approximately 50% reduction in BD limit.

#### **FR1 Results**

Table 10A: PDCCH blocking rate for FR1, with 30kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: C1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Notes |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |  |
| 1 | Vivo | 2 | 2 | C1 | 2.02% | C1 | 3.52% | 1.5% | C1 | 3.59% | 1.6% |  |
| 3 | 2 | C1 | 3.56% | C1 | 5.03% | 1.5% | C1 | 5.08% | 1.5% |  |
| 4 | 2 | C1 | 4.82% | C1 | 6.39% | 1.6% | C1 | 7.01% | 2.2% |  |
| 5 | 2 | C1 | 5.94% | C1 | 7.64% | 1.7% | C1 | 9.42% | 3.5% |  |
| 1~5 | 2 | C1 | 0.25% | C1 | 0.41% | 0.2% | C1 | 0.41% | 0.2% | Note 1 |
| 2 | Ericsson | 3 | <=2 | C2 | 3.00% | C2 | 3.00% | 0.0% | C2 | 3.50% | 0.5% | Note 8 |
| 6 | <=2 | C2 | 6.00% | C2 | 7.00% | 1.0% | C2 | 9.00% | 3.0% | Note 8 |
| 3 | Qualcomm | 1 | 2 | C1 | 0.00% | C6 | 0.00% | 0.0% | C1 | 0.00% | 0.0% | Note 2 |
| 2 | 2 | C1 | 0.42% | C6 | 0.65% | 0.2% | C1 | 0.81% | 0.4% | Note 2 |
| 3 | 2 | C1 | 1.00% | C6 | 1.30% | 0.3% | C1 | 1.68% | 0.7% | Note 2 |
| 4 | 2 | C1 | 1.62% | C6 | 2.09% | 0.5% | C1 | 2.87% | 1.3% | Note 2 |
| 5 | 2 | C1 | 2.67% | C6 | 3.27% | 0.6% | C1 | 4.65% | 2.0% | Note 2 |
| 6 | 2 | C1 | 3.55% | C6 | 4.33% | 0.8% | C1 | 6.50% | 3.0% | Note 2 |
| 7 | 2 | C1 | 4.69% | C6 | 5.89% | 1.2% | C1 | 8.72% | 4.0% | Note 2 |
| 8 | 2 | C1 | 6.40% | C6 | 8.07% | 1.7% | C1 | 11.5% | 5.1% | Note 2 |
| 9 | 2 | C1 | 8.25% | C6 | 10.4% | 2.2% | C1 | 14.3% | 6.1% | Note 2 |
| 10 | 2 | C1 | 10.6% | C6 | 13.1% | 2.5% | C1 | 17.4% | 6.8% | Note 2 |
| 1 | 2 | C4 | 0.00% | C7 | 0.00% | 0.0% | C6 | 0.00% | 0.0% | Note 3 |
| 2 | 2 | C4 | 0.08% | C7 | 0.08% | 0.0% | C6 | 0.08% | 0.0% | Note 3 |
| 3 | 2 | C4 | 0.48% | C7 | 0.53% | 0.1% | C6 | 0.55% | 0.1% | Note 3 |
| 4 | 2 | C4 | 1.12% | C7 | 1.17% | 0.1% | C6 | 1.23% | 0.1% | Note 3 |
| 5 | 2 | C4 | 2.10% | C7 | 2.16% | 0.1% | C6 | 2.22% | 0.1% | Note 3 |
| 6 | 2 | C4 | 3.00% | C7 | 3.04% | 0.0% | C6 | 3.07% | 0.1% | Note 3 |
| 7 | 2 | C4 | 4.03% | C7 | 4.06% | 0.0% | C6 | 4.11% | 0.1% | Note 3 |
| 8 | 2 | C4 | 5.43% | C7 | 5.49% | 0.1% | C6 | 5.57% | 0.1% | Note 3 |
| 9 | 2 | C4 | 7.00% | C7 | 7.04% | 0.0% | C6 | 7.16% | 0.2% | Note 3 |
| 10 | 2 | C4 | 8.95% | C7 | 9.00% | 0.1% | C6 | 9.15% | 0.2% | Note 3 |
| 4 | Nokia | 2 | 2 | C2 | 4.00% | C8 | 4.00% | 0.0% | C2 | 4.00% | 0.0% | Note 8 |
| 3 | 2 | C2 | 6.00% | C8 | 6.00% | 0.0% | C2 | 6.00% | 0.0% | Note 8 |
| 4 | 2 | C2 | 9.00% | C8 | 10.0% | 1.0% | C2 | 12.0% | 3.0% | Note 8 |
| 5 | 2 | C2 | 12.0% | C8 | 15.0% | 3.0% | C2 | 20.0% | 8.0% | Note 8 |
| 6 | 2 | C2 | 18.0% | C8 | 21.0% | 3.0% | C2 | 31.0% | 13.0% | Note 8 |
| 7 | 2 | C2 | 28.0% | C8 | 31.0% | 3.0% | C2 | 44.0% | 16.0% | Note 8 |
| 8 | 2 | C2 | 38.0% | C8 | 41.0% | 3.0% | C2 | 58.0% | 20.0% | Note 8 |
| 5 | Huawei, HiSilicon | 5 | Note 4 | C5 | 6.07% | - |  | - | C7 | 6.07% | 0.0% | Note 5 |
| 5 | 2 | C5 | 6.07% | C6 | 6.90% | 0.8% | C1 | 9.30% | 3.2% | Note 5 |
| 10 | Note 4 | C5 | 17.3% | - |  | - | C7 | 17.3% | 0.0% | Note 5 |
| 10 | 2 | C5 | 17.3% | C6 | 23.3% | 6.0% | C1 | 24.1% | 6.8% | Note 5 |
| 6 | InterDigital | 2 |  | C1 | 1.96% | C1 | 3.31% | 1.4% | C1 | 3.43% | 1.5% |  |
| 3 |  | C1 | 3.50% | C1 | 5.08% | 1.6% | C1 | 5.30% | 1.8% |  |
| 4 |  | C1 | 4.67% | C1 | 6.31% | 1.6% | C1 | 7.04% | 2.4% |  |
| 5 |  | C1 | 5.83% | C1 | 7.32% | 1.5% | C1 | 9.22% | 3.4% |  |
| 6 |  | C1 | 7.19% | C1 | 8.55% | 1.4% | C1 | 11.8% | 4.6% |  |
| 7 |  | C1 | 8.65% | C1 | 10.1% | 1.5% | C1 | 14.4% | 5.8% |  |
| 8 |  | C1 | 10.82% | C1 | 12.2% | 1.4% | C1 | 17.6% | 6.8% |  |
| 9 |  | C1 | 13.71% | C1 | 15.1% | 1.4% | C1 | 20.8% | 7.1% |  |
| 10 |  | C1 | 17.26% | C1 | 18.4% | 1.1% | C1 | 24.2% | 6.9% |  |
| 7 | Intel | 2 | 1 | C6 | 1.9% | C9 | 1.9% | 0.0% | C8 | 1.9% | 0.0% |  |
| 4 | 1 | C6 | 6% | C9 | 6% | 0.0% | C8 | 6% | 0.0% |  |
| 8 | 1 | C6 | 20% | C9 | 20% | 0.0% | C8 | 20% | 0.0% |  |
| 8 | ZTE | 2 | 2 | C7 | 2.01% | C10 | 2.01% | 0.0% | C9 | 4.21% | 2.2% |  |
| 4 | 2 | C7 | 3.04% | C10 | 3.10% | 0.1% | C9 | 10.8% | 7.8% |  |
| 6 | 2 | C7 | 4.72% | C10 | 4.87% | 0.2% | C9 | 16.9% | 12.2% |  |
| 8 | 2 | C7 | 7.31% | C10 | 7.53% | 0.2% | C9 | 35.5% | 28.2% |  |
| 9 | Samsung | 1 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 0.00% | 0.0% | Note 8 |
| 2 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 0.00% | 0.0% | Note 8 |
| 3 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 2.00% | 2.0% | Note 8 |
| 4 | 2 | C3 | 0.00% | C2 | 1.00% | 1.0% | C2 | 7.00% | 7.0% | Note 8 |
| 5 | 2 | C3 | 0.00% | C2 | 3.00% | 3.0% | C2 | 13.0% | 13.0% | Note 8 |
| 6 | 2 | C3 | 1.00% | C2 | 6.00% | 5.0% | C2 | 20.0% | 19.0% | Note 8 |
| 7 | 2 | C3 | 2.00% | C2 | 10.0% | 8.0% | C2 | 26.0% | 24.0% | Note 8 |
| 8 | 2 | C3 | 4.00% | C2 | 15.0% | 11.0% | C2 | 32.0% | 28.0% | Note 8 |
| 9 | 2 | C3 | 6.00% | C2 | 20.0% | 14.0% | C2 | 37.0% | 31.0% | Note 8 |
| 10 | 2 | C3 | 8.00% | C2 | 25.0% | 17.0% | C2 | 42.0% | 34.0% | Note 8 |
| 1 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 0.00% | 0.0% | Note 6, 8 |
| 2 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 0.00% | 0.0% | Note 6, 8 |
| 3 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 0.00% | 0.0% | Note 6, 8 |
| 4 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 0.00% | 0.0% | Note 6, 8 |
| 5 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 2.00% | 2.0% | Note 6, 8 |
| 6 | 2 | C3 | 0.00% | C2 | 0.00% | 0.0% | C2 | 2.00% | 2.0% | Note 6, 8 |
| 7 | 2 | C3 | 0.00% | C2 | 1.00% | 1.0% | C2 | 7.00% | 7.0% | Note 6, 8 |
| 8 | 2 | C3 | 0.00% | C2 | 1.00% | 1.0% | C2 | 7.00% | 7.0% | Note 6, 8 |
| 9 | 2 | C3 | 0.00% | C2 | 3.00% | 3.0% | C2 | 13.0% | 13.0% | Note 6, 8 |
| 10 | 2 | C3 | 0.00% | C2 | 3.00% | 3.0% | C2 | 13.0% | 13.0% | Note 6, 8 |
| 1 | 2 | C3 | 0.00% | C3 | 0.00% | 0.0% | C3 | 0.00% | 0.0% | Note 7, 8 |
| 2 | 2 | C3 | 0.00% | C3 | 0.00% | 0.0% | C3 | 8.00% | 8.0% | Note 7, 8 |
| 3 | 2 | C3 | 0.00% | C3 | 0.00% | 0.0% | C3 | 14.0% | 14.0% | Note 7, 8 |
| 4 | 2 | C3 | 0.00% | C3 | 1.00% | 1.0% | C3 | 19.0% | 19.0% | Note 7, 8 |
| 5 | 2 | C3 | 0.00% | C3 | 1.00% | 1.0% | C3 | 22.0% | 22.0% | Note 7, 8 |
| 6 | 2 | C3 | 1.00% | C3 | 2.00% | 1.0% | C3 | 25.0% | 24.0% | Note 7, 8 |
| 7 | 2 | C3 | 2.00% | C3 | 3.00% | 1.0% | C3 | 28.0% | 26.0% | Note 7, 8 |
| 8 | 2 | C3 | 3.00% | C3 | 5.00% | 2.0% | C3 | 31.0% | 28.0% | Note 7, 8 |
| 9 | 2 | C3 | 6.00% | C3 | 7.00% | 1.0% | C3 | 34.0% | 28.0% | Note 7, 8 |
| 10 | 2 | C3 | 8.00% | C3 | 10.0% | 2.0% | C3 | 38.0% | 30.0% | Note 7, 8 |
| 10 | Futurewei | 1 | <= 2 | C1 | 0.00% | C6 | 0.00% | 0.0% | C1 | 0.00% | 0.0% |  |
| 2 | <= 2 | C1 | 0.00% | C6 | 1.00% | 1.0% | C1 | 1.00% | 1.0% |  |
| 3 | <= 2 | C1 | 0.00% | C6 | 3.00% | 3.0% | C1 | 4.00% | 4.0% |  |
| 4 | <= 2 | C1 | 1.00% | C6 | 4.00% | 3.0% | C1 | 7.00% | 6.0% |  |
| 5 | <= 2 | C1 | 2.00% | C6 | 7.00% | 5.0% | C1 | 12.0% | 10.0% |  |
| 6 | <= 2 | C1 | 3.00% | C6 | 9.00% | 6.0% | C1 | 15.0% | 12.0% |  |
| 7 | <= 2 | C1 | 3.00% | C6 | 15.0% | 12.0% | C1 | 23.0% | 20.0% |  |
| 8 | <= 2 | C1 | 5.00% | C6 | 17.0% | 12.0% | C1 | 25.0% | 20.0% |  |
| 9 | <= 2 | C1 | 7.00% | C6 | 20.0% | 13.0% | C1 | 33.0% | 26.0% |  |
| 10 | <= 2 | C1 | 11.0% | C6 | 26.0% | 15.0% | C1 | 36.0% | 25.0% |  |
| Note 1: Metric: the whole system blocking probability. It can be calculated by summing the product of the percentage of each number of UE simultaneously scheduled per slot and its corresponding blocking probability.  Note 2: Each UE is configured with all the ALs  Note 3: Each UE is configured with a single AL  Note 4: Reference case：2；50% BD reduction case:1  Note 5: For RedCap UEs using 2RX; BD reduction by reducing DCI size budget is evaluated (i.e. 'the number of DCI sizes to monitor per PDCCH candidate' is set to 2 for the reference case and 1 for approximately 50% reduction in BD limits).  Note 6: With enhancement of UE group scheduling with 2 UEs per DCI.  Note 7: with enhancement of PDCCH drooping based on predetermined CCE AL priority order = [1 2 4 8 16]  Note 8: Good coverage | | | | | | | | | | | | |

Table 10B: PDCCH blocking rate for FR1, with 30kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: C2

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Notes |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |  |
| 1 | Ericsson | 3 | <=2 | C2 | 17.0% | C2 | 17.0% | 0.0% | C2 | 21.0% | 4.0% | Note 9 |
| 6 | <=2 | C2 | 40.0% | C2 | 42.0% | 2.0% | C2 | 46.0% | 6.0% | Note 9 |
| 2 | Qualcomm | 1 | 2 | C1 | 0.0% | C6 | 0.0% | 0.0% | C1 | 0.0% | 0.0% | Note 2 |
| 2 | 2 | C1 | 3.9% | C6 | 4.3% | 0.4% | C1 | 9.4% | 5.5% | Note 2 |
| 3 | 2 | C1 | 10.5% | C6 | 11.2% | 0.7% | C1 | 18.3% | 7.8% | Note 2 |
| 4 | 2 | C1 | 17.4% | C6 | 18.4% | 1.0% | C1 | 25.7% | 8.3% | Note 2 |
| 5 | 2 | C1 | 24.8% | C6 | 26.3% | 1.5% | C1 | 32.4% | 7.6% | Note 2 |
| 6 | 2 | C1 | 32.1% | C6 | 33.8% | 1.7% | C1 | 38.9% | 6.8% | Note 2 |
| 7 | 2 | C1 | 38.5% | C6 | 40.4% | 1.9% | C1 | 44.3% | 5.8% | Note 2 |
| 8 | 2 | C1 | 44.4% | C6 | 46.2% | 1.8% | C1 | 49.2% | 4.8% | Note 2 |
| 9 | 2 | C1 | 48.9% | C6 | 50.7% | 1.8% | C1 | 53.1% | 4.2% | Note 2 |
| 10 | 2 | C1 | 53.2% | C6 | 55.0% | 1.8% | C1 | 56.7% | 3.5% | Note 2 |
| 1 | 2 | C4 | 0.0% | C7 | 0.0% | 0.0% | C6 | 0.0% | 0.0% | Note 3 |
| 2 | 2 | C4 | 3.5% | C7 | 3.5% | 0.0% | C6 | 3.5% | 0.0% | Note 3 |
| 3 | 2 | C4 | 8.1% | C7 | 8.1% | 0.0% | C6 | 8.1% | 0.0% | Note 3 |
| 4 | 2 | C4 | 13.9% | C7 | 13.9% | 0.0% | C6 | 13.9% | 0.0% | Note 3 |
| 5 | 2 | C4 | 21.1% | C7 | 21.1% | 0.0% | C6 | 21.2% | 0.1% | Note 3 |
| 6 | 2 | C4 | 28.7% | C7 | 28.8% | 0.1% | C6 | 28.9% | 0.2% | Note 3 |
| 7 | 2 | C4 | 35.8% | C7 | 35.9% | 0.1% | C6 | 36.0% | 0.2% | Note 3 |
| 8 | 2 | C4 | 42.1% | C7 | 42.2% | 0.1% | C6 | 42.3% | 0.2% | Note 3 |
| 9 | 2 | C4 | 47.3% | C7 | 47.3% | 0.0% | C6 | 47.4% | 0.1% | Note 3 |
| 10 | 2 | C4 | 51.8% | C7 | 51.9% | 0.1% | C6 | 52.0% | 0.2% | Note 3 |
| 3 | Nokia | 2 | 2 | C2 | 19.0% | C8 | 21.0% | 2.0% | C2 | 21.0% | 2.0% | Note 8 |
| 3 | 2 | C2 | 36.0% | C8 | 38.0% | 2.0% | C2 | 47.0% | 11.0% | Note 8 |
| 4 | 2 | C2 | 64.0% | C8 | 68.0% | 4.0% | C2 | 78.0% | 14.0% | Note 8 |
| 5 | 2 | C2 | 87.0% | C8 | 88.0% | 1.0% | C2 | 94.0% | 7.0% | Note 8 |
| 6 | 2 | C2 | 97.0% | C8 | 98.0% | 1.0% | C2 | 99.0% | 2.0% | Note 8 |
| 7 | 2 | C2 | 100% | C8 | 100% | 0.0% | C2 | 100% | 0.0% | Note 8 |
| 4 | ZTE | 2 | 2 | C8 | 9.5% | C11 | 9.5% | 0.0% | C10 | 10.0% | 0.5% |  |
| 4 | 2 | C8 | 24.7% | C11 | 24.8% | 0.1% | C10 | 27.2% | 2.5% |  |
| 6 | 2 | C8 | 39.2% | C11 | 39.4% | 0.2% | C10 | 42.8% | 3.6% |  |
| 8 | 2 | C8 | 49.5% | C11 | 49.6% | 0.1% | C10 | 53.9% | 4.4% |  |
| 5 | Samsung | 1 | 2 | C3 | 0.0% | C2 | 0.0% | 0.0% | C2 | 0.00 | 0.0% | Note 8 |
| 2 | 2 | C3 | 0.0% | C2 | 1.0% | 1.0% | C2 | 3.0% | 3.0% | Note 8 |
| 3 | 2 | C3 | 0.0% | C2 | 1.0% | 1.0% | C2 | 7.0% | 7.0% | Note 8 |
| 4 | 2 | C3 | 1.0% | C2 | 3.0% | 2.0% | C2 | 12.0% | 11.0% | Note 8 |
| 5 | 2 | C3 | 2.0% | C2 | 5.0% | 3.0% | C2 | 18.0% | 16.0% | Note 8 |
| 6 | 2 | C3 | 3.0% | C2 | 8.0% | 5.0% | C2 | 23.0% | 20.0% | Note 8 |
| 7 | 2 | C3 | 5.0% | C2 | 11.0% | 6.0% | C2 | 28.0% | 23.0% | Note 8 |
| 8 | 2 | C3 | 8.0% | C2 | 15.0% | 7.0% | C2 | 32.0% | 24.0% | Note 8 |
| 9 | 2 | C3 | 11.0% | C2 | 18.0% | 7.0% | C2 | 36.0% | 25.0% | Note 8 |
| 10 | 2 | C3 | 15.0% | C2 | 22.0% | 7.0% | C2 | 40.0% | 25.0% | Note 8 |
| 1 | 2 | C3 | 0.0% | C2 | 0.0% | 0.0% | C2 | 0.0% | 0.0% | Note 6, 8 |
| 2 | 2 | C3 | 0.0% | C2 | 0.0% | 0.0% | C2 | 0.00, | 0.0% | Note 6, 8 |
| 3 | 2 | C3 | 0.0% | C2 | 2.6% | 2.6% | C2 | 3.0% | 3.0% | Note 6, 8 |
| 4 | 2 | C3 | 0.0% | C2 | 2.6% | 2.6% | C2 | 3.0% | 3.0% | Note 6, 8 |
| 5 | 2 | C3 | 0.0% | C2 | 4.6% | 4.6% | C2 | 7.0% | 7.0% | Note 6, 8 |
| 6 | 2 | C3 | 0.0% | C2 | 4.6% | 4.6% | C2 | 7.0% | 7.0% | Note 6, 8 |
| 7 | 2 | C3 | 1.0% | C2 | 7.3% | 6.3% | C2 | 12.0% | 11.0% | Note 6, 8 |
| 8 | 2 | C3 | 1.0% | C2 | 7.3% | 6.3% | C2 | 12.0% | 11.0% | Note 6, 8 |
| 9 | 2 | C3 | 2.0% | C2 | 12.4% | 10.4% | C2 | 18.0% | 16.0% | Note 6, 8 |
| 10 | 2 | C3 | 2.0% | C2 | 12.4% | 10.4% | C2 | 18.0% | 16.0% | Note 6, 8 |
| 1 | 2 | C3 | 0.0% | C4 | 0.0% | 0.0% | C4 | 0.0% | 0.0% | Note 6, 8 |
| 2 | 2 | C3 | 0.0% | C4 | 1.0% | 1.0% | C4 | 3.0% | 3.0% | Note 6, 8 |
| 3 | 2 | C3 | 0.0% | C4 | 1.0% | 1.0% | C4 | 6.0% | 6.0% | Note 6, 8 |
| 4 | 2 | C3 | 1.0% | C4 | 2.0% | 1.0% | C4 | 9.0% | 8.0% | Note 6, 8 |
| 5 | 2 | C3 | 2.0% | C4 | 3.0% | 1.0% | C4 | 11.0% | 9.0% | Note 6, 8 |
| 6 | 2 | C3 | 3.0% | C4 | 5.0% | 2.0% | C4 | 15.0% | 12.0% | Note 6, 8 |
| 7 | 2 | C3 | 5.0% | C4 | 7.0% | 2.0% | C4 | 18.0% | 13.0% | Note 6, 8 |
| 8 | 2 | C3 | 8.0% | C4 | 10.0% | 2.0% | C4 | 22.0% | 14.0% | Note 6, 8 |
| 9 | 2 | C3 | 11.0% | C4 | 13.0% | 2.0% | C4 | 25.0% | 14.0% | Note 6, 8 |
| 10 | 2 | C3 | 15.0% | C4 | 16.0% | 1.0% | C4 | 29.0% | 14.0% | Note 6, 8 |
| Note 1: Metric: the whole system blocking probability. It can be calculated by summing the product of the percentage of each number of UE simultaneously scheduled per slot and its corresponding blocking probability.  Note 2: Each UE is configured with all the ALs  Note 3: Each UE is configured with a single AL  Note 4: Reference case：2；50% BD reduction case:1  Note 5: For RedCap UEs using 2RX; BD reduction by reducing DCI size budget is evaluated (i.e. 'the number of DCI sizes to monitor per PDCCH candidate' is set to 2 for the reference case and 1 for approximately 50% reduction in BD limits).  Note 6: With enhancement of UE group scheduling with 2 UEs per DCI.  Note 7: with enhancement of PDCCH drooping based on predetermined CCE AL priority order = [1 2 4 8 16]  Note 8: Medium coverage | | | | | | | | | | | | |

Table 10C: PDCCH blocking rate for FR1, with 30kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: C3

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Notes |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| 1 | Ericsson | 3 | <= 2 | C2 | 46.0% | C2 | 47.0% | 1.0% | C2 | 49.0% | 3.0% | Note 8 |
| 6 | <= 2 | C2 | 66.0% | C2 | 67.0% | 1.0% | C2 | 69.0% | 3.0% | Note 8 |
| 2 | Qualcomm | 1 | 2 | C1 | 0.0% | C6 | 0.0% | 0.0% | C1 | 0.0% | 0.0% | Note 2 |
| 2 | 2 | C1 | 18.5% | C6 | 19.0% | 0.4% | C1 | 23.4% | 4.9% | Note 2 |
| 3 | 2 | C1 | 35.5% | C6 | 36.3% | 0.8% | C1 | 40.0% | 4.5% | Note 2 |
| 4 | 2 | C1 | 48.0% | C6 | 49.1% | 1.1% | C1 | 51.5% | 3.5% | Note 2 |
| 5 | 2 | C1 | 56.8% | C6 | 58.0% | 1.2% | C1 | 59.7% | 2.9% | Note 2 |
| 6 | 2 | C1 | 62.7% | C6 | 64.0% | 1.3% | C1 | 65.4% | 2.7% | Note 2 |
| 7 | 2 | C1 | 67.4% | C6 | 68.8% | 1.4% | C1 | 70.0% | 2.6% | Note 2 |
| 8 | 2 | C1 | 70.9% | C6 | 72.3% | 1.4% | C1 | 73.4% | 2.5% | Note 2 |
| 9 | 2 | C1 | 73.5% | C6 | 74.8% | 1.3% | C1 | 75.9% | 2.4% | Note 2 |
| 10 | 2 | C1 | 75.7% | C6 | 77.0% | 1.3% | C1 | 78.0% | 2.3% | Note 2 |
| 1 | 2 | C4 | 0.0% | C7 | 0.0% | 0.0% | C6 | 0.0% | 0.0% | Note 3 |
| 2 | 2 | C4 | 17.9% | C7 | 17.9% | 0.0% | C6 | 17.9% | 0.0% | Note 3 |
| 3 | 2 | C4 | 33.9% | C7 | 33.9% | 0.0% | C6 | 33.9% | 0.0% | Note 3 |
| 4 | 2 | C4 | 46.2% | C7 | 46.3% | 0.0% | C6 | 46.3% | 0.1% | Note 3 |
| 5 | 2 | C4 | 54.8% | C7 | 54.9% | 0.1% | C6 | 54.9% | 0.1% | Note 3 |
| 6 | 2 | C4 | 60.8% | C7 | 60.8% | 0.1% | C6 | 60.9% | 0.1% | Note 3 |
| 7 | 2 | C4 | 65.4% | C7 | 65.5% | 0.1% | C6 | 65.6% | 0.2% | Note 3 |
| 8 | 2 | C4 | 69.0% | C7 | 69.1% | 0.1% | C6 | 69.1% | 0.2% | Note 3 |
| 9 | 2 | C4 | 71.5% | C7 | 71.6% | 0.1% | C6 | 71.7% | 0.2% | Note 3 |
| 10 | 2 | C4 | 73.7% | C7 | 73.8% | 0.1% | C6 | 73.9% | 0.2% | Note 3 |
| 3 | ZTE | 2 | 2 | C9 | 32.0% | C12 | 32.1% | 0.1% | C11 | 32.2% | 0.2% |  |
| 4 | 2 | C9 | 55.3% | C12 | 55.5% | 0.1% | C10 | 57.7% | 2.3% |  |
| 6 | 2 | C9 | 66.4% | C12 | 66.6% | 0.2% | C10 | 69.0% | 2.6% |  |
| 8 | 2 | C9 | 72.0% | C12 | 72.5% | 0.5% | C10 | 75.0% | 3.0% |  |
| 4 | Samsung | 1 | 2 | C3 | 0.0% | C2 | 0.0% | 0.0% | C2 | 0.00 | 0.0% | Note 8 |
| 2 | 2 | C3 | 0.0% | C2 | 8.0% | 8.0% | C2 | 12.0% | 12.0% | Note 8 |
| 3 | 2 | C3 | 3.0% | C2 | 15.0% | 12% | C2 | 22.0% | 19.0% | Note 8 |
| 4 | 2 | C3 | 7.0% | C2 | 20.0% | 13% | C2 | 30.0% | 23.0% | Note 8 |
| 5 | 2 | C3 | 12.0% | C2 | 26.0% | 14% | C2 | 36.0% | 24.0% | Note 8 |
| 6 | 2 | C3 | 17.0% | C2 | 30.0% | 13% | C2 | 41.0% | 24.0% | Note 8 |
| 7 | 2 | C3 | 22.0% | C2 | 34.0% | 12% | C2 | 46.0% | 24.0% | Note 8 |
| 8 | 2 | C3 | 28.0% | C2 | 37.0% | 9.0% | C2 | 49.0% | 21.0% | Note 8 |
| 9 | 2 | C3 | 33.0% | C2 | 41.0% | 8.0% | C2 | 52.0% | 19.0% | Note 8 |
| 10 | 2 | C3 | 38.0% | C2 | 43.0% | 5.0% | C2 | 55.0% | 17.0% | Note 8 |
| 1 | 2 | C3 | 0.0% | C2 | 0.0% | 0.0% | C2 | 0.0% | 0.0% | Note 6, 8 |
| 2 | 2 | C3 | 0.0% | C2 | 0.0% | 0.0% | C2 | 0.0% | 0.0% | Note 6, 8 |
| 3 | 2 | C3 | 0.0% | C2 | 1.0% | 1.0% | C2 | 12.0% | 12.0% | Note 6, 8 |
| 4 | 2 | C3 | 0.0% | C2 | 1.0% | 1.0% | C2 | 12.0% | 12.0% | Note 6, 8 |
| 5 | 2 | C3 | 3.0% | C2 | 1.0% | -2.0% | C2 | 22.0% | 19.0% | Note 6, 8 |
| 6 | 2 | C3 | 3.0% | C2 | 1.0% | -2.0% | C2 | 22.0% | 19.0% | Note 6, 8 |
| 7 | 2 | C3 | 7.0% | C2 | 3.0% | -4.0% | C2 | 30.0% | 23.0% | Note 6, 8 |
| 8 | 2 | C3 | 7.0% | C2 | 3.0% | -4.0% | C2 | 30.0% | 23.0% | Note 6, 8 |
| 9 | 2 | C3 | 12.0% | C2 | 5.0% | -7.0% | C2 | 36.0% | 24.0% | Note 6, 8 |
| 10 | 2 | C3 | 12.0% | C2 | 5.0% | -7.0% | C2 | 36.0% | 24.0% | Note 6, 8 |
| 1 | 2 | C3 | 0.0% | C5 | 0.0% | 0.0% | C5 | 0.0% | 0.0% | Note 7, 8 |
| 2 | 2 | C3 | 0.0% | C5 | 0.0% | 0.0% | C5 | 0.0% | 0.0% | Note 7, 8 |
| 3 | 2 | C3 | 3.0% | C5 | 3.0% | 0.0% | C5 | 4.0% | 1.0% | Note 7, 8 |
| 4 | 2 | C3 | 7.0% | C5 | 8.0% | 1.0% | C5 | 8.0% | 1.0% | Note 7, 8 |
| 5 | 2 | C3 | 12.0% | C5 | 13.0% | 1.0% | C5 | 13.0% | 1.0% | Note 7, 8 |
| 6 | 2 | C3 | 17.0% | C5 | 18.0% | 1.0% | C5 | 18.0% | 1.0% | Note 7, 8 |
| 7 | 2 | C3 | 22.0% | C5 | 23.0% | 1.0% | C5 | 24.0% | 2.0% | Note 7, 8 |
| 8 | 2 | C3 | 28.0% | C5 | 28.0% | 0.0% | C5 | 30.0% | 2.0% | Note 7, 8 |
| 9 | 2 | C3 | 33.0% | C5 | 34.0% | 1.0% | C5 | 35.0% | 2.0% | Note 7, 8 |
| 10 | 2 | C3 | 38.0% | C5 | 38.0% | 0.0% | C5 | 40.0% | 2.0% | Note 7, 8 |
| Note 1: Metric: the whole system blocking probability. It can be calculated by summing the product of the percentage of each number of UE simultaneously scheduled per slot and its corresponding blocking probability.  Note 2: Each UE is configured with all the ALs  Note 3: Each UE is configured with a single AL  Note 4: Reference case：2；50% BD reduction case:1  Note 5: For RedCap UEs using 2RX; BD reduction by reducing DCI size budget is evaluated (i.e. 'the number of DCI sizes to monitor per PDCCH candidate' is set to 2 for the reference case and 1 for approximately 50% reduction in BD limits).  Note 6: With enhancement of UE group scheduling with 2 UEs per DCI.  Note 7: with enhancement of PDCCH drooping based on predetermined CCE AL priority order = [1 2 4 8 16]  Note 8: Poor coverage | | | | | | | | | | | | |

Table 10D: PDCCH blocking rate for FR1, with 30kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: Others except C1/C2/C3

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Company | AL distribution in Table 8 | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Comments |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| Huawei, HiSilicon | C4 | 5 | Note 4 | C5 | 12.3% | - |  | - | C7 | 12.30% | 0.0% | Note 1 |
| C4 | 5 | 2 | C5 | 12.3% | C6 | 13.8% | 1.5% | C1 | 16.30% | 4.0% | Note1 |
| C4 | 10 | Note 4 | C5 | 29.4% | - |  | - | C7 | 29.40% | 0.0% | Note1 |
| C4 | 10 | 2 | C5 | 29.4% | C6 | 33.9% | 4.5% | C1 | 34.30% | 4.9% | Note1 |
| Panasonic [5] | C7 | 4 |  | C1 | 5.93% | C14 | 7.07% | 1.1% | C13 | 13.9% | 8.0% |  |
| C7 | 6 |  | C1 | 10.1% | C14 | 13.7% | 3.6% | C13 | 23.2% | 13.1% |  |
| Note 1: For RedCap UEs using 2RX; BD reduction by reducing DCI size budget is evaluated (i.e. 'the number of DCI sizes to monitor per PDCCH candidate' is set to 2 for the reference case and 1 for approximately 50% reduction in BD limits). | | | | | | | | | | | | |

The following table 11A~11E summarized the PDCCH blocking rates due to reduced blind decoding for FR1with optional values for at least one parameter in Table 13 (describe and highlighted in the Table Title)

Table 11A: PDCCH blocking rate for FR1, with 15kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Company | AL distribution in Table14 | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Comments |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| vivo | C1 | 2 | 2 | C1 | 0.00% | C1 | 1.36% | 1.36% | C1 | 1.17% | 1.17% |  |
| C1 | 3 | 2 | C1 | 0.56% | C1 | 2.14% | 1.58% | C1 | 2.32% | 1.76% |  |
| C1 | 4 | 2 | C1 | 1.31% | C1 | 2.94% | 1.63% | C1 | 3.35% | 2.04% |  |
| C1 | 5 | 2 | C1 | 1.90% | C1 | 3.73% | 1.83% | C1 | 4.14% | 2.24% |  |
| C1 | 1~5 | 2 | C1 | 0.02% | C1 | 0.17% | 0.15% | C1 | 0.05% | 0.03% | Note 1 |
| Note 1: Metric: the whole system blocking probability. It can be calculated by summing the product of the percentage of each number of UE simultaneously scheduled per slot and its corresponding blocking probability. | | | | | | | | | | | | |

Table 11B: PDCCH blocking rate for FR1, with 15kHz/20MHz, CORESET duration: 3 symbols, Delay toleration: 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Company | AL distribution in Table14 | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Note |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| vivo | C1 | 2 | 2 | C1 | 0.00% | C1 | 0.89% | 0.89% | C1 | 0.90% | 0.90% |  |
| C1 | 3 | 2 | C1 | 0.34% | C1 | 1.54% | 1.20% | C1 | 1.59% | 1.25% |  |
| C1 | 4 | 2 | C1 | 0.62% | C1 | 2.25% | 1.63% | C1 | 2.16% | 1.54% |  |
| C1 | 5 | 2 | C1 | 1.08% | C1 | 2.76% | 1.68% | C1 | 2.82% | 1.74% |  |
| C1 | 1~5 | 2 | C1 | 0.01% | C1 | 0.18% | 0.17% | C1 | 0.25% | 0.24% | Note 1 |
| Nokia | C1 | 2 | 2 | C2 | 0.00% | C8 | 0.00% | 0.00% | C2 | 0.00% | 0.00% |  |
| C1 | 3 | 2 | C2 | 1.00% | C8 | 1.00% | 0.00% | C2 | 2.00% | 1.00% |  |
| C1 | 4 | 2 | C2 | 2.00% | C8 | 3.00% | 1.00% | C2 | 6.00% | 4.00% |  |
| C1 | 5 | 2 | C2 | 4.00% | C8 | 7.00% | 3.00% | C2 | 11.0% | 7.00% |  |
| C1 | 6 | 2 | C2 | 10.0% | C8 | 12.0% | 2.00% | C2 | 16.0% | 6.00% |  |
| C1 | 7 | 2 | C2 | 15.0% | C8 | 17.0% | 2.00% | C2 | 23.0% | 8.00% |  |
| C1 | 8 | 2 | C2 | 18.0% | C8 | 22.0% | 4.00% | C2 | 31.0% | 13.0% |  |
| Intel | C1 | 2 | 1 | C10 | 0.01% | C13 | 0.01% | 0.00% | C12 | 0.01% | 0.00% |  |
| C1 | 4 | 1 | C10 | 0.02% | C13 | 0.02% | 0.00% | C12 | 0.12% | 0.10% |  |
| C1 | 8 | 1 | C10 | 0.07% | C13 | 0.07% | 0.00% | C12 | 0.28% | 0.21% |  |
| C1 | 10 | 1 | C10 | 0.20% | C13 | 0.20% | 0.00% | C12 | 0.6% | 0.40% |  |
| C1 | 15 | 1 | C10 | 1.80% | C13 | 1.80% | 0.00% | C12 | 2.5% | 0.70% |  |

Note 1: Metric: the whole system blocking probability. It can be calculated by summing the product of the percentage of each number of UE simultaneously scheduled per slot and its corresponding blocking probability.

Table 11C: PDCCH blocking rate for FR1, with 15kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1, 2 or 3 slots

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Company | AL distribution in Table14 | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Comments |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |  |
| ZTE | C1 | 2 | 2 | C7 | 0.00% | C10 | 0.00% | 0.00% | C9 | 0.14% | 0.14% | Note 1 |
| C1 | 4 | 2 | C7 | 0.08% | C10 | 0.08% | 0.00% | C9 | 0.62% | 0.54% | Note 1 |
| C1 | 6 | 2 | C7 | 0.30% | C10 | 0.49% | 0.19% | C9 | 1.34% | 1.04% | Note 1 |
| C1 | 8 | 2 | C7 | 0.70% | C10 | 1.12% | 0.42% | C9 | 2.26% | 1.56% | Note 1 |
| C1 | 2 | 2 | C7 | 0.00% | C10 | 0.00% | 0.00% | C9 | 0.06% | 0.06% | Note 2 |
| C1 | 4 | 2 | C7 | 0.03% | C10 | 0.05% | 0.02% | C9 | 0.29% | 0.26% | Note 2 |
| C1 | 6 | 2 | C7 | 0.15% | C10 | 0.25% | 0.10% | C9 | 0.67% | 0.52% | Note 2 |
| C1 | 8 | 2 | C7 | 0.37% | C10 | 0.61% | 0.24% | C9 | 1.18% | 0.81% | Note 2 |
| C1 | 2 | 2 | C7 | 0.00% | C10 | 0.00% | 0.00% | C9 | 0.04% | 0.04% | Note 3 |
| C1 | 4 | 2 | C7 | 0.03% | C10 | 0.04% | 0.01% | C9 | 0.22% | 0.19% | Note 3 |
| C1 | 6 | 2 | C7 | 0.08% | C10 | 0.16% | 0.08% | C9 | 0.46% | 0.38% | Note 3 |
| C1 | 8 | 2 | C7 | 0.24% | C10 | 0.40% | 0.16% | C9 | 0.84% | 0.60% | Note 3 |
| C2 | 2 | 2 | C8 | 0.00% | C10 | 0.76% | 0.76% | C9 | 2.02% | 2.02% | Note 1 |
| C2 | 4 | 2 | C8 | 2.48% | C10 | 4.28% | 1.80% | C9 | 9.01% | 6.53% | Note 1 |
| C2 | 6 | 2 | C8 | 10.23% | C10 | 11.14% | 0.91% | C9 | 16.91% | 6.68% | Note 1 |
| C2 | 8 | 2 | C8 | 18.23% | C10 | 18.88% | 0.65% | C9 | 24.53% | 6.30% | Note 1 |
| C3 | 2 | 2 | C9 | 0.00% | C10 | 0.03% | 0.03% | C9 | 0.03% | 0.03% | Note 1 |
| C3 | 4 | 2 | C9 | 23.58% | C10 | 24.32% | 0.74% | C9 | 26.61% | 3.03% | Note 1 |
| C3 | 6 | 2 | C9 | 39.39% | C10 | 39.50% | 0.11% | C9 | 41.55% | 2.16% | Note 1 |
| C3 | 8 | 2 | C9 | 48.95% | C10 | 49.18% | 0.23% | C9 | 51.50% | 2.55% | Note 1 |
| Note 1: Delay toleration is 1 slot  Note 2: Delay toleration is 2 slots  Note 3: Delay toleration is 3 slots | | | | | | | | | | | | |

Table 11D: PDCCH blocking rate for FR1, with 30kHz/20MHz, CORESET duration: 3 symbols, Delay toleration: 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Company | AL distribution in Table14 | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Comments |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |  |
| vivo | C1 | 2 | 2 | C1 | 0.67% | C1 | 1.58% | 0.91% | C1 | 1.48% | 0.81% |  |
| C1 | 3 | 2 | C1 | 1.62% | C1 | 2.95% | 1.33% | C1 | 3.13% | 1.51% |  |
| C1 | 4 | 2 | C1 | 2.34% | C1 | 4.39% | 2.05% | C1 | 4.80% | 2.46% |  |
| C1 | 5 | 2 | C1 | 3.35% | C1 | 5.74% | 2.39% | C1 | 5.81% | 2.46% |  |
| C1 | 1~5 | 2 | C1 | 0.10% | C1 | 0.20% | 0.10% | C1 | 0.20% | 0.10% | Note 1 |
| Note 1: Metric: the whole system blocking probability. It can be calculated by summing the product of the percentage of each number of UE simultaneously scheduled per slot and its corresponding blocking probability. | | | | | | | | | | | | |

Table 11E: PDCCH blocking rate for FR1, with 30kHz/20MHz, CORESET duration: 2 symbols, Delay toleration: 1, DCI size = 60 bits (NOT including CRC)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Company | AL distribution in Table14 | # users | # DCI sizes | Case 1 | | Case 2 | | Case 3 | | | Comments |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |  |
| Huawei, HiSilicon | C5 | 5 | Note 1 | C5 | 8.60% | - | - | C2 | 8.60% | 0.0% | Note 2 |
| C5 | 10 | Note 1 | C5 | 23.20% | - | - | C2 | 23.20% | 0.0% | Note 2 |
| C6 | 5 | Note 1 | C5 | 14.5% | - | - | C2 | 14.5% | 0.0% | Note 2 |
| C6 | 10 | Note 1 | C5 | 33.70% | - | - | C2 | 33.70% | 0.0% |  |
| Note 1: Reference case：2；50% BD reduction case:1  Note 2: For RedCap UEs using 2RX; BD reduction by reducing DCI size budget is evaluated (i.e. 'the number of DCI sizes to monitor per PDCCH candidate' is set to 2 for the reference case and 1 for approximately 50% reduction in BD limits). | | | | | | | | | | | |

**Proposal 8.2.3.1-1: Incorporate the above Table 9 and Table 10A/B/C/D/E into text proposal in the Redcap TR 38.875 for FR1. If not, what changes to the Tables are needed in order to add into Redcap TR. If concerns on results from specific source(s) to be captured in TR 38.875, please explicitly comment with reasoning in ‘comments’ column.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Y/N** | | **Comments** |
| CATT | Y | |  |
| LG | Y | | We are okay with the tables. |
| vivo | N | | We have two major concerns in capturing the results like above   1. For AL distribution, C1 makes sense and most companies have simulated this case. Other configurations (C2~C7), no simulation results have been provided by any company showing those configurations are valid in any simulated scenario. Without such justification, we do not agree to capture results for C2~C7 2. For number of co-scheduled UEs, the range of 2~10 was arbitrarily chosen. From our simulation results, we observed it is rare case that number of co-scheduled UEs is 4 or 5, more than 5 co-scheduled UEs cannot be seen from the simulation. We would like to ask for justification for the number larger than 5. |
| Huawei, HiSilicon | Y | |  |
| Panasonic | Y | |  |
| Sharp | Y | |  |
| Samsung | Y with modification. | | Table 9 is quite large. It’s better to split it into three tables based on channel conditions, i.e. different assumption for AL distribution. At least C1, C2, C3 of AL distributions should be considered. It will help us to draw conclusions or observations for different channel conditions as well. |
| Nokia | Y | |  |
| Qualcomm | Y | |  |
| InterDigital | Y | |  |
| Fraunhofer | Y | |  |
| Futurewei | Y | | Regarding Vivo ‘s comment of only capturing C1: our understanding that it was up to the companies to decide which distribution to use, so other distributions should be included. Besides, C1-C6 model different scenarios (good/medium/bad coverage, etc.) and provide good insight that should be captured in the TR |
| Ericsson | Y | For consistency, we suggest using either percentage or non-percentage values in the tables.  In Table 8, some of the configurations for the number of PDCCH candidates per AL are not valid. The candidates should be among {0, 1, 2, 3, 4, 5, 6, 8} to be valid. In our view, such configurations should not be captured in the TR.  Our suggestion is to have a table summarizing the blocking rate values reported by the companies, instead of including Table 9 and Table 10A/B/C/D/E in the TR. The excel sheet can then be provided as a reference. | |
| Intel | Y for Table 9, Tables 10A/B/D | Other Tables 10C/E are not in line with baseline or optional configurations. Agreement does not include “Other values not precluded” for DCI size and CORESET duration. Hence, we suggest to capture tables based on agreed observations for more focused observations.  Also, note that we have corrected a copy-paste error and also added some new results. | |
| DOCOMO | Y |  | |
| OPPO | Y |  | |
| ZTE,sanechips | Y | From our point of view, any method for BD reduction is not precluded before evaluation. The candidates number after reduction should not be limited by the legacy candidates {0, 1, 2, 3, 4, 5, 6, 8}.  The delay tolerance has an impact on the PDCCH blocking and 2 slots can be an optional configuration according to the agreement. Therefore, the simulation about the delay tolerance should be included. Further, the delay tolerance simulation results are collected in Table10C and we made a revision for Table10C. | |

**Summary of 1st round email discussions**

All responses except companies agree to capture the results of Table 9 and Table 10A/B/C/D/Einto TR 38.875.

Companies views are summarized in Table below:

|  |  |  |
| --- | --- | --- |
|  | Companies | # Companies |
| Yes | CATT, LG, Huawei, HiSilicon, Panasonic, Sharp, Samsung (split Table 9), Nokia, Qualcomm, InterDigital, Fraunhofer, Futurewei, Ericsson, DoCoMo, OPPO, ZTE,sanechips | 17 |
| No | vivo (1st concern on results with AL distributions configuration Cx except C1; 2nd concern on co-scheduled UEs > 5) | 1 |
| Partially yes | Intel (Yes to Table 9/10A/10B/10D) | 1 |

**Discussion Point for GTW:**

* Handling results with AL distributions configuration Cx except C1 and co-scheduled UEs > 5 [vivo]

One response [Samsung] suggested to split the PDCCH blocking rate Table into three tables based on AL distributions configuration C1, C2, or C3, which sounds make a lot of sense and actually necessary to figure out the corresponding observations. Hence, it was implemented in the new version of feature leader summary.

**[FL4] Proposal 8.2.3.1-1: Incorporate the revised Table 8/9, Table 10A/10B/10C/10D, Table 11A/11B/11C/11D/ 11E into Redcap TR 38.875.**

* It is up to TR editor to use a separate excel sheet to include these Tables or directly capture these tables for inclusion in the TR.

**Except the concerns raised on results of AL distribution C2/C3 and co-scheduled UEs >5 as already captured in ‘Discussion point’ above (Note that it is planned to be separately discussed first in next GTW session and not focus of this proposal), any other concerns on FL Proposal 8.2.3.1-1?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N | * + - 1. We do not agree to capture the results assuming arbitrary AL distributions (C2/C3) without given any justification for their rationality in the practical deployment or simulation scenarios. We suggest either delete the results for AL distribution C2/C3, or if there is strong desire to capture them we should add a statement to the TR that “there is no common understanding in RAN1 regarding the AL distribution other than C1”       2. We do not agree to capture the results assuming arbitrary number of co-scheduled UEs, especially for numbers larger than 5. We suggest to either delete those results, or if there is strong desire to capture them we should add a statement to the TR that “there is common understanding in RAN1 regarding the number of co-scheduled UEs larger than 5 assuming non-full buffer traffic model”       3. One minor comment is that notation Cx is used to name both the AL distribution and the PDCCH candidate configurations, which may cause some confusion for the readers. |
| LG | Partially yes | With regard to **[FL4] Proposal 8.2.1-1**, the tables should be captured excluding the results with reduced DCI size budget. Or, it is okay to capture the whole results with a note that explicitly mentions BD is reduced by reducing the DCI size budget. |
| CATT | Y |  |
| ZTE,sanechips | Y |  |
| Huawei, HiSilicon | Y | We are fine to incorporate the revised Table 8/9, Table 10A/10B/10C/10D, Table 11A/11B/11C/11D/ 11E into Redcap TR 38.875. |
| Samsung | Y |  |
| Futurewei | Y | The template that was agreed for power savings has a column for indicating the aggregation level distribution, thereby making it clear that the evaluation was not restricted to C1. Consequently, other configurations (C2, etc.) can, and should be captured. In addition, there is no good reasons to limit the number of UEs to 5. Consequently, the tables should be included as is. |
| Qualcomm | Y |  |
| Ericsson | N | There can be a confusion related to the column for “Blocking rate increase compared to Case 1” in the Tables. The blocking rate increase can be presented in two ways. Let a and b be the blocking rate for the reference case and reduced BD case. The blocking rate increase can be:   * Option 1: Absolute increase: (b%-a%) * Option 2: Relative increase: 100\*[(b-a)/a] %   For example, if the blocking rate increases from 20% to 30%, the absolute increase is 10% while the relative increase is 50%.  In our opinion, it is important to clarify this metric and the way that it should be presented in the TR. We are fine with including both absolute and relative values, in line with ZTE’s comments.  In Table 10B, we think it should be Note 8, instead of Note 9.  In Table 9, some of the configurations (e.g., configurations 7, 9, 13) for the number of PDCCH candidates per AL are not valid. The candidates should be among {0, 1, 2, 3, 4, 5, 6, 8} to be valid. In our view, such configurations should not be captured in the TR. |
| Nokia, NSB | Y |  |

**On Observations**

Similar as drafting observations for evaluation results of power saving gain, it is necessary to first agree sort of high-level methodology regarding how to formulate the observations based on the collected results e.g. how to separate observations for PDCCH blocking rate performance.

The following was observed in companies’ contributions:

* Separate observations for Aggregation Level (AL) distributions for AL [1,2,4,8,16] i.e. C1/C2/C3/Others
* Separate observations based on the number of simultaneously scheduled UEs.

**[FL4] Proposal 8.2.3.1-2:**

* Determine the Xx (smallest PDCCH blocking rate)-Yy (largest PDCCH blocking rate) value based on the smallest and largest values reported by each company at least considering:
  + Separate observations with corresponding Xx-Yy values are captured at least for Aggregation Level (AL) distributions for AL [1,2,4,8,16] i.e. C1/C2/C3/Others.
  + Separate observations with corresponding Xx-Yy values for number of simultaneously scheduled UEs.
  + Separate observations with corresponding Xx-Yy values for 25% and 50% reduction in BD limit.
* Capture average/mean value of Xx-Yy excluding the smallest and the largest values among companies.
* Explicitly mention the result/observations if it was provided by a few source companies e.g. 1 or 2 with special setup or assumptions.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo | N | As an technical report, observations should be only drawn for the reasonable scenarios/configurations, which is the AL configuration C1 and when the number of co-scheduled UEs is less than 5. For any other cases, we do not think observations can be drawn since the those cases are not technically justified.  The Xx and Yy should not be the absolute blockage value for the corresponding cases, instead, it should be the relative increase value by a given % of BD reduction, i.e. the numbers from the column in red color. It is fine to take the similar approach as the power saving evaluation to derive the range and mean values. |
| CATT | Y | The same method as power saving evaluation should be applied here. |
| ZTE,sanechips | Partially Yes | First of all, similar with vivo’s second point, the relative increase percentage, which actually is a range (Pp,Qq), can be adopted to describe the blocking rate increase by BD reduction, since it can mitigate the impacts on the PDCCH blocking rate brought by different simulation platforms from each company.  Further, besides the relative increase percentage, the absolute blockage value with a range (Xx,Yy) also should be adopted, because in some cases, the absolute blockage value is extremely low (e.g.,0.0001) and the relative increase percentage up to 200 % may be also acceptable.  Therefore, both an absolute blockage value (Xx,Yy) and a relative increase percentage (Pp,Qq) based on separate observations should be adopted to obtain the overall results. |
| Huawei, HiSilicon | Partially Yes | The way to obtain the value range can be reused. In detail, we have the following comments:   1. Regarding the separation for the simultaneously scheduled UEs, we just need to take two typical values. 5 and 10 are suggested. There is no need to give 10 observations with respective to the simultaneously scheduled UEs from 1 to 10. 2. We think only capturing the relative increment of PDCCH blocking rate in observations is not enough. According to the simulation results, there are some results to show zero or very small PDCCH blocking rate increment, however the PDCCH blocking rate of baseline is already very high. We think in this case, the PDCCH blocking is not increased due to the fact the baseline is already very bad. Therefore, the observation of very low PDCCH blocking rate increase without knowing the baseline blocking rate may not help to draw a useful conclusion. Both baseline PDCCH blocking rate and blocking rate increase should be reflected in the observation. 3. Capture that BD reduction with reduced DCI size budget shall not increase the PDCCH blocking rate. |
| Samsung | Yes with modification | Besides the observations with respect to different PDCCH BD rate, it’s also important to draw the observations about enhancements/techniques from companies regarding how to reduce PDCCH blocking probability.  In our evaluations, we provide results of reduced PDCCH blocking probability based on techniques, including   * One PDCCH to schedule multiple PDSCHs/PUSCHs. * Enhancement of PDCCH candidate dropping based on predetermined CCE AL priority order.   Therefore, we suggest to add the following bullet   * Capture techniques that can help reducing PDCCH blocking probability, e.g. one PDCCH schedules multiple PDSCHs/PUSCHs, enhancement of PDCCH candidates dropping |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson | Y, partially | In our view, observations should be separate for baseline parameters and optional parameters. |
| Nokia, NSB | Y |  |

#### **FR2 Results**

Table 12A: PDCCH blocking rate due to reduced blind decoding for FR2, with 120kHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: C1

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Comments |
| # PDCCH candidates for AL [1,2,4,8,16] in Table9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table19 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| 1 | Ericsson | 3 | <=2 | C2 | 1.00% | C2 | 1.2% | 0.20% | C2 | 4.4% | 3.4% | Note 1,5 |
| 6 | <= 2 | C2 | 3.90% | C2 | 6.8% | 2.90% | C2 | 14.0% | 10.1% | Note 1, 5 |
| 2 | Qualcomm | 2 | 2 | C1 | 0.20% | C5 | 0.4% | 0.20% | C1 | 4.0% | 3.8% |  |
| 4 | 2 | C1 | 1.10% | C5 | 1.9% | 0.80% | C1 | 11.4% | 10.3% |  |
| 6 | 2 | C1 | 2.60% | C5 | 4.5% | 1.90% | C1 | 17.7% | 15.1% |  |
| 8 | 2 | C1 | 5.10% | C5 | 7.8% | 2.70% | C1 | 23.5% | 18.4% |  |
| 10 | 2 | C1 | 8.40% | C5 | 12.0% | 3.60% | C1 | 28.9% | 20.5% |  |
| 12 | 2 | C1 | 12.70% | C5 | 16.6% | 3.90% | C1 | 33.5% | 20.8% |  |
| 14 | 2 | C1 | 17.70% | C5 | 21.5% | 3.80% | C1 | 38.0% | 20.3% |  |
| 16 | 2 | C1 | 22.90% | C5 | 26.5% | 3.60% | C1 | 41.7% | 18.8% |  |
| 18 | 2 | C1 | 28.20% | C5 | 31.4% | 3.20% | C1 | 45.4% | 17.2% |  |
| 20 | 2 | C1 | 33.50% | C5 | 36.1% | 2.60% | C1 | 48.7% | 15.2% |  |
| 3 | Nokia | 2 | 2 | C1 | 0.00% | C1 | 1.0% | 1.00% | C1 | 3.0% | 3.0% |  |
| 3 | 2 | C1 | 2.00% | C1 | 4.0% | 2.00% | C1 | 7.0% | 5.0% |  |
| 4 | 2 | C1 | 6.00% | C1 | 9.0% | 3.00% | C1 | 15.0% | 9.0% |  |
| 5 | 2 | C1 | 11.00% | C1 | 14.0% | 3.00% | C1 | 26.0% | 15.0% |  |
| 6 | 2 | C1 | 15.00% | C1 | 20.0% | 5.00% | C1 | 40.0% | 25.0% |  |
| 7 | 2 | C1 | 20.00% | C1 | 29.0% | 9.00% | C1 | 59.0% | 39.0% |  |
| 8 | 2 | C1 | 26.00% | C1 | 40.0% | 14.00% | C1 | 77.0% | 51.0% |  |
| 4 | Samsung | 1 | 2 | C1 | 0.00% | C2 | 5.0% | 5.00% | C2 | 8.0% | 8.0% | Note 5 |
| 2 | 2 | C1 | 0.00% | C2 | 5.0% | 5.00% | C2 | 8.0% | 8.0% | Note 5 |
| 3 | 2 | C1 | 0.00% | C2 | 7.0% | 7.00% | C2 | 14.0% | 14.0% | Note 5 |
| 4 | 2 | C1 | 1.00% | C2 | 12.0% | 11.00% | C2 | 22.0% | 21.0% | Note 5 |
| 5 | 2 | C1 | 3.00% | C2 | 18.0% | 15.00% | C2 | 31.0% | 28.0% | Note 5 |
| 6 | 2 | C1 | 7.00% | C2 | 24.0% | 17.00% | C2 | 38.0% | 31.0% | Note 5 |
| 7 | 2 | C1 | 11.00% | C2 | 31.0% | 20.00% | C2 | 45.0% | 34.0% | Note 5 |
| 8 | 2 | C1 | 16.00% | C2 | 37.0% | 21.00% | C2 | 50.0% | 34.0% | Note 5 |
| 9 | 2 | C1 | 22.00% | C2 | 42.0% | 20.00% | C2 | 55.0% | 33.0% | Note 5 |
| 10 | 2 | C1 | 26.00% | C2 | 47.0% | 21.00% | C2 | 59.0% | 33.0% | Note 5 |
| 1 | 2 | C1 | 0.00% | C2 | 5.0% | 5.00% | C2 | 8.0% | 8.0% | Note 3, 5 |
| 2 | 2 | C1 | 0.00% | C2 | 5.0% | 5.00% | C2 | 8.0% | 8.0% | Note 3, 5 |
| 3 | 2 | C1 | 0.00% | C2 | 5.0% | 5.00% | C2 | 8.0% | 8.0% | Note 3, 5 |
| 4 | 2 | C1 | 0.00% | C2 | 5.0% | 5.00% | C2 | 8.0% | 8.0% | Note 3, 5 |
| 5 | 2 | C1 | 0.00% | C2 | 7.0% | 7.00% | C2 | 14.0% | 14.0% | Note 3, 5 |
| 6 | 2 | C1 | 0.00% | C2 | 7.0% | 7.00% | C2 | 14.0% | 14.0% | Note 3, 5 |
| 7 | 2 | C1 | 1.00% | C2 | 12.0% | 11.00% | C2 | 22.0% | 21.0% | Note 3, 5 |
| 8 | 2 | C1 | 1.00% | C2 | 12.0% | 11.00% | C2 | 22.0% | 21.0% | Note 3, 5 |
| 9 | 2 | C1 | 3.00% | C2 | 18.0% | 15.00% | C2 | 31.0% | 28.0% | Note 3, 5 |
| 10 | 2 | C1 | 3.00% | C2 | 18.0% | 15.00% | C2 | 31.0% | 28.0% | Note 3,5 |
| 1~10 | 2 | C1 | 0.00% | C3 | 10.0% | 10.00% | C3 | 10.0% | 10.0% | Note 4,5 |
| 1~10 | 2 | C1 | 0.00% | C3 | 10.0% | 10.00% | C3 | 18.0% | 18.0% | Note 4,5 |
| 1~10 | 2 | C1 | 0.00% | C3 | 10.0% | 10.00% | C3 | 24.0% | 24.0% | Note 4,5 |
| 1~10 | 2 | C1 | 1.00% | C3 | 11.0% | 10.00% | C3 | 29.0% | 28.0% | Note 4,5 |
| 1~10 | 2 | C1 | 3.00% | C3 | 13.0% | 10.00% | C3 | 32.0% | 29.0% | Note 4,5 |
| 1~10 | 2 | C1 | 7.00% | C3 | 16.0% | 9.00% | C3 | 36.0% | 29.0% | Note 4,5 |
| 1~10 | 2 | C1 | 11.00% | C3 | 20.0% | 9.00% | C3 | 41.0% | 30.0% | Note 4,5 |
| 1~10 | 2 | C1 | 16.00% | C3 | 25.0% | 9.00% | C3 | 44.0% | 28.0% | Note 4,5 |
| 1~10 | 2 | C1 | 22.00% | C3 | 30.0% | 8.00% | C3 | 49.0% | 27.0% | Note 4,5 |
| 1~10 | 2 | C1 | 26.00% | C3 | 35.0% | 9.00% | C3 | 52.0% | 26.0% | Note 4,5 |
| Note 1: Digital Beamforming.  Note 3: With enhancement of UE group scheduling with 2 UEs per DCI.  Note 4: with enhancement of PDCCH drooping based on predetermined CCE AL priority order = [1 2 4 8 16]  Note 5: Good coverage | | | | | | | | | | | | |

Table 12B: PDCCH blocking rate due to reduced blind decoding for FR2, with 120kHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: C2

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Notes |
| # PDCCH candidates for AL [1,2,4,8,16] in Table 9 | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table9 | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| 1 | Ericsson | 3 | <= 2 | C2 | 18.0% | C2 | 20.0% | 2.0% | C2 | 24.00% | 6.0% | Note 1,6 |
| 6 | <= 2 | C2 | 36.0% | C2 | 40.0% | 4.0% | C2 | 44.00% | 8.0% | Note 1,6 |
| 2 | Qualcomm | 1 | 2 | C1 | 0.0% | C5 | 0.0% | 0.0% | C1 | 0.00% | 0.0% |  |
| 2 | 2 | C1 | 7.4% | C5 | 7.8% | 0.4% | C1 | 10.80% | 3.4% |  |
| 3 | 2 | C1 | 14.2% | C5 | 15.3% | 1.1% | C1 | 20.30% | 6.1% |  |
| 4 | 2 | C1 | 20.4% | C5 | 22.0% | 1.6% | C1 | 28.00% | 7.6% |  |
| 5 | 2 | C1 | 25.9% | C5 | 27.9% | 2.0% | C1 | 34.50% | 8.6% |  |
| 6 | 2 | C1 | 31.2% | C5 | 33.6% | 2.4% | C1 | 40.40% | 9.2% |  |
| 7 | 2 | C1 | 35.8% | C5 | 38.4% | 2.6% | C1 | 45.30% | 9.5% |  |
| 8 | 2 | C1 | 40.3% | C5 | 43.0% | 2.7% | C1 | 49.70% | 9.4% |  |
| 9 | 2 | C1 | 44.0% | C5 | 46.7% | 2.7% | C1 | 53.30% | 9.3% |  |
| 10 | 2 | C1 | 47.5% | C5 | 50.1% | 2.6% | C1 | 56.60% | 9.1% |  |
| 3 | ZTE | 2 | 2 | C2 | 9.2% | C6 | 10.0% | 0.8% | C1 | 22.88% | 13.7% | Note 5 |
| 4 | 2 | C2 | 26.1% | C6 | 28.9% | 2.9% | C1 | 44.00% | 18.0% | Note 5 |
| 6 | 2 | C2 | 40.9% | C6 | 43.3% | 2.5% | C1 | 54.92% | 14.1% | Note 5 |
| 8 | 2 | C2 | 51.9% | C6 | 54.3% | 2.5% | C1 | 62.61% | 10.7% | Note 5 |
| 4 | Samsung | 1 | 2 | C1 | 0.0% | C2 | 40.0% | 40.0% | C2 | 61.00% | 61.0% | Note 5 |
| 2 | 2 | C1 | 11.0% | C2 | 42.0% | 31.0% | C2 | 61.00% | 50.0% | Note 5 |
| 3 | 2 | C1 | 19.0% | C2 | 45.0% | 26.0% | C2 | 61.00% | 42.0% | Note 5 |
| 4 | 2 | C1 | 25.0% | C2 | 47.0% | 22.0% | C2 | 62.00% | 37.0% | Note 5 |
| 5 | 2 | C1 | 30.0% | C2 | 50.0% | 20.0% | C2 | 63.00% | 33.0% | Note 5 |
| 6 | 2 | C1 | 35.0% | C2 | 52.0% | 17.0% | C2 | 64.00% | 29.0% | Note 5 |
| 7 | 2 | C1 | 39.0% | C2 | 54.0% | 15.0% | C2 | 66.00% | 27.0% | Note 5 |
| 8 | 2 | C1 | 43.0% | C2 | 56.0% | 13.0% | C2 | 67.00% | 24.0% | Note 5 |
| 9 | 2 | C1 | 46.0% | C2 | 58.0% | 12.0% | C2 | 68.00% | 22.0% | Note 5 |
| 10 | 2 | C1 | 49.0% | C2 | 60.0% | 11.0% | C2 | 69.00% | 20.0% | Note 5 |
| 1 | 2 | C1 | 0.0% | C2 | 40.0% | 40.0% | C2 | 61.00% | 61.0% | Note3, 5 |
| 2 | 2 | C1 | 0.0% | C2 | 40.0% | 40.0% | C2 | 61.00% | 61.0% | Note3, 5 |
| 3 | 2 | C1 | 11.0% | C2 | 42.0% | 31.0% | C2 | 61.00% | 50.0% | Note3, 5 |
| 4 | 2 | C1 | 11.0% | C2 | 42.0% | 31.0% | C2 | 61.00% | 50.0% | Note3, 5 |
| 5 | 2 | C1 | 19.0% | C2 | 45.0% | 26.0% | C2 | 61.00% | 42.0% | Note3, 5 |
| 6 | 2 | C1 | 19.0% | C2 | 45.0% | 26.0% | C2 | 61.00% | 42.0% | Note3, 5 |
| 7 | 2 | C1 | 25.0% | C2 | 47.0% | 22.0% | C2 | 62.00% | 37.0% | Note3, 5 |
| 8 | 2 | C1 | 25.0% | C2 | 47.0% | 22.0% | C2 | 62.00% | 37.0% | Note3, 5 |
| 9 | 2 | C1 | 30.0% | C2 | 50.0% | 20.0% | C2 | 63.00% | 33.0% | Note3, 5 |
| 10 | 2 | C1 | 30.0% | C2 | 50.0% | 20.0% | C2 | 63.00% | 33.0% | Note3, 5 |
| 1 | 2 | C1 | 0.0% | C4 | 0.0% | 0.0% | C4 | 20.00% | 20.0% | Note 4, 5 |
| 2 | 2 | C1 | 11.0% | C4 | 11.0% | 0.0% | C4 | 30.00% | 19.0% | Note 4, 5 |
| 3 | 2 | C1 | 19.0% | C4 | 19.0% | 0.0% | C4 | 38.00% | 19.0% | Note 4, 5 |
| 4 | 2 | C1 | 25.0% | C4 | 27.0% | 2.0% | C4 | 43.00% | 18.0% | Note 4, 5 |
| 5 | 2 | C1 | 30.0% | C4 | 32.0% | 2.0% | C4 | 48.00% | 18.0% | Note 4, 5 |
| 6 | 2 | C1 | 35.0% | C4 | 37.0% | 2.0% | C4 | 52.00% | 17.0% | Note 4, 5 |
| 7 | 2 | C1 | 39.0% | C4 | 41.0% | 2.0% | C4 | 55.00% | 16.0% | Note 4, 5 |
| 8 | 2 | C1 | 43.0% | C4 | 45.0% | 2.0% | C4 | 58.00% | 15.0% | Note 4, 5 |
| 9 | 2 | C1 | 46.0% | C4 | 49.0% | 3.0% | C4 | 61.00% | 15.0% | Note 4, 5 |
| 10 | 2 | C1 | 49.0% | C4 | 53.0% | 4.0% | C4 | 63.00% | 14.0% | Note 4, 5 |
| Note 1: Digital Beamforming.  Note 3: With enhancement of UE group scheduling with 2 UEs per DCI.  Note 4: with enhancement of PDCCH drooping based on predetermined CCE AL priority order = [1 2 4 8 16]  Note 5: Medium coverage | | | | | | | | | | | | |

Table 12C: PDCCH blocking rate due to reduced blind decoding for FR2, with 120kHz, CORESET duration: 2 symbols, Delay toleration: 1, AL distribution: C3

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| # | Company | # users | # DCI sizes | Case 1 | | Case 2 | | | Case 3 | | | Notes |
| # PDCCH candidates for AL [1,2,4,8,16] in Table15B | PDCCH blocking rate | # PDCCH candidates for AL [1,2,4,8,16] in Table15B | PDCCH blocking rate | Blocking rate increase compared to Case 1 | # PDCCH candidates for AL [1,2,4,8,16] in Table15B | PDCCH blocking rate | Blocking rate increase compared to Case 1 |
| 1 | Ericsson | 3 | <= 2 | C2 | 45.0% | C2 | 47.0% | 2.0% | C2 | 49.0% | 4.0% | Note 1, 5 |
| 6 | <= 2 | C2 | 63.0% | C2 | 65.0% | 2.0% | C2 | 67.0% | 4.0% | Note 1, 5 |
| 2 | Qualcomm | 1 | 2 | C1 | 0.0% | C5 | 0.0% | 0.0% | C1 | 0.0% | 0.0% |  |
| 2 | 2 | C1 | 21.2% | C5 | 21.7% | 0.5% | C1 | 23.1% | 1.9% |  |
| 3 | 2 | C1 | 36.2% | C5 | 37.0% | 0.8% | C1 | 39.4% | 3.2% |  |
| 4 | 2 | C1 | 46.8% | C5 | 47.9% | 1.1% | C1 | 50.5% | 3.7% |  |
| 5 | 2 | C1 | 54.1% | C5 | 55.4% | 1.3% | C1 | 58.3% | 4.2% |  |
| 6 | 2 | C1 | 59.5% | C5 | 60.9% | 1.4% | C1 | 63.8% | 4.3% |  |
| 7 | 2 | C1 | 63.9% | C5 | 65.4% | 1.5% | C1 | 68.3% | 4.4% |  |
| 8 | 2 | C1 | 67.2% | C5 | 68.7% | 1.5% | C1 | 71.5% | 4.3% |  |
| 9 | 2 | C1 | 69.7% | C5 | 71.2% | 1.5% | C1 | 74.1% | 4.4% |  |
| 10 | 2 | C1 | 71.7% | C5 | 73.1% | 1.4% | C1 | 76.1% | 4.4% |  |
| 3 | Samsung | 1 | 2 | C1 | 0.0% | C2 | 20.0% | 20.0% | C2 | 49.0% | 49.0% | Note 5 |
| 2 | 2 | C1 | 15.0% | C2 | 32.0% | 17.0% | C2 | 58.0% | 43.0% | Note 5 |
| 3 | 2 | C1 | 25.0% | C2 | 42.0% | 17.0% | C2 | 64.0% | 39.0% | Note 5 |
| 4 | 2 | C1 | 34.0% | C2 | 49.0% | 15.0% | C2 | 68.0% | 34.0% | Note 5 |
| 5 | 2 | C1 | 41.0% | C2 | 55.0% | 14.0% | C2 | 72.0% | 31.0% | Note 5 |
| 6 | 2 | C1 | 47.0% | C2 | 59.0% | 12.0% | C2 | 74.0% | 27.0% | Note 5 |
| 7 | 2 | C1 | 52.0% | C2 | 63.0% | 11.0% | C2 | 76.0% | 24.0% | Note 5 |
| 8 | 2 | C1 | 56.0% | C2 | 66.0% | 10.0% | C2 | 78.0% | 22.0% | Note 5 |
| 9 | 2 | C1 | 59.0% | C2 | 68.0% | 9.0% | C2 | 79.0% | 20.0% | Note 5 |
| 10 | 2 | C1 | 62.0% | C2 | 71.0% | 9.0% | C2 | 80.0% | 18.0% | Note 5 |
| 1 | 2 | C1 | 0.0% | C2 | 20.0% | 20.0% | C2 | 49.0% | 49.0% | Note 3, 5 |
| 2 | 2 | C1 | 0.0% | C2 | 20.0% | 20.0% | C2 | 49.0% | 49.0% | Note 3, 5 |
| 3 | 2 | C1 | 15.0% | C2 | 32.0% | 17.0% | C2 | 58.0% | 43.0% | Note 3, 5 |
| 4 | 2 | C1 | 15.0% | C2 | 32.0% | 17.0% | C2 | 58.0% | 43.0% | Note 3, 5 |
| 5 | 2 | C1 | 25.0% | C2 | 42.0% | 17.0% | C2 | 64.0% | 39.0% | Note 3, 5 |
| 6 | 2 | C1 | 25.0% | C2 | 42.0% | 17.0% | C2 | 64.0% | 39.0% | Note 3, 5 |
| 7 | 2 | C1 | 34.0% | C2 | 49.0% | 15.0% | C2 | 68.0% | 34.0% | Note 3, 5 |
| 8 | 2 | C1 | 34.0% | C2 | 49.0% | 15.0% | C2 | 68.0% | 34.0% | Note 3, 5 |
| 9 | 2 | C1 | 41.0% | C2 | 55.0% | 14.0% | C2 | 72.0% | 31.0% | Note 3, 5 |
| 10 | 2 | C1 | 41.0% | C2 | 55.0% | 14.0% | C2 | 72.0% | 31.0% | Note 3, 5 |
| 1 | 2 | C1 | 0.0% | C4 | 0.0% | 0.0% | C5 | 5.0% | 5.0% | Note 4,5 |
| 2 | 2 | C1 | 14.0% | C4 | 15.0% | 1.0% | C5 | 19.0% | 5.0% | Note 4,5 |
| 3 | 2 | C1 | 26.0% | C4 | 26.0% | 0.0% | C5 | 31.0% | 5.0% | Note 4,5 |
| 4 | 2 | C1 | 34.0% | C4 | 35.0% | 1.0% | C5 | 40.0% | 6.0% | Note 4,5 |
| 5 | 2 | C1 | 41.0% | C4 | 42.0% | 1.0% | C5 | 47.0% | 6.0% | Note 4,5 |
| 6 | 2 | C1 | 47.0% | C4 | 48.0% | 1.0% | C5 | 52.0% | 5.0% | Note 4,5 |
| 7 | 2 | C1 | 52.0% | C4 | 52.0% | 0.0% | C5 | 57.0% | 5.0% | Note 4,5 |
| 8 | 2 | C1 | 56.0% | C4 | 56.0% | 0.0% | C5 | 61.0% | 5.0% | Note 4,5 |
| 9 | 2 | C1 | 59.0% | C4 | 60.0% | 1.0% | C5 | 64.0% | 5.0% | Note 4,5 |
| 10 | 2 | C1 | 62.0% | C4 | 63.0% | 1.0% | C5 | 67.0% | 5.0% | Note 4,5 |
| Note 1: Digital Beamforming.  Note 3: With enhancement of UE group scheduling with 2 UEs per DCI.  Note 4: with enhancement of PDCCH drooping based on predetermined CCE AL priority order = [1 2 4 8 16]  Note 5: Poor coverage | | | | | | | | | | | | |

**Proposal 8.2.3.1-2: Incorporate the above Table 11 into text proposal in the Redcap TR for FR2. If not, what changes to the Tables are needed in order to add into Redcap TR? If concerns on results from one or more source(s) to be captured in TR 38.875, please explicitly comment with reason in ‘Comments’ column.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| CATT | Y |  |
| LG | Y | We are okay with the tables. |
| Panasonic | Y |  |
| Samsung | Y with modification. | Similar as Table 9, Table 11 is quite large. It’s better to split it into three tables based on channel conditions, i.e. different assumption for AL distribution. At least C1, C2, C3 of AL distributions should be considered. It will help us to draw conclusions or observations for different channel conditions as well. |
| Qualcomm | Y |  |
| InterDigital | Y |  |
| Futurewei | Y |  |
| Ericsson | Y | In Ericsson’s results in Table 11, Note 2 (Analog Beamforming) is not applicable. It is always Note 1 (Digital Beamforming).  Our suggestion is to also have a table summarizing the PDCCH blocking rate reported by the companies, instead of including Table 11, in the TR. The excel sheet can then be provided as a reference. |
| Intel | Y |  |
| DOCOMO | Y |  |
| ZTE,sanechips | Y |  |

**Summary of 1st round email discussions**

All responses agree to capture the results in Table 12 into TR. One company suggested to put the table into excel sheet. Another company suggest split the table into three based on the AL distribution configuration C1, C2 or C3.

**[FL4] Proposal 8.2.3.1-3: Incorporate the revised Table 12A/12B/12C into Redcap TR 38.875**

* It is up to TR editor to use a separate excel sheet to include these Tables or directly capture these tables for inclusion in the TR.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| LG | Y |  |
| CATT | Y |  |
| ZTE,sanechips | Y |  |
| Samsung | Y |  |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson |  | There can be a confusion related to the column for “Blocking rate increase compared to Case 1” in the Tables. The blocking rate increase can be presented in two ways. Let *a* and *b* be the blocking rate for the reference case and reduced BD case. The blocking rate increase can be:   * Option 1: Absolute increase: (*b*%-*a*%) * Option 2: Relative increase: 100\*[*(b-a)/a*] %   For example, if the blocking rate increases from 20% to 30%, the absolute increase is 10% while the relative increase is 50%. In our opinion, it is important to clarify this metric and the way that it should be presented in the TR. We are fine with including both absolute and relative values.  In Table 12B, we believe there is a typo. It should be Note 5, instead of Note 6. |
| Nokia, NSB | Y |  |

**Observations**

**[FL4] Proposal 8.2.3.1-4:**

* Determine the Xx (smallest PDCCH blocking rate)-Yy (largest PDCCH blocking rate) value based on the smallest and largest values reported by each company at least considering:
  + Separate observations with corresponding Xx-Yy values are captured at least for Aggregation Level (AL) distributions for AL [1,2,4,8,16] i.e. C1/C2/C3.
  + Separate observations for number of simultaneously scheduled UEs.
  + Separate observations for 25% and 50% reduction in BD limit.
* Capture average/mean value of Xx-Yy excluding the smallest and the largest values among companies for each separate observation.
* Explicitly mention the result/observations if it was provided by a few source companies e.g. 1 or 2 with special setup or assumptions.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| vivo |  | Similar comments are for **Proposal 8.2.3.1-2:** |
| ZTE,sanechips |  | Similar with FR1 |
| Samsung | Y with modification | Same comments as for FR1 |
| Futurewei | Y |  |
| Qualcomm | Y |  |
| Ericsson | Y, partially | In our view, observations should be separate for baseline parameters and optional parameters. |
| Nokia, NSB | Y |  |

### 8.2.3.2 Latency and Scheduling flexibility

The latency impacts were studied in [2,6] with following observations:

* P1 [2]: Reduction of BD and CCE limits increases PDCCH blocking probability as well as latency. Moreover, it restricts scheduling flexibility and efficient multiplexing for scheduling multiple UEs.
* P2 [6]: The latency increase caused by BD reduction is negligible.

**Q 8.2.3.2-1: Which of the listed (P1, P2) can be incorporated into text proposal in the Redcap TR for the potential latency and scheduling flexibility performance impacts? If none of them, what is suggested to be captured in the latency and scheduling flexibility analysis section in TR?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | P1 |
| LG | P1 |
| vivo | P2. Due to the long DRX cycle associated with the simulated traffic model, the additional latency impact due to different PDCCH monitoring cases is marginal. For PDCCH blocking and scheduling flexibility, they are more suitable for the previous section 8.2.3.1 |
| Huawei, HiSilicon | We also have an observation in [4], which could be the P3:   * Observation 6: When BD reduction with the same DCI size budget is considered, the number of outage UEs would be increased due to the higher PDCCH blocking rate.   We think we should distinguish the reduction of BD into:   1. BD reduction by reducing DCI size budget; 2. BD reduction with the same DCI size budget;   Based on our results in Table 9, the following is suggested to be captured:  BD reduction by reducing DCI size budget shall not impact the latency and scheduling flexibility and when BD reduction with the same DCI size budget is considered, the number of outage UEs would be increased due to the higher PDCCH blocking rate. |
| Panasonic | P1 |
| Sharp | P2 |
| Samsung | P2. Latency can be negligible for RedCap use cases. |
| Nokia | P1 |
| Qualcomm | None of the two seems to capture the overall picture. We propose to add the following based on our evaluation study of PDCCH blocking probability by BD reduction   * Pn [24]: 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. |
| MediaTek | P1 |
| InterDigital | P1 |
| Fraunhofer | P1 |
| Futurewei | More discussion is needed before concluding this aspect: if BDs are reduced, all other things being the same (scheme 1a in question 1), P1 is appropriate. However, other schemes (e.g., reducing the number of DCI sizes to monitor) do not affect performance, but may have other impact to study (e.g., what is the impact of reducing the number of DCI sizes).  The QC suggestion could be a good starting point for a top level observation but then, more details should be provided to quantify the impact of each listed parameter |
| Ericsson | P1 should be captured, but not P2. |
| Intel | More discussion is needed before such as observations can be captured. In our analysis, scheduling flexibility loss due to BD reduction up to 50% was minimal at least for the agreed configurations. Below is our observation, copied here for reference:  **Observation 5: For AL distribution [0.5, 0.4, 0.05, 0.03, 0.02], scheduling flexibility is not compromised for 30kHz, 2OS CORESET configuration and only minimally impacted for 15kHz 3OS CORESET, when BD numbers are reduced by half.** |
| DOCOMO | P1 |
| Lenovo, Motorola Mobility | P2. Considering relaxed latency requirements (e.g. 5-10ms, <100ms, < 500ms) for RedCap UEs, a small increase of latency related to PDCCH blocking shouldn’t be a concern. |
| OPPO | P2 |
| ZTE,sanechips | We think P1 and P2 can be applied for different cases according to companies’ simulation scenarios, and both of them should be counted.  Therefore, Combine P1 and P2 as following.  In some cases, reduction of BD and CCE limits increases PDCCH blocking probability as well as latency. Moreover, it restricts scheduling flexibility and efficient multiplexing for scheduling multiple UEs(P1)  In some other cases, the latency increase caused by BD reduction is negligible (P2). |

## 8.2.4 Analysis of coexistence with legacy UEs

Several contributions [2, 7] analyzed potential coexistence issues with legacy UEs caused by reduced PDCCH monitoring. The specification impact analysis based on papers were listed below:

* C1 [2]: The potential impacts on legacy UEs, in terms of PDCCH blocking probability, when coexisting with RedCap UEs depend on the scheduling strategy and system parameters. If legacy UEs are prioritized over RedCap UEs in the gNB scheduling, we do not expect any coexistence impact on the legacy UEs.
* C2 [7]: The coexistence impacts from reducing BD and CCE limits can be mitigated by gNB configuration.

**Q 8.2.4-1: Does the list above (C1, C2) can be incorporated into text proposal in the Redcap TR for the coexistence impacts that need to be considered? If not, please explain why? what other aspects need to be added?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG | C1 can be incorporated but further study is needed. For coverage recovery, RedCap UEs’ PDCCHs tend to be on higher ALs, and legacy UEs in poor coverage cannot avoid impact. RedCap UEs may be fine with relaxed latency requirement, but, it should be clarified. |
| vivo | There should be no impact to legacy UEs as BD are not reduced for legacy UEs. |
| Huawei, HiSilicon | We think C2 is reasonable observation. |
| Panasonic | FFS |
| Sharp | C1 and C2 |
| Samsung | No. The PDCCH blocking probability for legacy UEs is impacted by the number of UEs served per cell. It doesn’t matter the coexistence UE is RedCap UE or legacy UE. The reduced PDCCH monitoring capability of RedCap won’t cause any coexistence issue for legacy UEs. |
| Nokia | C1 and C2 |
| Qualcomm | C1 is obvious for legacy UE. It would be equally important if proponent of C1 [2] can clarify how RedCap UEs are impacted if legacy UEs are always prioritized.  It is unclear what does C2 really mean. It is better if proponent of C2 [7] can present some details about whether the impact is to legacy UE or to RedCap UE and how gNB can mitigate the impact by configuration. |
| MediaTek | C1 |
| InterDigital | It is not clear why leagcy UEs are impacted by reduced PDCCH monitoring of RedCap UEs. |
| Futurewei | Both observations are acceptable |
| Ericsson | C1 and C2 should be captured. |
| Intel | It seems this topic received limited attention in this meeting. More discussion is needed. |
| DOCOMO | No. Reduced PDCCH monitoring does not have impact on coexistence with legacy UEs |
| Lenovo, Motorola Mobility | C1 |
| OPPO | Both |
| ZTE,sanechips | C1 and C2. |

## 8.2.5 Analysis of specification impacts

Several contributions [2,7] also point out the specification impacts from the reduced PDCCH monitoring.

* 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.
* S2 [2]: If a specific set of number of PDCCH candidates needs to be hardcoded for RedCap, there will be a specification impact.
* S3 [7]: The specification impacts by reducing the BDs and CCEs may be mainly on the RRC parameters, DCI design or the UE behaviors related to blind decoding.

**Q 8.2.5-1: Which of list above (S1, S2, S3) capture the most important specifications impacts that need to be considered for reduced PDCCH monitoring? If none, what other aspects need to be added?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| CATT | Y |  |
| LG | Y | S1, S2 |
| vivo | N | For scheme #1, agree with S2  For scheme #2, the spec impact would be the specification of supported PDCCH monitoring span gap (i.e. X) and potentially multi-slot scheduling from a single monitoring span. |
| Huawei, HiSilicon | N | In our view, BD limit, DCI size budget and DCI format design shall be impacted. |
| Panasonic | Y | S1 and S2. |
| Sharp | Y | S2 and S3 |
| Samsung | Y | Both S2 and S3 are possible. It depends on what type of power saving schemes (in Section 8.2.1 we support eventually. |
| Nokia | Y | S1 and S2 |
| Qualcomm | Y | For S1, it is unclear how UE can be guaranteed that actual BD number is reduced by network without any change to specification. If there is not any specification impact, then even eMBB may use the network assisted BD reduction. S1 should not be captured.  S2 can be captured. But it can be changed from “If a specific set of number of PDCCH candidates” to “a specific set of “reduced” number”. This is because Rel-15 BD limit is also a specific set of number of PDCCH candidates.  For S3, it is a very broad conclusion. Would be better to further clarify by proponent ([7]) the specification change is for adaptive PDCCH monitoring configuration, PDCCH overhead reduction (i.e., by using less PDCCH for scheduling) or DCI size reduction etc. or all of them. Then it can be captured.  For the table in “12. Conclusion”, please also add Qualcomm to the companies supporting scheme 3. |
| MediaTek | Y | S1 and S2 |
| InterDigital | Y | S2 and S3 |
| FUTUREWEI |  | S1 as written is too strong, but could be reworded as:  S4 If the network assist BD reduction and UE power saving using existing configurations without any specified restriction for RedCap, only limited specification changes are ~~not~~ required |
| Ericsson | Y | S1 and S2 should be captured. |
| Intel |  | We think specification impact can be discussed together with the methods for reducing BD numbers, Section 8.2.1 |
| DOCOMO | Y | S1, S2 |
| Lenovo, Motorola Mobility | Y | S2, S3 |
| OPPO | N | The specification impact can be discussed further. |
| ZTE,sanechips | Y | S2 and S3. The details can be clarified according to the discussion of Proposal 8.2.1-1 |

# 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] | 6 |
| 4 (Remain same as in Rel-15/16) | Futurewei [3], Nokia [13], MTK [22], LG[12], Ericsson [2], DOCOMO [23] | 6 |

# References

1. 3GPP TR 38.875 Study on support of reduced capability NR devices (Rel-17)
2. [R1-2007530](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007530.zip) Reduced PDCCH monitoring for RedCap Ericsson
3. [R1-2007535](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007535.zip) Power savings for RedCap UEs FUTUREWEI
4. [R1-2007597](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007597.zip) Power saving for reduced capability devices LH, HiSilicon
5. [R1-2007625](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007625.zip) Discussion on PDCCH monitoring reduction for RedCap UEs Panasonic
6. [R1-2007669](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007669.zip) Reduced PDCCH monitoring for Reduced Capability NR devices vivo, Guangdong Genius
7. [R1-2007716](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007716.zip) Consideration on reduced PDCCH monitoring ZTE
8. [R1-2007863](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007863.zip) Discussion on PDCCH monitoring reduction CATT
9. [R1-2007888](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007888.zip) Reduced PDCCH monitoring TCL Communication Ltd.
10. [R1-2007948](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007948.zip) On reduced PDCCH monitoring for RedCap UEs Intel Corporation
11. [R1-2008017](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008017.zip) Discussion on PDCCH monitoring reduction CMCC
12. [R1-2008049](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008049.zip) Discussion on PDCCH monitoring for reduced capability NR devices LG Electronics
13. [R1-2008069](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008069.zip) Reduced PDCCH monitoring Nokia, Nokia Shanghai Bell
14. [R1-2008085](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008085.zip) Discussion on reduced PDCCH monitoring for reduced capability device Xiaomi
15. [R1-2008105](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008105.zip) Discussion on reduced PDCCH monitoring Spreadtrum Communications
16. [R1-2008115](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008115.zip) Reduced PDCCH monitoring for REDCAP NR devices NEC
17. [R1-2008171](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008171.zip) Reduced PDCCH monitoring Samsung
18. [R1-2008261](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008261.zip) Solutions of reduced PDCCH monitoring OPPO
19. [R1-2008336](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008336.zip) PDCCH monitoring at reduced capability UE Lenovo, Motorola Mobility
20. [R1-2008395](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008395.zip) Reduced PDCCH Monitoring for RedCap Devices Sharp
21. [R1-2008470](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008470.zip) Reduced PDCCH Monitoring for RedCap Devices Apple
22. [R1-2008511](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008511.zip) Discussion on reduced PDCCH monitoring for NR RedCap UEs MediaTek Inc.
23. [R1-2008552](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008552.zip) Discussion on reduced PDCCH monitoring for RedCap NTT DOCOMO, INC.
24. [R1-2008621](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008621.zip) PDCCH Monitoring Reduction and Power Saving for RedCap Devices Qualcomm Incorporated
25. [R1-2008685](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008685.zip) Reduced PDCCH monitoring for reduced capability NR devices InterDigital, Inc.
26. [R1-2008712](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008712.zip) Reduced PDCCH Monitoring for RedCap UEs Fraunhofer HHI, Fraunhofer IIS
27. [R1-2008727](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008727.zip) Discussion on PDCCH monitoring for RedCap UE WILUS Inc.
28. [R1-2008739](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008739.zip) Reduced PDCCH monitoring for RedCap UE Sequans Communications
29. [R1-2007482](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2007482.zip) FL summary on initial collection of RedCap evaluation results Moderator (Ericsson, Apple, Qualcomm)

# 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.