**[104b-e-NR-R17-PowSav-01] Email discussion on potential paging enhancements - Version 0.0.6**

**RAN1**

3GPP TSG-RAN1 Meeting # 104-bis-e

Electronic Meeting, April 12-20, 2021

R1-2103848 (feedback form part)

Agenda item: 8.7.1.1

Source: Moderator (MediaTek)

Document for: Discussion

# 1 Introduction

This NWM document is for collecting companies views with respect to the observation(s) and proposal(s) in the summary provided the following links:

**Table 1: Location of the reference summary files**

| | |
|---|---|
| 1st_Round | https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104 e/Inbox/drafts/8.7.1.1/1st_Round |
| 2nd_Round | https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104 e/Inbox/drafts/8.7.1.1/2nd_Round |
| 3rd_Round | https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104 e/Inbox/drafts/8.7.1.1/3rd_Round |

The following feedback forms will be based on the corresponding tables in the reference summary file and will be referred explicitly. The outcome of the NWM document will also be integrated as part of the final moderator summary.

# 2 1st Round of Email Discussion

## 2.1 Comparison of PEI Candidate Designs

### 2.1.1 Coexistence with Rel-15 Channels/Signals

The reference subsection is **Subsection 2.1** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

From companies' views in the reference subsection, Rel-15 multiplexing schemes can be utilized

(together with proper gNB handling if necessary) for PEI coexistence with Rel-15 channels. In particular, the following observation is suggested:

**Observation 1:**

For the coexistence between paging early indication with Rel-15 channels/signals, Rel-15 multiplexing schemes with gNB handling if necessary are summarized as follows (please refer to Proposal 1 of the reference summary if the following table/figure can be be shown properly):

| | General coexistence method | Coexistence with PDSCH of legacy UE | Coexistence with PDCCH of legacy UE | Coexistence with SSB |
|---|---|---|---|---|
| **PDCCH-based PEI** | A CORESET that can be shared with legacy UE | The Rel-15 supports the multiplexing CORESET with PDSCHs from different UEs. | The Rel-15 PDCCH design supports the multiplexing between PDCCHs from different UEs. | Follow Rel-15 behavior: UE is not required to monitor the PDCCH candidate colliding with SSB. |
| **SSS-based PEI** | Semi-static RB-level rate matching pattern | Based on UE capability #5-27, dynamic RB-level rate matching is an optional capability | Not defined in legacy specification for a new SSS based PEI and legacy UE's PDCCH, SSB and SIB1. Legacy UE cannot handle it.<br>gNB needs to carefully handle it. | |
| **TRS/CSI-RS-based PEI** | Semi-static RB-level rate matching pattern | Dynamic rate matching is mandatory feature. However only 3 aperiodic ZP-CSI-RS resource sets for one BWP are supported at most. | Legacy UE assumes reception of PDCCH/SSB regardless of whether they collide with ZP CSI-RS or not.<br>gNB needs to carefully handle it. | |

**Figure 1: Summary of PEI coexistence methods with Rel-15 channels/signals**

**Feedback Form 1: Companies' views for Observation 1, including support or not and any update to the summary table**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | Support |
| 2 | Nordic Semiconductor ASA | Thanks for nice summary. It is clearly specified that NZP CSI-RS shall not be configured on top of CORESET resource. But for ZP CSI-RS, our understanding is that collision of ZP CSI-RS and CORESET is not specified. Please correct me if I am wrong. |
| 3 | CATT | We think the table is kind of misleading. For TRS/CSI-RS coexistence with PDSCH of legacy UE, only one ZP-CSI-RS resource is needed for dynamic rate matching by DCI format 1_1 for TRS/CSI-RS TEI. Current specification with up to 3 ZP-CSI-Rs resources per BWP is more than enough. For coexistence with PDCCH of legacy UE and SSB, both DCI based and sequence based PEI have rate matching mechanism for the configured CORESET since Rel-15. The statements in the table for SSS-based and TRS/CSI-RS based PEI are quite misleading. In conclusion, we don't agree with the observation in current form since they are misleading and biased toward DCI-based PEI. |

| Item | Company | Comments |
|---|---|---|
| 4 | Samsung Research America | 1) We think there is no need to capture the table for the details of existing multiplexing method. The important observation to draw is whether or not there is any coexistence issue, such that whether or not gNB needs to reserve all configured REs when PEI is not transmitted.<br>2) In our view, there is no rate matching issue for any of the candidate design. In addition to Rel-15 rate matching schemes, we think power boosting can also be considered to help utilize the reserved REs for PEI when not occupied. They are not many as a % of the total frequency resources and a NW can always easily use empty REs to boost power (up to 3 dB, if the reserved REs are 50% of the REs in a symbol, is easy).<br>3) However, for PDCCH-based PEI, PDCCH blocking for legacy UEs during initial access is an issue when the CORESET can be shared with legacy UEs. This should be captured as an coexistence issue. |
| 5 | Intel K.K. | We also think the table is misleading and biased towards PDCCH based PEI. A certain coexistence method is assumed as general gNB implementation, which is concerning given the fact that dynamic RM can be used for both SSS and TRS based PEI and gNB is not prohibited to use any UE transparent method for coexistence. For fair overview, we suggest to list different semi static and dynamic handling of coexistence that can be used. We suggest to remove the column on "general coexistence method".<br><br>We would like to highlight two important factors here:<br>- Unavoidable collisions between PEI and PDSCH are not expected to be typical for usual paging rates (especially in context of Behv.A).<br>- Even when they may collide, unless the PDSCH code rate is high, performance difference from transmitter-side puncturing when compared to rate-matching is not significant. As a consequence of the above, the overall impact to DL cell spectral efficiency or user throughput will be minimal even when not using rate-matching.<br><br>We suggest following updates to the table and capture the Observation as follows:<br><br>**Observation 1: According to Rel-15 methods, gNB is not mandated to reserve resources for sequence or PDCCH-based PEI transmission for coexistence with legacy signals/channels.**<br><br>(A Table could not be inserted here. We share the proposed revision to the table in the email) |
| 6 | Ericsson India Private Limited | OK with observation 1.<br>Coexistence should be captured as an advantage for PDCCH-based PEI because multiplexing PEI with legacy UE's PDCCH is already supported. Sequence-based designs will impact legacy UEs since they may not support or may not have knowledge to rate-match around these resources. |

| Item | Company | Comments |
|---|---|---|
| 7 | Apple Italia S.R.L. | [Apple] We have a few comments on the table:<br>(1) it is not clear to us what "general coexistence method" intends to cover. Isn't it sufficient already to have the other 3 columns?<br>(2) The column for coexistence with PDSCH looks fine to us. They are stating what is currently supported.<br>(3) On the coexistence with PDCCH and SSB, the message seems a bit unclear. Even for PDCCH-based PEI, we think it is still up to the gNB implementation to avoid the collision of PEI with other PDCCH or SSB. |
| 8 | DOCOMO Communications Lab. | We are fine with observation 1. |
| 9 | Qualcomm Technologies Int | CORESET based dynamic rate matching is also applicable to SSS-based PEI if the SSS is fitted into the bandwidth and symbol duration of a CORESET. |
| 10 | HiSilicon Technologies Co. Ltd | We support the observation, which reflects the coexistence of PEI with other legacy physical layer channel/signal of legacy UE. Also, we don't agree with some companies that no need to capture the table. The table is finishing our work as agreed in RAN1#104bis, and it is the input of resource overhead evaluations.<br>Agreements:<br>For the evaluation and comparison of PEI candidate designs, companies to report<br>• Description of how PEI design can co-exist with existing channels/signals, and impact to legacy UEs.<br>– Rel-15 designs for multiplexing PEI with legacy channels/signals are assumed as baseline<br>– Other multiplexing method with legacy channels/signals can be additionally reported with justification<br><br>Some further comments on the reply from some companies:<br>1) ZP-CSI-RS resource set is used for CSI measurement, interference measurement etc. and it is already very limited in deployment. Several network vendors raised this concern.<br>2) The puncturing of REs always introduces degraded performance, and that is why we introduce rate matching mechanism in Rel-15. We are also not sure whether the power boosting can work well considering power boosting on some of symbols of PDSCH, e.g. symbols with or without DMRS, may impact the channel estimation and demodulation performance. |

| Item | Company | Comments |
|---|---|---|
| 11 | ZTE Corporation | [ZTE, Sanechips]<br>We support the observation 1. And we think the observation is important and should be capture for the comparison of the three PEI candidates.<br>Regarding the comment on the number of ZP-CSI-RS, we don't think one ZP-CSI-RS resource for rate matching is sufficient. We need to keep it in mind that ZP-CSI-RS based rate matching is not solely designed for potential TRS-like PEI transmission. It is specified in Rel-15 and used for other purposes, such as interference management,etc.<br>Besides, we need to note that the periodicity (or interval) of the potential TRS-like PEI transmission occasion(s) may not be consistent with the legacy periodicity of ZP-CSI-RS. Hence, whether one ZP-CSI-RS resource/legacy RM pattern for TRS-like PEI is enough or not is questionable. There is a similar issue for SSS-like PEI.<br>Moreover, the dynamic rate matching indicator is carried by such as DCI format 1-1, not fallback DCI format 1-0. It means if the PDSCH is scheduled by fallback DCI, the current dynamic RM indication is not applicable, only semi-static RM mechanism can be used. Hence, the resources allocated to sequence-like PEI need to be reserved from network scheduling perspective.<br>In addition to PDCCH or PDSCH, the co-existence with other signals also needs to be considered. Specially, the RM indicator is only applicable for PDSCH mapping, new solutions are needed to handle the case that the sequence-based PEI may collide with other DL signals (such as SRS for CLI measurement, Positioning RS, etc) |
| 12 | vivo Communication Technology | The table is not sufficiently and accurately described and may lead to some misleading.<br>(1) for SSS coexistence with PDSCH, serverla approaches can be soncisdered with very limited system level impact in terms of spectrum effiency, such as,<br>• dynamic RB-level rate matching,. ALthough it is optional for some UE, from system perspective, the overall system throughput may not be impacted.<br>• gNB can properly schedule the resources to make sure the resource for the SSS-like sequence is orthogonal to legacy signals and channels.<br>• Also as DocoMo commented, CORESET based dynamic rate matching is also applicable to SSS-based PEI.<br>(2) for SSS coexistence with PDCCH and SSB, we do not agree with the observation. gNB does not nessasry to configure the PEI collied with PDCCH and SSB. gNB can properly schedule the resources to make sure the resource for the SSS-like sequence is orthogonal to legacy signals and channels. We think it might not be a typical issue. |
| 13 | LG Electronics Inc. | we are fine with observation 1. |

| Item | Company | Comments |
|---|---|---|
| 14 | MediaTek Inc. | It is understood the intention of Observation 1 is to capture a matrix of how different PEI candidate designs can coexist with existing channels/signals based on Rel-15 specification. Because it is objective specification check, we are supportive to Observation 1 and would like to suggest adding references of the relevant specifications for ease of companies' detail check.<br>Regarding TRS-based PEI, it should be noticed that Rel-15 UEs support dynamic rate-matching indication via **only DCI format 1_1**. For UE receiving PDSCH scheduled by **DCI format 1_0** or PDSCHs with SPS activated by DCI format 1_0, **the UE assumes that REs corresponding to configured resources in *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList* are available for PDSCH** (Sec. 5.1.4.2 TS 38.214). Such limitation will cause **performance impact to (cell-edge) UEs** and should be captured in the table.<br>Regarding other coexistence method(s) **not** based on Rel-15 specification, it highly depends on gNB implementation and should not be assumed always achievable. Current table with further updates strictly based on Rel-15 specification should be the best way forward for consensus. |
| 15 | Nokia Germany | We support the observation 1 and as noted by others we think that it is needed. Also as said in last meeting, we think it is important to understand how the particular PEI design affects the system operation in a case when other users are present in the system and if the given PEI design results in restrictions to the scheduling |
| 16 | PANASONIC R&D Center Germany | 1. In general, all three candidates for PEI design have no substantial issue to coexist with legacy UEs, at least by semi-static configuration, and/or dynamic symbol and RB level rate matching.<br>2. Regarding the TRS/CSI-RS based PEI, it has also advantage to be potentially CDMed with CSI-RS configured for CONNECTED UEs, which should be mentioned. |
| 17 | Guangdong OPPO Mobile Telecom. | Support the observation 1. |
| 18 | InterDigital Communications | We agree with several other companies that this observation may be a bit misleading. The impact of puncturing/rate matching would be negligible for practical paging rates. gNB can use some transparent methods such as power boosting to compensate for the loss. Also, we believe coexistence for both SSS and TRS is possible using some of the already raised methods. Finally, blocking for PDCCH based method should be captured. |

From companies' inputs to Feedback Form 1, we suggest to reference the Rel-15 specification as much as possible and clarify additional assumption(s) on gNBs or UEs if required. In this way, there can ensure minimum disagreement, and the following updated Observation 1a is therefore proposed for further checking companies feedback:

**Observation 1a**:

For the coexistence between paging early indication with Rel-15 channels/signals, Rel-15 multiplexing schemes with additional gNB handling, if necessary, are summarized as follows:

| | Coexistence with PDSCH | Coexistence with PDCCH | Coexistence with SSB | Suggested Coexistence Design |
|---|---|---|---|---|
| **PDCCH-based PEI** | [Sec. 5.1.4.1 TS 38.214]<br>✓ Semi-static rate-matching<br>? Dynamic rate-matching<br>- Based on UE capability #5-27 which is **optional** [TR 38.822]<br>- Based on DCI format 1_1 only, and UE assumes the rate-matched REs are not available for PDSCH by DCI format 1_0 | [Sec. 10 TS 38.213]<br>✓ Transparent to Rel-15 UEs by virtue of mandatory support of blind decoding | [Sec. 10 TS 38.213]<br>✓ Rel-15 UEs is not required to monitor the PDCCH candidate colliding with SSB. | Coexistence with PDCCH |
| **SSS-based PEI** | | UE behaviour is not defined in Rel-15 specification. **gNB should avoid resource conflict**. | | Coexistence with PDSCH |
| **TRS/CSI-RS-based PEI** | [Sec. 5.1.4.2 TS 38.214]<br>✓ Semi-static rate-matching<br>? Dynamic rate-matching<br>- Based on UE capability #2-33a which is mandatory [TR 38.822]<br>- Based on DCI format 1_1 only<br>- UE assumes the rate-matched REs are **available** for PDSCH by DCI format 1_0, and **gNB should avoid resource conflict**. | UE behaviour is not defined in Rel-15 specification. **gNB should avoid resource conflict**. | | Coexistence with PDSCH |

**Figure 2: Rel-15 multiplexing schemes for PEI coexistence with Rel-15 channels/signals**

Companies please provide views in the following Feedback Form for Observation 1a:

**Feedback Form 2: Companies' views on Observation 1a, including support or not and any suggested revision**

| Item | Company | Comments |
|---|---|---|
| 1 | Nordic Semiconductor ASA | Thanks Weide for update, looks good. However, still it is a bit unclear what is meant by "suggested coexistence design". What one wants to capture is that (i) R17 PDCCH can coexist with both R15/R16 PDSCH and PDCCH. (ii) R17 SSS/TRS can coexist with R15/R16 PDSCH only. In other words, gNB must make sure that does not configure some R15/R16 UE's CORESET on top of TRS/SSS PEI. |
| 2 | Motorola Mobility UK Ltd. | We don't think there is any rate matching/coexistence issue for any of candidate designs. |

| Item | Company | Comments |
|---|---|---|
| 3 | Samsung Research America | We have the following comments.<br>1) We think power boosting by gNB implementation can be reasonably assumed to use empty REs in addition to Rel-15 multiplexing schemes. It should be captured.<br>2) Even though Rel-15 UEs is not required to monitor the PDCCH candidate colliding with SSB, the gNB still has some burden to avoid conflict. (otherwise, PDCCHs cannot be received. A note to capture the system impact is necessary.<br>3) PDCCH blocking rate can increase when PDCCH-based PEI coexists with legacy PDCCH. A note to capture the system impact is necessary.<br>4) Rel-15 TRS/CSI-RS has the PDCCH/SSB coexistence issue – the gNB anyway has to avoid resource conflict, that is not a new thing. |
| 4 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>We think the current table is not clear compared with the proposed table in the first round. We think only listing the UE capability does not really give the answer to the coexistence issue. In our view, the key point of PDCCH based PEI is that a CORESET that is shared with PDCCHs of legacy UEs can be configured, and therefore, the introduction of PDCCH based PEI shall not create new coexistence cases and gNB just reuse Rel-15 mechanism to handle the PDCCH PEI and other PDCCHs in the shared CORESET.<br><br>Differently, SSS-based PEI is basically a new downlink physical layer channel, which is not visible by legacy UE. This creates new coexistence issue for gNB to handle the transmission of SSS based PEI and other channels. Even, as Qualcomm commented, if a **dedicated** CORESERT and **dedicated Search space set** are configured as a rate matched pattern, gNB needs to additionally handle the coexistence of the dedicated CORESET and PDSCHs. Furthermore, if dedicated CORESET and dedicated search space set are configured just for rate matching of SSS-based PEI, CORESET and search space set budget are wasted. And the legacy UE may need to waste the power on the channel estimation, blind detection in the configured CORESET and search space set. This is in our view also not reasonable to have impact on the power consumption of legacy UE.<br><br>Therefore, we should at least split PDCCH based PEI and SSS based PEI, and capture above points.<br><br>For TRS based PEI, we would like to emphasize again that the number of ZP-CSI-RS resource set is limited, and it is expected from network perspective that there is no available ZP-CSI-resource set used for PEI rate matching.<br><br>We have concerns on the power boosting, which we have already shown our concern in the reply in the last round.<br>We made the following updates based on Weide's update(Please see my reply in email reflector of [104b-e-NR-R17-PowSav-01]). |

| Item | Company | Comments |
|---|---|---|
| 5 | ZTE Corporation | [ZTE, Sanechips]<br>Thanks for the updated proposal.<br>(1)We are also confusing about the column “suggested co-existence design”.<br>(2)We also agree that the co-existence with PDSCH for PDCCH based PEI and SSS-like PEI are basically quite different. For SSS-like PEI, a dedicated CORESET and search space need to be configured to be matched with the transmission occasion of PEI. The side effect of handling the collision is that it increases UE blind detection times with the “fake” CORESET and search space. While for PDCCH based PEI, we think it is naturally supported by the legacy spec. Hence, we agree with Huawei that these two rows should be decoupled.<br>(3)Regarding the increase of UE blocking rate,we don’t think it is unique for PDCCH based PEI, we believe it also applies for the sequence based PEI (either SSS-like or TRS-like)when the resources are collided.<br>(4)For the power boosting part, we don’t think it is always possible considering the power continuity between the DMRS and corresponding data. For example, the DMRS of PDSCH is not allocated with the same symbol with PDSCH, while the DMRS of PDCCH can be wide-band or sub-band. Hence, the resource collision between PEI+ data and PEI+DMRS may be different.<br>(5) Regarding the note “same as for Rel-15 TRS/CSI-RS”, I am not sure what is the same with legacy mechanism considering it would be a new signal anyway. |
| 6 | Intel K.K. | We still have concern on the updated table. Purpose of the column ”suggested coexistence design” is not clear. It is clear from the three other columns that co-existence with PDCCH, PDSCH, SSB could happen in a slot for each candidate.<br><br>Moreover, for SSS and TRS-based PEI, description ”UE behavior is not defined in Rel-15 specification. gNB avoids conflict” should be limited to coexistence with SSB only. It should not apply to coexistence with PDCCH. ”Transparent to Rel-15 UEs by virtue of mandatory support of blind decoding” applies to SSS and TRS-based PEI as well for coexistence with PDCCH. In other words, if gNB decides to send sequence based PEI not PDCCH, then legacy UE would do blind decoding as usual and would not receive PDCCH, and this behavior is no different than using PDCCH based PEI.<br>Since this tables intends to capture possible gNB mechanism for coexistence, other UE transparent method such as puncturing should also be included. |

| Item | Company | Comments |
|---|---|---|
| 7 | Sony Europe B.V. | Thanks Wiede for the update, we have the following comments:<br>• It is not clear what it is meant by "Suggested Coexistence Design" added to the last column.<br>• When it comes to coexistence of SSS-based (and TRS/CSI-RS-based) PEI with PDCCH and SSB, we suggest the following modification (find it in red): "…**gNB should avoid resource conflict, and FFS the possible spec impact**." LTE can smoothly accommodate the inclusion of WUS (SSS-based) for MTC and NB-IoT, we would expect it will be similar for NR. Additionally, PDCCH-based PEIs increase blocking rate of the legacy PDCCH and also the power saving gain is still questionable considering the UE needs to be in synch and its receiver needs to operate in its full functionality. |
| 8 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>1. Regarding Toufiq's addition of "where rate-matching granularity is at the CORESET level which can occupy much more resource than a candidate", I need to repeat my comment that PDCCH based PEI can share CORESET with other PDCCHs of other UEs. The PDCCH based PEI just occupies one of the PDCCH candidate in the shared CORESET and the PDCCH candidates can be shared by different UEs in the CORESET. The resource overhead is very limited (anyway we will discuss on the resource overhead later in other observation). There is no new co-existence problems compared with legacy system. We cannot agree on the addition from Toufiq on this.<br>2. Regarding the change of "Transparent to Rel-15 UEs by virtue of mandatory support of blind decoding" for SSS-based PEI and TRS-based PEI for the coexistence with PDCCH. I share similar concern with Spreadtrum. We know clearly how SSS and TRS are defined in the specification. We don't think a SSS-based PEI or a TRS-based PEI can be put as a PDCCH candidate. We should keep the original wording of "UE behaviour is not defined in Rel-15 specification. **gNB should avoid resource conflict**." for the coexistence of SSS-based PEI/TRS based PEI with PDCCH of legacy UE.<br>3. Regarding the implementation of power boosting and puncturing, we have shown our concern and not sure whether it can work. We agree with Moderator and other companies this unclear gNB implementation should not be captured.<br>4. Furthermore, Nokia and Huawei/HiSilicon commented online that the cell search and neighbor cell measurement on legacy UE shall be impacted if SSS-based PEI is introduced. We should also capture this in the table or somewhere else. |

### 2.1.2 Paging Detection Performance Check

The reference subsection is **Subsection 2.2** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

From companies' results, all PEI candidate designs can achieve better paging indication performance than paging PDSCH performance given sufficient physical resource amount and proper trade-off with

subgroup indication capacity. The following companies further show there requires new multi-symbol format for SSS-based PEI:

Multi-symbol format required for SSS-based PEI (7): HW/Hi-Silicon, vivo, ZTE, CATT, MTK, QC, Samsung

In the regard, the following observation is suggested:

**Observation 2**:

PEI candidate designs based on PDCCH, SSS and TRS/CSI-RS can all achieve better paging indication performance than paging PDSCH performance given sufficient physical resource amount and proper trade-off with UE (sub)group indication capacity.

For PDCCH-based PEI and TRS/CSI-RS-based PEI, Rel-15 channel/signal can be reused.

For SSS-based PEI, 7 companies show new multi-symbol format is required.

**Feedback Form 3: Companies' views for Observation 2, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | Support. It is an assumption of evaluation |
| 2 | CATT | The conclusion is not clear. The critical element is to list the required number of REs for DCI-based and sequence-based PEI to achieve better performance than that of PDSCH. In addition, the assumption of residual errors for imperfect channel compensation for PEI, paging DCI and PDSCH should also be captured in the conclusion. In CATT's study, we found out that the residual frequency error for PDSCH is much smaller than that of paging DCI and PEI since the additional frequency offset will be corrected after each detection of PEI and paging DCI. |
| 3 | CATT | We believe the observation is misleading. The assumption and required number of REs to achieve PEI misdetection had been shown by most companies. It would be better to show the observation in scientific way with number of REs required for each candidates. |
| 4 | Sony Europe B.V. | Support |
| 5 | Samsung Research America | Not support. The observation is too broad, and doesn't provide much useful information to tell the performance difference. It's necessary to capture the results in terms of minimum required REs for each candidate design and corresponding assumptions agreed in last meeting. |

| Item | Company | Comments |
|---|---|---|
| 6 | Intel K.K. | This proposal does not provide much context. In the agreement related to MDR performance check, we have the following captured and it is expected that Observation would reflect the numbers reported by the companies.<br><br>· Companies to provide:<br>o Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)<br>o The required #REs to comply with the performance assumptions<br>o The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions |
| 7 | Ericsson India Private Limited | OK with observation 2. |
| 8 | Apple Italia S.R.L. | [Apple] Observation 2 is generally fine with us. |
| 9 | Beijing Xiaomi Mobile Software | Fine with this observation. |
| 10 | Qualcomm Technologies Int | It might be worth clarifying that SSS-based design mainly means:<br>• The PEI is narrow band (within 12RBs)<br>• Tone spacing is 1<br><br>It does not have to mean that a SSS sequence is transmitted. So we do not think it is a new SSS with multiple symbols, but it is just a multi-symbol narrow band signal. This narrow bandwidth may allow UE to further reduce power consumption by using the same narrow band hardware with potential limited baseband upgrade, without activating the wideband hardware as required by PDCCH and CSI-RS based PEI. |
| 11 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>We support the observation. Regarding the number of REs of link level simulation, it is just intermediate results for the input of evaluation on resource overhead. We don't see a need to have observations on the detailed number of REs of link level simulation. |
| 12 | ZTE Corporation | [ZTE, Sanechips]<br>We support the observation 2. We think the observation reflects companies' simulation results. If companies are interested in the detailed simulation assumptions, such as the number of REs, they can always check it out with the submitted contributions. |

| Item | Company | Comments |
|---|---|---|
| 13 | vivo Communication Technology | We think the observation need to be more accurate in terms of the followings,<br>(1) # of REs used for each alternative when perform link-level simulation,<br>(2) Alt 1 or Alt 2<br>(3) associated subgroups or POs with the PEI |
| 14 | LG Electronics Inc. | we are fine with observation 2. |
| 15 | MediaTek Inc. | Observation 2 captures basic facts from companies' contributions where **sequence-based PEI shows quite diverse performance results**. However, as per chair's guidance, it is useful to capture more quantitative results to better align companies' understanding.<br>For the candidate design(s) with diverse performance results, we suggest to capture the proponents' simulation and detection algorithm assumptions so as to clarify the feasibility. It is also noticed that RAN4 hasn't defined any performance test for SSS or TRS detection, and there is risk PEI design based on SSS or TRS has no common performance ground for RAN1 specification. |
| 16 | Nokia Germany | We support the observation 2. |
| 17 | PANASONIC R&D Center Germany | It is preferable to include the overhead and assumption Alt.1/Alt.2 and Behv-A/B to have a clearer picture. |
| 18 | Guangdong OPPO Mobile Telecom. | Support the observation 2.<br><br>The PEI candidate designs can all achieve the required performance via the appropriate simulation assumptions. We should consider other aspects, such as standard impact, compatibility, etc. |
| 19 | InterDigital Communications | We believe 1 symbol SSS is sufficient for the required performance and 2 symbol may further improve the performance. |

### 2.1.3 Resource Overhead

The reference subsection is **Subsection 2.3** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

From companies' results, the following statistics on which PEI candidate design achieves the lowest average resource overhead per PO can be collected:

**Table 2: Companies' views on which PEI candidate design achieves the lowest average resource overhead per PO**

| | |
|---|---|
| PDCCH-based PEI | (5 companies) HW/HiSilicon, OPPO, ZTE, MTK, Ericsson |
| SSS-based PEI | (3 companies) vivo, CATT, QC |
| TRS-based PEI | (2 companies) CATT, Samsung |
| Comparable | (1 company) Spreadtrum |

Accordingly the following observation is suggested:

**Observation 3**:

Comparing average resource overheads per PO for PDCCH-based PEI, SSS-based PEI and TRS/CSI-RS based PEI,

5 companies show PDCCH-based PEI achieves the lowest overhead,

3 companies show SSS-based PEI achieves the lowest overhead,

2 companies show TRS/CSI-RS-based PEI achieves the lowest overhead, and

1 company show the three candidate designs achieve comparable overheads

**Feedback Form 4: Companies' views for Observation 3, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | Support |
| 2 | Nordic Semiconductor ASA | Regarding PDCCH overhead, it seems to be dependent on (i) whether 12bit or 41bit PDCCH is assumed (ii) whether PEI may indicate wake-up for more than one PO (iii) whether PEI could be carrier in reserved bits of other UE group Paging DCI -> This means that overhead depends on final design and for the comparison of PDCCH, TRS, SSS the most efficient design for given type of signal/channel should be selected. |
| 3 | CATT | A lot of companies show the absolute number of REs for overhead calculation in achieving the desired miss-detection performance. We suggest that the overhead is presented with a table of number of REs for DCI-based and sequence-based PEI from each company's contributions. The current format does not show the scientific values for overhead calculations. |

| Item | Company | Comments |
|---|---|---|
| 4 | CATT | We do NOT agree on the observation. The resource overhead should be captured in scientific way, such as number of REs. Several companies had provided the link level detection performance results based on number of REs for SSS, TRS/CSI-RS and PDCCH with different aggregation levels. A table of number of REs required to achieve the demanding miss-detection performance should be captured as the resource overhead. |
| 5 | Samsung Research America | During the GTW today, companies mixed the idea of discussing assumption and capturing the observation with corresponding assumptions. We spent much time discussing the assumptions in last meeting, no need to repeat that. But, in order to do comprehensive comparison between the three candidate designs, it's necessary to capture the corresponding assumptions we discussed in last meeting, such as whether Behav-A or Behav-B is assumed, Whether and how coexistence with legacy UEs is considered, and etc. |
| 6 | Intel K.K. | Without aligning assumptions, we are not sure how this observation can be useful. For example, one company assumes PDCCH based PEI associates to multiple PO, and sequence-based PEI assumes 1to 1 PO. Resource overhead should be captured in number of REs and we have observed TRS achieves lowest overhead for meeting a given MDR target. SSS can also achieve similar performance. We have not agreed any formula for calculating average resource overhead, such as including multiple PO association. |
| 7 | Ericsson India Private Limited | OK with observation 3. |
| 8 | Apple Italia S.R.L. | [Apple] Even though Observation 3 may be simply stating the fact, it is not clear to us how this observation is useful and can help us progress. The assumptions behind these evaluations are too different to be compared in a meaningful way in this format. |
| 9 | Beijing Xiaomi Mobile Software | [Xiaomi] Agree with Apple |
| 10 | DOCOMO Communications Lab. | We agree with observation 3. |

| Item | Company | Comments |
|---|---|---|
| 11 | Qualcomm Technologies Int | It is hard to say whether the comparison is meaningful or not without further looking at some details:<br>• How multiple sequences are multiplexed for indicating multiple UE subgroups<br>• Rate matching of sequences<br>• Besides, it should be clarified whether for PDCCH-based PEI, a CORESET rate matching is assumed, or rate matching only around the PDCCH is assumed. |
| 12 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>We support the observation.<br>Some further detailed comments:<br>1) Some companies who showed lower overhead of SSS based PEI assumes dynamic rate matching, which is not correct. The realistic coexistence mechanism needs to be considered in the evaluation for resource overhead evaluations.<br>2) The number of A-ZP-CSI-RS resource set number is limited to 3. In our view, only static configured rate match pattern could be used. And at most one ZP-CSI-RS resource set can be used, which would impact the occupation probability significantly. This was not considered by the two companies showing lower resource overhead of TRS based PEI. |
| 13 | ZTE Corporation | [ZTE, Sanechips]<br>We support the observation 3. We think it reasonable to draw the conclusion that PDCCH based PEI occupies the lowest resource overhead considering the flexibility to carry more information |
| 14 | vivo Communication Technology | [vivo]It is more meaningful to list the assumptions when draw conclusion. At least based on our assumptions, the results is as follows,<br>SSS = TRS < PDCCH, and this is true for the following assumptions<br>• For behavA and 1 PEI associated with 1 PO, PO rate =10%<br>• For behavA and 1 PEI associated with 4 PO, PO rate =10%<br>• For behavB and 1 PEI associated with 1 PO, PO rate =10%<br>• For behavB and 1 PEI associated with 4 PO, PO rate =10% |
| 15 | LG Electronics Inc. | We are fine with this observation. |
| 16 | Nokia Germany | We are OK with this observation. |
| 17 | PANASONIC R&D Center Germany | It is preferable to include the overhead and assumption Alt.1/Alt.2 and Behv-A/B to have a clearer picture. |

| Item | Company | Comments |
|---|---|---|
| 18 | PANASONIC R&D Center Germany | With diversified assumptions, this may not provide sufficiently helpful information |
| 19 | MediaTek Inc. | ETo capture more specific observation for resource overhead, we can base on the conditions of performance observation and coexistence observation. In addition to both dimensions, whether one PEI can indicate multiple PO should be additionally included. On the other hand, if the product space of all dimensions becomes too wide, we can select some cases, e.g., corresponding to the best and worst average resource overheads per PO. |
| 20 | Guangdong OPPO Mobile Telecom. | OK with the observation 3.<br>Maybe we need a unified calculation method on the overhead by the different assumptions provided by companies. |
| 21 | InterDigital Communications | We agree that the without having an agreed set of assumptions, it would be difficult to compare the resource overhead. We showed that SSS has the lowest overhead, so the list of companies needs to be updated. |

### 2.1.4 UE Power Saving Gain

The reference subsection is **Subsection 2.4** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

For the UE power saving gain comparison, the following statistics can be collected:

**Table 3: Which of the PEI candidate designs can achieve better UE power saving gain**

| | |
|---|---|
| All comparable | (5 companies) Spreadtrum, ZTE, MTK, Xiaomi, Apple |
| Sequence-based PEI | (3 companies) vivo, CATT, Samsung |
| PDCCH-based PEI | (1 company) Nokia |

The following observation is therefore suggested:

**Observation 4**:

Comparing UE power saving gains with PDCCH-based PEI and sequence-based (SSS-based or TRS-based) PEI,

5 companies show the UE power saving gains are comparable,

3 companies show better UE power saving gain with sequence-based PEI, and

1 company shows better UE power saving gain with PDCCH-based PEI

**Feedback Form 5: Companies' views for Observation 4, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | Support |
| 2 | Nordic Semiconductor ASA | Power gains are all highly dependent on assumptions. Instead we suggest to identify what are the power saving mechanism, and whether PDCCH/TRS/SSS can facilitate those.<br>For example, as we pointed out, one power saving mechanism is reduction of number of SSBs UE must read before PO, the other power saving mechanism is coming from the fact that UE only monitors for signal/channel, which consumes less than when UE monitors also PDSCH. These two power saving goals can be achieved by PDCCH based PEI. |
| 3 | CATT | We have shown the assumptions and power saving gain results for both DCI-based and sequence-based PEI. In order to show a comparable results, we need to align the assumptions for power saving gain. We have questions of the power saving gain results R1-2103405, which shows the higher power saving gain for DCI-based PEI comparing to that of sequence-based PEI. The number of SSB required for DCI-based PEI for low and middle SINR is 2 and 3 respectively comparing to 1 for sequence PEI. It is counter intuitive to have higher power saving gain for DCI-based PEI with shorter deep sleep and coherent detection comparing to that of longer deep sleep and non-coherent detection of sequence-based PEI. |
| 4 | Sony Europe B.V. | Sony supports sequence-based PEI (but Sony has not been included in observation 4). |
| 5 | Samsung Research America | The observation doesn't provide any meaningful information. More concrete results including the exact power saving gain and corresponding assumptions should be provided for different observations. So we can understand the proper use case for each design and performance difference before doing down-selection. |
| 6 | Intel K.K. | We also explained in our paper that if sequence-based PEI can help in tracking, further power saving gain can be observed. Difference can be large or small, depending on assumptions, such as how many SSBs are skipped and/or paging rate. |
| 7 | Ericsson India Private Limited | OK with Observation 4. |

| Item | Company | Comments |
|---|---|---|
| 8 | Beijing Xiaomi Mobile Software | [Xiaomi] Same comment as overservation 3 |
| 9 | Qualcomm Technologies Int | For SSS-based/RS-based PEI design, power saving by only activating a small part of the hardware (i.e., front end) cannot be evaluated based on current power model.<br>For SSS-based PEI design, power saving gain by only activating the narrow band hardware cannot be evaluated for the same reason.<br>The comparison result is kind of misleading due to the limitation of power modeling. |
| 10 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>Support the observation 4.<br>we also share the view that power saving gains are comparable for the three candidates as the five companies. |
| 11 | ZTE Corporation | [ZTE, Sanechips]<br>We support the observation 4. We think it reasonable to draw the conclusion that PDCCH based PEI and sequence based PEI have comparable power saving gain. |
| 12 | LG Electronics Inc. | We are fine with this observation. |
| 13 | vivo Communication Technology | [vivo] We show the same view with Intel that sequence-based PEI in some sense can play the same role with SSB burst for tracking, ACG adjustment, RRM measurement and so on. To this end, even more than one SSB burst can be skipped by using sequence-based PEI, and the power saving gain by comparing sequence-based PEI and DCI-based PEI will be large. As show in our contribution, sequence-based PEI can take place one SSB burst before PO reception. Besides, up to 10% power saving gain can be obtained by using sequence-based PEI compared to DCI-based PEI as shown in our contribution. |
| 14 | Nokia Germany | We are OK with observation 4.<br>Regarding the assumptions in R1-2103405, we assumed reception of one SSB for the PDCCH based PEI and PEI was multiplexed in the same slots as SSB. For TRS based PEI we evaluated two different cases, with one or 0 SSBs prior TRS based PEI. For SSS based, we assumed reception of single SSB prior (SSS-)PEI to ensure tracking.<br>In the case that UE is paged, the total number of SSBs for PDCCH-PEI and SSS-PEI dependent on the SNR (1,2,3), while for TRS based we assumed still 0 or 1 SSB.<br>In our understanding UE would need to do SSB reception for serving cell tracking, e.g. for cell quality and beam, and thus cannot therefore always omit SSB reception. Considering Behv-A, and also Behv-B, UE cannot rely that PEI is always sent, thus would need to do the tracking based on SSB. |

| Item | Company | Comments |
|---|---|---|
| 15 | PANASONIC R&D Center Germany | Sequence-based PEI reception requires less number of SSB bursts than PDCCH-based PEI and it also helps on T/F tracking and ACG training before the paging PDCCH and PDSCH reception. It should be clarified on how comparable gains are achieved and under what assumption. |
| 16 | MediaTek Inc. | Current Observation 4 reflects the fact all PEI candidate designs show comparable UE power saving gains. For better understanding on the reason, the following facts are suggested to be further captured:<br>• When UE is not paged, all PEI candidate designs lead to the same reduced amount of UE operations and thus the same power consumption<br>• Given PO paging rate of 10%, UE is not paged for 90% of the idle time |
| 17 | Guangdong OPPO Mobile Telecom. | Support the observation 4. |
| 18 | InterDigital Communications | With current agreed power saving evaluations, this observation seems fair. However, for SSS based method, detection may be more power efficient. This was not included in the models used. |

### 2.1.5 Overall Recommendation for PEI Physical Channel/Signal Design

The reference subsection is **Subsection 2.5** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

There are 18 companies expressing explicit recommendations for PEI physical layer channel/signal design. The following statistics can be collected:

**Table 4: Companies' views on overall recommended PEI candidate design**

| | |
|---|---|
| PDCCH-based PEI | (12 companies) HW/HiSilicon, OPPO, Spreadtrum, ZTE, MTK, Xiaomi, Apple, QC, LG, Nokia, DoCoMo, Ericsson |
| Sequence-based PEI (6) | (7 companies) vivo, CATT, Intel, QC, Samsung, Sony, IDC |
| | (SSS-based: 6 companies) vivo, CATT, Intel, QC, Sony, IDC |
| | (TRS-based: 4 companies) vivo, CATT, Intel, Samsung |

Since selection of the physical layer candidate design is fundamental to any further specification work, the following working assumption is therefore suggested:

**Proposal 1**:

(Working Assumption) PDCCH-based paging early indication design is supported.

**Feedback Form 6: Companies' views for Proposal 1, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | Support |
| 2 | Nordic Semiconductor ASA | Support |
| 3 | CATT | We can NOT agree on the conclusion and proposed working assumption. So far, the comparison of power saving gain, link level performance, co-existence and overhead are not conclusive when the assumptions were not aligned. In particular, the selection of PEI candidate should based on the technical merit in power saving gain and performance. |
| 4 | Sony Europe B.V. | Do not support. Power saving gains reported by companies are not calculated based on the same assumptions and concluding a working assumption based on statistics of observation 4 is not fair. |
| 5 | Samsung Research America | Not supported. Have no clue why PDCCH-based solution is the best design. |
| 6 | Intel K.K. | Do not support. In particular, we should stay at sequence and PDCCH level. There is no justification available yet to rule out one type of sequence, given both SSS and TRS can achieve impressive MDR performance and provides advantage in RE numbers. And as explained above that for realizing coexistence with other legacy signal/channels, gNB does not have to reserve resource for PEI transmission for any of the candidates considered.<br><br>So far until last meeting, we discussed simulation assumptions, methodology. This is the first meeting we are discussing results, such as MDR, RE numbers etc. Hence, discussion on the results is needed first before reaching any conclusion |

| Item | Company | Comments |
|---|---|---|
| 7 | LG Electronics Inc. | Support the proposal.<br>According to the evaluation results from several companies, PDCCH based PEI shows better/comparable power saving gain. Also, PDCCH based solution can convey more information than sequence based PEI.<br>Regarding coexistence issue, we would like to point out that sequence based PEI can affect not only PDSCH for connected mode but also broadcast PDSCH. Note that, except for SSB and DMRS, there is no way to deal with the overlap between the broadcast PDSCH and the reference signal. |
| 8 | China Mobile Com. Corporation | [CMCC] Support the proposal. |
| 9 | Ericsson India Private Limited | Support. |
| 10 | Apple Italia S.R.L. | [Apple] support |
| 11 | Beijing Xiaomi Mobile Software | [Xiaomi] Support the proposal 1. |
| 12 | DOCOMO Communications Lab. | We agree with this proposal. |
| 13 | Qualcomm Technologies Int | We think SSS-based PEI can have best potential power saving gain among three candidate solutions. The reason we say potential gain is because of the limitation of current power modeling methodology as mentioned under observation 4. RS based design can have less power saving gain but higher than PDCCH if limited part of the WB hardware is activated to receive the PEI. In comparison, PDCCH based PEI requires the UE to use the entire baseband hardware for receiving the PEI. This level of differentiation can not be reflected by current power modeling, and hence is ignored in the analysis. |
| 14 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>We support the proposal 1. |
| 15 | ZTE Corporation | [ZTE, Sanechips]<br>We support the proposal 1 considering the simulation results of LL performance, resource overhead, power saving gain, co-existence issue etc. |

| Item | Company | Comments |
|---|---|---|
| 16 | vivo Communication Technology | [vivo] We cannot support the observation considering the observations in 2.1.1-2.1.4 from our understnding. Actually from overhead, power gain, performance and coexistence perspeactive, sequence-based PEI does not worse thaN PDCCH based. |
| 17 | Nokia Germany | Support. |
| 18 | PANASONIC R&D Center Germany | Not support due to the reasons mentioned earlier. |
| 19 | MediaTek Inc. | We are supportive to make a working assumption for PEI physical-layer channel/signal; otherwise many design details are pended (as can be observed from companies' feedbacks on Proposals 2, 3 and 4).<br>If down-selection to a single physical layer channel/signal is too difficult to be achieved, we suggest RAN1 needs to restrict to two candidates. Then, by allowing parallel characterizing the two candidates, RAN1 can still make progress in design specification. This also helps companies' understanding on the remaining candidate designs and assists the final decision. |
| 20 | Guangdong OPPO Mobile Telecom. | Support the proposal 1. |
| 21 | InterDigital Communications | We do not support this proposal. Without aligning assumptions, it is really difficult to compare different schemes. Results from different companies seem to diverge quite significantly; so we may need further calibration. |

### 2.1.6 Support of Behv-A and/or Behv-B

The reference subsection is **Subsection 2.6** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

From companies' views, the following statistics can be collected:

**Table 5: Companies' views on the support of Behv-A and/or Behv-B**

| | |
|---|---|
| Only Behv-A supported | (7 companies) OPPO, vivo, Intel, Apple, QC, Samsung, Sony |
| Both Behv-A and Behv-B supported | (3 companies) MTK, Panasonic (with Behv-B in some condition), Nokia |

Following the majority view, the following proposal is suggested:

**Proposal 2**:

For paging early indication, the following Behv-A is supported: PEI indicates UE should monitor a PO if UE's group/subgroup is paged, and UE is not required to monitor a PO if UE does not detect any PEI out of all PEI occasion(s) for the PO

FFS whether the following Behv-B is supported by network configuration or under some condition: PEI indicates whether or not UE should monitor a PO, and UE is required to monitor a PO if UE does not detect any PEI out of all PEI occasion(s) for the PO

**Feedback Form 7: Companies' views on Proposal 2, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | In our view, BehvA and BehvB are both for evaluation. It can be left to gNB indicating in higher layer parameter like DCI format 2-6 in R16 to solve the corner case, e.g. DCI format 2-6 can be DTXed if all UEs in DCI format 2-6 is not waken up for CDRX ON. |
| 2 | Nordic Semiconductor ASA | We prefer to have only one behavior, and that would be BehvA, but if consensus cannot be reached, this is one way forward |
| 3 | CATT | We are OK with the main proposal 2. For FFS, we simply state "Behv-B FFS" since we have clear definition and associated UE behavior of Behv-B agreed in RAN1#104-e. |
| 4 | Sony Europe B.V. | Agree with CATT's comment. |
| 5 | Samsung Research America | We are fine with the main text part. But, we suggest to remove FFS. Behv-B will result in large resources overhead and should not be considered for idle/inactive UEs. |
| 6 | Intel K.K. | Support in principle. Behv A clearly provides more PS gain advantage with respect to Behv B. In our view, Proposal 2 can be discussed before Proposal 1, since this seems not dependent on Proposal 1 which may take more time to converge. It seems most, if not all, companies have no objection to Behv A at least. |
| 7 | LG Electronics Inc. | We support the proposal and prefer to keep FFS. |
| 8 | China Mobile Com. Corporation | Prefer keep Behv-A only to reduce NW PEI signalling overhead. |

| Item | Company | Comments |
|---|---|---|
| 9 | Ericsson India Private Limited | Prefer to support both Behv-A and Behv-B. We think this is related to PEI structure and prefer to discuss after PEI structure is agreed. Behv-B reduces unnecessary NW signaling overhead. |
| 10 | Apple Italia S.R.L. | [Apple] We also prefer to keep Behv-A only. But if consensus cannot be reached in this meeting, we could be fine with the proposal and keep Behv-B FFS. |
| 11 | Qualcomm Technologies Int | Behv-A is sufficient. Behv-B is a bit overkill for Rel-17 without clear benefit. Keeping Behv-B will unnecessarily require UE to implement another mode. We think Behv-B can be removed from Rel-17 design. |
| 12 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>We think Behv-A and Behv-B should be configured by gNB to give the network flexibility. We also agree with Ericsson that this should be discussed after PEI structure is agreed. |
| 13 | ZTE Corporation | [ZTE, Sanechips]<br>Regarding proposal 2, we also think Behv-A and Behv-B should be configured by gNB to give the network<br>flexibility. And this can be discussed later. |
| 14 | vivo Communication Technology | [vivo] We are in principle fine with the proposal. Furthermore, we are more preferrable to keep Behv-A only to reduce NW PEI signalling overhead. Based on our analysis in R1-2102532, **Behavior B will consume 64.6% 80% more PEI resources than Behavior A when assuming the same power saving gain achieved by Behavior A/B.** |
| 15 | vivo Communication Technology | [vivo2] The modified red parts (i.e. any PEI out of all PEI occasions) seem confused. Does it implicitly mean that UE needs to detect all the PEI occasions? according to TS 38.304, the selection of the beam(s) for the reception of the paging message and Short Message is up to UE implementation. And the same can be applied to the PEI reception, in which different PEI occasion will associate with different beams. Hence, the issue above should be clearly clarified. |
| 16 | Nokia Germany | We are OK with the proposal 2. Like said it would be sufficient in most cases to have only Behv-A, but considering different deployments and different type of UEs, Behv-B might have it's merits. Hence, therefore we proposed to support both. |
| 17 | PANASONIC R&D Center Germany | Okay. |

| Item | Company | Comments |
|---|---|---|
| 18 | MediaTek Inc. | The definition of resource occupation is that the resource cannot be used by other legacy channel/signal. But, with Behv-B, network has full flexibility in prioritizing physical resources for legacy channels/signals, so there is no increased resource occupation issue with Behv-B. In this regard, we are supportive to further study how to incorporate Behv-B.<br>Regarding the revised description for clarifying the condition "if UE does not detect **any** PEI **out of** all PEI occasion(s) for the PO", we think it is reasonable UE should check all PEI occasion(s) before deciding no PEI is detected. On the other hand, for the case UE detects a PEI indication, UE can skip other PEI occasions and save power consumption. |
| 19 | Guangdong OPPO Mobile Telecom. | [OPPO]Prefer to keep Behv-A only. We suggest to remove FFS. |
| 20 | InterDigital Communications | We prefer Beh-A as well. Agree with Intel that maybe first we need to agree on this proposal. |
| 21 | DOCOMO Communications Lab. | We prefer to support both Behv-A and Behv-B.<br>It can be discussed l after PEI design is agreed. |

### 2.1.7 Other Aspects

The reference subsection is **Subsection 2.7** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

From companies' inputs, there are quite a few inputs on whether and what information PEI can carry in addition to UE (sub)group indication for PO monitoring. In particular, the following statistics can be collected:

**Table 6: Companies' views on additional information carried by PEI**

| | |
|---|---|
| Indication of TRS availability | (Supported by 5 companies) HW, ZTE, QC (conditioned on PDCCH-based PEI), DoCoMo, Nordic<br>(Objected by 1 company) vivo (dependency on PEI PHY selection) |
| Indication of system information update and/or ETWS | (Supported by 3 companies) ZTE, LG, DoCoMo |
| Short message | (Supported by 2 companies) HW/Hi-Silicon, LG<br>(Objected by 1 company) Nokia |

By the above, the following proposal is suggested:

**Proposal 3**:

For PDCCH-based paging early indication, indication of TRS availability in PEI is supported.

FFS: Indication for system information change and/or ETWS

**Feedback Form 8: Companies' views on Proposal 3, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | FFS point. The DCI size of PEI should be small enough |
| 2 | Nordic Semiconductor ASA | DCI size depends whether PEI is stand-alone DCI or part of Paging DCI. But we agree that the overhead of PEI should be small. |
| 3 | Nordic Semiconductor ASA | And we agree that validation of TRS should be in PEI, may be just a single bit |
| 4 | CATT | We do NOT agree with the proposal since using TEI for TRS availability has technical issue of wrong indication when UE moves from one cell to another cell. UE receiving the TRS availability indication from TEI at once cell can not apply to the TRS resource and availability of another cell since each cell has different TRS resource configuration and availability. Moreover, TRS availability indication should be discussed in AI-8.7.1.2. |
| 5 | Sony Europe B.V. | Do not support. Too early to decide on this at current stage. |
| 6 | Samsung Research America | The two functionalities should be decoupled. No need to discuss this issue before L1 signal/channel design of PEI is determined. |
| 7 | Intel K.K. | Discuss in 8.7.1.2 |
| 8 | China Mobile Com. Corporation | support the main bullet |

| Item | Company | Comments |
|---|---|---|
| 9 | LG Electronics Inc. | Indication for system information change and/or ETWS should be supported. Power saving gain from the PEI can be achieved by skipping paging PDCCH monitoring. However if Indication for system information change and/or ETWS are not supported by the PEI, UE should monitor both PEI and paging PDCCH to check short message field in paging PDCCH, and power saving gain by the PEI would be degraded. Also, only 2 additional bits are required for indicating those information. Conveying 2 bit information with the PEI would not be a big problem.<br>Also we prefer to support indication of TRS availability in PEI as well. The number of bits required and details on indication method can be discussed in 8.7.1.2. |
| 10 | Ericsson India Private Limited | OK with proposal 3. |
| 11 | Apple Italia S.R.L. | [Apple] Even though we support the main bullet of the proposal, we also feel it is better to be discussed in 8.7.1.2, after the physical design for PEI is agreed. We are fine to have FFS for indication for system information change and/or ETWS, but it may not make much difference whether to agree on an FFS point at the moment. |
| 12 | Beijing Xiaomi Mobile Software | [Xiaomi] Not support, It's too early to make this decision here, at least some discussion should be in 8.7.1.2. |
| 13 | DOCOMO Communications Lab. | Basically fine.<br>When PEI is supported, it is very important that how to inform UE of legacy information (ETWS,SI update) in paging PDCCH. If PEI does not inform the UE of the above information, it is necessary for UE to wake up at PO every cycle and receive a Paging PDCCH to get SI change and so on. |
| 14 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>Support the proposal 3. |
| 15 | Qualcomm Technologies Int | We prefer TRS/CSI-RS availability indication is carried by paging DCI to keep PEI design simple and PEI/TRS/CSI-RS two features decoupled. We also do not think PEI should carry anything else other than UE sub-group paging indication. The power saving effect due to PEI carrying system information change and/or ETWS information is unclear. We believe it will be very minimal in reality unless network frequently transmit short message or update SIB through paging. |
| 16 | ZTE Corporation | [ZTE, Sanechips]<br>We support the proposal 3. |

| Item | Company | Comments |
|---|---|---|
| 17 | vivo Communication Technology | TRS/CSI-RS availability indication through PEI is not unified solution since PEI and TRS/CSI-RS for idle/inactive UEs are decoupled features for UE power saving. |
| 18 | Nokia Germany | In principle we are fine to have this option i.e .we should not preclude it, but as commented in thread 02, this should not be only availability indication mechanism. Also, we need to have mechanism to support availability indication only for sub-set of beams. |
| 19 | PANASONIC R&D Center Germany | We should discuss this later on. |
| 20 | MediaTek Inc. | Given that deciding whether TRS availability indication is carried in PEI depends on what is PEI physical-layer channel/signal, we are supportive to agree the availability indication is supported at least for PDCCH-based PEI.<br>Regarding that **network cannot judge idle-mode UEs of different feature support**, we think it is reasonable to assume that **a UE capable of R17 idle-mode power saving enhancement should jointly support both PEI and TRS**. In this regard, there is no issue to specify carrying TRS availability indication when both features are configured. |
| 21 | Guangdong OPPO Mobile Telecom. | [OPPO]<br>Basically we are fine with the indication of TRS availability in PEI. However, it's too early to make this decision before PDCCH-based paging early indication is agreed. |

## 2.2 PHY Design for Carrying Subgroups Info

The reference subsection is **Section 3** of 1st_Round summary available @ https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Inbox/drafts/8.7.1.1/1st_Round

From companies' views, the following statistics on what physical channel to carry UE subgroup indication can be collected:

If PEI configured,

**Table 7: Companies' views on what PHY channels to carry UE subgroup indication if PEI is configured**

| | |
|---|---|
| Paging PDCCH/DCI | (4 companies) Xiaomi, QC, Samsung, Leveno |

| | |
|---|---|
| PEI | (18 companies) HW/Hi-Silicon, OPPO, spreadtrum, vivo, ZTE, CATT, MTK, CMCC, Xiaomi, Intel, Apple, QC, Samsung, Sony, LG, Nokia, DCM, Ericsson |
| PEI + Paging PDCCH/DCI | (2 companies) Panasonic, Intel<br>Note: Under the condition UE subgroup number per PO is large |

On the other hand, when PEI is not configured,

**Table 8: Companies' views on whether and what PHY channel to carry UE subgroup indication if PEI is not configured**

| | |
|---|---|
| Not support UE subgrouping | (2 companies) OPPO, vivo |
| Paging PDCCH/DCI | (2 companies) MTK, Panasonic |

Regarding the number of maximum supported UE subgroup number per PO, the following statistics can also be collected:

**Table 9: Companies' views on maximum supported number of UE subgroups per PO**

| | |
|---|---|
| 4 | (3 companies) vivo, CMCC, Samsung |
| 8 | (4 companies) vivo, CMCC, CATT, Intel |
| Larger than 8 | (2 companies) MTK (12 bits), Intel |

If the maximum UE subgroup number per PO is not large, carrying subgroup indication all in PEI looks agreeable. The following proposal is therefore suggested:

**Proposal 4**:

If PEI is configured, UE (sub)group indication is carried by PEI, and the maximum supported number of UE subgroups per PO is [8].

FFS: Whether and how to support carrying UE (sub)group indication in paging PDCCH if PEI is not configured.

**Feedback Form 9: Companies' views on Proposal 4, including support or not and any suggested update**

| Item | Company | Comments |
|---|---|---|
| 1 | Spreadtrum Communications | FFS point. DCI size of PEI should be small enough |
| 2 | Nordic Semiconductor ASA | Support |
| 3 | CATT | We like to clarify CATT's position. We supports up to 4 and 8 maximum number of subgroups carried by PEI and/or paging DCI depending on RAN2 decision in determination and partition of paging subgroups within the paging group. Proposal 4 should be discussed after RAN2 finalizes the decision in paging subgroup determination. |
| 4 | Sony Europe B.V. | Support. |
| 5 | Samsung Research America | The maximum number of UE subgroups can be FFS. 8 is too large according to our evaluation. |
| 6 | Intel K.K. | Postpone discussion until PEI signal/channel design is selected and feedback from RAN2 is received, such as on number of sub-groups. |
| 7 | LG Electronics Inc. | Support |
| 8 | China Mobile Com. Corporation | Support |
| 9 | Ericsson India Private Limited | OK with proposal 4. |
| 10 | Apple Italia S.R.L. | [Apple] support |
| 11 | Beijing Xiaomi Mobile Software | [Xiaomi] OK |
| 12 | DOCOMO Communications Lab. | We agree with this proposal. |

| Item | Company | Comments |
|---|---|---|
| 13 | Qualcomm Technologies Int | Prefer to wait for RAN2's conclusions on the UE sub-grouping indication design. |
| 14 | vivo Communication Technology | We also support subgroups Info carried by Paging PDCCH. |
| 15 | ZTE Corporation | [ZTE, Sanechips]<br>Okay with the main bullet. The sub-bullet can be further discussed. |
| 16 | HiSilicon Technologies Co. Ltd | [Huawei, HiSilicon]<br>We support the proposal. |
| 17 | Nokia Germany | We support the proposal 4 for having sub-grouping in PEI, but so far we have not seen any power saving benefit to provide the sub-grouping in paging DCI. |
| 18 | PANASONIC R&D Center Germany | Okay with us and preferably to remove "if PEI is not configured". |
| 19 | MediaTek Inc. | We are supportive to Proposal 4.<br>**From companies' contributions, sequence-based PEI is also capable of supporting indication of multiple UE (sub)groups**. As long as the number of UE (sub)groups can be accommodate by a proper mapping design, there is no issue in agreeing the proposal and making progress. |
| 20 | Guangdong OPPO Mobile Telecom. | [OPPO]<br>OK with the proposal 4. |
| 21 | InterDigital Communications | We are fine with [8] user groups. It was shown in our Tdoc that there is no degradation with 8 UE groups when sequence based method is used. |