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

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

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

**Title: Feature lead summary #10 on reduced PDCCH monitoring**

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

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

# 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 until 11/17.

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 FL10.

# 8.2 Reduced PDCCH monitoring

## 8.2.2 Analysis of UE power saving

**[FL10] Proposal 8.2.2-1: Adding the rows in proposal 8.2.2-1 for Table 2A,2B,2C and 2D with new notes.**

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 |
| 12 | Ericsson | 0.30% | 0.00% | 0.01% | 0.01% | 0.01% | 0.01% |  |  |  | Note 6B |
| 13 | InterDigital | 4.40% | 8.80% | 1.16% | 2.04% | 0.45% | 0.92% |  |  |  |  |
| Note 6B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

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 |
| 9 | Ericsson | 0.32% | 0.01% | 0.01% | 0.02% | 0.01% | 0.02% |  |  |  | Note 2B |
| Note 2B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

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 |
| 14 | Ericsson | 0.36% | 0.67% | 0.01% | 0.02% | 0.01% | 0.02% |  |  |  | Note 6B |
| Note 6B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

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 |
| 9 | Ericsson | 0.44% | 0.82% | 0.01% | 0.03% | 0.01% | 0.02% |  |  |  | Note 2B |
| Note 2B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

Table 4A: Power Saving gain, FR2, 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 |
| 7 | Ericsson | 0.55% | 1.03% | 0.02% | 0.04% | 0.02% | 0.04% |  |  |  | Note 2B |
| Note 2B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

Table 4B: Power Saving gain, FR2, 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 |
| 5 | Ericsson | 0.77% | 1.43% | 0.03% | 0.06% | 0.03% | 0.05% |  |  |  | Note 2B |
| Note 2B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

Table 5A: Power Saving gain, FR2, 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 |
| 7 | Ericsson | 0.75% | 1.40% | 0.03% | 0.06% | 0.03% | 0.05% |  |  |  | Note 2B |
| Note 2B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

Table 5B: Power Saving gain, FR2, 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 |
| 5 | Ericsson | 1.04% | 1.92% | 0.04% | 0.08% | 0.04% | 0.07% |  |  |  | Note 2B |
| Note 2B: DL and UL (For IM traffic and Heartbeat, traffic is 50% in DL and 50% in UL) | | | | | | | | | | | |

**[FL10] Proposal 8.2.2-2: Update the agreement as follows based on the new evaluation results for IM traffic model and Heartbeat traffic models:**

|  |
| --- |
| For FR1, 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],[Intel], [ZTE], [InterDigital]) reported the evaluation results of power saving gain for FR1 with same-slot scheduling for the 1 Rx antenna case.   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 [0.3%~5.7%] and [0.0%~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 2.97% and 6.1%, 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 [0.01%~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 2.91%, 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 [0.01%~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 1.33% and 2.58%, respectively. * 13 sources ([vivo], [Ericsson], [Qualcomm], [Nokia], [CATT], [Spreadtrum], [OPPO], [Huawei, HiSilicon], [Apple], [Futurewei], [Intel], [ZTE], [InterDigital]) reported the evaluation results of power saving gain for FR1 with same-slot scheduling for 2 Rx antennas cases.   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 [0.36%~6.20%] and [0.67%~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 3.05% and 6.59%. * 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 1.65% and 3.92%, 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 1.49% and 3.62%, respectively.   Agreements:  For FR1, 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 [0.32%~4.5%] and [0.01%~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 2.58% and 4.26%, 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 1.66% and 2.17%, 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 1.6% and 2.34%, 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 [0.44%~4.69%] and [0.82%~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 3.08% and 5.70%, 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 3.13%, 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.   Agreements:  Fo FR2, 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 [0.55%~6.6%] and [1.03%~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 4.20% and 8.60%, 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 [0.02%~4.30%] and [0.04%~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 1.72% and 3.69%, 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%~4%] and [0.04%~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 1.28% and 2.58%, 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 [0.75%~6.8%] and [1.4%~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 4.52% and 8.98%, 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 [0.06%~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 2.13% and 4.14%, 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 [0.05%~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 1.99% and 3.88%, respectively.   Agreements:  For FR2, 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 [0.77%~6.30%] and [1.43%~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 3.19% and 76.17%, 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 0.87% and 1.75%, 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 0.84% and 1.67%, 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 [1.04%~6.6%] and [1.92%~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 3.43% and 6.59%, 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 2.11%, 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 0.93% and 1.85%, respectively. |

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| ZTE,sanechips | N | The power saving gain with 50% BD reduction for IM traffic is less than that with 25% BD reduction in table2A and table2B, which is unreasonable. Additionally, the power saving gain for same slot scheduling is less than that for cross slot scheduling in table 2A,2B,3A,3B,4A,4B,5A and 5B, which is also conflicting with the agreed observation. So the corresponding results in table 2A,2B,3A,3B,4A,4B,5A and 5B seems to be not appropriate to be captured.  Moreover,as described above “ 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 [0.3%~5.7%] and [0.0%~11.4%]”, we have the following confusion. Firstly, the minimum power saving gain for 25% BD reduction should be less than that for 50% BD reduction. Secondly, the minimum power saving gain for 50% BD reduction would not be 0. So,the range [0.3%~5.7%] for 25% BD reduction and [0.0%~11.4%] for 50% BD reduction seems to be unreasonable here.  BTW, as we agreed, if the result/observations was provided by a few source companies e.g. 1 or 2 with special setup or assumptions, the results should be explicitly mentioned,e.g. the simulation results for DL and UL from Ericsson.  So we suggest to discuss the simulation results from Ericsson separately if the simulation results need to be captured, and update the agreements according to the updated simulation results from [InterDigital] |
| Samsung |  | For the new results in 2A, 2B, it’s unreasonable that power saving gain for 50% BD reduction is less than that for 25% BD reduction. |
| Futurewei |  | Ok, assuming results are corrected per email discussion |
|  |  |  |

### 8.2.3.2 Latency and Scheduling flexibility

**[FL9] Proposal 8.2.3.2-1: Which of the listed Option1 and Option can be captured into TR 38.875 for section 8.2.3 for scheduling flexibility impacts:**

|  |
| --- |
| **Option 1:** Scheduling flexibility impact by BD reduction depends on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution, channel condition, number of Als per UE, number of UEs that need to be simultaneously scheduled.  **Option 2:** Reduction of BDs reduces scheduling flexibility when scheduling multiple UEs. The ~~Scheduling~~ impact ~~by BD reduction~~ depends on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution, channel condition, number of Als per UE, number of UEs that need to be simultaneously scheduled. |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE,sanechips | Option 1. We have no strong view here.”the impact depends ...” seems not so clear, since which kind of impact may be missing. |
| vivo | *Option 1. The multiple factors as listed there are equally important.* |
| Spreadtrum | Option 1. |
| Huawei, HiSilicon | Option 1 is supported by us.  The first sentence in Option2 is not correct. There are observation agreed to see that there is no PDCCH blocking rate increase if DCI size budget is also reduced with the BD reduction. |
| MediaTek | Option 2 |
| NEC | Option 1 |
| Fraunhofer | Option 2 |
| Futurewei | Option 1 |
| Intel | Option 1  Did you intend to write “number of ALs per candidate”, not “number of ALs per UE”? |
| Ericsson | Option 2 (for Scheme #1)  To be more acceptable to other companies and to also capture the impacts of Scheme #1a (which is agreed to be captured as one of the alternatives in Friday’s GTW), we propose the following changes to Option 2:  **Option 2:** Reduction of BDs may reduce~~s~~ scheduling flexibility when scheduling multiple UEs. The ~~Scheduling~~ impact ~~by BD reduction~~ depends on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution, channel condition, number of Als per UE, number of UEs that need to be simultaneously scheduled, extent of DCI size budget reduction, etc.  In our understanding, both Option 1 and Option 2 reflect the impacts of Scheme #1. For Scheme #2, for instance, there can be significant impact on the scheduling flexibility depending on the value of *X*. Therefore, we suggest the FL to clarify this in the proposal/agreement. |
| Qualcomm | Option 1 |
| Samsung | Option 1 |

**Summary of 9th round email discussions**

Table below summarized companies positions on this issue:

|  |  |  |
| --- | --- | --- |
|  | Supportive companies | #of supportive companies |
| Option 1 | ZTE, Sanechips, vivo, Huawei, HiSilicon, NEC, Futurewei, Intel, Qualcomm, Samsung | 10 |
| Option 2 | MediaTek, Fraunhofer, Ericsson, | 3 |

Option 1 is clearly majority companies’ preference. FL intends to modify the description of Opt.1 to address concerns raised by proponents of Opt.2. One response indicates to clarify the number of ALs per UE or per candidates. The intention is ‘per UE’ as simulated by Table 8/9 on a per UE basis.

One response also suggests adding proposal/agreement to reflect the impact of scheme #2, which is not covered by current Opt.1 text proposal.

**[FL10] Proposal 8.2.3.2-1: Capture the following into TR 38.875 for section 8.2.3 for scheduling flexibility impacts.**

|  |
| --- |
| **Option 1:** Scheduling flexibility may or may not be impacted by BD reduction depending on multiple factors at least including BW, Subcarrier Spacing (SCS), CORESET size, AL distribution, channel condition, number of Als per UE, number of UEs that need to be simultaneously scheduled, DCI size budget reduction, etc. |

FL hope all of companies understand that we must move forward with majority preference to make progress, following 3GPP general rule. If we both stick to our own preference, no progress can be made regardless of extension of email discussion. Given the current situation, capturing ‘May or May not’ is the best way we can do as a neutral statement to include both, which is also the fact.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Sharp | Y |  |
| vivo | *Y* |  |
| ZTE,sanechips | Y |  |
| Huawei, HiSilicon | Y |  |
| Samsung | Y |  |
| Fraunhofer | Y |  |
| Qualcomm | Y |  |
| InterDigital | Y |  |
| Intel | Y |  |
| Futurewei | Y |  |

## 8.2.5 Analysis of specification impacts

**[FL9]** **Proposal 8.2.5-1: Capturing the following into TR 38.875 for section 8.2.5**

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

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

* **FL strongly stresses that please note that this is the last round of email discussion. Without consensus on this section may cause the incompletion of this study item.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| ZTE,sanechips | Y | A modification may be needed for the second paragraph if Proposal 8.2.1-2 is agreed. |
| vivo | Y |  |
| Spreadtrum | Y |  |
| Huawei, HiSilicon | Y |  |
| CATT | Y |  |
| MediaTek | Y |  |
| NEC | Y |  |
| Fraunhofer | Y |  |
| Futurewei | Y |  |
| intel | Y with minor change | * Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the limit on maximum number of PDCCH candidates, reducing the DCI size budget, modification to DCI size alignment rule and/or DCI format design, to minimize the PDCCH blocking rate impact.   Without ‘or’ , it may seem all of these impacts are jointly possible. |
| Ericsson | N | As a 5th bullet, the following should be added:  “If BD reduction/extension of the PDCCH monitoring gap is achieved using existing Rel-15/16 configurations without any specified restriction for RedCap, specification changes are not required.”  With this added bullet, we are fine with the text proposal, otherwise we cannot accept the proposal.  In the 4th bullet, we suggest a minor update:  - Additional specification impacts may include reducing DCI size budget, DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact and ~~avoid~~ network restriction. |
| Qualcomm | Y with minor modification | Minor updates are made to align with scheme #1 per slot BD limit and scheme #2 wording   * For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two consecutive slots with configured PDCCH candidates ~~PDCCH monitoring occasion~~ is increased ~~from 1 slot~~ to X>1 slots and X needs to be specified. * For dynamic adaptation of PDCCH BD parameters in connected mode, specification impacts may include mechanisms used to dynamically adapt PDCCH BD parameters e.g., maximum number of BDs per slot ~~PDCCH monitoring occasion~~ and minimum time separation between two consecutive slots with configured PDCCH candidates ~~PDCCH monitoring occasions~~. |
| Samsung | Y with minor change | In the first paragraph, the part about minimizing PDCCH blocking rate starting from reducing DCI size budget is redundant with the last paragraph, thus can be deleted.  The impact on minimizing PDCCH blocking probability is common to all candidate schemes.  Depending on the considered techniques, for scheme with reducing maximum number of PDCCH candidates, specification impact may include reducing the limit on maximum number of PDCCH candidates. ~~reducing the DCI size budget, modification to DCI size alignment rule and DCI format design, to minimize the PDCCH blocking rate impact.~~ |
| Qualcomm2 | Update | Similar to **[FL9]**Updated **Proposal 8.2.1-1:,** the 2nd and 3rd bullets can be updated   * For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two consecutive PDCCH monitoring occasions, spans or slots configured with PDCCH candidates is increased from 1 slot to X>1 slots and X needs to be specified. * For dynamic adaptation of PDCCH BD parameters in connected mode, specification impacts may include mechanisms used to dynamically adapt PDCCH BD parameters e.g., maximum number of BDs per PDCCH monitoring occasion, span or slot and minimum time separation between two consecutive PDCCH monitoring occasions, spans or slots configured with PDCCH candidates. |

**Summary of 9th round email discussions**

All responses except four responses indicated that FL proposal is acceptable for progress. Four responses indicate to modify the text proposals to make it clearer, which are intended to be reflected by the updated FL proposal below. One response proposed to add one more sentence, which was also added to check companies views on it.

**[FL10] Updated Proposal 8.2.5-1: Capturing the following into TR 38.875 for section 8.2.5**

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

**Can we add the following sentence into the proposal above for TR 38.875?**

|  |
| --- |
| “If BD reduction/extension of the PDCCH monitoring gap is achieved using existing Rel-15/16 configurations without any specified restriction for RedCap, specification changes are not required.” |

**Note that:**

* **If you support FL proposal with adding the sentence, please response with ‘Yes, with adding sentence’.**
* **If support FL proposal without adding the sentence, please response with ‘Yes, without adding sentence’. Also, please provide reasons why you think this sentence is not needed.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Sharp | Yes, without adding sentence | Because we think it is obvious. |
| vivo | **Yes, without adding sentence** | The reduction is about UE capability on BD budget, which is currently hardcoded in the specification. Specification shall be changed if the hardcoded UE capability is to be reduced. |
| ZTE | Yes, with adding sentence | A minor modification in the second paragraph may be needed as following:  “X needs to be specified” is modified as “X needs to be specified at least” |
| Huawei, HiSilicon | N | If the related description in scheme#1 is deleted, the ‘for multiple PDSCHs scheduling’ in the last paragraph needs to be deleted to keep it common. Otherwise, the original description in Scheme#1 should be kept.  The added sentence is not needed. |
| Samsung | Yes, without adding sentence | It’s obvious that RRC (re)configuration of search space sets in Rel-15/16 doesn’t change BD limit as the candidate schemes studied here.  RRC (re)configuration of PDCCH candidates is not designed/used for power saving purpose. It cannot guarantee the BD reduction as the candidate schemes studied.  Also, an editorial change needed. Replace “and” by “,” as follows.  Additional specification impacts may include reducing DCI size budget, modification to DCI size alignment rule ~~and~~, DCI format design for multiple PDSCHs scheduling |
| Fraunhofer | Yes, without adding sentence | We do not see a reason to add this sentence as this is obvious. |
| Qualcomm | Yes, without adding sentence | The new sentence is not correct because there is no guarantee that network will do the proper configuration and then there may not be any reduction. |
| InterDigital | Yes, without adding sentence |  |
| Intel | Yes, without adding sentence | As other companies mentioned, this is obvious and purpose of the text is to identify what specification impacts are expected if one of more of the evaluated schemes are adopted. So that sentence also seems out of context.  Minor suggestion for revising the last paragraph.  -Additional specification impacts may include **one or more of** reducing DCI size budget, modification to DCI size alignment rule and DCI format design for multiple PDSCHs scheduling, modification to PDCCH candidates dropping rule, to minimize the PDCCH blocking rate impact and network restriction.  Following is suggested to make the description of span-based monitoring more clear. Note that two consecutive MOs can be back to back within a slot. Based on previous version, it may be possible that someone could still interpret it wrongly even with the "1 slot" phrase in there, since the "1 slot" assumption is not quite consistent with the use of spans. The intention is to identify gap between MOs in consecutive spans.   * For Extending the PDCCH monitoring gap to X slots (X), the minimum separation between two ~~consecutive~~ PDCCH monitoring occasions inconsecutive spans or slots configured with PDCCH candidates is increased from 1 slot to X>1 slots and X needs to be specified. |
| Futurewei | N | We don’t fully understand why the “reducing the DCI size…” sentence was deleted? From our perspective, this is an important element that should be here, and from our recollection, was problematic to only one company  The 4th paragraph, in our view, should be removed, and the specification impacts should be listed for each paragraph.  No strong view one way or another for the additional sentence |

# 12. Conclusion

|  |
| --- |
| The PDCCH monitoring reduction for RedCap UEs has been studied. The study includes the evaluation of power saving benefit, system performance impacts, coexistence impacts, potential schemes and the corresponding specification impacts.  The power saving benefit by PDCCH monitoring reduction for RedCap UEs has been evaluated based on the agreed power model and traffic model, with the results and observations captured in section 8.2.2.  The system performance impact has been evaluated using PDCCH blocking rate as the metric, with the results and observations captured in section 8.2.3. In addition, scheduling flexibility and latency impacts have also been studied in Section 8.2.3.  Three candidate schemes for PDCCH monitoring reduction have been identified and studied with the corresponding coexistence and specification impacts captured in sections 8.2.4 and section 8.2.5, respectively.  Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) with minimized PDCCH blocking rate in Rel-17 to avoid the network scheduling impact. |

**[FL9] Q 12-1: Which of the paragraphs above can be captured into TR 38.875 clause 12 for conclusion?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE,sanechips | All the above paragraphs can be captured into the TR. |
| vivo | *All* |
| Spreadtrum | All |
| Huawei, HiSilicon | We would like to add the following revisions for the third paragraph and last paragraph to capture operators’ concern.  The third paragraph:  The system performance impact has been evaluated using PDCCH blocking rate as the metric, with the results and observations captured in section 8.2.3. In addition, scheduling flexibility and latency impacts have also been studied in Section 8.2.3. In section 8.2.3, It can be observed that some of the candidate solutions can provide 50% maximum PDCCH candidates reduction with 0% increment of PDCCH blocking rate.  The last paragraph:  Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) with ~~minimized~~ targets for zero increment of PDCCH blocking rate in Rel-17 to avoid the network scheduling impact. |
| LG | Firstly, the recommendation in the conclusion is too broad or abstract in this conclusion. We need to be more specific about what is recommended or not recommended.  From our perspective, the power saving gain less than 10% is not enough to recommend for RedCap WI, especially considering the small net gain over what we can achieve with the existing techniques and configurations to reduce the power consumption, and also considering the impact on the PDCCH blocking rate which is also not small.  We also think Scheme #2 and Scheme #3 are out of scope of this SI which are not relevant for recommendation in conclusion. Scheme #1 can be considered but the additional gain that can be achieved with Scheme#1 over what can already be achieved by existing Rel-15/16 network configuration is not clear.  Some companies mentioned that the power saving gain is very important in use cases such as wearables. But if you think about the LTE IoT, the extended (e.g., years of) battery life can only be achieved by the techniques such as extended DRX which has already been started in RAN2.  For those reasons above, from our perspective, it is hard to recommend to specify any of the new schemes from the RedCap SI in RAN1. Therefore we prefer to remove the last sentence. |
| CATT | All |
| MediaTek | Not the last sentence (i.e. recommendation of the schemes)  The power saving by BDs limit reduction can already be achieved using existing R15/16 configurations (e.g., PDCCH candidates and DCI sizes to monitor) without an impact to the system performance.  Also, with the existing mechanisms in R15/16 that can be used for power saving (e.g. cross-slot scheduling, larger PDCCH monitoring periodicity) the impact of the configured (or supported) PDCCH candidates on the power consumption is marginal (~1.6% for 30KHz as we shown in our results in R1-2008511). |
| NEC | All |
| Fraunhofer | All |
| Futurewei | The conclusion as proposed is too vague. We agree with changes proposed by Huawei.  For the last paragraph, in addition: schemes 2 and 3 are not within scope, thus need to be excluded. Thus, we propose to modify as follows:  Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) based on scheme 1 with ~~minimized~~ targets for zero increment of PDCCH blocking rate in Rel-17 to avoid the network scheduling impact.  Note: generally speaking, the power saving gains of blind decoding reductions are low. We would thus also be okay with the last paragraph stating that “*there is no consensus to recommend by RAN1 to specify PDCCH monitoring reduction scheme(s) with minimized PDCCH blocking rate in Rel-17”* |
| Intel | All. It would be great if we state the recommendation to be more inline with the description of the WID to make it more clear.  Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) to obtain smaller BD numbers, ensuring minimum system impact such as blocking rate increase is not significant. ~~with minimized PDCCH blocking rate in Rel-17 to avoid the network scheduling impact~~.  WID description:  Study UE power saving and battery lifetime enhancement for reduced capability UEs in applicable use cases (e.g. delay tolerant) [RAN2, RAN1]:   * Reduced PDCCH monitoring by smaller numbers of blind decodes and CCE limits [RAN1]. |
| Ericsson | 1st paragraph: OK  2nd paragraph: OK  3rd paragraph: partially OK (In our understanding, the scheduling flexibility impacts have only been captured for Scheme #1. This fact should be reflected. So, we suggest to simply add “for Scheme 1” in the end of this paragraph.  4th paragraph: OK (as a compromise)  5th paragraph: NOT OK. We have already provided detailed reasons in our earlier response on why PDCCH monitoring reduction should not be recommended. Therefore, we suggest to simply remove the last paragraph, or update it as follows: ~~Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) with minimized PDCCH blocking rate in Rel-17 to avoid the network scheduling impact.~~ There is no consensus in RAN1 to recommend specifying reduced PDCCH monitoring reduction scheme(s) in Rel-17.  We do not see a need to include the blocking probability results from one source company in the conclusion section. This doesn’t represent a full picture and risks being misleading. |
| Qualcomm | All |
| Samsung | All. |

**Summary of 9th email discussions**

The responses can be categorized as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Yes | | No | |
| Company | # of companies | Company | # of companies |
| 1st /2nd/3rd/4th paragraph | ZTE, Sanechips, vivo, Spreadtrum, CATT, NEC, Fraunhofer, Intel, Ericsson, Qualcomm, Samsung, Huawei (modification on 3rd sentence). | 12 |  |  |
| 5th paragraph | ZTE, Sanechips, vivo, Spreadtrum, CATT, NEC, Fraunhofer, Intel (With modification), Huawei/HiSilicon (with modification), Futurwei (With modification), Qualcomm, Samsung | 13 | LG, MediaTek, Ericsson | 3 |

To make progress, two proposals were formulated separately for the first four paragraphs and the 5th paragraph.

On the first four paragraphs, one response indicates to add the sentence “some of the candidate solutions can provide 50% maximum PDCCH candidates reduction with 0% increment of PDCCH blocking rate”. However, the conclusion clause typically provides a full picture of study, instead of focusing on one scheme as it has been clearly captured in the section 8.2.3. Hence, FL does not include this level of details in conclusion clause to keep all schemes with same level of description. One response indicates to add “for scheme 1” at the end of 3rd paragraph. However, as proposed earlier, the latest proposal is quite generally and can be applied for all schemes.

**[FL10] Proposal 12-1: Capture the following four paragraphs into TR 38.875 clause 12 for PDCCH monitoring:**

|  |
| --- |
| The PDCCH monitoring reduction for RedCap UEs has been studied. The study includes the evaluation of power saving benefit, system performance impacts, coexistence impacts, potential schemes, and the corresponding specification impacts.  The power saving benefit by PDCCH monitoring reduction for RedCap UEs has been evaluated based on the agreed power model and traffic model, with the results and observations captured in section 8.2.2. In addition, scheduling flexibility and latency impacts have also been studied in Section 8.2.3.  The system performance impact has been evaluated using PDCCH blocking rate as the metric, with the results and observations captured in section 8.2.3. In addition, scheduling flexibility and latency impacts have also been studied in Section 8.2.3.  Three candidate schemes for PDCCH monitoring reduction have been identified and studied with the corresponding coexistence and specification impacts captured in sections 8.2.4 and section 8.2.5, respectively. |

**Please comment paragraph by paragraph if you intend to say “No” on one of them. If no, please provide suggested modification that is likely to be accepted by other companies to move forward to complete study item on time.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Sharp | Y |  |
| vivo | *Y* |  |
| ZTE,sanechips | Y |  |
| Huawei, HiSilicon | Y |  |
| Samsung | Y |  |
| Fraunhofer | Y |  |
| Qualcomm | Y |  |
| InterDigital | Y |  |
| Intel | Y |  |
| Futurewei | Y with modification | At one point, we will have to capture that schemes 2 and 3 are not really within scope of the SID. The 4th paragraph seems to be a good place to do so by adding “Note: there was no consensus that schemes 2 and 3 were within the scope of the SID." |

On the 5th sentence, 9 responses indicate to accept FL proposal without change. Two responses indicate to emphasize ‘targeting to zero increment of PDCCH blocking rate’ as condition to specify PDCCH monitoring reduction scheme in Rel-17.

**[FL10] Q 12-2: Which of listed Option 1 and Option 2 can be captured the following four paragraphs into TR 38.875 clause 12 for PDCCH monitoring:**

|  |
| --- |
| Option 1: Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) to obtain smaller BD numbers, with target for zero increment PDCCH blocking rate in Rel-17 to avoid the network scheduling impact.  Option 2: There is no consensus in RAN1 to recommend specifying reduced PDCCH monitoring reduction scheme(s) in Rel-17. |

**If one option is preferred but needs some modification, please indicate it explicitly to add it into TR 38.875.**

* **For example, ‘Option 1, with following modification …” into comment column.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Sharp | Option 1 |
| vivo | *Option 1 with slight modification*  Option 1: Based on the study, it is recommended by RAN1 to specify PDCCH monitoring reduction scheme(s) to obtain smaller BD numbers, with target for ~~zero~~ minimized increment PDCCH blocking rate in Rel-17 to avoid the network scheduling impact. |
| ZTE,sanechips | Option1, with following modification.  On one hand, zero increment is totally unnecessary for some delay tolerant UEs. On the other hand, for some cases, the negligible increase,e.g.,0.01% is also acceptable. Therefore, we prefer the original version with “minimized increment” instead of “zero increment”. |
| Huawei, HiSilicon | Option1. We think it is ‘target for zero increment’. Therefore, ‘Zero increment’ is essential for the conclusion. |
| MediaTek | We support Option 2. The power saving by BDs limit reduction can be already achieved using existing R15/16 configurations (e.g., PDCCH candidates and DCI sizes to monitor) without an impact to the system performance.  Regarding the suggestions to have “minimized increment” in Option-1, this is very generic recommendation and every company will have its own understating of meaning of “minimized increment”. Thus, we are not supportive of such generic wording in general. |
| Samsung | Option 1 and support vivo’s modification.  Minimized PDCCH blocking is sufficient. |
| Fraunhofer | Option 1. Vivo’s suggestion seems reasonable to us. |
| Qualcomm | Option 1, agreed with companies that “zero increment” is too extreme and should be removed. Probably we can use “marginal increment”. |
| InterDigital | Option 1. Vivo’s change seems ok to us. Zero increment looks too strict. |
| Intel | Option 1 with modification.  In general, “zero increment” sounds neither practical nor inclusive of different schemes studied. It seems we are not recommending any specific scheme at this point. Vivo’s or QC’s suggestion is fine and looks more general. |
| Futurewei | Option 1 as proposed by FL. If we target zero and get 0.01% in the end it is OK as we still targeted zero, thus no need to modify FL wording. |