**3GPP TSG RAN WG1 #107-e R1-211xxxx**

**e-Meeting, November 11th – 19th, 2021**

**Agenda item:** 8.17

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** [draft] Summary on Rel-17 TEIs

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the discussions and proposals in AI 8.18 for Rel-17 NR TEI related discussion and following email discussion.

[107-e-R17-TEI-01] Email discussion/approval on Rel-17 TEIs – Shinya (DOCOMO)

* 1st check point: November 15
* Final check point: November 19

Based on the discussions summarized in Section 2, following TEI proposals are identified in AI 8.17. According to the guidance from RAN1 chair (i.e., same guidance as in Rel-16 TEI [9] should still hold), it should be checked first whether each TEI proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor so that the discussion on the TEI proposal can be prioritized over other TEI proposals. **Companies are encouraged to clarify which TEI proposal can be supported in the list below, i.e., please add your company name if you support the TEI proposal. Detailed feedback/question on each TEI proposal can also be provided in Section 2.**

* **TEI proposal #2: Improved Frequency-Domain Interleaving**
  + Supported by Qualcomm, [Ericsson]
* **TEI proposal #3: Enhancements to PUCCH format 2**
  + Supported by Qualcomm, [NTT DOCOMO], Softbank
* **TEI proposal #4: Enhancements to CSI-RS design to solve false PMI reporting issue**
  + Supported by Ericsson, [NTT DOCOMO], Softbank, [Verizon, Intel, T-Mobile USA, Qualcomm, LGE]
* **TEI proposal #6: Enhancements on the scheduling of PUSCH over multiple slots**
  + Supported by Huawei, HiSilicon, China Unicom, Ericsson, Softbank, [NTT DOCOMO]
* **TEI proposal #7: Enhancements on SSB resources for RLM**
  + Supported by CATT, Ericsson
* **TEI proposal #8: Periodic SRS transmission outside DRX active time**
  + Supported by Qualcomm
* **TEI proposal #9: Joint configuration of DRX groups and Rel-16 Power saving features**
  + Supported by Qualcomm
* **TEI proposal #12: Mitigating half-duplex issue in NR V2X groupcast NACK-only case regime**
  + Supported by Intel, Qualcomm, NTT DOCOMO, Ericsson, Bosch, [LGE, Samsung, OPPO]
* **TEI proposal #13: Support of 2 Tx codebook configuration to 4Tx capable UE in UL**
  + Supported by vivo, ZTE, CMCC, Samsung, Qualcomm, [NTT DOCOMO, Ericsson]
* **TEI proposal #15: HARQ-ACK feedback enhancements for TDD-FDD CA**
  + Supported by CATT, CMCC, Ericsson, Huawei, HiSilicon
* **TEI proposal #16: Support of default power control parameter per TRP**
  + Supported by OPPO, ZTE

Please note that as announced at the previous RAN1 meetings, making any agreement on a particular TEI proposal in this quarter requires to complete all work including CRs for the TEI proposal within this quarter according to the TEI guidance B as shown in Appendix [10].

Please also note the following chair’s guidance announced over the RAN1 reflector for this RAN1 meeting:

|  |
| --- |
| - RAN1 will discuss Rel-17 TEIs with possible impact to other WGs  - For those TEIs agreeable, RAN1 makes agreement and send LSs to relevant WGs  - The agreement is with the understanding that relevant RAN1 CRs will be submitted with other WGs to the March RAN plenary  Note that the bar for TEIs with impact to other WGs will have to be higher than usual. As we all know, 2022 Q1 is a critical timing for RAN2 to complete Rel-17. The extra workload that RAN1 imposes on RAN2 has to be reasonably small. While I trust all the delegates involved in TEI discussions to keep this in mind during the discussions, I will also check the situation myself. If the TEI workload to RAN2 is not reasonably contained, I will suggest that we just stop the discussions for the entire agenda item. |

1. Discussion on Rel-17 NR TEI proposals
   1. Improved Frequency-Domain Interleaving

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [7] | Starting from NR Rel-15, it was identified that at large BWs and high data rates and high rank, several codeblocks (~12) can be mapped onto any single OFDM symbol. When this happens, even though interleaving exists within any given code block, the frequency diversity of each codeblock can be relatively small since each CB occupies only a small set of PRBs. VRB-to-PRB interleaved mapping was introduced to distribute codeblocks across frequency.    Unfortunately, several limitations of the NR Rel-15 VRB-to-PRB solution were identified in practice:   * Small performance gains are observed since CBs are only distributed along two sub-bands that are diverse in frequency. Much larger gains can be achieved with higher-depth interleavers having more diversity. * VRB-to-PRB interleaved mapping is happening within the BWP and not within the UE’s scheduled allocation which limits the ability to multiplex UE’s with different BWP configurations. VRB-to-PRB mapping may preclude coexistence of different UE’s with BWP switching for power savings. * There is no mode of CSI reporting which assumes VRB-To-PRB interleaved mapping, while dynamic switching between the interleaved and non-interleaved mapping is specified. The scheduler does not have an indication from the UE whether, in any given conditions, it will be beneficial to dynamically switch ON/OFF the interleaved mapping.   As a simple simulation example, we consider the case of high throughput / high spectral efficiency (where the interleaving was supposed to provide most of the gains): Rank 4, 100MHz BW, 30kHz SCS, TDL-A 30 nsec with MCS 13, 19 which correspond to the following cases:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **MCS** | **Rate** | **Modulation Order** | **# of CBs** | **# of CBs / Symbol** | | **19** | 0.85 | 6 | 79 | 7.9 | | **13** | 0.55 | 6 | 51 | 5.1 |   The gains in SINR over NR Rel-15 options to reach 90% throughput is shown below:   |  |  |  | | --- | --- | --- | | **Interleaver** | **Delta in dB, MCS = 19, MMSE** | **Delta in dB, MCS = 13, MMSE** | | **Rel-15 (No-ILV)** | 0 | 0 | | **Rel-15 (VRB2PRB ILV)** | 1.0 | 0.6 | | **8-Row** | **6.5** | **2.8** |   Based on the above observations, we make the following proposals:  Proposal 1: For the VRB-To-PRB interleaved mapping:   * **Increase the depth of the interleaver (e.g. 4 or 8 rows instead of 2 rows in NR Rel-15)** * **Perform the interleaved mapping within the scheduled allocations and not within the active BWP** |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | Huawei, HiSilicon | We think the implement impact is considerable while the benefits would be limited in practical configurations. | | NTT DOCOMO | We have the same comments as in the last meeting.   * We are generally supportive to introduce the new interleaver in addition to the existing one to improve the performance * We are still not sure how such gain can be obtained while ensuring coexistence with legacy UEs with different BWPs by supporting the 2nd sub-bullet | | Nokia, NSB | Same comment as last time, this implies a major rework on the data path, and would require strong justification based on RAN1 analysis. Should be considered as a possible component to study for Rel-18 MIMO WI. | | MediaTek | Same comments as before: We are ok to discuss the first sub-bullet. But we are not sure about the benefit of the second sub-bullet. | | Intel | Additional study is required to understand the benefit of this enhancement taking into account channel correlation across MIMO layers | | Ericsson | Continue to support the proposal | | ZTE | The applicable use cases and performance gain need to be justified. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow. Also, it seems this proposal has not yet met the criteria that the proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #2**

* **Support following improvements for the VRB-To-PRB interleaved mapping**
  + **Increase the depth of the interleaver (e.g. 4 or 8 rows instead of 2 rows in NR Rel-15)**
  + **Perform the interleaved mapping within the scheduled allocations and not within the active BWP**

This proposal is already supported by Qualcomm, [Ericsson].

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Samsung | N | This proposal leads to major work on implementation on data reception especially for large TBS. This should be studied in RAN1 first whether the meaningful benefit can be obtained or not and it needs to be done in MIMO WI if needed |
| OPPO | N | We think it is not suitable to be studied in TEI, where we have only one meeting left. |
| Nokia, NSB | N | Same comment as last time, this implies a major rework on the data path, and would require strong justification based on RAN1 analysis. |
| HW, HiSi | N | Same comments as previous meetings. |
| Ericsson | Y | Support depth 8 |
| NTT DOCOMO | N | We haven’t received any reply from proponent to the comment provided in the last meeting as follows, and hence, we cannot support the proposal as is.   * We are still not sure how such gain can be obtained while ensuring coexistence with legacy UEs with different BWPs by supporting the 2nd sub-bullet |
| Moderator |  | Given that this proposal has not met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will not be treated in this RAN1 meeting anymore. |

* 1. Enhancements to PUCCH format 2

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | Short PUCCH format, specifically, PUCCH Format 2 spans one to two OFDM symbols and is restricted to use CP-OFDM waveform. The table below summarizes the configurations available for various PUCCH formats. The lack of DFT-S-OFDM support for short PUCCH Format is a significant shortcoming that we wish to address.    Table 1 Configurations for different PUCCH Formats  Short PUCCH formats have found significant use in FR2 deployments where a large number of analog antenna beams are used to serve users in uplink/downlink. Due to large number of antenna beams, long PUCCH formats are not favored since it’s easier to support beam sweeping operations using short PUCCH formats. Further since certain beams are intended to provide cell-edge coverage while certain beams are intended for cell-center UEs, beam-specific PUCCH configurations are ideally desired. However, defining beam-specific PUCCH formats is a tedious effort and adds to overall network configuration complexity. Therefore, short PUCCH formats are typically configured across all beams. Additional details on these aspects are presented in [1].  Further, with uplink being a typical bottleneck in NR deployments, it is worth considering enhancements that help improve uplink control coverage. It is well known that DFT-S-OFDM waveforms have a smaller PAPR compared to CP-OFDM, and this enables them to be transmitted at a higher power.  Using power class 3 UE as a motivating example, Table 6.2.2-1 of 38.101-1 as provided in Table 2 specifies a set of power reduction values dependent on RB allocation and modulation order for power class 3 UEs. The power back off values are then used by the UE to calculate the lower bound on its value.  Table 2 MPR Table from 38.101-1    Note that DFT-S-OFDM with pi/2 BPSK has two sets of values defined, one for the case where the 0 dB MPR is in reference to 23 dBm and another where the 0 dB MPR is in reference to 26 dBm. This change in reference power to 26 dBm is permitted when UE is operating in TDD mode with less than 40% of the slots in a radio frame being used for uplink transmission.  It is thus seen that for a wide range of RB allocations, DFT-S-OFDM waveforms can be transmitted at a transmit power that is 2 dB higher than that possible for CP-OFDM waveforms. This motivates us to make the following proposal:  Proposal 2: Support transmitting PUCCH Format 2 using DFT-S-OFDM waveform.  Introducing DFT-S-OFDM for short PUCCH format requires a careful consideration of how the resources are split between DMRS and data. To support single symbol PUCCH transmission, it is required that DMRS and data be multiplexed on the same symbol. One option is to multiplex DMRS and data in time domain before the DFT operation [2], [3].  **Transmit-side operations**  The proposed scheme multiplexes data and reference signal within one symbol duration by virtual TDM. The time domain signal before DFT-spread and the transmitter block diagram is shown in Figure 1.    **Figure 1. Transmitter for Virtual TDM of Reference Signal and Data**  The first part of the pre DFT-spread time-domain signal is the reference signal. It is preferable for the reference signal to have low PAPR property on both time and frequency domain to keep the PAPR of the final DFT-s-OFDM waveform low and at the same time make the frequency domain channel estimation efficient.  To reduce inter-symbol interference, an additional virtual CP for reference signal can be optionally added at the beginning of the pre DFT-spread time-domain signal by copying the last symbols of the reference signal.  The reference signal symbols are followed by data symbols to form the pre DFT-spread time domain sequence. The pre DFT-s sequence goes through the conventional DFT-s-OFDM waveform synthesis to generate the final time domain waveform.  Denote the signals in Figure 1 as follows:  : pre DFT-s Reference signal with length  : pre DFT-s Data signal with length  : pre DFT-s Virtual Cyclic Prefix for Reference Signal with length  : pre DFT-s Time-domain signal with length  From the above discussion, we can see that should be , and should be  .  **Receive-side operations**  Figure 2 shows the receiver block diagram for the virtual TDM shown in Figure 1. Except the channel estimation block, the receiver is essentially equivalent to the conventional DFT-s-OFDM receiver. After FFT and tone demapper, the extracted tones are equalized and go through IDFT to obtain M time domain symbols. Then, data symbols are extracted for the decoding.  Figure 2. Receiver for Virtual TDM of Reference Signal and Data  There can be multiple options for the channel estimator. Figure 3 shows a channel estimator for the virtual TDM of reference signal and data. After FFT and tone demapper, the extracted tones go through IDFT to obtain M time domain symbols. Denote the discrete-time equivalent channel between the Tx antenna and Rx antenna for the M time domain symbols as . When the CP length for Reference signal is chosen longer than the propagation delay of , the reference signal is protected from inter-symbol interference and circular convolution is preserved. Therefore, the extracted RS symbols in Figure 3 can be represented as where denotes the -point circular convolution. The channel can be obtained by converting the extracted reference signal symbols to frequency domain by -point DFT. Finally, the estimated channel for tones can be upsampled by a factor of to obtain the channel estimation for tones, which can be used for the channel equalization in the receiver of Figure 2.    Figure 3. Channel Estimator for Virtual TDM of Reference Signal and Data – Option A.  Alternatively, the upsampling block can be further removed by using -point DFT. Figure 4 shows an alternative option for the channel estimator. The extracted tones go through -point IDFT to obtain time domain symbols. Then, the data symbols are replaced by zeros, and the modified time domain symbols converted to the frequency domain by -point DFT. Finally, the channel tones can be estimated in the frequency domain.  Figure 4. Channel Estimator for Virtual TDM of Reference Signal and Data – Option B.  Clearly, this proposed transmission scheme can provide the multiplexing of reference signal and data with arbitrary pilot ratio while keeping the low PAPR property of DFT-s-OFDM waveform.  **Simulation Results**  In this section, we simulate and compare the link performances of the proposed virtual TDM scheme and compare with that of OFDM where the reference signal and data is FDMed.  Figure 5 presents two plots that illustrate the characteristics and the performance of the DFT-S-OFDM waveform. First, Figure 5 shows that DFT-s-OFDM waveform has at least 2 to 2.5 dB PAPR gain over CP-OFDM --- this is a reasonably well known result. Second, Figure 5 also shows that when comparing the link level performance between CP-OFDM (with data-RS FDM) and DFT-S-OFDM, it is observed that there is little to no difference at least for small payloads. For the link level performance, a three-bit payload is considered, and transmitted over 2 RB. The additional virtual CP length for RS is set to be zero, and the pilot ratio is chosen as 50% for both cases. Thus, taking both these observations into account, we see that the proposed scheme can provide up to 2 dB better performance than a CP-OFDM-based approach.    Figure 5 PAPR for CP-OFDM and DFT-s-OFDM waveforms (on the left) and link level performance comparison between DFT-S-OFDM and CP-OFDM (on the right).  Based on the discussion above and the simulation results, we make the following proposal:  Proposal 3: Consider pre-DFT data-DMRS multiplexing to enable DFT-S-OFDM waveform for PUCCH Format 2. |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | SoftBank | Just to repeat our comment in the previous meeting, we support the proposal as the coverage issue is critical. We want to achieve better PUCCH performance with short format | | Huawei, HiSilicon | The work required and implementation impact for this TEI proposal does not fit a TEI, although we agree that coverage enh is always welcome. | | NTT DOCOMO | Our view is same as previous meeting.  We support the proposal. As mentioned previously, short PUCCH format is an important feature for FR2 deployment with beam-based operation. In some practical situations, long format is not available. | | LGE | We are not sure if this is necessary in Rel-17 timeline. Also, this topic seems too large to handle as TEI | | Nokia, NSB | As said in RAN1#105 and RAN1#106, we don’t see a new physical channel to be a TEI item. | | MediaTek | As we commented before: We don’t support this TEI because the overall system performance gain is not clear while the improvement is at expense of UE design change. If coverage is a problem, gNB can apply PUCCH formats 3 and 4. | | Intel | Same view as last meeting. This TEI has substantial impact on receiver implementation, especially channel estimation algorithm, which is largely different from existing algorithm. Given the large workload for this topic, it is not clear to us whether it can fit into the TEI. | | Ericsson | Similar comment as last time that this seems rather large for a TEI item. | | ZTE | As we commented before, we think this proposal is more suitable for Rel-18 enhancement, with more thorough evaluation about the performance gain and analysis on potential spec impacts. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow. Also, it seems this proposal has not yet met the criteria that the proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #3**

* **Support transmitting PUCCH Format 2 using DFT-S-OFDM waveform**
  + **Consider pre-DFT data-DMRS multiplexing to enable DFT-S-OFDM waveform for PUCCH Format 2**

This proposal is already supported by Qualcomm, [NTT DOCOMO, Softbank].

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Samsung | N | This proposal may lead to substantial change to current implementation. Also, more simulation works may be needed to see some impacts like potential ISI increase between RS and data. With these reasons, we don’t think this proposal is suitable as a TEI item. |
| SoftBank | Y | We support the proposal as the coverage issue is critical. We want to achieve better PUCCH performance with short format |
| Nokia, NSB | N | As said in RAN1#105 and RAN1#106, we don’t see a new physical channel to be a TEI item. |
| HW, HiSi | N | Same comments as previous meetings |
| Ericsson | N | Same view that this seems large for a TEI |
| NTT DOCOMO | Y | Our view is same as previous meeting.  We support the proposal. As mentioned previously, short PUCCH format is an important feature for FR2 deployment with beam-based operation. In some practical situations, long format is not available. |
| Moderator |  | Given that this proposal has not met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will not be treated in this RAN1 meeting anymore. |

* 1. Enhancements to CSI-RS design to solve false PMI reporting issue

Following proposals are made in the contributions.

|  |  |
| --- | --- |
| [3] | As been previously informed [R1-2001918], from OTA testing of commercial NR UEs, a critical issue has been found related to MIMO performance near cell edge. The issue has been detected for both 32 and 8 port CSI-RS and for two UEs with chipsets from different vendors.  This is a real-life network issue related to MIMO which severely impacts NR performance and can be summarized as:   * **Near cell edge**, while still connected to a serving cell, **the NR UE selects PMI as if it was served by an interfering cell**, hence false PMI selection and reporting   + This leads to a sharp drop in PDSCH throughput at cell edge   + PMI selection logged at UE, hence this issue is not due to poor UCI feedback channel quality * The problem occurs **whenever a CSI-RS resource from the serving cell collides with a CSI-RS resource from a neighboring cell**    + The problem occurs even though different seed is used for CSI-RS sequence generation in serving and interfering cell respectively * As the analysis in this contribution shows, a cause of the problem is **due the Rel.15 design that the same CSI-RS sequence** is used for all CSI-RS ports in the CSI-RS resource   + To mitigate this, the UE must perform more advanced channel estimation, which is unnecessary complex and can be avoided if the problem with the CSI-RS design is mitigated * It is argued that the false-PMI selection problem can be solved with **cell planning of non-colliding CSI-RS** in adjacent cells, however,   + Non-overlapping CSI-RS in different cells (reuse larger than one) introduces the need for cell planning which is cumbersome and against the reuse one principle of modern RAN   + Even if non-colliding CSI-RS is configured by the use of CSI-RS cell planning, colliding CSI-RS between different cells is very hard to avoid in practical networks even if such frequency reuse is adopted because the topology is much different from hexagonal and far away gNB with colliding CSI-RS still hits the UE   + Simulations (see section 3.1) shows that the peak PDSCH throughput performance when using colliding CSI-RS (with a new Rel.17 CSI-RS sequence) is better than when non-overlapping CSI-RS. Hence, it seems it is better to have another, well designed CSI-RS as interference than PDSCH.   + Deliberately configuration of colliding CSI-RS has huge benefits for operators as it relives the need for network planning of CSI-RS, ease of migration and densification, lower interference and minimal overhead. This is elaborated in Section 4.     Figure 1 Illustration of the observed problem from field testing with commercial UEs. The UEs served by gNB 1 are reporting PMII instead of PMID where PMII is the PMI the UE would report if served by gNB 2.  To solve this problem, we suggest the following   1. Correct the CSI-RS design as a TEI-17 to remove the false PMI reporting problem.   Note that the repetition of same sequence of multiple CSI-RS ports also lead to high PAPR of the CSI-RS transmission and was discussed to be corrected in Rel.16 eMIMO WI. However, RAN1 was divided on the severity of the issue for CSI-RS and it was concluded to be non-consensus to correct this problem. Only DM-RS PAPR was corrected in Rel.16.  It now turns out that the same problematic CSI-RS design with repetitive behaviour also creates the false PMI problem and if a resolution is introduced by this TEI, it can be designed to resolve both PAPR issue and false PMI selection issue.  ~   1. Using measurements using commercial NR UEs from two different vendors, the PMI reporting fails at low SINR. It seems the PMI reporting when nearing the cell edge behave as the PMI reporting the UE would have been reporting if instead served by the interfering cell. This leads to a signifcant drop of throughput of NR at cell edge.   ~  The following sections provides an in-depth analysis of the cause of the problem and why configuration of non-colliding CSI-RS is not a solution that is attractive or even work in all deployments. In this section, we give the standardization based solution together with simulation results that shows that the issue completely disappears.  To summarize, the solution makes the interference from an adjacent base station that transmit CSI-RS appear as spatially white noise at the receiver. This is accomplished by introducing a port specific scrambling of CSI-RS ports while preserving orthogonality between the ports of a CDM group.  The solution is illustrated by Table 1 for the 4 port CSI-RS resource from row 4 of 38.214, where a new Rel.17 sequence per port (is introduced and which is multiplied with the original sequence. The index runs over the resource blocks, so in each RB, a new value of is used for each port. If the CDM group spans multiple OFDM symbols, the same value is used in all these OFDM symbols.  Table 1 TEI-17 proposal to the CSI-RS sequence, to solve the false PMI reporting issue observed in the field    The sequences can be based on the existing Gold-31 pseudo random sequence already used throughout the 38.211 specifications.   1. As a TEI-17, support a port specific multiplier sequence to the CSI-RS resource sequence to remove the false PMI reporting issue.   ~   1. Using raw CSI-RS channel estimates (K=1) that doesn’t utilize the processing gain of the use of pseudo-orthogonal sequences in different cells exaggerate the problem of false PMI selection   ~   1. Due to the use of same sequence sample for all CSI-RS ports, the spatial covariance matrix is dominated by the spatial covariance of the CSI-RS transmitted from the interfering cell if raw channel estimation samples are used   ~   1. If per port sequence is introduced, the spatial interference covariance matrix is randomized and appear “close to spatially white”, which reduce the problem as the spatial colored property in the covariance matrix from the interfering cell is removed   ~   1. So far only Type I CSI feedback has been analysed, the false PMI selection issue may be even more pronounced for Type II CSI feedback. In addition, the impact of this on any new CSI feedback schemes introduced in future releases is at risk. Hence, leaving this issue unsolved may yet again hit us back in a future release.   ~   1. Network deployments where cell planning is used for CSI-RS can only partially mitigate the problem in the general case, due to strongly interfering stray signals transmitted from cells further away which are commonly observed in e.g. metropolitan deployments.   ~   1. Network deployment with colliding CSI-RS between all cells have significant benefits to the operator in terms of no need for such network planning, ease of network densification and evolution when adding new sites, lower reference signal overhead and low interference at low load in network. Deploying with non-colliding RS should be avoided due to these reasons.   ~   1. It must be ensured that UE implementation is prepared well for colliding CSI-RS (including TRS and all other uses of CSI-RS), and RAN4 test cases should include colliding CSI-RS deployments. Further note that such a test case with two TRS is currently being considered in RAN4 for multi-TRP operation in Rel.16   To summarize the situation from the previous meeting:   * **Support:** Ericsson, NTT DOCOMO, Softbank, Verizon, Intel and T-Mobile USA. * **Open for discussion and/or consider “smart implementation”:** vivo, Sanechips, Qualcomm * **Support proposal in principle but prefer RAN4 solution:** Intel, Nokia, ZTE * **Do not support the proposal:** MediaTek, Huawei, HiSilicon, OPPO   In addition, Qualcomm provided the following late comment “*port-dependent scrambling is a safer solution from multiple viewpoints, so we are supportive of considering it further*.”, thereby indication an openness for a RAN1 solution to the issue. Questions from previous meetings, to be answered Based on the discussion previous meeting, there were some questions posed by companies in the feature lead summary, that still didn’t obtain an answer:   1. **From Qualcomm to Ericsson:** In order to alleviate possible concerns, it would be interesting to know in what scenarios the problems were observed, if such information is shareable. It appears likely that when large delay spread is assumed in CSI-RS processing, there may be more false PMI reporting issue. Therefore, it would be also interesting to know in what network topology the issues occurred. 2. **From Ericsson to MediaTek:** You mention “descrambling over neighbor cell interference,” is what you mean that UE shall average over sufficiently large bandwidth that the per RB sequence values have an effect? It may be so that some UEs doesn’t show the false PMI reporting behaviour but some other does, depending on the implementation and the bandwidth used for such descrambling. How to ensure that all UEs is behaving . 3. **From Ericsson to MediaTek:** If this new sequence is used for TRS (as you hint towards), what potential new problematic issues do you foresee that needs to be studied? 4. **From Ericsson to OPPO:** You mentioned other network vendors and that they didn’t observe the issue of false PMI reporting. Did these vendors use overlapping CSI-RS in neighbouring cells? 5. **From Ericsson to Huawei/HiSilicon:** You mentioned that you didn’t observe the issue of false PMI reporting. Did you use overlapping or non-overlapping CSI-RS in neighboring cells when performing these tests? In addition, you seem to favor a RAN4 solution, how to make RAN4 aware of this problem?  Reply to Question #1 (Qualcomm to Ericsson): Regarding the scenario, the problem occurred in a test network with two gNB:   * Two gNB configured with cell ID 470 and 960 respectively, same output power * Test network in Kista, Stockholm, Sweden. * The same problem was observed with chipset from two different vendors. * CSI feedback and MIMO throughput tests with both 32 and 8 port CSI-RS using Type I codebook * The frequency was 3.5 GHz. * The handover threshold was -4 dB * The delay spread was not estimated in this test network, but the measurement was made in an industrial park similar to a modern suburban village with parks and some high rise buildings (up to 8 floors).  Related RAN4 work In RAN4, there is an ongoing Rel-17 work item (Further enhancement on NR demodulation performance) that contains CQI reporting requirements under inter-cell interference scenario.  This work may possibly be extended to also include tests that ensure UE implementations that doesn’t have the false PMI reporting issue. To pursue this, RAN4 need to be made aware and their work needs to be extended:   * Their current discussions only consider CQI reporting with inter-cell interference scenario, it has the be extended to include at least PMI reporting as well to capture the false PMI reporting issue * The CSI-RS from serving and interfering cell needs to be overlapping for this test to be relevant. RAN4 has already agreed to configure the CSI-RS resources for tracking and CSI acquisition on the serving cell are overlapped with interfering cell(s) for the PDSCH demodulation requirements. RAN4 will continue the discussion if the same configuration is applied for CQI reporting test.   Our suggestion is to discuss whether this ongoing RAN4 work could be a possibility to complement or replace the TEI-17 proposal in RAN1.  Please check these references for RAN4 way forwards:   * R4-2108664 “Way Forward on general and PDSCH demodulation requirements for inter-cell interference MMSE-IRC”, Intel * R4-2108665​ “WF on CQI reporting requirements for inter-cell interference MMSE-IRC”, Ericsson. |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | SoftBank | Just to repeat our comment in the previous meeting, we support the proposal. In order to make the interference coordination of CSI-RS easier, this enhancement should be introduced to the spec as soon as possible. | | Huawei, HiSilicon | We would prefer to discuss this directly in RAN4. | | NTT DOCOMO | We support the proposal. We believe this issue could happen in any of operation with more than 4 CSI-RS ports operation, and once it happens, large performance degradation is observed. Thus, we support the proposal to solve the issue.  We believe the spec. impact is not big, and this proposal is suitable for Rel.17 TEI. | | LGE | In general, we don’t think it is good to endorse Rel-17 TEI item at this stage considering the current Rel-17 progress. However, if we should choose some, this topic may be considered as Rel-17 TEI since the motivation is relevant and the required work looks relatively simple | | Qualcomm | We are supportive of this proposal. Port-dependent scrambling would be a safer way to resolve some of these issues. | | Nokia, NSB | We still strongly believe that the false PMI reporting problem can be and should be fixed in the PMI estimator of the UE. Introducing an optional feature for Rel-17 is just a convenient way to avoid fixing the underlying issue and developing RAN4 requirement and RAN5 conformance test case “when this is a functional problem that has a Rel-17 solution just around the corner”. | | MediaTek | As explained in R1-2105739, we do not support this TEI proposal for the following reasons.  1) There has been inter-cell interference mitigation mechanism in place since Rel-15. There is no missing critical technical component in the spec.  2) There are UEs already implemented descrambling over neighbor cell interference. Procedurally the proposal does not qualify as Rel-17 TEI but a new spec’s mechanism designed for enabling certain UEs to upgrade to new RRC without changing low-level CSI-RS channel estimation implementation.  3) The new sequence is not backward-compatible. | | Intel | Support the TEI proposal as RAN1 or RAN4 enhancement. | | Ericsson | We of course support | | ZTE | We prefer to solve this issue in RAN4 as the new sequence will cause CSI-RS overhead issue which may compromise the benefit. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies including operator, infra vendor and UE vendor, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | Ericsson | Reply To MediaTek: Not sure what interference mitiagion mechanism you refer to. The structure of the Rel.15 CSI-RS with repeated samples, makes it more difficult for UE to mitigate the interference. With a RAN1 spec change, it is less sensitive in how the UE performs the channel estimation and averaging.  We are open to send an LS to RAN4 to make them aware of the issue and ask them to take this into account in their work. We can discuss the content of such LS. | | LGE | Among the many TEI proposals, we think this proposal is relatively simple and efficient one and we are supportive for this TEI proposal. | | ZTE | We still think RAN4 can directly discuss this issue. RAN1’s LS is unnecessary. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #4**

* **Correct the CSI-RS design as below to remove the false PMI reporting problem**
  + **Support a port specific multiplier sequence y^(p^' ) (n) to the CSI-RS resource sequence**

This proposal is already supported by Ericsson, [NTT DOCOMO, Softbank, Verizon, Intel, and T-Mobile USA, Qualcomm, LGE].

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | Yes | Support. Okay to take it up in RAN4 as well. |
| Samsung | N | Since the performance issue raised in the proposal can be resolvable by improved UE implementation and the corresponding test case, we prefer to discuss this issue not in RAN1, but in RAN4. |
| OPPO | N | We also prefer not to discuss it in RAN1. |
| SoftBank | Y | In order to make the interference coordination of CSI-RS easier, this enhancement should be introduced to the spec as soon as possible. |
| Nokia, NSB | N | We don’t support changing the CSI-RS design.We support developing RAN4 requirements ensuring that the PMI estimator has good performance also under interferene. |
| HW, HiSi | N | Suggest to take it directly in RAN4 |
| Ericsson | Y | Encourage Huawei and OPPO to answer the questions. |
| NTT DOCOMO | Y | We support the proposal. We believe this issue could happen in any of operation with more than 4 CSI-RS ports operation, and once it happens, large performance degradation is observed. Thus, we support the proposal to solve the issue.  We believe the spec. impact is not big, and this proposal is suitable for Rel.17 TEI. |
| Moderator |  | This proposal is supported by Ericsson, NTT DOCOMO, Softbank, Qualcomm  Given that this proposal has met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will be treated in the 2nd round discussion.  Proponent and supporting companies are requested to solve companies' concern by the 1st check point (Nov. 15) |
| Intel |  | We support the TEI proposal as RAN1 or RAN4 enhancement. |
| MediaTek | N | As we have responded for multiple meetings, this is a problem that can be resolved by proper UE implementation. We don’t support to change the CSI-RS design to be port specific. This should not be discussed in RAN1.  We prefer propoents bring this problem to RAN4 (and maybe RAN5 as well) to ensure UE implemtation will be done properly and the issue will not occur. |
| MediaTek2 | N | The following is to respond Ericsson’s questions for us.   1. Ericsson’s Question1: “*You mention “descrambling over neighbor cell interference,” is what you mean that UE shall average over sufficiently large bandwidth that the per RB sequence values have an effect? It may be so that some UEs doesn’t show the false PMI reporting behaviour but some other does, depending on the implementation and the bandwidth used for such descrambling. How to ensure that all UEs is behaving?*”    * MediaTek’s response: It’s out of RAN1’s scope to discuss how to ensure it. We are open on whether RAN4 would like to discuss this false PMI issue or not. **However, we don’t support this to be resolved in RAN1 and we don’t support to send LS to RAN4.** This is not a commonly observed issue for all UEs and it is unlikely onsensus could be reached in RAN1. 2. Ericsson’s Question 2: “If this new sequence is used for TRS (as you hint towards), what potential new problematic issues do you foresee that needs to be studied?”    * MediaTek’s response: After further check, we admit TRS may not be an issue. However currently we see no issues of legacy sequences for all CSIRS related functionalities. 3. Ericsson’s Question 3: “Reply to MediaTek: Not sure what interference mitigation mechanism you refer to. The structure of the Rel.15 CSI-RS with repeated samples, makes it more difficult for UE to mitigate the interference. With a RAN1 spec change, it is less sensitive in how the UE performs the channel estimation and averaging.”    * MediaTek’s response: We think your suggestion “*With a RAN1 spec change, it is less sensitive in how the UE performs the channel estimation and averaging.*” can be considered only if this is a common issue for all UEs which apparently not the case. Utilizing channel estimation and averaging to mitigate interference are up to UE’s implementation, and we have observed that the legacy sequence already works well.    * MediaTek’s response (cont’d): Furthermore, if new sequence is introduced, it’s only valid for R17 new UEs. The false-PMI problem (although we didn’t observe this issue) still exists for Rel-15/16 gNB/UEs. It’s also not efficient that gNB needs to send both legacy CSIRS and Rel-17 CSIRS with no colliding, for both legacy and Rel-17 UEs. |

* 1. Enhancements on the scheduling of PUSCH over multiple slots

Following proposal is made in the contribution.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| [1] | Optimization of the scheduling restriction  Following the timing order of DL/UL DCI formats, as shown in Figure 1, the first DL format in slot n schedules PDSCH\_1 with corresponding HARQ feedback in slot n+k, if there is a UL DCI format transmitted in slot n+1 scheduling a PUSCH transmission in slot n+k, thus the second DL DCI format in slot n+2 is no longer allowed to schedule PDSCH\_2 corresponding to HARQ information transmitted in slot n+k and overlaps with the scheduled PUSCH by the UL DCI format.    Figure 1. Timing restriction on UL/DL scheduling for HARQ information multiplexed on PUSCH  An example is given in Figure 2 further. Assume a DL domain frame configured as DDDSU pattern and gNB schedules a PUSCH transmission occupying 14 symbols in a slot. gNB schedules PUSCH\_1 in slot 4 using UL DCI\_1 in slot 0. While PUSCH\_2 has to be indicated in slot 9, since the first UL slot of frame N, slot 4, has been occupied, which results in a large K2 (i.e. K2=7 in Figure 2). Following the specified scheduling restriction, the PDSCH reception from slot 5~7 with corresponding HARQ feedback in slot 9 cannot be assigned. For this case, the corresponding HARQ has to be reported in frame N+1 which results in large HARQ delay.    Figure 2. Impact of PUSCH scheduling restriction for K2=7  ***Observation 1: For a single-slot PUSCH scheduled with a large K2, the PUSCH scheduling restriction has impact the scheduling of PDSCH reception after the UL grant and introduce large HARQ delay.***  The same scheduling restriction, although not described explicitly in the spec, is also applied to the PUSCH with repetitions. However, due to the length of PUSCH transmissions in time, the restriction introduces more strict constrains on gNB scheduling for the case of PUSCH repetition. For example, still in Figure 2, if the PUSCH\_2 is repeated for multiple times, the HARQ delay will become larger by adding the extra repetitions in time.  ***Observation 2: If PUSCH repetition is configured, the timing restriction on scheduling HARQ after UL grant introduces large delay for HARQ feedback, which could be as large as (k2 + number of PUSCH repetition) slots.***  In Rel-16, the number of PUSCH repetitions are counted by configured transmissions, the canceled repetitions caused by DL/UL collision will not be deferred. However, in Rel-17, the repetitions of PUSCH are enhanced to transmit in available UL slots only, PUSCH repetitions may keep occupying contiguous UL slots and leave no opportunity to transmit PUCCH for a long period, especially for TDD system. Illustrated in Figure 3, in the slot 0 of frame N, UL DCI triggers PUSCH to repeat 4 times and each repetition occupies 14 symbols like the example in FDD system. Consequently, for the consecutive UL slots for frame N and N+1, gNB cannot schedule PUCCH to transmit the HARQ information associate with the PDSCHs scheduled in the DL slots of both frames. In other word, due to the PUCCH scheduling restriction, the DL traffic is blocked for lots of dedicated k1 values. For example, if the value of k1 is set as 1< k1<7, PDSCHs cannot be scheduled within any slots of frame N and frame N+1.    Figure 3. Scheduling of HARQ feedback with timing restriction in FDD system  ***Observation 3: If PUSCH repetition is configured, the timing restriction on scheduling HARQ after UL grant causes PDSCH blockage for dedicated k1 values.***  As the analysis above, the restriction introduces a large delay for HARQ reporting. Furthermore, the PDSCH scheduling is also blocked due to lack of PUCCH resource. Therefore, optimizations on the scheduling restriction should be studied to overcome the performance loss caused by the restriction.  ***Proposal 1: The timing restriction on scheduling HARQ after UL grant should be removed for the cases of PUSCH with/without repetition.***  Considering from the gNB configuration perspective, a RRC parameter to configure the function of scheduling HARQ-ACK in response to the PDSCH(s) after a DCI format multiplexed on the PUSCH scheduled by the DCI format, can be introduced in Rel-17. When gNB configures the function, it will schedule such HARQ-ACK information multiplexed on the PUSCH scheduled previously. Otherwise, the scheduling restriction is maintained and there is no change to current specifications.  ***Proposal 2: A RRC parameter to configure the function of multiplexing HARQ-ACK feedback in response to PDSCH(s) scheduled after a UL DCI format on the PUSCH indicated by the UL DCI format can be introduced in Rel-17.***  DAI enhancements  The optimization of timing restriction in section 2.1 relaxes the scheduling of PUCCH and makes it possible to piggyback the HARQ information corresponding to PDSCHs scheduled later than UL DCI. However, in this case the total DAI specified currently in a UL grant cannot reflect the number of scheduled PDSCH(s) after the UL grant. Therefore, some enhancements are needed here.  As shown in Figure 4, if the scheduling restriction is relaxed for both repetition and non-repetition cases one simple way is reusing the DAI mechanism of the HARQ feedback piggybacked on CG PUSCH or a PUSCH scheduled by DCI format 0\_0, which is following HARQ on PUCCH procedure and using the DAI in the last DL DCI for calculating HARQ bits on CG PUSCH. Relative description in TS38.213 to multiplex HARQ on CG PUSCH can be found in the Appendix.     1. PUSCH without repetition     (b) PUSCH with repetition  Figure 4. Update total DAI in UL DCI by the DAI in DL DCI  Further enhancements on the DAI mechanism to address the impact from DCI missing is to still use the total DAI in the UL DCI format, but take the DL scheduling after the UL grant into account in further. Assuming the total DAI covers both the number of PDCCHs sent before the UL DCI and the ones would be delivered after the UL grant. Although in the PHY layer, it may be difficult for gNB to anticipate how many PDSCHs will be scheduled in the future, gNB could simply set an upper bound of HARQ bits as the total DAI in UL grant to cover all the possible PDSCH(s) receptions, as shown in Figure 5. The challenge of this solution is the uncertainty for the future scheduling from gNB side. If the upper bound is set too large, additional resources are wasted. If the bound is set too small, it will also limit the potential PDSCH receptions so that to degrade the downlink data rate.    Figure 5. Total DAI in UL DCI cover all past and future DL grants  Another method is to update the total DAI by other signaling. For example, a new DCI can be sent to UE to update the total DAI value just before the PUSCH transmission subject to the timeline conditions, similar operation as DCI format 2\_4 which used to cancel the PUSCH transmission scheduled previously. As shown in Figure 7, UL DCI\_2 is transmitted to UE to update the total DAI value which has been notified by UL DCI\_1 in slot n+1, to incorporate the HARQ information corresponding to the PDSCH\_2 scheduled in slot n+2. The shortage of this method is also obvious, additional DAI update signaling will bring more scheduling complexity and resources waste.    Figure 7. New UL DCI delivered to update DAI value  Considering above three methods to determine the HARQ information bits on PUSCH comprehensively, it seems the first option (i.e. rely on the DAI in last DL DCI) is more appropriate for TEI from the specification impact perspective. It has been applied for HARQ codebook carried in PUCCH and multiplexing HARQ on CG PUSCH, and can be reused without too much spec change. Considering the possibility of gNB implementation, the total DAI in the UL DCI format can be also set as same as the one in the last DL DCI format, which maintains the current total DAI mechanism. Therefore, following proposal is made.  ***Proposal 3: When the timing restriction on scheduling HARQ after UL grant is released for PUSCH with/without repetitions, DAI in the last DCI is applied to determine the number of HARQ information bits multiplexed on the PUSCH which is similar to HARQ multiplexing on CG-PUSCH as in current specification.***  To reflect proposal 1~3, some changes on the spec are provided as examples as below. How to capture the proposals once they are agreed can be further discussed during meeting and the example could be a starting point.   |  | | --- | | 9 UE procedure for reporting control information  **<Unchanged parts omitted>**  When [*newRRC*] is not configured, a UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release, a DCI format 1\_1 indicating SCell dormancy, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.  **<Unchanged parts omitted>** |  |  | | --- | | **9.1.2.2 Type-1 HARQ-ACK codebook in physical uplink shared channel**  If a UE would multiplex HARQ-ACK information in a PUSCH transmission that is not scheduled by a DCI format or is scheduled by a DCI format that does not include a DAI field or if a UE would multiplex HARQ-ACK information including that corresponding to the PDSCHs scheduled after a DCI format in the PUSCH scheduled by the DCI format when [*newRRC*] is configured, then  - if the UE has not received any PDSCH or SPS PDSCH release that the UE transmits corresponding HARQ-ACK information in the PUSCH, based on a value of a respective PDSCH-to-HARQ\_feedback timing indicator field in a DCI format scheduling the PDSCH reception or the SPS PDSCH release or on the value of *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 1\_1 or on the value of *dl-DataToUL-ACK-ForDCI-Format1-2* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 1\_2, in any of the occasions for candidate PDSCH receptions by a DCI format or SPS PDSCH on any serving cell , as described in clause 9.1.2.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission;  - else the UE generates the HARQ-ACK codebook as described in clause 9.1.2.1, except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*, unless the UE receives only a SPS PDSCH release, or only SPS PDSCH reception, or only a PDSCH that is scheduled by DCI format 1\_0 with a counter DAI field value of 1 on the PCell in the occasions for candidate PDSCH receptions in which case the UE generates HARQ-ACK information only for the SPS PDSCH release or only for the PDSCH reception as described in clause 9.1.2.  A UE sets to NACK value in the HARQ-ACK codebook any HARQ-ACK information corresponding to PDSCH reception or SPS PDSCH release that the UE detects in a PDCCH monitoring occasion that starts after a PDCCH monitoring occasion where the UE detects a DCI format scheduling the PUSCH transmission.  A UE does not expect to detect a DCI format switching a DL BWP within symbols prior to a first symbol of a PUSCH transmission where the UE multiplexes HARQ-ACK information, where is defined in [6, TS 38.214].  If a UE multiplexes HARQ-ACK information in a PUSCH transmission that is scheduled by DCI format that includes a DAI field when [*newRRC*] is not configured or does not detect any PDCCH scheduling PDSCH with HARQ-ACK to be multiplexed in the PUSCH scheduled by a previous PDCCH when [*newRRC*] is configured, the UE generates the HARQ-ACK codebook as described in clause 9.1.2.1 when a value of the DAI field is except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*. The UE does not generate a HARQ-ACK codebook for multiplexing in the PUSCH transmission when unless the UE receives only a SPS PDSCH release, or only SPS PDSCH(s), or only a PDSCH that is scheduled by DCI format 1\_0 with a counter DAI field value of 1 on the PCell in the occasions for candidate PDSCH receptions in which case the UE generates HARQ-ACK information only for the SPS PDSCH release or only for the PDSCH reception as described in clause 9.1.2. if the PUSCH is scheduled by a DCI format that includes a DAI field and the DAI field is set to '0'; otherwise, .  **<Unchanged parts omitted>** |  |  | | --- | | **9.1.3.2 Type-2 HARQ-ACK codebook in physical uplink shared channel**  If a UE would multiplex HARQ-ACK information in a PUSCH transmission that is not scheduled by a DCI format or is scheduled by a DCI format that does not include a DAI field or if a UE would multiplex HARQ-ACK information including that corresponding to the PDSCHs scheduled after a DCI format in the PUSCH scheduled by the DCI format when [*newRRC*] is configured, then  - if the UE has not received any PDCCH within the monitoring occasions for DCI formats scheduling PDSCH receptions, or SPS PDSCH release, or DCI format 1\_1 indicating SCell dormancy on any serving cell and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission;  - else, the UE generates the HARQ-ACK codebook as described in clause 9.1.3.1, except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*.  If a UE multiplexes HARQ-ACK information in a PUSCH transmission that is scheduled by a DCI format that includes a DAI field when [*newRRC*] is not configured or does not detect any PDCCH scheduling PDSCH with HARQ-ACK to be multiplexed in the PUSCH scheduled by a previous PDCCH when [*newRRC*] is configured, the UE generates the HARQ-ACK codebook as described in clause 9.1.3.1, with the following modifications:  - For the pseudo-code for the HARQ-ACK codebook generation in clause 9.1.3.1, after the completion of the and loops, the UE sets where is the value of the DAI field according to Table 9.1.3-2  - For the case of first and second HARQ-ACK sub-codebooks, the DCI format includes a first DAI field corresponding to the first HARQ-ACK sub-codebook and a second DAI field corresponding to the second HARQ-ACK sub-codebook  *- harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*.  **<Unchanged parts omitted>** |   Applicability of scheduling enhancements  In section 2, the impact of scheduling restriction is analyzed. Based on the analysis, removal of the restriction for both PUSCH with and without repetition cases is proposed. As the ambiguity of DAI used for HARQ-ACK generation, the DAI in the last DL DCI format is clarified to be used. During the discussion of previous RAN1 meetings, more clarifications are provided below.  *Last DCI missing*  First of all, the issue of last DCI missing is not introduced by the enhancement of PUSCH scheduling. For HARQ-ACK on PUCCH, the DAI in the last DCI is used originally to construct the HARQ-ACK codebook. The same procedure is also applied to HARQ-ACK multiplexed on CG PUSCH or PUSCH scheduled by DCI format 0\_0, as currently specified. So last DCI missing is a common issue for all cases that using DAI in DL DCI format to generate HARQ-ACK codebook. However, considering the reliability requirement of PDCCH decoding, the probability of DCI missing is relatively low, and according to observation of actual deployment, last DCI is still quite reliable. Therefore, we think the last DCI missing issue might not be very serious and the proposed enhancement can be a first step that enables to remove the scheduling restriction for proper use cases.  If reliability is further pursued as that has been provided by the total DAI in UL grant, further enhancement can also be considered. For example, to allow a second UL grant indicating to the same TB but only with an updated total DAI after the second group of PDCCHs. This will require further specification work and we are open to consider, including other possible approaches with minimized specification impacts.  *Restriction of A-CSI report*  Restriction on PUSCH scheduling is also applied to A-CSI reporting. When gNB triggers an A-CSI reporting on a PUSCH, the consequent HARQ after CSI trigger cannot be multiplexed on the PUSCH with A-CSI report. In other word, the restriction on CSI reporting is caused by the restriction on HARQ-ACK multiplexing on PUSCH. Thus, A-CSI reporting can be seen as a special case of single PUSCH case. Even for that PUSCH repetition is configured, A-CSI will be only transmitted in the first repetition. Therefore, once a general solution to remove the restriction on PUSCH with/without repetition is agreed, it would apply to A-CSI reporting naturally and no more discussion is needed for A-CSI specifically. |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | SoftBank | We are supportive on this proposal. | | Huawei, HiSilicon | Support. And the TP as examples given can be starting point - in any case the changes seem minor while enabling to remove a significant restriction to network without introducing new features (the mechanis is already used for CG-PUSCH multiplexing). | | NTT DOCOMO | We are supportive of this proposal. BTW, current proposal in [1] applies same mechanism between repetition-case and non-repetition case. The above TEI proposal #6 has unrequired first bullet, I guess. | | LGE | In general, we don’t think it is good to endorse Rel-17 TEI item at this stage considering the current Rel-17 progress. However, if we should choose some, This may be considered as Rel-17 TEI since the motivation is relevant and the required work is limited and already defined well. | | QC | We want to better understand the scope of this proposal. We are not in favor of any major changes to the existing framework around tDAI as Ericsson seems to propose. | | Intel | We understand the motivation of this proposal to relax scheduling restriction. However, as mentioned in previous meetings, it seems the new DCI missing after UL grant would introduce ambiguity between gNB and UE side on the HARQ-ACK codebook size on PUSCH. In R15/16, this issue was resolved by the T-DAI in UL grant. We think we may need more discussion on the detailed solution to make the design more robust. | | Ericsson | We support the proposal.  We share the same view as HW that such restriction has put a lot of constraints on scheduling and cpnsequently affecting system performance in real deployment.  As HW mentioned, we are fine with a simple solution and the TPs in contribution are examlpes to further investige how to solve this issue.  With respect to QC comment, we are also fine with solutions that does not change any tDAI and related behaviour. As we mentioned, the proposed solutions are example. We can also consider that NW would indicate tDAI by indicating a larger value. UE follows the same behaviour to construct codebook using last scheduling DCI which its tDAI matches the tDAI in UL grant. | | ZTE | We don’t see the urgency of this TEI, while we are also ok to further discuss the potential solution if we could be more focused in terms of the applicable scenarios. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies including operator, infra vendor and UE vendor, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | Huawei, HiSilicon 2 | Thanks all for comments, please find further reply from our side.  @QC  The proposal is seeking to relax the scheduling restriction on HARQ multiplexing on a PUSCH, which the HARQ corresponding to the PDSCH scheduled after the UL DCI format scheduling the PUSCH, and clarify which DAI is used for HARQ generation on the PUSCH after scheduling restriction removal. It does not intend to change the current tDAI framework but simply reuse the exsiting procedure of HARQ multiplexing on CG PUSCH. The spec change is an example to have better understanding.  We are also open to the solution explained by Ericsson that NW would indicate tDAI with a larger value and construct the HARQ codebook based on that value accordingly. In this way, the total DAI value in UL DCI format matches with the DAI in last scheduling DCI.  @Intel  The DCI missing issue is not introduced by the removal of scheduling restriction. Similar risk would also occur for using DL DAI to generate the HARQ, such as HARQ codebook type 2, HARQ on CG PUSCH and HARQ on the PUSCH scheduled by DCI format 0\_0. An alternative thinking to maintain the tDAI effect, just as we explained to QC above, a larger tDAI could be indicated, which is equal to the value in last scheduling DCI.  @ZTE  As we observed, the applicable scenarios are quite universial. No matter PUSCH with or without repetition, the restrictions will result in a lager HARQ delay or even blockage on PDSCH schedulding since no PUCCH resource can be indicated for HARQ feedback. Specific explaination can be found in our contribution R1-2108737. | | Ericsson 2 | We fully support the explanations and justifications provided by HW/HiSi.  We would like to emphasize that existing restriction was mainly a result of lack of consensus at RAN1 when a decision was needed. We believe at the time of decisions, its detrimental consequecnes were not fully known to the group. However, as NR started to take off, the drawbacks of such decisions became very apparent.  As TEI should be justified by issues in the field, we request the group to kinly consider the real issues that NW vendors are facing and help us in finding/adjusting the solution that would be acceptable. | | Moderator | No concern/objection has been received so far. Therefore, following proposal is set for final check **TEI proposal #6**  * **Support the optimization of timing restriction on scheduling HARQ after UL grant for the case of PUSCH repetition**   + **The time restriction on scheduling HARQ after UL grant is only applied to initial PUSCH repetition, and HARQ information bits corresponding to the PDSCH(s) scheduled after UL grant which triggers the PUSCH transmission are allowed to be multiplexed on the non-initial repetitions**   + **The timing restriction on scheduling HARQ after UL grant should be removed for the cases of PUSCH with/without repetition**   + **A RRC parameter to configure the function of multiplexing HARQ-ACK feedback in response to PDSCH(s) scheduled after a DCI format on the PUSCH indicated by the DCI format can be introduced in Rel-17**   + **When the timing restriction on scheduling HARQ after UL grant is released for PUSCH with/without repetitions, DAI in the last DCI is applied to determine the number of HARQ information bits multiplexed on the PUSCH – this is the similar to the CG-PUSCH multiplexing as in current specification**   + **Text proposals shown in Section 2.2 of R1-2108737 are applied** | | QC | The proposal is still worded in an ambiguous manner. The second bullet seems to contradict what the first bullet says. In the fourth bullet, is “DAI in the last DCI” referring to the DCI carrying the downlink grant? If so please state this clearly.  More generally, this does bring the issue of missing the last DCI to the forefront. PUSCH repetitions could run into rate matching complications when the multiplexed payload is greater than 2 HARQ bits. Given that its hard to assess its overall impact and given that this brings nothing more than latency reduction of ACK/NACK back to gNB, we are not convinced that this TEI proposal is ready to be approved. | |

Based on the above contribution and discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #6**

* **Support the optimization of timing restriction on scheduling HARQ after UL grant for the case of PUSCH with/without repetition**
  + **The timing restriction on scheduling HARQ after UL grant should be removed for the cases of PUSCH with/without repetition**
  + **A RRC parameter to configure the function of multiplexing HARQ-ACK feedback in response to PDSCH(s) scheduled after a UL DCI format on the PUSCH indicated by the UL DCI format can be introduced in Rel-17**
  + **When the timing restriction on scheduling HARQ after UL grant is released for PUSCH with/without repetitions, DAI in the last DCI is applied to determine the number of HARQ information bits multiplexed on the PUSCH which is similar to HARQ multiplexing on CG-PUSCH as in current specification.**
  + **Text proposals shown in Section 2.2 of R1-2110856 are applied**

This TEI proposal is already supported by Huawei, HiSilicon, China Unicom, Ericsson, [Softbank, NTT DOCOMO].

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | tentative | We are open to exploring a solution that resolves this issue.  Upon a more careful examination of the discussion from the previous meeting, we prefer to go with the approach briefly outlined by Ericsson, and also motivated in Section 2.2 of the proponents tdoc. We would urge you to go with the proposal where the tDAI in the uplink grant continues to be used to determine the codebook size for second and subsequent repetitions. To us, this seems like the only way to ensure some level of protection against missing DL DCIs.  To be clear this is what we have in mind:   1. Do not make any changes w.r.t. the first PUSCH transmission, i.e., no DL grants are to be expected after the UL grant and before the first transmission that would result in adjusting or adding UCI in the first transmission. 2. For second and subsequent transmissions, the uplink tDAI continues to play a role. The uplink grant’s tDAI acts like a “modulo function” in determining the actual codebook size.  For example, if the uplink tDAI indicates a total of 2 HARQ bits, then the allowed codebook sizes on the subsequent PUSCH repetitions are 2, 6, 10, and so on. Thus, there is no strict need for the gNB to predict the future DL grants. If say the UE received 4 grants, it would round it up, and set codebook size to be 6. As you can see, downlink tDAI plays no role here and its not catastrophic to miss the last DCI. UE tracks DL cDAI and takes action as per legacy behavior.   Please confirm that this explanation lines up with what you had in mind in Section 2.2 (especially the text around Figure 5).   1. Restrict any change/relaxation we make to DG PUSCH scheduling. On aspects such as SPS scheduling or one shot HARQ, we don’t see an issue with the current restriction. We prefer to leave this behavior unchanged. This should ensure ancillary impact from this change is contained to DG PDSCH. We don’t want to get into maintenance phase with a lost list of broken features.   Here is an amended proposal capturing these points:  **Proposal: Support the optimization of timing restriction on scheduling DG-PDSCH~~HARQ~~ after UL grant for the case of PUSCH with~~/without~~ repetition**   * 1. **The timing restriction on scheduling DG-PDSCH ~~HARQ~~ after UL grant ~~should be~~ is removed for the cases of PUSCH with~~/without~~ repetition**   2. **Legacy scheduling restriction continues to apply for the first repetition, i.e., no DL grants are expected after the UL grant and before the transmission of the first repetition.**   3. **A RRC parameter to configure the function of multiplexing HARQ-ACK feedback in response to PDSCH(s) scheduled after a UL DCI format on the second and subsequent PUSCH repetitions indicated by the UL DCI format can be introduced in Rel-17**   4. **When the timing restriction on scheduling DG-PDSCH ~~HARQ~~ after UL grant is released for PUSCH with~~/without~~ repetitions, total DAI in the ~~last~~ uplink DCI is applied to determine the ~~number~~ size of HARQ ~~information bits~~ codebook multiplexed on the PUSCH repetition ~~which is similar to HARQ multiplexing on CG-PUSCH as in current specification~~.**   5. **This change is restricted only to DG-PDSCH scheduling. No relaxation applies to SPS activation, one shot HARQ request, etc.** |
| Samsung | N | This proposal have been submitted many time in last RAN1 meeting without any consensus. Main motivation is to remove DAI benefits which have been introduced in LTE. Furthermore, this is gNB scheduling issue and can be avoided by proper scheduler such that UL grant should be scheduled right before PUSCH. If HARQ-ACK is important than PUSCH and it should be transmitted in faster time, priority conception (which is designed for Rel-16 eURLLC) can be considered as an alternative. Furthermore, it is noted that simultaneous PUCCH and PUSCH transmission will be introduced in Rel-17 IIoT/URLLC Item. So, using this feature can address this issue as well. |
| SoftBank | Y | We think this proposal is worth considering, and Rel-18 would be a bit late. |
| Nokia, NSB |  | We would not oppose this TEI item, it is fixing an unnecessary restriction. |
| Ericsson | Y | We appreciate QC constructive approach.  From our point of view, we are fine with the changes QC proposed, to limit the relaxation for 2nd and 2rd,. PUSCHs and only limit to it HARQ-ACK corresponding to DG-PUSCH.  With respect to Samsung comment, due to this restriction, there is not much option left for gNB to handle. Please consider the case of repetition and a TDD pattern is DDDDU. To achieve repetition of factor two for 4 DL slots, their corresponding feedback should be delayed after repetiton.  The issue is even more severe for URLLC because the scheduling restrciton is per priority, i.e. applicable for HP too.  Also, this is a real field issue and we would like to have a solution that fixes that. As we follow Rel-17 URLLC discussion, we are not sure sbout the outcome of simultaneous PUCCH and PUSCH. F it goes as it seems, different priority and inter-band CA, it is not helping this situation that is present for single cell. |
| NTT DOCOMO | Y | We are supportive of this proposal. |
| Moderator |  | This proposal is supported by Huawei, HiSilicon, China Unicom, Ericsson, Softbank, NTT DOCOMO  Given that this proposal has met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will be treated in the 2nd round discussion.  Proponent and supporting companies are requested to solve companies' concern by the 1st check point (Nov. 15) |
| Intel |  | We do not see the urgency to change current behavoir. Further, as commented previously, new DCI missing after UL grant would introduce ambiguity between gNB and UE side on the HARQ-ACK codebook size on PUSCH. |
| Huawei, HiSilicon | Y | **On QC’s approach:**  We are generally fine with the suggestion from QC that to limit the relaxtion on the non-initial PUSCH repetition, which is also the original proposal we provided at the beginning of discussion. However, based on our understanding, it seems no difference between with and without repetition case from UE capability perspective. Let us check whether this can be acceptable for QC and the group: to remove the scheduling restriction for PUSCH with repetition and without repetition and introduce a UE capability which UE can report to support them both or none of them.  On the suggestion on reusing tDAI in the UL grant, we are ok with that.  To limit the removal of restriction on DG-PDSCH , I am not sure whether there is a lot difference between DG-PDSCH and SPS activation/one-shot HARQ feedback. For the time being, we can accept to remove the restriction on DG-PDSCH now.  **On Samsung’s comments:**  This proposal does not intend to remove tDAI, expecailly based on the suggestion from QC and Ericsson, the tDAI in the UL grant is still applied to generate HARQ codebook on PUSCH. This proposal provides more flexibilities on gNB scheduling and avoid too much HARQ delay.  Also condisering the example that Ericsson provides, the UE may report HARQ feedback only after the finishing PUSCH repetitions, which results in a huge HARQ delay.  As the simultaneous transmission of PUSCH and PUCCH in Rel-17 URLLC discussion, they are different issues. UE may be not capable to support such URLLC feature in Rel-17, but it still can achieve the flexibility based on this proposal to report HARQ. Therefore, we think the issue is differen and this proposal should be treated separately.  **On Intel’s comment:**  Based on the lastest proposal suggested from QC, tDAI is kept to generate HARQ codebook on PUSCH and no ambiguity between UE and gNB, are you ok with this? |

* 1. Enhancement on SSB resources for RLM

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [6] | A UE is required to monitor the downlink radio link quality of the primary cell to indicate out-of-sync/in-sync status to higher layers. The reference signals for radio link monitoring (RLM) can be SSB or CSI-RS, which are configured by *RadioLinkMonitoringRS.* Each *RadioLinkMonitoringRS* corresponds to a resource, either SSB or CSI-RS, for the radio link failure detection.  For a UE that supports the use of CSI-RS for RLM, if the UE is not provided with *RadioLinkMonitoringRS*, the UE can use the CSI-RS provided for the active TCI state for PDCCH receptions as the RLM resources. However, not all UEs have the capability to support the use of CSI-RS for RLM. For a UE that does not have the capability, the UE can only use the SSBs explicitly configured through *RadioLinkMonitoringRS* as the RLM resources.  However, a UE can only be configured with up to  SSB resources for RLM as shown in Table 1, where  is much smaller than the maximum number of SSBs from a serving cell. In this case, a UE may undesirably declare the radio link failure (RLF), if it cannot detect the SSBs configured by *RadioLinkMonitoringConfig*,even if it can receive one or more other SSBs from the serving cell properly. The issue was already identified in the real deployment scenarios even for FR1. It requires the network to very frequently re-configure the RLM SSBs for a moving UE to avoid the UE undesirably declares the RLF.  Table 1:  as a function of maximum number (TS 38.213)   |  |  | | --- | --- | |  |  | | 4 | 2 | | 8 | 4 | | 64 | 8 |   A potential solution for the above issue could be that if a UE cannot receive the SSBs configured by *RadioLinkMonitoringConfig* for radio link monitoring, but it has detected the SSBs from the same serving cell, the UE will use the detected SSBs with the maximum RSRP from the same serving cell for RLM instead of declaring the RLF. With this approach, it will provide the gNB enough time to re-configure the *RadioLinkMonitoringConfig* with the SSBs reported from the UE in RRM measurements, and reduce the probability of triggering the unnecessary RLF procedure.  In our view, the proposed solution has the following advantages:   1. It does not increase the number of SSBs for RLM or other purposes at any given time because it simply uses an already detected non-RLM SSB for RLM when UE cannot detect configured RLM SSBs; 2. It has no impact on other procedures (e.g., beam management, PDCCH channel, beam failure recovery, etc.). RLM is UE’s internal operation based on the hypothetical PDCCH BLER rates derived from UE based on SINR of the monitored SSB, and it is not related to any procedures and signaling related data communication. 3. It may potentially reduce the RLM operation complexity when it is used properly, since it may allow reducing the number of SSBs configured for RLM for some scenarios without too much concern on UE to prematurely declare RLF, especially for slow-moving or stationary UEs.   ***Proposal 1: When a UE cannot detect any of the SSBs configured in RadioLinkMonitoringConfig for radio link monitoring for a serving cell, but it has detected one or more other SSBs from the same serving cell, the UE should use the detected SSB with the maximum RSRP as the RLM resource.*** |

This TEI proposal has been proposed and discussed in the previous meeting, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | Huawei, HiSilicon | Some additional comments: does this need RAN2/RAN4 work for e.g. requirements? | | NTT DOCOMO | We have the same comments as in the last meeting.   * We are still wondering how much this TEI proposal is beneficial/essential in practical cases, since RLM-RS can be appropriately set explicitly or implicitly based on BM/BFR results. * We think that the proposal (performing IS/OOS evaluation for the additional SSB outside RLM-RS) is equivalent to the increase of the number of RLM-RSs, and hence we are wondering whether the proposal will be implemented for the commercial use even if agreed since the number of RLM-RSs is a compromised value after extensive discussion in Rel-15. | | QC | We are not in favor of this proposal. Restating a comment we made in R1-105e:  We are concerned that this proposal seems to go against the purpose of configuring RLM resources i.e., what is the point in configuring resources if the UE is expected to ignore the configuration anyway? If the network chose to use multiple beams and expects the UE to perform beam management, then the onus is on the network to properly configure and update the appropriate resources. Since the gNB has to reconfigure TRS upon beam change in response to a UE report indicting a new best serving beam, the gNB has no reason not to reconfigure the RLM resources as well, if needed, which simply avoids the issue that the proposal itended to address. | | Intel | We have requested for bit more information on the proposal in the previous meeting that have not been addressed.  Please find some questions on the proposal.  Q1) Is there any extra time allowed for UE to switch to a new best RSRP SSB to start making measurement? Or is the UE expected to continue to report OOS to upper layers while UE tries to find the best RSRP SSB and start making measurements? If OOS is continuously reported to higher layer during the new search process, how would this stop early RLF declaration? We would like to understand the how the interaction between physical and upper layer is handled and whether this would require changes to RAN4 RLM measurement requirements, especially timing aspects.  Q2) Does the UE switch to measure the best RSRP SSB after a single OOS measurement from the configured set of SSB(s)? What is the criteria for the UE to switch back to configured SSB from non-configured SSB? Basically what is the criteria for switching to new non-configured SSB and what is the criteria for the UE to switch back from non-configured to configured SSB?  Q3) if the UE needs to switch back and forth between configured and non-configured SSB depending on measurements, isn’t this the same as increasing the measurement RS? I assume the only way to switch back and forther between configured and non-configured is to perform measurement of both at the same time. How we make sure UE complexity is necessarily overburdened by this operation? | | Ericsson | We continue to support | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow. Also, it seems this proposal has not yet met the criteria that the proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | CATT | Thanks for the discussion and the comments to our proposal. We would like to add some responses to the received comments:  To Huawei, HiSilicon: There is no need of RAN2/RAN4 work in our view.  To NTT DOCOMO: The issues were observed in the field tests. We don’t see it as equivalent to the increase of the number of RLM-RSs. There is no increase in the UE load for the detection of the SSBs. UE has the same total number of SSBs configured for RRM and RLM.  To QC: The proposal does not promote the gNB not to follow the current way to configure RLM resources. The configuration of RLM-SSBs may not perfectly follow the dynamic changes of the UE RF environment. The proposed approach is to reduce the impact when the UE cannot detect RLM-SSBs, when the re-configuration of the RLM-SSB does not follow perfectly the dynamic changes of the UE RF environment.  To Intel:  For Q1, we assume it is up to UE to decide how much time delay to switch to a new best RSRP SSB to start making the measurement. In general, we assume once UE makes the judgement that it cannot detect any RLM-SSB, it can do the switch. Similarly, once the UE has re-detected the RLM-SSB, it can decide to switch back. It should be up to UE to make the decision, and no RAN4 requirement is needed.  For Q2), we assume there is no UE need for UE to switch to measure the best RSRP SSB, since the best RSRP SSB is assumed to be already found by UE from the RRM-SSBs. Again, UE will decide when to switch back to configured SSB from non-configured SSB, once the UE consider the configured SSB is good enough for RLM.  For Q3), in our proposal, we assume what the UE needs to detect (or the measurement of the RSRSP) is not changed, i.e., it includes both the RLM-SSB and RRM-SSB. Among these SSBs, if none of the RLM-SSB can be detected by the UE, the UE uses the best RSRP RRM-SSB for RLM. | | NTT DOCOMO | Thanks CATT for the reply with explanations!  Although we understand that the proponent considers the proposal does not change the UE load for the detection of the SSBs, we think actually there is additional thing UE needs to do for the proposal, which is to perform IS/OOS evaluation for non-RLM-SSB. IS/OOS evaluation is performed based on SINR measurement and typically UE only performs RSRP/RSRQ measurement for RRM-SSB. In the proposal, UE first performs SINR measurement on RLM-SSBs, and if there is no detected RLM-SSB, then the UE performs SINR measurement on non-RLM-SSB detected during RRM procedure. So, the total number of SSBs UE performing SINR measurement in the proposal is increased. This is why we think it is equivalent to the increase of the number of RLM-RSs. Although we agree that it would be good if the issue can be addressed, we think this proposal seems complex. RRM-SSBs include both serving cell SSB and neighbor cell SSB, and for RRM, UE does not need to distinguish them but for this proposal UE needs to select serving cell SSB to perform RLM. As the issue is observed in the field, maybe we can consider more straightforward approach which is to define new UE capability for supporting larger number of RLM-RSs? | | MediaTek | Thanks for CATT’s response to our previous questions. We have some more questions for clarification.  (1) So the problem happened in field when the beam management was not properly implemented and RLM-RS was not updated frequently enough. We are wondering how often RLM-RS needs to be updated in FR1 and FR2, respectively, to avoid this issue.  (2) Can RSRP respresent the link quality? If so, why RLM is based on SINR in the very beginning which is more computationally expensive? Did you implement the proposed solution in field? How much gain can this proposed solution bring?  (3) We share similar views with Docomo and QC and have similar questions as Intel. It is not clear to us based on your response so far how many OOSs UE should accumulate before it decides to use a detected SSB with maximum RSRP as one of its RLM-RS? Having this asked, we believe this is a cross-WG topic which is hence not fit for TEI. | | Moderator | Moderator would like to ask proponent to reply to the objection/concern in this round and provide updated proposal, if necessary | | CATT | Thanks for the further discussion.  To NTT DOCOMO:  Yes, IS/OOS evaluation is performed based on SINR measurement and typically UE only performs RSRP/RSRQ measurement for RRM-SSB.  Maybe we haven’t not make our intention clear. Our proposal does not mean “UE first performs SINR measurement on RLM-SSBs, and if there is no detected RLM-SSB, then the UE performs SINR measurement on non-RLM-SSB detected during RRM procedure.” Instead, it means: “If UE cannot find any RLM-SSBs (e.g., RSRP is under the certain threahold as defined in RAN4), then the UE uses the best RSRP SSBs for RLM”. If the UE can find any RLM-SSBs and uses the measured SINR for the IS/OOSevaluation, the UE still uses these RLM-SSBs for IO/OOS evaluation. In this way, there is no increase of total number of SSBs UE performing SINR measurement.  To MediaTek:   1. So the problem happened in field when the beam management was not properly implemented and RLM-RS was not updated frequently enough. We are wondering how often RLM-RS needs to be updated in FR1 and FR2, respectively, to avoid this issue.   CATT: This really depends on the scenarios. The RF conditions could be changed very fast, especially for FR2 due to the very narrow beam widths.   1. Can RSRP respresent the link quality? If so, why RLM is based on SINR in the very beginning which is more computationally expensive? Did you implement the proposed solution in field? How much gain can this proposed solution bring?   CATT: RSRP alone is not enough to decide IS/OOS. We propose to use the best RSRP SSB for RLM. It means we need to obtain the SINR from the best RSRP SSB for the evaluation of IS/OOS, the same as the case when RLM-SSB is used.   1. We share similar views with Docomo and QC and have similar questions as Intel. It is not clear to us based on your response so far how many OOSs UE should accumulate before it decides to use a detected SSB with maximum RSRP as one of its RLM-RS? Having this asked, we believe this is a cross-WG topic which is hence not fit for TEI.   CATT: The proposal assumes when the best RSRP SSB is used, it works as if it were a configured RLM-SSB. We do not propose any change related to RLM parameters, e.g., number of OOS to be accumulated to declare RLF. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #7**

* **When a UE cannot detect any of the SSBs configured in RadioLinkMonitoringConfig for radio link monitoring for a serving cell, but it has detected one or more other SSBs from the same serving cell, the UE should use the detected SSB with the maximum RSRP as the RLM resource**

This proposal is already supported by CATT and Ericsson.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Samsung | N | We cannot be convinced whether there is clear benefit or not, since the solution is same as to increase the number of RLM RSs. |
| CATT | Y | Re Samsung:  Thanks for the comments. The maximum number SSB that a UE can be configured is up to  as shown following Table 1, where  is much smaller than the maximum number of SSBs from a serving cell.  Table 1:  as a function of maximum number (TS 38.213)   |  |  | | --- | --- | |  |  | | 4 | 2 | | 8 | 4 | | 64 | 8 |   The problem happened in field even when  SSBs are configured as RLM RS. This is the reason that we brought up this proposal. |
| Nokia, NSB | N | This doesn’t seem to work if the UE is estimating RLM based on an SSB that the gNB did not ask it to be on. Agree with Samsung that the increased number of RLM RS would be more helpful. |
| HW, HiSi |  | We are open to the proposal. To understand better, when UE uses additional SSBs that are detected, some feedback is needed for gNB to know? |
| Ericsson | Y |  |
| NTT DOCOMO | N | We can be supportive to address the issue observed in the field test. However, we still have different understanding from proponents.  The proponent kindly explained that “*If UE cannot find any RLM-SSBs (e.g., RSRP is under the certain threahold as defined in RAN4), then the UE uses the best RSRP SSBs for RLM*”. However, there is no RAN4 defined threshold for RSRP to decide whether to perform SINR measurement on RLM-SSB for RLM. In TS38.133 8.1, only Qin and Qout are defined as thresholds used for RLM, and those are not RSRP threshold but BLER threshold for hypothetical PDCCH based on SINR measurement, i.e., UE anyway needs to perform SINR measurement on all configured RLM-SSBs to decide whether it needs to declare OOS (hypothetical PDCCH BLER based on SINR for all RLM-SSBs are below Qout) or not in the concerned scenario (“*UE cannot find any RLM-SSBs*”).  Therefore, as the proponent mentioned, if the proposal intends “*no increase of total number of SSBs UE performing SINR measurement*”, the applicable case is only when UE already performed SINR measurement on detected RRM-SSB and the detected RRM-SSB is not configured as RLM-SSB. In such case, it may be possible to reuse measured SINR result for IS/OOS evaluation without requiring additional SINR measurement. Otherwise, UE needs to perform additional SINR measurement on detected RRM-SSB for the proposal as UE anyway performs SINR measurement on configured RLM-SSBs as explained above.  Based on above, we still think this proposal is complex and applicable case would be quite limited if above our understanding is correct. As allowed discussion time for TEI-17 proposals is limited in this e-meeting and we are not only one company having question/concern on this proposal, we suggest to not proceed this proposal in Rel-17 TEI, but we are open to discuss potential enhancement to address the issue in future release. |
| Moderator |  | Given that this proposal has not met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will not be treated in this RAN1 meeting anymore. |

* 1. Periodic SRS transmission outside DRX active time

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | According to NR Rel-15, when a UE is configured with DRX operation, the UE is not required to measure and report periodic and semi-persistent CSI outside the DRX active time. In Rel-16 UE power saving WI, as an enhancement for the DRX operation, a PDCCH-based wake-up signal (WUS), i.e., DCI format 2-6, has been introduced, based on which, the network can indicat the UE whether to start or skip a *drx-onDurationTimer* for a DRX cycle. In the later stage of Rel-16 discussion, an issue was identified with the periodic and semi-persistent CSI reproting when both DRX and DCI format 2\_6 are configured: if the UE is not indicated to wake-up by the network for a long time, e.g., due to DL traffic inactivity, the UE needs to stay outside DRX active time during at least a few DRX cycles, and cannot get a chace to measure and report CSI during that time. Thus, when a new DL traffic arrives later and the UE is woken-up by the network, even the most recent CSI report from the UE is a few DRX cycles ago and may already be stale. This may result in an increased decoding error rate of earlier data packets, until the CSI at the network is updated by a new CSI report from the UE.  To address this issue, in Rel-16, when both DRX and DCI format 2\_6 are configured, it was agreed to allow measurement and reporting for periodic CSI during the time duration indicated by drx-onDurationTimer outside DRX active time. Two new higher layer parameters, *ps-TransmitPeriodicL1-RSRP-r16* and *ps-TransmitOtherPeriodicCSI-r16*, are introduced for separately enabling CSI reporting for L1-RSRP (i.e., cri-RSRP and ssb-Index-RSRP) and other report quantities, respectively, outside DRX active time.  Like periodic and semi-persistent CSI reporting, in Rel-15, the UE is not required to transmit periodic SRS and semi-persistent SRS outside the DRX active time. Thus, when the UE is configured with DRX and DCI format 2\_6, the same issue aforementioned for CSI reporting persists for SRS transmission; the UE may not get an opportunity to transmit SRS for a very long time outside DRX active time. When SRS is used for either DL or UL channel sounding, this may impact the overall system performance. In Rel-16, nevertheless, only the issue of CSI reporting outside DRX active time was addressed, while the issue with SRS transmission was overlooked due to lack of time.  Although periodic CSI reporting outside active time can help keep the CSI updated, it may not be sufficient in some case. For example, without channel reciprocity, the network should rely on SRS to assess UL channels. With channel reciprocity, relying on SRS for DL channel sounding may be more power efficient from the UE perspective, since the UE is not required to measure CSI-RS and compute the CSI report. Also, for SUL, SRS may be the only resource that the network can assess the UL channel. Therefore, it seems necessary to allow a UE to transmit SRS outside DRX active time, when the UE is configured to monitor DCI format 2\_6.  Proposal 4: When UE is configured with DRX and to monitor DCI format 2\_6, it can also be configured to transmit at least periodic SRS outside DRX active time during the time duration indicated by *drx-onDurationTimer*. |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | NTT DOCOMO | We are open to discuss this proposal. It seems more justification which shows this enhancement is critical is needed. | | LGE | We think the proposal itself needs further agreement and don’t think can be completed as in Rel-17 TEI | | Qualcomm | It is well understood why it was decided in Rel-16 that supporting periodic CSI outside of active time is beneficial. Periodic SRS serves the exact same purpose in TDD when the network relies on reciprocity-based CSI. Therefore, in our view the justification of applying the same conclusion to periodic SRS is straightforward.  As some companies have pointed out, in the Rel-16 UE power saving WI, we have identified both periodic SRS and periodic/semi-persistent CSI measurement and reporting as operations being impacted by DCI format 2\_6. However, in the end, we agreed on only allowing periodic CSI/L1-RSRP measurement and reporting outside active time. The reason that the periodic SRS was not agreed was not because it has no gain, but because we didn’t have enough time to discuss, since the discussion arose in RAN1#99 near the end of the Rel-16 WI. | | Intel | Our views have not changed. We do not think this is a critical enhancement. | | Ericsson | From our perspective, this is not critical enhancement. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow. Also, it seems this proposal has not yet met the criteria that the proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | MediaTek | In principle, we are ok to discuss the proposal. But for clarity, we would like provide some editorial revision in the following for further discussion.  Proposal: When UE is configured with DRX and to monitor DCI format 2\_6, it can be configured to transmit at least periodic SRS during the time duration indicated by drx-onDurationtimer regardless whether or not it detects DCI 2\_6. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #8**

* **When UE is configured with DRX and to monitor DCI format 2\_6, it can also be configured to transmit at least periodic SRS outside DRX active time during the time duration indicated by *drx-onDurationTimer***

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Samsung | N | We think periodic SRS is not necessary. For the UL channel condition without reciprocity, UE only needs to transmit SRS when there are UL traffic. It can be done by transmitting SR first to extend the active time. |
| HW, HiSi |  | It is not clear whether there is any RAN1 impact for this proposal as the configuration limitation is in RAN2 and we noticed that RAN2 is being discussing the same/similar issue (for dormancy). This, if so, should be handled in RAN2 in our view. |
| Ericsson | N | From our perspective, this is not critical enhancement. |
| Moderator |  | Given that this proposal has not met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will not be treated in this RAN1 meeting anymore. |

* 1. Joint configuration of DRX groups and Rel-16 power saving features

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | The feature of DRX groups was discussed under TEI16 in RAN2 as a solution to reduce power consumption when UE is configured with FR1+FR2 CA, and agreed in RAN#88-e. During the discussion, RAN4 confirmed that there is minimal impact on their specs [4]. On the other hand, RAN1 could not reach a consensus [5] on whether it may have any impact on other Rel-16 power saving features. As a way-forward, it was agreed that in Rel-16 DRX groups cannot be jointly configured with WUS or SCell dormancy.  Later, in RAN #90-e, it was further discussed whether to continue the discussion on the enhancement of DRX groups in Rel-17 UE power saving WI, focusing on the joint configuration with WUS or SCell dormancy. However, due to the concern on the limited TU for Rel-17 UE power saving WI, no consensus was made in RAN #90-e.  In our view, the discussion on the enhancement of DRX groups should be continued due to the evident power saving benefits, and Rel-17 TEI should handle it. Although the discussion was initiated in RAN2, we do not think this is a cross-WG issue, since there is no RAN2 or RAN4 impact with the joint configuration and can solely be handled by RAN1. More in-depth discussion follows below.  **Joint configuration of DRX group and WUS**  It is easily expected that additional power can be saved if DRX group and WUS can be configured together. For example, suppose WUS configured on SpCell indicates to UE whether it should wake up for next on duration or not. Then skipping on durations when there is no data can help UE save extra power on top of savings enabled by DRX groups, in the same way as how WUS saves UE power if there is only single DRX group. In Appendix A.2 of [6], we provide a quantitative analysis on the power savings that can be achieved by joint configuration, compared with the baseline in which WUS is not configured. The analysis shows that ~82% more power can be saved per DRX cycle than the baseline when there is no data and ~18% when there is data.  Observation 1: If WUS and DRX groups are jointly configured, UE can save extra ~82% power per DRX cycle when there is no data and ~18% when there is data.  If we have to minimize the impact of joint configuration of DRX group and WUS in RAN1, then the existing UE behaviors need to be reused as much as possible. More specifically,   * WUS should be configured only on SpCell, as in legacy; * Conditions for WUS monitoring is completely determined by DRX state of SpCell and independent from DRX state of the secondary DRX group. For example, UE monitors WUS if SpCell is not in DRX active time, even if secondary DRX group is in DRX active time at the same time. This requirement avoids changes to the RAN1 spec; * If WUS is not received or does not indicate wakeup, none of UE’s carriers should wake up, as in legacy; * If a WUS occasion is not monitored (e.g., SpCell is already in DRX active time) or WUS indicates wakeup, UE should start DRX on duration timers of both DRX groups at their respective next occurrence. This behavior can be captured in RAN2 MAC specification. Note that this behavior works even in the corner case where FR1 (SpCell) is outside DRX active time but FR2 is within DRX active time.   As one may see from the above, no new PHY-layer behaviors need to be defined. We only need to add the following clarifications to the RAN1 standards:   * Clarify that, if secondary DRX group is configured, DRX active time for a serving cell refers to DRX active time of its associated DRX group; * Clarify that DRX on-duration timer refers to those of all DRX groups in the text on WUS procedure.   Text proposal for the above clarifications can be found in [7].  Observation 2: Joint configuration between WUS and DRX groups can be supported with minimal change to RAN1 specs.  **Joint configuration with SCell dormancy**  In legacy, there are two scenarios in which SCell dormancy indication can be sent:   * Case 1. In a WUS occasion outside UE’s DRX active time, it can be sent together with WUS to indicate which SCell dormancy group(s) should switch to dormant BWP; * Case 2. When UE is in DRX active time, it can be sent in a non-fallback DCI to indicate which SCell dormancy group(s) should switch to dormant BWP.   Case 1 requires joint configuration with WUS. In case secondary DRX group is configured, it effectively overrides DRX state of a SCell. For example, if a FR2 carrier is in a SCell dormancy group and receives dormancy indication, then it does not need to monitor PDCCH until the next DRX cycle, i.e., before receiving the next WUS. Therefore, network can take advantage of this property and use SCell dormancy indication to selectively wakeup secondary DRX group. In Appendix A.2.2 of [6], we provide a quantitative analysis on the power saving gains that can be achieved in this scenario. Our analysis shows that ~18% more power can be saved than the baseline.  In this case, because SCell dormancy indication is sent together with WUS, we do not expect much changes to RAN1/2 standards other than those described above for WUS.  Observation 3: If SCell dormancy is jointly configured with DRX groups, dormancy indication sent outside DRX active time can help save ~18% power.  In Case 2, if secondary DRX group is also configured, we think SCell dormancy operation and DRX operation can be independent from each other. More specifically,   * If both DRX groups are in DRX active time, SCell dormancy procedure can be performed exactly the same as in legacy (i.e. only a single DRX group is configured); * If the secondary DRX group is outside DRX active time, UE can still switch active BWPs of any carriers in that DRX group according to the received indication (i.e. either from dormant to non-dormant BWP or from non-dormant to dormant BWP). It is only an implementation matter that UE first stores the new active BWP indication for a carrier and then uses it after the carrier starts the next DRX active time.   It is straightforward to see that this case also requires no spec changes. Even though joint configuration in this case may not enable extra power savings, we think it is still beneficial for operators if the two features can co-exist. Otherwise, it would not be desirable if operators are forced to choose one feature over the other. For example, DRX groups may be deployed earlier than other power saving features, including SCell dormancy, because operators typically have more field experience with DRX. Then the artificial exclusivity imposed by the current Rel-16 agreement could delay the deployment of SCell dormancy, which clearly is not desirable for both operators and UEs.  Observation 4: Joint configuration between SCell dormancy and DRX groups can be supported without any change to RAN1 specs.  Based on the above analysis, we propose to discuss the following proposal in Rel-17 TEI:  Proposal 5: Support joint configuration between DRX groups and WUS, SCell dormancy, or both, without changes to their PHY-layer configurations and procedures. |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | NTT DOCOMO | We are open to discuss this proposal. The impact on RAN2/RAN4 spec needs to be further discussed. | | LGE | We think the proposal itself needs further agreement and don’t think can be completed as in Rel-17 TEI | | Qualcomm | Based on numerical evaluation results that we provided in our contribution, the additional power saving gain of joint configuration of DRX groups and WUS/SCell dormancy is significant.  With all the power saving gain, we also think the joint configuration is beneficial for operators. For example, DRX groups may be deployed earlier than Rel-16 power saving features (WUS/SCell dormancy), because the operators may be more experienced with DRX. Thus, joint configuration allows cost-efficient and phased introduction of other Rel-16 power saving features in later stages. Otherwise, if the joint configuration is not allowed, it could further delay the introduction of Rel-16 power saving features.  Regarding the concern that this is a cross-WG issue, in our view, there is no RAN2 or RAN4 impact with the joint configuration. If any, it would be just editorial issues, such as revising the field description of *drx-ConfigSecondaryGroup* in TS 38.331. In our proposed TP presented in our contribution, we showed that RAN1 spec change is also limited, i.e.,   * Clarify that, if secondary DRX group is configured, DRX active time for a serving cell refers to DRX active time of its associated DRX group;   Clarify that DRX on-duration timer refers to those of all DRX groups in the text on WUS procedure. | | Intel | Our view has not changed. This is a cross-WG issue and also significant spec work is expected for the feature. Hence, it does not seem to be a good fit for TEI | | Ericsson | We are OK to discuss this. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow. Also, it seems this proposal has not yet met the criteria that the proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #9**

* **Support joint configuration between DRX groups and WUS, SCell dormancy, or both, without changes to their PHY-layer configurations and procedures.**

This proposal is already supported by Qualcomm.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Samsung | Y (partially) | We are open to consider it if the RAN1 spec change is limtied. According to QC’s contribution, it seems only joint configuration between DRX groups and WUS has impact in RAN1, i.e. modify active time of DRX cycle when there are two InactivityTimer associated with two DRX groups. So, we suggest to remove “SCell dormancy, or both” and leave it up to RAN2 decision/discussion since no RAN1 spec change is expected. |
| HW, HiSi | N | This proposal seems to require many restrictions in order to minimize the RAN1 specification impact. On the other hand, we view it also requires many RAN2 work as a cross-WG issue. |
| Ericsson |  | We are open to discuss this |
| NTT DOCOMO | Not object | It seems beneficial if the two features can co-exist. However, since there are many descriptions for DRX, WUS and SCell dormancy in RAN2 spec, we are still not sure whether or not there is no/small RAN2 impact, and it needs to be discussed further. |
| Moderator |  | Given that this proposal has not met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will not be treated in this RAN1 meeting anymore. |

* 1. Mitigating half-duplex issue in NR V2X groupcast NACK-only case

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [5] | In V2X sidelink resource allocation Mode-1 and Mode-2, UEs can use groupcast transmissions with NACK only feedback. In this mode of operation, receivers within target communication range from the transmitter provide NACK feedback in case of unsuccessful reception and do not provide ACK in case of successful reception. The susceptibility to half-duplex collisions can be illustrated by the following simple example:   1. UE1, UE2, and UE3 operate with groupcast NACK only feedback and are group members (i.e., within target communication range from each other). 2. UE1 and UE2 selected/were granted with resources in the same slot and transmitted in slot ‘*n*’. 3. UE3 has successfully received UE1 and UE2 transmissions and thus has not provided HARQ feedback. 4. UE1 and UE2 were not able to receive each other transmissions. 5. Due to lack of NACK feedback UE1 and UE2 assume successful reception by UEs within target communication range.    1. In Mode-1, the UE reports ACK to gNB, and gNB considers successful transmission on SL, thus do not grant retransmissions    2. In Mode-2, the UE reports ACK to higher layer, and the higher layer does not grant retransmissions 6. UE1 and UE2 stop transmissions of TBs without receiving each other transmissions.   The above problem was also confirmed by system level evaluations [1][3][4]. Figure 1 shows comparative analysis of the current Rel.16 design vs scenario when two blind retransmissions are used for groupcast communication with NACK only feedback (assumptions listed in Annex C). As it can be seen, the performance of Rel.16 solution at short communication distances has error floor even at high SNR (short distances) and can be easily improved in the order of magnitude.    Figure 1: Illustration of the Rel.16 groupcast communication with NACK only feedback  Since the half-duplex collision is a fundamental issue in distributed communication systems, it may not be possible to completely avoid it. But it is possible to apply a simple enhancement which reduces the issue dramatically. Such an enhancement is to allow a UE to transmit at least two TB (re-)transmissions without considering the feedback (Figure 2), thus increasing the chances that at least one of the two control channels were successfully received, as illustrated in the analysis above.    Figure 2: Illustration of mitigation of half-duplex for NACK-only feedback regime by ignoring first N feedbacks  **Observation**   * **Rel-16 groupcast sidelink communication with NACK-only is susceptible to half-duplex issue which could limit the achievable reliability even at very high SNR links**   To mitigate the illustrated half-duplex problem for groupcast NACK only sidelink communication, there could be different solutions with different spec impact, as was analyzed in the previous submissions [5][6][7].  The following further detailed alternatives are considered from the last TEI discussion round:   * Alternative 1: For groupcast NACK-only feedback case, introduce a mechanism of ignoring N first PSFCH receptions and considering NACK instead   + The (pre-)configuration may be provided per resource pool and per priority, similar to the *maximum* number of retransmissions specified in Release 16. If it is not provided, then Release 16 behavior is applied. Further, this feature may only be applicable to NACK-only feedback case or to other cases as well. Possible values for N include 1, 2, and 3. * Alternative 2: For groupcast NACK-only feedback case, introduce a mechanism of ignoring PSFCH reception after the initial transmission   + To support both the proposed behavior and Release 16 behavior, introduce a (pre-)configuration to enable/disable this option, also considering UE capability for Rel.17. This (pre-)configuration may be provided per resource pool and per transmission priority, similar to the maximum number of retransmissions specified in Release 16.   + When the UE is configured with only one transmission, the mechanism of course should not be in action.   In the last meeting, Alternative 2 received most support from involved companies, and this time it is proposed to be adopted directly. The example text proposals for Alternative 2 are provided in Annex A. The details of signaling related to Alternative 2 are discussed in Annex B.  **Proposal**   * **For groupcast sidelink transmission with NACK only sidelink feedback,**   + **when UE is (pre)-configured with a new per transmission priority Rel.17 RRC parameter *ignoreInitialNackOnlyFeedback* and has transmitted a TB with a priority for which *ignoreInitialNackOnlyFeedback* is provided:**     - **UE reports NACK for the initial transmission of the TB to higher layers in the procedure for receiving HARQ-ACK on sidelink (TS 38.213, section 16.3.1) if number of resources indicated by SCI Format 1A carrying initial transmission of a TB is larger than one.** * **Define UE capability to indicate whether this feature is supported**   Example Text Proposal for TS 38.213   |  | | --- | | 16.3.1 UE procedure for receiving HARQ-ACK on sidelink  A UE that transmitted a PSSCH scheduled by a SCI format 2-A or a SCI format 2-B that indicates HARQ feedback enabled, attempts to receive associated PSFCHs according to PSFCH resources determined as described in clause 16.3. The UE determines an ACK or a NACK value for HARQ-ACK information provided in each PSFCH resource as described in [10, TS 38.133]. The UE does not determine both an ACK value and a NACK value at a same time for a PSFCH resource.  For each PSFCH reception occasion, from a number of PSFCH reception occasions, the UE generates HARQ-ACK information to report to higher layers. For generating the HARQ-ACK information, the UE can be indicated by a SCI format to perform one of the following  - if the UE receives a PSFCH associated with a SCI format 2-A with Cast type indicator field value of "10"  - report to higher layers HARQ-ACK information with same value as a value of HARQ-ACK information that the UE determines from the PSFCH reception  - if the UE receives a PSFCH associated with a SCI format 2-A with Cast type indicator field value of "01"  - report an ACK value to higher layers if the UE determines an ACK value from at least one PSFCH reception occasion from the number of PSFCH reception occasions in PSFCH resources corresponding to every identity of UEs that the UE expects to receive corresponding PSSCHs as described in Clause 16.3; otherwise, report a NACK value to higher layers  - if the UE receives a PSFCH associated with a SCI format 2-B or a SCI format 2-A with Cast type indicator field value of "11"  - if a UE is provided with *ignoreInitialNackOnlyFeedback* for a priority indicated in the associated SCI 1-A, and if the transmitted PSSCH scheduled by the SCI format 2-A or SCI format 2-B is the initial transmission of the TB, and the number of resources indicated by the ‘Time Resource Assignment’ field in the associated SCI format 1-A is larger than one, report to higher layers a NACK value; otherwise  - report to higher layers an ACK value if the UE determines absence of PSFCH reception for the PSFCH reception occasion; otherwise, report a NACK value to higher layers |   RRC parameters impact   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **WI code** | **Sub-feature group** | **RAN1 specification** | **Section** | **RAN2 Parant IE** | **RAN2 ASN.1 name** | **Parameter name in the spec** | **New or existing?** | **Parameter name in the text** | **Description** | **Value range** | **Default value aspect** | **Per (UE, cell, TRP, …)** | **UE-specific or Cell-specific** | **Specification** | | R17 TEI | TEI #12 | 38.213 | 16.3.1 | SL-ResourcePool |  | ignoreInitialNackOnlyFeedback | New | ignoreInitialNackOnlyFeedback | If configured, indicates that the initial PSFCH feedback for NACK-only case is ignored | true | NA | Per resource pool per TX priority | UE-specific or Cell-specific | 38.331 | |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | OPPO | According to the above TEI proposal #12, both TPs in R1-2109657 (Annex A, instead of Section 4) are applied, but we should select only one of them as proposed in the Tdoc, if it is agreed on having a such TEI. So maybe the moderator can clarify on this point.  [moderator] It is correct understanding that RAN1 must agree not only TEI proposal but also corresponding TP so that CR shall be fully completed within one TSG cycle/quarter.  Technically, in R17 we are enhancing UE power saving. So in principle, by introducing a minimum number of blind retransmissions will increase UE power consumption compared to the case if no NACK is received for the initial transmission, as well as occupying more resources (hence creating potentially more interference to others). Considering these factors, our preference is TP for Alternative 2, meaning the fixed number of transmissions is 2 including the initial transmission. After which, there is no more blind retransmissions for the same TB. | | NTT DOCOMO | We support this proposal. This proposal can mitigate half-duplex issue with quite small spec impact. | | LGE | We support this proposal as Rel-17 TEI. From a technical point of view, we are supportive of the main bullet of the proposal, but it is somewhat unclear what the meaning of its sub-bullet is considering that two alternatives of TPs implementing the proposed enhancement are described in R1-2109657. So, it would be better to try agreeing with the main bullet first, and then the details of necessary TP can be discussed | | Qualcomm | We support the proposal as it would improve performance in a backward compatible manner with very limited spec impact. The text change could be one of the examples in Annex A, which were moved there from Section 4 in a previous version of the TEI, or based on them. | | Intel | We support the proposal. | | Ericsson | We continue to support | | Moderator | Thank you very much for the feedbacks!  It seems there are 7 companies supporting (or being supportive) this proposal, and there is no clear objection/concern provided so far.  Therefore, moderator would like to check whether RAN1 can reach consensus to agree on the proposal. **TEI proposal #12**  * **Introduce mitigation of half-duplex issue for sidelink V2X communication in groupcast NACK-only feedback regime by introducing a minimum number of retransmissions performed without considering the feedback from receivers**   + **Text proposals shown in Section 4 of R1-2109657 are applied** | | Moderator | In case if some TEI proposal is agreed, next step is to agree on the corresponding TP.  I had some offline discussion with proponent of TEI proposal #12 (Alexey, Intel) on how to proceed the TP discussion, since they have two alternative TPs in their contribution R1-2109657. They prefer to further discuss which TP should be agreed. Therefore, I would like to update TEI proposal #12 as follows: **TEI proposal #12**  * **Introduce mitigation of half-duplex issue for sidelink V2X communication in groupcast NACK-only feedback regime by introducing a minimum number of retransmissions performed without considering the feedback from receivers**   + **Text proposals shown in Annex A of R1-2109657 are considered as a starting point** | | Samsung | We are sorry for missing the initial round of discussion.  For TEI proposal #12, we have the following question and comments.  - At first, one question for Figure 1 in R1-2109657 is whether re-evaluation and pre-emption are applied or not in the evaluation (This was not described in the table of evaluation assumption). If these are applied, the possibility for UE-2 and UE-3 selects the same resource can be decreased in the example for Section 2.  - Secondly, the performance gain in Figure 1 is within almost 1%. So, this TEI does not provide much benefit.  - Lastly, in Rel-17 eSL, we are specifying mode2 enhancements where avoiding half-duplex issue is included. Therefore, we think that Rel-17 TEI proposal #12 is highly correlated with Rel-17 eSL. Parallel discussion for the same aspects between eSL and TEI would be not desirable.  In this regards, we think that TEI proposal #12 is not necessary. | | ZTE | Sorry for providing the comment late. We still think there is no strong need to support this TEI feature regarding the flexibility of three HARQ feedback schemes for groupcast transmission and the power consumption issue. But for progress, we can compromise to the logic of TP for Alternative 2 in R1-2109657, i.e. only one blind retransmission would be allowed. | | Qualcomm | We’d like to answer some of the questions raised in this thread.   * One of the issues being addressed in this TEI is that the UE misses reception of the initial transmission due to half-duplex for example and wouldn’t transmit feedback, this is separate from collisions for a reserved resource and neither re-evaluation nor preemption would address it. That said, in Qualcomm’s evaluation results, re-evaluation was applied. * The performance gain is in the half-duplex limited region which tends to have high PRR. Therefore, a 1 percentage point gain is significant in that region. In our contribution, R1-2009273, we show that this gain extends the range at which 99% PRR is achievable by almost 70% in congested scenarios.   The half-duplex recovery mechanism, Scheme 2 with detected/past conflict indication, that addreses similar issues as this TEI was not agreed. The remaining proposals are about half-duplex avoidance, and we provide results in our contribution R1-2110209 showing that they don’t perform as well as half-duplex recovery. This is a consequence of those proposals not addressing half-duplex of the unreserved initial transmission either. Moreover, the proposal in this TEI does not involve any new signaling, so it’s simpler to implement, and would benefit Rel-16 receiver UEs in the same pool. The same cannot be said about the the Rel-17 proposals because they introduce new signaling that cannot be understood by Rel-16 UEs. | | LG Electronics | Considering Samsung's comment, let me quickly share our opinion on TEI proposal#12.  First of all, we think that the purpose of enhancement is not to focus only on mitigating the half-duplex problem, but rather to mitigate the general DTX problem for the case when performing the service with high reliability requirement. The half-duplex problem is just one example of this DTX problem. So, we emphasize that this enhancement can be useful in a wider area than the half-duplex problem. In this sense, our preference is to modify the wording of “half-duplex issue” in the following proposal as “**DTX-to-ACK error**".  ***TEI proposal #12***   * ***Introduce mitigation of half-duplex issue for sidelink V2X communication in groupcast NACK-only feedback regime by introducing a minimum number of retransmissions performed without considering the feedback from receivers***   + ***Text proposals shown in Annex A of R1-2109657 are considered as a starting point*** | | vivo | Sorry for joining late, we also concern UE power consumption as mentioned by companies. | | Ericsson 2 | We are still supportive of the proposal.  Regarding Samsungs comments:   * We think that a range increase over 25% for most of the target communication range is very good.   Inter-UE coordination addresses quite different situations. For Scheme 1, we think that there is no commonality whatsoever. For Scheme 2, the agreed functionality prevents future collisions but does not help in resolving past collisions. If a first transmission results in no NACK being transmitted (e.g., due to collision, half duplex, etc.), there will not be any retransmission regardless of whether inter-UE coordination is triggered or not. | | Intel | Response on comments from Samsung  We would like to check whether Samsung can accept TEI based on additional clarifications that we provide here:  For the first point   * Re-evaluation is applied and it does not help because the issue is in half-duplex for the initial transmission. Pre-emption also could not help in this case for the same reason. In addition, we consider a scenario with the same sidelink transmission priority and thus preemption does not have any impact.   For the second point   * We see issue in V2X reliability in case of NACK only groupcast transmission which is the error floor ~1% even for short communication distance, which cannot be improved by any other simple solution at this stage. * We would like to emphasize that 1% in PRR converts to 10x gain in PER = (1-PRR) metric which is a more representative indicator of reliability, i.e., from the error of 10-2 (for the case w/o enhancement), we can achieve 10-3 (with TEI proposal). Please see the figure below illustrating the difference. * Note that if we do not introduce changes, then even fully blind transmissions can perform better than NACK only mode, which is obviously should not be the case and needs to be corrected   For the third point   * At first, we do not believe that inter-UE coordination solution is a better design choice from complexity and implementation perspective * At second, the proposed TEI solution is backward compatible to Rel16 UEs, which is not the case for inter-UE coordination framework * Finally, for Rel.17 scheme 2 there is still FFS whether to address the detected conflict and it is unclear if we will have time to define it in Rel17. Other agreed inter-UE coordination schemes cannot address this issue in our understanding and based on our evaluations and have much higher complexit comparing to proposed TEI.     We hope that above explanation is useful and helps to address your concerns on correlation with R17 work on inter-UE coordination.  Response on comments from ZTE, OPPO  Thanks a lot for accepting at least Alt.2. Overall, we think it is fairer to decide on alternative considering feedback from all companies and thus we prefer to go ahead with proposal from moderator.  Response on comments from vivo  UE power consumption is not a concern for this scenario. First, this feature is generic and targets to improve performance for Rel.16 groupcast communication between vehicles, which do not experience limited battery capacity issue. Second, this feature is optional and configurable, thus for UEs with limited battery it may not be supported/activated. Third, we believe the power consumption increase is negligible comparing to ~10 times better reliability for short range communication, and it can be alleviated by Alt.2. The main issue is current design cannot combat the error floor at short communication distances by any means for NACK-only communication. We hope that provided explanations are helpful for acceptance of the latest proposal from moderator.  Response on comments from LGE  Thanks a lot for your support. Technically we can agree with the proposed correction (it more accurately describes problem), but at this stage we do not see the strong need to revise/rediscuss change given that we assume that companies have clear understanding on TEI discussion scope after 3 meeting cycles. | | Samsung2 | Thanks for your good responses for our question and commnets.  At first, we still think that there is a correlation between TEI proposal #12 and eSL in regarding to resolve half duplex problem.  However, based on companies’ responses, we understand the solution between TEI and eSL is different. Also, we see the importance of V2X reliability in the senarios of sidelink groupcast NACK-only feedback case.  Therefore, we can accept this TEI. | | OPPO2 | @Moderator @Intel, please note our reasoning for accepting this R17 TEI is on the condition that **TP for Alternative 2** is adopted, but NOT using text proposals shown in Annex A of R1-2109657 (which contains two TPs) as a starting point. At this point, we cannot accept the latest TEI proposal #12 from the moderator. | | vivo2 | To be fair with the proposals, we have question on urgency of TEI#12. | | Moderator | Moderator would like to ask proponent to reply to the objection/concern in this round and provide updated proposal, if necessary | | Intel | To Samsung  Thanks a lot for accepting the TEI proposal.  To OPPO  We can accept Alternative 2, although we our preference is Alt.1 and we do not see strong motivation to put Alt.2 as a condition for TEI approval. Anyway, we can accept Alt.2 and therefore suggest revising TEI#12 proposal as follows: **TEI proposal #12**  * **Introduce mitigation of half-duplex issue for sidelink V2X communication in groupcast NACK-only feedback regime by introducing a minimum number of retransmissions performed without considering the feedback from receivers**   + **Text proposal of Alternative 2 shown in Annex A of R1-2109657 is considered as a starting point**   To vivo  In our view, the issue (being mitigated by this TEI) is critical and urgent to address. Unfortunately, we did not have time to fix it in R16 and there is no such scope in R17. As you know, it was found in R16 and results in sub-optimal performance of NACK only transmission. As we explained earlier, the reliability of mission critical V2X services can be improved ~10 times if TEI is approved. The proposed solution is simple and compatible with Rel.16. Fixing this issue early would benefit both R16 and R17 UEs performance as well as 5G V2X ecosystem looking for robust 5G V2X solutions. | | Huawei, HiSilicon | We are concerned at the scope expansion from LG. If the scope is not stable and/or cannot avoid expansion, it’s not so clear what to do.There should be no need to set a TP as a starting point – it is the work of the TEI to come up with TP(s). | | Qualcomm | While Alt 1 is a superset of Alt 2, we are ok to directly adopt Alt 2 as suggested by OPPO.  We view this TEI as urgent and very important for a more robust V2X system deployment. It is also beneficial to Rel-16 UEs and doesn’t have an alternative mechanism being discussed in RAN1. We think it is important to have the issue addressed and this feature agreed as early as possible to maximize performance gains, rather than in a later release, which would reduce the number of UEs that can support it. | | NTT DOCOMO | Also we accept Alt 2 while Alt 1 is slighty preferred.  Regarding urgency of this TEI, we agree with Intel/QC. UEs as many as possible should follow this rule. | | Moderator | Assuming the concern from Huawei, HiSilicon on scope expansion does not apply to the latest proposal from Intel, and the other concern on TP aspect can be further discussed (the sub-bullet reflects compromise among comopanies), we can try final check for the following proposal **TEI proposal #12**  * **Introduce mitigation of half-duplex issue for sidelink V2X communication in groupcast NACK-only feedback regime by introducing a minimum number of retransmissions performed without considering the feedback from receivers**   + **Text proposal of Alternative 2 shown in Annex A of R1-2109657 is considered as a starting point** | | OPPO3 | If proponents from Intel and Qualcomm can accept and directly adopt Alternative 2 in Annex A of R1-2109657, then we don’t need to use that as the starting point, which means further discussion between Alt.1 and Alt.2 is still needed. Then this is not something we can consider.  We can potentially agree and close this TEI within this meeting. | | LG Electronics | From our perspective, it is not fully convinded why Alternative 2 is should be adopted when considering the power consumption of UE. Rather having a flexibility of Alternative 1 would be better even in terms of power saving aspect because it can make a UE perform the packet transmission with the minimum number of retransmissions only when transmitting the packe with high reliability requirement. Note that we assume that the RRC parameter for the minimum number of retransmissions is defined as at least “per priority”.  In this sense, we think that at this moment the following version of proposal is more desirable to be agreed for now, and RAN1 can have futher discussion on how to implement/specify this enhancement. **TEI proposal #12**  * **Introduce mitigation of half-duplex issue for sidelink V2X communication in groupcast NACK-only feedback regime by introducing a minimum number of retransmissions performed without considering the feedback from receivers** * **Text proposals shown in Annex A of R1-2109657 are considered as a starting point** | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #12**

* **For groupcast sidelink transmission with NACK only sidelink feedback,**
  + **when UE is (pre)-configured with a new per transmission priority Rel.17 RRC parameter *ignoreInitialNackOnlyFeedback* and has transmitted a TB with a priority for which *ignoreInitialNackOnlyFeedback* is provided:**
    - **UE reports NACK for the initial transmission of the TB to higher layers in the procedure for receiving HARQ-ACK on sidelink (TS 38.213, section 16.3.1) if number of resources indicated by SCI Format 1A carrying initial transmission of a TB is larger than one.**
  + **Define UE capability to indicate whether this feature is supported**
  + **Text proposal shown in Annex A of R1-2111538 is applied**

This proposal is already supported by Intel, Qualcomm. NTT DOCOMO, Ericsson, Bosch, [LGE, Samsung, OPPO]

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Suppport (Y/N) | | Comment |
| LGE | See comment | | We in principle support some enhancement in this direction but has concern on the current proposal. To be specific, the condition on the number of resources indicated by SCI needs to be removed because a UE can always decide to use a single slot transmission by its implementation, e.g., as per the congestion control, and thus this can make the feature not useful. We suggest the following update with the understanding that a reasonable implemantion in gNB (mode 1) and UE (mode 2) will try to provide two transmissions for TB transmissions whose priority is configured to use this new feature which was motivated to ensure the reliability requirements:  **UE reports NACK for the initial transmission of the TB to higher layers in the procedure for receiving HARQ-ACK on sidelink (TS 38.213, section 16.3.1) ~~if number of resources indicated by SCI Format 1A carrying initial transmission of a TB is larger than one~~.** |
| Ericsson | Y | | As a proponent company, we continue to be supportive. Our preference is configurable value, but we are OK with fixed N=2 too. |
| NTT DOCOMO | Y | We support this proposal. This proposal can mitigate half-duplex issue with quite small spec impact. | |
| Moderator |  | | This proposal is supported by Intel, Qualcomm. NTT DOCOMO, Ericsson, Bosch.  Given that this proposal has met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will be treated in the 2nd round discussion.  Proponent and supporting companies are requested to solve companies' concern by the 1st check point (Nov. 15) |
| vivo |  | | This proposal is for reliability enhancement, there is no relevance to priority issue, hence it cannot achieve the said target. This will lead to multiple transmission even in the case of high priority with lower reliability, leading to higher power consumption. |

* 1. Support of 2 Tx codebook configuration to 4Tx capable UE in UL

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [2] | Rel-15 NR specified 4Tx UL MIMO transmission while supporting various UE implementations. Depending on hardware implementation, UE Tx chains could be fully-coherent, partially-coherent or non-coherent and hence corresponding codebook subsets are specified. Rel-15 also supports coherent or non-coherent codebook subsets for 2Tx UL MIMO corresponding to coherent or non-coherent Tx chains capability. If an UE is capable of coherent 4Tx chains supporting coherent codebook subset for 4Tx UL MIMO, it can be straight forward to assume that the same UE can support coherent codebook subset for 2Tx UL MIMO from 2 out of 4 antennas; similarly UE supporting non-coherent 4Tx codebook subset can support non-coherent 2Tx codebook subset. However, for an UE capable of partial-coherent 4 Tx chains, it could support either coherent 2Tx codebook subset with 2 coherent Tx chains or non-coherent 2Tx codebook subset with 2 non-coherent Tx chains.  In 38.214, following is specified,  “A UE reporting its UE capability of 'partialAndNonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetForDCI-Format0-2* with 'fullyAndPartialAndNonCoherent*'*.”  The intention of the above statement is to prevent gNB configuring 4Tx full-coherent codebook subset to an UE capable of 4Tx partial-coherent chains. It is not clear from the current spec whether 2Tx coherent codebook subset can be configured for an UE supporting 4Tx partial codebook subset.  gNB may configure 2-port SRS for an UE supporting 4Tx in UL for different reasons; it could be for UE power saving purpose, gNB may configure fewer number of SRS ports than max number of ports UE supported in different BWPs, or it could be due to overall SRS overhead in the cell.  For 4Tx partial-coherent UE not supporting Rel-16 UL full power transmission, if configured with 2-port SRS, maximum deliverable output power could be different with coherent codebook subset and non-coherent codebook subset. Let’s assume PC3 UE, 2Tx non-coherent codebook subset contains only antenna selection TPMIs, that means the maximum output power for rank=1 transmission is scaled by 1/4, if 2Tx coherent codebook subset can be configured then the maximum output power for rank=1 transmission with non-antenna selection TPMIs is scaled by 2/4 since there are 2 non-zero PUSCH ports, which means 3dB more power.  For example, as shown in figure 1 below, for 4Tx partial-coherent UE (with 17dBm PAs), by virtualizing 2 antennas it can operate as 2Tx coherent or non-coherent UE. If it is assumed 2Tx non-coherent UE after virtualization, due to power scaling mechanism, for rank=1 transmission the maximum output power is 1/4 of Pc\_max, i.e. 17dBm for PC3 UE and if assuming 2Tx coherent UE after virtualization, the non-antenna selection TPMIs can deliver 1/2 of Pc\_max, i.e. 20dBm for PC3 UE. On the other hand, if such an UE chooses two coherent antenna pair without antenna virtualization for 2Tx operation, the non-antenna selection TPMIs can also deliver 1/2 of Pc\_max.    Figure 1, 4Tx partial-coherent UE operating as 2Tx UE  Hence, following proposal is made.  Proposal 1:   * For 4Tx partial-coherent capable UE, 2Tx coherent codebook subset is supported when the network configures 2-port SRS (for codebook) and SRS resource set includes 1 SRS resource or configured with same number of ports for all resources.   + Introduce a new UE capability which is per FS   TP for 38.214 section 6.1.1.1  A UE reporting its UE capability of 'partialAndNonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetForDCI-Format0-2* with 'fullyAndPartialAndNonCoherent', except for the case when a UE supporting 4 antenna ports is configured with 2 antenna port codebook depending on UE reported capability 'fullyAndPartialAndNonCoherent' can be configured by either *codebookSubset* or *codebookSubsetForDCI-Format0-2*. |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | NTT DOCOMO | We are fine with the proposal. | | LGE | This proposal has been proposed by some company during Rel-16 but fail to achieve consensus. Although the proposal may provide more flexibility, UL performance benefit has not been shown. We prefer not to discuss this in Rel-17 TEI. | | Qualcomm | We are supportive of this. One request would be the ensure the UE capability is introduced per FS. | | Intel | 4Tx UE doesn’t exist from RAN4 perspective. This is not urgent issue to address at this moment. | | vivo | @Intel, yes from RAN4 perspective 4Tx UE doesn’t exist for now, if there is/are UE friendly solution/spec then UE vendors will be willing to implement. It is a simple fix in RAN1 spec which encourage UE vendors consideration on implementing it.  @Qualcomm, thanks for comment, please find updated proposal below **Updated TEI proposal #13**  * **For 4Tx partial-coherent capable UE, 2Tx coherent codebook subset is supported when the network configures 2-port SRS (for codebook) and SRS resource set includes 1 SRS resource or configured with same number of ports for all resources.**   + **Introduce a new UE capability which is for FS** | | Ericsson | We continue to support this proposal, as we explained above. It addresses a longstanding issue that we think could have been solved in Rel-15. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies including operator, infra vendor and UE vendor, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | vivo2 | @LG, sorry I forgot to respond to your comment. With 3dB more power, performance benefit is obvious. | | OPPO | The issues we raised in RAN1#106-e meeting still exist. Hence, we don’t think this issue needs to be solved in Rel-17. | | vivo3 | @OPPO, I am copying my response in RAN1#106-e here: @OPPO, maybe from your implementation point of view it is not urgent doesn’t mean that not urgent for other UE vendors. New UE capablility allows you not support it.  Additionally, different vendors have different product plans. | | QC | We think this might be a useful change to haveEWQ. Vivo makes a good point that the difference between the two cases could be a full 3 dB because UE is restricted to using just one of the two PAs (Think of a PC2 UE with 2 23 dBm PAs).  RAN1 is discussing multi-panel UEs, and even scoping 6tx/8tx UEs for R18. The situation might change rapidly and the UE roadmap is likely to evolve. Since this is a very lightweight change that can deliver a 3 dB boost, we feel its worth pursuing. Our other concern is that the fallback from 4tx to 2tx is motivated by power saving at the UE and we feel such restrictions in the spec will discourage a network from configuring a UE in 2 tx mode. This is another reason motivating us to pursue this.  As a UE vendor, we are always looking for ways to improve uplink performance and this one in particular seems like an easy fix. | | OPPO | @vivo Thanks for your reply. However, your reply seems only for the first one of our comments. We faild to see some reply to our other comments (please correct us if we missed something). FL has caputered our previous comments in the summary. Thus, it is not efficient for companies to always copy&paste the same comments just becourse the proponent(s) does not repy to these comments. Anyway, we copy&paste them in the table at the end of the reply for the reference.  As for your comment “@OPPO, maybe from your implementation point of view it is not urgent doesn’t mean that not urgent for other UE vendors. New UE capablility allows you not support it.”, we are totally confused. Do you mean your company has a plan for such kind of UE? However, I read the claim of the same company as below in RAN planery [RP-211652]. If vivo thinks simultanesous transmission is no more than 2Tx even for Rel-18, what’s the urgency? We don’t think an Rel-17 TEI should address an issue which is regarded as too early for Rel-18 by the same company.  Moreover, as many companies commented, RAN4 doesn’t have supported 4Tx so far. That means the ecosystem doesn’t see the urgency.   |  | | --- | | Comments raised by OPPO in last meeting. And most of them does not get any response.  First of all, we cannot see there would be 4Tx UE in the market in the near furture. Thus, we don’t think it should be a R17 TEI for this feature not deriven by product or practical deployment or urgent requirement.  Secondly, as we mentioned before, compared with 2tx coherent codebook, 4tx partial coherent codebook can achieve better performance via antenna selection, especially in antenna blocking scenario. In this case, UE may need more power to achieve the same coverage as current 4tx partial coherenet codebook.  Thirdly, if gNB really cares about the UE power saving and configures two ports, R15 scheme is better since only 1 port is used for PUSCH and less power transmission is expected. If we follow this proposal, gNB will schedule 2 port transmission, which will comsume more power.  Last but not the least, the mapping of physical antennas and antenna ports is not fixed. From LTE, the UE will switch its Tx antenna once the original Tx antenna is blocked. This mechanism is widely used for commercial smart phones. If gNB configure 2-port transsion, it is benefitial for a UE to switch its Tx antenna(s) once the original Tx antenna(s) is blocked. In this case, UE may use two non-cohernet antennas.  In summary   * From the perspective of practical deployment, we don’t see the motivation. * From the technical point of view, this proposal does not provide benefits for UE. |   @Qualcomm  First of all, the full power transmission can be supported by Rel-16 mechanism (UE can also use 2Tx for a non-cohernet codebook by using some full power transmission mode). Thus, there is no such issue and no such benefit. That is why the 2nd orginal proposal was removed as it was suggested by many companies.  Sencondly, from our understanding, the procedure of TEI and normal WI/SI are different. For Rel-18, companies are discussing much more advanced features (e.g., multi-panel UE, 6Tx,/8Tx). For 3GPP, Rel-18 is expected to be a milestone of NR evoluation. Thus, we need to study/specify advanced features for feature, e.g., 8Tx UE, XDD (full duplexing), AI and so on. But TEI should only focus on critical and urgent issues, rather than “good-to-have” features. The “good-to-have” features should be discussed in normal WI/SI. | | vivo4 | @OPPO, Rel-18 related discussion to be discussed in Rel-18. The proposed TEI#13 is a fix in RAN1 spec, we can discuss market availability when 4Tx comes to RAN4 radar and this proposal is not proposing to specify in RAN4 yet! Regarding 3 points you mentioned in the comment, as we explained the the tdoc, the UE can turn off Tx antennas for power saving and the coherent 2Tx can boost 3dB power. Power saving mainly comes for turning off RF chains and 3dB power boost increase coverage. | | OPPO | If the purpose is for power saving, as mentioned before, gNB can configure single port transmission or two ports non-corehent transmission (then some of the chains can also be turned off). If it is for power boosting, single port transmission or two port with Rel-16 full power (e.g. with corehent codeword) can also achive the same functionility. That is why we don’t think it is a urgent feature. Also, we think it is helpless and inefficient to repeat the same comments/resoponses again and again. Considering the concerns from us and Intel, we propose to consider the “good-to-have” feature in future release, e.g. when there is some progress for 4Tx in RAN4. | | vivo4 | @OPPO, with “single port transmission or two port with Rel-16 full power (e.g. with corehent codeword) can also achive the same functionility.” I assume you are pointing to fullpower mode 2, if it is the case then all RF chains are “ON”, UE can save power by turning OFF RF chains.  Regarding 4Tx in RAN4, I do agree it is not yet in the spec, which shouldn’t stop fixing RAN1 spec. if RAN1 spec support different implementations, there will be motivation for RAN4 spec e.g. for CPE type of devices. | | Moderator | Moderator would like to ask proponent to reply to the objection/concern in this round and provide updated proposal, if necessary | | Intel2 | In addition to the raised concern, we also have the following questions for clarifications:  1. Why the proposed UE capability is per FS, while in Rel-15 coherence capability is per band combination?  2. How the proposed UE capabiliuty works with UL full power configured? Can it be used when UE is in the full Tx power mode? | | OPPO4 | We still have concern on this proposal. 4 Tx UEs are too far if companies even think 3 tx UE is infeasible in Rel-18. Also, we think current single port transmission and two port transmission with full power mode 2 (e.g. for typical UE with four 20dBm Tx) can achive the same transmit power (e.g. 23dBm) even with some tx chain OFF.  As we explained several times, there is no issue for the current spec. The proposal #13 is just an “optimization” (in fact, it doesn’t achieve better performance), rather than fixing anything. Unfortunately, it will encourage worse UE implementation since it prevents the flexible antenna adaptation to mitigate blockage. | | vivo | @OPPO, @Intel, just to remind you that RAN1#106-e already made following agreements.  **Agreement**  Support 4T6R SRS antenna switching in Rel-17.  @OPPO, regarding turning off Tx chains using full power mode 2 this is applicable to some othe of PA architectures, there various PA architectures, we have shown in the tdoc that for certain PA architectures turning off RF chains is not possible with full power mode 2. And, let’s discuss Rel-18 item in Rel-18 discussion. | | Moderator | Assuming vivo replied to objection/concern from companies, we can try final check for the following proposal **Updated TEI proposal #13**  * **For 4Tx partial-coherent capable UE, 2Tx coherent codebook subset is supported when the network configures 2-port SRS (for codebook) and SRS resource set includes 1 SRS resource or configured with same number of ports for all resources.**   + **Introduce a new UE capability which is for FS** | | OPPO | Dear moderator, obviously, the replies don’t address our conern so far. We cannot support it at the current stage.   * Urgency: * One company said this issue is urgent for them. However, the same company said in RAN planery that 3Tx is infeasible and suggest only support enhancement with up to 2Tx in Rel-18. We don’t think a Rel-17 TEI should address an issue which is regarded as too early for Rel-18 by the same company. “Rel-18 related discussion to be discussed in Rel-18.” is not directly related this issue. We encourage and apprecicate companies to keep consistency of in 3GPP. Thus, I would like to repeat the question: Is it urgent for the companies to support 4Tx product now? * As many companies commented, RAN4 doesn’t have supported 4Tx so far. That means the ecosystem doesn’t see the urgency. It is not only OPPO’s view, but the whole view of 3GPP. * Fix spec: * There is no issue for the current spec. Nothing needs to be fixed. * Use cases / benfits * The target use cases are not justified. * Configuration of 2-port transmssion will lead to performance degradation. Compared with 2tx coherent codebook, 4tx partial coherent codebook can achieve better performance via antenna selection, especially in antenna blocking scenario. In this case, UE may need more power to achieve the same coverage as current 4tx partial coherenet codebook. * If the intetion of gNB is to reduce UE power consumption, R15 scheme is better since only 1 port is used for PUSCH and less power transmission is expected. gNB doesn’t need to schedule 2 port transmission, which will comsume more power. * Full power transmission * Rel-16 has supported various full power transmission schemes, e.g., mode 1, mode 2. This proposal does not provide anything new from the perspective of the full power transmisision. Full power transmission mode 1 does not need any specific RF architectures. Thus, there is no 3dB power gain for this proposal. * 4T6R introduced in 3GPP * We would like to emphasize the procedure of TEI and normal WI/SI are different. TEI should only focus on critical and urgent issues, rather than “good-to-have” or future-proof features. The “good-to-have” or future-proof features should be discussed in normal WI/SI. * 4T6R is obviously a feauture for future. That is why 4T6R antennas switching is dissussed in MIMO WI, rather than any TEI. * Impact on UE * The mapping of physical antennas and antenna ports is not fixed. From LTE, the UE will switch its Tx antenna once the original Tx antenna is blocked. This mechanism is widely used for commercial smart phones. If gNB configure 2-port transsion, it is benefitial for a UE to switch its Tx antenna(s) once the original Tx antenna(s) is blocked. In this case, UE may use two non-cohernet antennas. However, supporting the proposal will prevent this widely-used mechanism and encourage worse implementation that has worse performance. * Prefer not to repeat the same issue through releases. This issue has been touched in previous releases, but the group didn’t get any consensus. Thus, it is discouraging for the group to repeat the same issue again and again, from one release to another release. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #13**

* **For 4Tx partial-coherent capable UE, 2Tx coherent codebook subset is supported when the network configures 2-port SRS (for codebook) and SRS resource set includes 1 SRS resource or configured with same number of ports for all resources.**
  + **Introduce a new UE capability which is per FS**
  + **Text proposal shown in Annex of R1-2111061 is applied**

This proposal is already supported by vivo, ZTE, CMCC, Samsung, Qualcomm, [NTT DOCOMO, Ericsson]

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Suppport (Y/N) | Comment | |
| Samsung | Y | We are supportive of this proposal. | |
| OPPO | N | We still think the enhancement is not essential. Please see our comments above. | |
| Ericsson | N\* | We are supportive in principle, but prefer to not address the per FS UE capability issue here. The per FS UE capability is being discussed in this meeting in parallel in agenda item 7.2.11. We can be OK with the proposal if the ‘which is per FS’ in the bullet on UE capability is removed.  Regarding the proposal in R1-2111061, the wording might be clarified:  A UE reporting its UE capability of 'partialAndNonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetForDCI-Format0-2* with 'fullyAndPartialAndNonCoherent', unless the UE supports being configured with a 2 antenna port codebook and *‘fullyAndPartialAndNonCoherent'.* ~~, except for the case when a UE supporting 4 antenna ports is configured with 2 antenna port codebook depending on UE reported capability 'fullyAndPartialAndNonCoherent' can be configured by either~~ *~~codebookSubset~~* ~~or~~ *~~codebookSubsetForDCI-Format0-2~~* | |
| NTT DOCOMO | Y | We are fine with the proposal. | |
| Moderator |  | This proposal is supported by vivo, ZTE, CMCC, Samsung, Qualcomm, NTT DOCOMO.  Given that this proposal has met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will be treated in the 2nd round discussion.  Proponent and supporting companies are requested to solve companies' concern by the 1st check point (Nov. 15) | |
| vivo |  | Revision from Ericsson is fine as there is separate discussion going in AI 7.2.11 (a new UE capability indicating UL MIMO coherence per band per band combination).  @OPPO, technical benefit has been clarified multiple times, and now with the discussion on going in AI 7.2.11 one UE may report 4Tx partial-coherent capability in band A with some combination and same UE may report 2Tx coherent capability in band A. In this this case, current description in spec 38.214 is incomplete. | |
| Intel |  | There is no chance that RAN4 will work on the requirements for 4Tx UE within Rel-17. Thus, this feature would not be implemented within Rel-17 regardless of RAN1 outcome. The more sensible way is to align with RAN4, possibly in Rel-18. | |
| OPPO |  | For the on going discussion in AI 7.2.11, UE may report partial-coherent capability in band A in one band combination, and report coherent capability in band A in another combination. This would not have any impact on 38.214 and is isirrelevant to this proposal. |
| vivo |  | In 38.214, there is restriction as below:  A UE reporting its UE capability of 'partialAndNonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetForDCI-Format0-2* with 'fullyAndPartialAndNonCoherent' |
|  |  | We support the proposal in principle. We think the 2Tx coherent codebook subset can be applied to the cases that there is no SRS resource configured with 4 ports.  Regarding the proposal in R1-2111061, we prefer to change the wording as follows:  A UE reporting its UE capability of '*partialAndNonCoherent*' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetForDCI-Format0-2* with '*fullyAndPartialAndNonCoherent*', except for the case that the UE supports being configured with a 2 antenna port codebook with ‘*fullyAndPartialAndNonCoherent*' and there is no SRS resource in the SRS resource set(s) with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook'  is configured with 4 antenna ports~~when a UE supporting 4 antenna ports is configured with 2 antenna port codebook depending on UE reported capability  'fullyAndPartialAndNonCoherent' can be configured by either~~ *~~codebookSubset~~* ~~or~~ *~~codebookSubsetForDCI-Format0-2~~*. |

* 1. HARQ-ACK feedback enhancements for TDD-FDD CA

Following proposal is made in the contribution.

|  |  |  |
| --- | --- | --- |
| [6] | In Rel-15/16, the slot offset between dynamic PDSCH and PUCCH is indicated by PDSCH-to-HARQ\_feedback timing indicator field in scheduling DCI. For DCI format 1\_0, the PDSCH-to-HARQ\_feedback timing indicator field values map to {1, 2, 3, 4, 5, 6, 7, 8}. For DCI format 1\_1, if present, the PDSCH-to-HARQ\_feedback timing indicator field values map to up to eight values provided by *dl-DataToUL-ACK* (a.k.a K1) ranging from 0 to 15.  In this section, we discuss HARQ-ACK feedback enhancements to support more than eight K1 values to solve the problem of HARQ-ACK feedback in CA in the real NR deployment.  We first discuss the problem of HARQ-ACK feedback enhancements for TDD-FDD CA with TDD UL-DL configuration and SCS configurations shown in Figure 1, which is the real deployment with 2.6GHz+700MHz carrier frequencies.    Figure 1: Target TDD-FDD CA configuration  The following agreement was agreed in RAN1#106-e meeting for HARQ-ACK timing in case UL SCS>DL SCS in Rel-16.  **Agreement**  Confirm the RAN1#105-e working assumption with the following modification (in RED):  For HARQ-ACK timing in Rel-16 with slot-based HARQ-ACK feedback, in case UL SCS is larger than DL SCS, k = 0 corresponds to the last UL slot that overlaps with the DL slot for the PDSCH.   * ~~Further discuss the HARQ-ACK timing for sub-slot-based HARQ-ACK feedback~~ * FFS specification impact   For the target DL dominate TDD configuration shown in Figure 1, a relatively large number of K1 values needs to be configured to cover the potential PDSCH transmissions in all the slots on PCell and SCell. Accroding to the above agreement, in Rel-16 if the HARQ-ACKs for all the PDSCH transmissions are transmitted only in one UL slot in an UL-DL configuration periodicity, nine K1 values are required as shown in Figure 2, which exceed the maximum number of K1 values that can be configured in Rel-15/16.    Figure 2: Required K1 values for the target TDD-FDD CA configuration if HARQ-ACK feedback only in one slot between the two UL slots in an UL-DL configuration periodicity  Otherwise, if HARQ-ACK for all the PDSCH transmissions can be transmitted in both UL slots in an UL-DL configuration periodicity, up to eight K1 values are sufficient. For example, a set of eight K1 values of {2, 3, 4, 5, 6, 7, 8, 9} can be configured as shown in Figure 3.    Figure 3: Example of K1 configurations for the target TDD-FDD CA with HARQ-ACK feedback in both UL slots in an UL-DL configuration periodicity  However, according to the restriction defined in TS38.213 clause 9, a UE does not expect to transmit PUCCHs with HARQ-ACK in the two consecutive UL slots on PCell and a PUSCH on SCell overlapping in time with the two PUCCH transmissions. Therefore, either gNB avoids scheduling PUSCH on SCell overlapping with two PUCCH transmissions on PCell which results in scheduling restriction and UE uplink throughput reduction, or gNB avoids scheduling two PUCCH transmissions via scheduling PDSCH in a subset of the DL slots which would also result in scheduling restriction and UE DL throughput reduction.   |  | | --- | | A UE does not expect to multiplex in a PUSCH transmission in one slot with SCS configuration  UCI of same type that the UE would transmit in PUCCHs in different slots with SCS configuration  if . |   In addition, the above agreement applies to Rel-16 which is different from Rel-15. For Rel-15, one more additional K1 is required for the PDSCHs ending in the first UL slot within an UL-DL configuration periodicity with reference to the UL numerology. Therefore, even if HARQ-ACK for all the PDSCH transmissions can be transmitted in both UL slots in an UL-DL configuration periodicity, more than eight K1 values are required to cover the PDSCH transmissions in all the slots.  We then discuss another CA case with 2.6GHz+4.9GHz carrier frequencies with unaligned frame boundary as shown in Figure 4. It can be observed that up to 8 K1 values cannot support HARQ-ACK feedback for all the DL slots.  cid:image012.png@01D7B518.D3937D60  Figure 4: Required K1 values for the target 2.6-4.9GHz CA with unaligned frame boundary  In order to solve the HARQ-ACK feedback problem analyzed above, the most straightforward and the simplest solution is to support 4-bit PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1. It is a simple extension and has minimal specification impact. It is noted that the similar proposal is under discussion in Rel-17 NTN WI but the views are divergent from companies [1]. In addition, even if it is supported in NTN, it is not clear whether it is applicable to non-NTN scenario. Therefore, we have the following proposal.  ***Proposal 2: Support 4-bit PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 with up to 16 values configured by dl-DataToUL-ACK in Rel-17 for NR terrestrial networks.*** |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | Huawei, HiSilicon | Support | | NTT DOCOMO | We understand the motivation. But at the same time, there is another solution for this case, which is that 1\_1 is used in PCell and 1\_2 is used in SCell for example. In that sense, whether this enhancement is really necessary should be discussed/clarified further. Note that we do not object the proposal. | | QC | Similar to DCM, we don’t see much benefit to this proposal. Other alternatives seem to be available. | | Nokia, NSB | We have seen the problem in some cases, and would be open to discuss possible solutions. | | Intel | We are fine to enhance for the identified combination of TDD/FDD cells, if majority companies want to do that. | | Ericsson | Support.  Increasing the PRI field in DCI solves a lot of problems in realy deployment. Currently, although K1 up to 15 is supported, the usage is restricted.  With respect to DCM, QC comment: usage of DCI 1\_2 is very URLLC specific and there are related capabilities involved with. In short, comes with a lot of package, as if there should be support for UL CA, etc. We don’t understand the rational for such solutions which appears to us, instead of allowing to use all K1 values by increasing field size, we have to fix the problem only for uses that support certain capabilities, including Ul CA, …Also, please note that the problem exists even for single cell (non-CA). | | ZTE | As commented before, we agree that there is scheduling restriction for the concerned deployment scenario. However, there could be other solutions, e.g., re-defining K1=0 is the first available UL slot. So, it may need more discussion about which solution we should be chosen. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies including operator, infra vendor and UE vendor, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | CATT | Thank you for the particapting companies for the comments.  First of all, we would like to emphasize that the problem is found in the real deployment and the proposal is the simplest solution with minimum specification change to resolve the identified problems and that is why the proposal is supported by operation and a number of gNB vendors.  From the comments from DOCOMO, Qualcomm and ZTE, it seems to us that they acknowledge the issue as well but would like to solve the problem with other alternatives. DCM and QC suggest to use DCI format 1\_2 for SCell scheduling, which is subject to the UE support of DCI format 1\_2. As we know, it is an optional UE feature in Rel-16 targeting for URLLC and it should be obvious that support of DCI format 1\_2 would be much more complicated compared with our proposal. Therefore, we do not think it is reasonable to rely on support of DCI format 1\_2 to solve the issues. Regarding ZTE’s comment, it changes the definition of K1 fundamentally thus it would be much more difficult to be accepted by companies.  We really appricate that companies can be more open to the proposal to solve the real issues in the field, especially the proposal is just a simple extension of the exsting scheme. | | ZTE2 | If majority companies support this enhancement, we would be fine in principle even though we think there are some other solutions. However, we think this enhancement should be useful for NTN as well, it is unnecessary to restrict to TN only. Here is our suggestion:  **Support 4-bit PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 with up to 16 values configured by dl-DataToUL-ACK in Rel-17 ~~for NR terrestrial networks~~** | | Ericsson 2 | We appreciate the flexilibity from ZTE and we are fine with the update by ZTE.  In addition to our previous comments, we fully support the clairficatiosn by CATT.  We would like to emphasize that the benefit of this simple proposal is considerable. The current restriction, not only has complicated the scheduling for limited k1 valeus to work with, also has put restriction on fully utilizing DL due to being short of K1 values. Therefore, we enourage companies to kindly consider the proposal. | | NTT DOCOMO | On CATT’s kind reply, we know that DCI format 1\_2 is an optional feature introduced for URLLC purpose. However, the format can be used for any purpose in specification. There is no restriction to use only for URLLC, whihch is same as other features like type-3 HARQ-ACK CB for licensed spectrum.  Regarding mandatory/optional, DCI 1\_2 is optional feature exactly. But this extending K1 field in DCI is also optional feature since the extended field is new feature, isn’t it? I’m not sure whether the situation is so much different…  But again, we do not object this proposal. Our company name can be excluded from objecting companies.  On ZTE’s suggestion, we do not support the update. The field extention for NTN has been discussed under 8.4, but there has been no concensus so far. NTN perspective should be discussed in NTN WI, not in TEI. | | Moderator | No concern/objection has been received so far. Therefore, following proposal is set for final check **TEI proposal #15**  * **Support 4-bit PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 with up to 16 values configured by dl-DataToUL-ACK in Rel-17 for NR terrestrial networks** | | ZTE | In our view, to enable the integration between TN and NTN, the basic feature defined cross agenda will be shared. Since it has already agreed to extend the value range of K1 in NTN, it’s straightforward to take the unified solution in DCI for indication without additional efforts and spec impacts. | | QC | We are not convinced that this is a critical enhancement given the very specific scenario/setting used to motivate the proposal. As mentioned earlier, other options also seem to be available if a fix is absolutely necessary. We are not convinced that this TEI proposal is ready to be endorsed. | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #15**

* **Support 4-bit PDSCH-to-HARQ\_feedback timing indicator in DCI format 1\_1 with up to 16 values configured by dl-DataToUL-ACK in Rel-17 for NR terrestrial networks.**

This proposal is already supported by CATT, CMCC, Ericsson, Huawei, and HiSilicon.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | tentative | There are two aspects that we wish to comment on.  Criticality/Importance/Impact:  To us, the theoretical max data rate case, where all grants are received by a single UE, is associated with freely selecting the PCell. When considering the case where PCell choice is constrained by the need for control load balancing, we are automatically focusing on the commercial network where there is a need to support multiple UEs in parallel. Even there, the choice of TDD as PCell may only be relevant to a cell-center UE and such a UE may not significantly benefit from an additional DL slot scheduled on a FDD carrier with the smaller BW and smaller rank.  There are other potential alternatives to explore as well, including allowing PUCCH on Scell, switching between DCI formats, alternate TDD slot patterns, etc.  Setting these aside, we are viewing this mostly as a means to have more scheduling flexibility and to potentially come up with a universal K1 offset set without the need for any careful selection by the gNB. Towards this we would like to hear more views from other gNB vendors (besides the supporting companies listed above) to understand whether they too see this as being urgent or critical.  Solution Methodology:  Setting aside the question of whether or how critical it is to solve this issue, we are trying to see if there is an easier way to address this without requiring a DCI change and avoiding an increase in Type 1 codebook sizes. Upon closer examination of the highlighted problem, it appears that some of the issues arise due to mixed numerology and an inability to pick K1 offset sets that are fine tuned to each cell. Towards this end, we think a better solution would be to provide a DL-dataToACK-UL list on a per-cell basis, i.e., move it out of PUCCH config and place it under, say, PDSCH config for each BWP of each cell. This way each set of offset values can be tailored to the cell in question and in fact results in a better optimized Type 1 HARQ codebook. This approach also scales nicely to cases where more than 2 cells are involved. Here is an overlay of our proposal on top of the figure shared in the tdoc:    This has the advantage of not incurring any DCI overhead and seems to be a relatively straightforward RRC change. We would urge the proponents to consider this more carefully. |
| Samsung | N | We think that this solution is very specific case, and also using multiple DCI formats (based on existing specification) or using two PUCCH cell groups can be candidate solution to resolve the issue. Thus, we don’t think that this proposal is quite essential at this stage. (It is noted that bar is much higher than previous meeting). It can be handled by gNB implementation. |
| CATT | Y | First of all, we would like to thank QC for the technical discussions and alternative proposal. For the alternative proposal, we are open to discuss and would like to hear more views from other companies. From our perspective, it is our understanding that the proposal would require more specification/implementation changes compared with Rel-15.  For the comments from Samsung, we admit that we are targeting for some specific cases otherwise it would be already been taken into account in previous design. The use cases we provided are the realistic configurations in the field so that I hope that companies can be more open. For the alternative solutions, we have commented in the last meeting that using two DCI formats to solve the issue is too much from UE and gNB. For using two PUCCH cell groups, additional PUCCH overhead is expected which we would like to avoid especially considering the limited bandwidth in 700MHz carrier. |
| Ericsson | Y | We share similar comment as CATT. We appreciate QC constructive approach to solve the real field issue and we are open to solutions.  With respect to Samsung comment, we would like to mention that being short on K1 values leads to scheduling restrictions. The fact that we have 16 values but by design we put restriction in using them, have caused real problems in the field.  The cases shown in the contribution are to show examples that are faced indeployments. But in general, there are many cases that the feedback should be postponsed to later. But the limited K1 values doesn’t allow to reach far enough. Therefore, the scheduling is not possible. We appreciate if Samsung kindly considers the issues that we are facing and helping us to solve the problem. |
| NTT DOCOMO |  | Although we think there is already another option in the current spec – DCI format 1\_2, we do not block this proposal. |
| Moderator |  | This proposal is supported by CATT, CMCC, Ericsson, Huawei, HiSilicon.  Given that this proposal has met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will be treated in the 2nd round discussion.  Proponent and supporting companies are requested to solve companies' concern by the 1st check point (Nov. 15) |
| CMCC | Y | This issue is very critical for commercial deoployment not only for 700MHz+2.6GHz FDD-TDD CA but also for 2.6GHz+4.9GHz unalignment CA, we also appreciate companies’ support to slove it. Regadring the alternative solutions proposed by companies, as the comment from CATT/Ericsson, using DCI 1\_2 or two PUCCH cell groups needs advanced UE capability or casue resource overhead, we think increase of K1 values is a simple solution. |
| CATT | Y | As commented by operator, the use cases are commercial deployment which has not been carefully taken into account in previous design. It is desirable to resolve the issue within Rel-17 time frame.  For the alternative approach of using two DCI formats, the burden of implementation changes for both gNB and UE would be much higher than this proposal which makes it impossible to rely on.  For two PUCCH cell groups, the overhead would be much higher.  For the alternative proposal from QC to support K1 set configuration per DL BWP, it seems feasible. However, the specification/implementation impact would be higher considering the impact on DCI bit-width determination, Type-1 HARQ-ACK CB construction etc. It would be good to hear more views. |

* 1. Support of default power control parameter per TRP

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [4] | According to current 38.213[1], if *SRI-PUSCH-PowerControl* is not provided by RRC or SRI is not included in a DCI, only single close loop index  can be assumed by UE for the PUSCH, .and the UE determines P0 and alpha from the value of the first P0-PUSCH-AlphaSet in p0-AlphaSets. Furthermore, a default pathloss RS, the pathloss RS with *PUSCH-PathlossReferenceRS-Id=0* configured by RRC, will be used for pathloss measurement of the PUSCH. In this case, for PUSCHs scheduled for different TRPs, e.g. PUSCHs associated with different values of *CORESETPoolindex*, the same default P0, alpha, pathloss RS and closed loop index will be applied. Similar issues exist for PUCCH when the UE is not provided *PUCCH-SpatialRelationInfo*, e.g. for FR1.  *Observation 1: The default power control parameters (e.g. P0, alpha and close loop index) are the same for PUSCH/PUCCH associated with different values of CORESETPoolIndex (e.g. for different TRPs).*  *Observation 2: The same downlink signal (from one TRP) is used as default pathloss RS of PUSCH/PUCCH associated with different values of CORESETPoolIndex (e.g. for different TRPs) when spatial relation information is not configured.*  In Rel-17, for enhancements on Multi-TRP for PUSCH, default P0, alpha, PL-RS, and closed loop index was agreed to be defined per TRP as agreed in RAN1#105 meeting below for S-DCI based M-TRP:  ***Agreement***  *For single-DCI based M-TRP PUSCH repetition schemes, when one SRS resource per SRS resource set is configured (i.e., when two SRI fields are absent in DCI formats 0\_1 / 0\_2), default P0, alpha, PL-RS, and closed loop index is defined per TRP. Select one from the following in RAN1 #106-e meeting,*   * *Alt.1*   + *The first P0/alpha, PL-RS, and closed loop index are determined by sri-PUSCH-PathlossReferenceRS-Id, sri-P0-PUSCH-AlphaSetId, and sri-PUSCH-ClosedLoopIndex mapped to the first sri-PUSCH-PowerControl associated with the first SRS resource set.*   + *The second P0/alpha, PL-RS, and closed loop index are determined by sri-PUSCH-PathlossReferenceRS-Id, sri-P0-PUSCH-AlphaSetId, and sri-PUSCH-ClosedLoopIndex mapped to the first sri-PUSCH-PowerControl associated with the second SRS resource set.*   + *Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.* * *Alt.2*   + *The first set of values {the first value in P0-AlphaSet, the PL-RS corresponded to PUSCH-PathlossReferenceRS-Id = 0 and closed-loop index l = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS corresponded to PUSCH-PathlossReferenceRS-Id = 1 and closed-loop index l = 1 if twoPUSCH-PC-AdjustmentStates is configured, l=0 otherwise } can be used for TRP2.*   + *Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.* * *Alt.3*   + *If the UE is provided enablePL-RS-UpdateForPUSCH-SRS, the first set of values {the first value in P0-AlphaSet, the PL-RS corresponding to the first sri-PUSCH-PowerControl associated with the first SRS resource set and closed-loop index l = 0} is used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS corresponding to the first sri-PUSCH-PowerControlassociated with the second SRS resource set and closed-loop index l = 1 if  twoPUSCH-PC-AdjustmentStates is configured, l=0 otherwise} is used for TRP2.*   + *Otherwise, the first set of values {the first value in P0-AlphaSet, the PL-RS with PUSCH-PathlossReferenceRS-Id=0 and closed-loop index l = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS with PUSCH-PathlossReferenceRS-Id = 1 and closed-loop index l = 1 if  twoPUSCH-PC-AdjustmentStates is configured, l=0 otherwise } can be used for TRP2.*   + *Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.*   Similar enhancement should also be considered for multiple DCI based M-TRP for PUSCH transmission.  Default close loop index for different CORESETPoolIndex  The UE features list for Rel-16 NR [2] includes a feature group 16-2a-3 to support of out-of-order operation for PDCCH to PUSCH for multi-DCI based M-TRP transmission. To reduce the UE complexity for close loop power control, a note was added as below to introduce the restriction that same closed loop index for PUSCHs associated with different *CORESETPoolIndex* is not supported by a UE supporting UL out-of-order. That is, for a UE supporting this FG, different close loop indexes should be configured for PUSCHs associated with different *CORESETPoolIndex*.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 16-2a-3 | Out-of-order operation for UL | 1. Support out-of-order operation for PDCCH to PUSCH | 16-2a | Yes | N/A |  | Per band | No | No |  | Note: “Same closed loop index for power control across PUSCHs associated with different CORESETPoolIndex values is not supported by a UE indicating the support of this feature” | Optional with capability signalling |   For a UE indicating support of FG 16-2a-3, additional scheduling restriction will be introduced for the following cases:   * Once DCI format 0\_0 is scheduled for *CORESETPoolIndex*=0 (*l*=0), the DCI format can’t be scheduled by *CORESETPoolIndex*=1, and only close loop index *l*=1 can be configured for PUSCH associated with *CORESETPoolIndex*=1. * If UE reports capability of single SRS resource in the SRS resource set for codebook (*maxNumberSRS-ResourcePerSet* equal to 1), SRI will not be included in any UL grant. In this case, only PUSCH associated with one value of *CORESETPoolIndex* can be scheduled, which means multi-DCI based M-TRP transmission can’t be supported for uplink. * In FR1, gNB is not likely to configure *SRI-PUSCH-PowerControl* or multiple SRS resources for beam selection in the SRS resource set for codebook. Without SRI in DCI or *SRI-PUSCH-PowerControl*, only PUSCH associated with one value of *CORESETPoolIndex* can be scheduled by gNB.   In a summary, for a UE supporting out-of-order operation for uplink, PUSCHs scheduled by different *CORESETPoolIndex* can hardly be supported especially in FR1, since the same default close loop index is defined for different *CORESETPoolIndex*. There is not such restriction for UEs not supporting this FG. The restriction makes the FG 16-2a-3 meaningless and support of it becomes a block to support PUSCH scheduled with different *CORESETPoolIndex*. To avoid such unreasonable restriction on scheduling, different default close loop indexes should be defined for different *CORESETPoolIndex*. That is, if *SRI-PUSCH-PowerControl* is not provided or SRI is not included in a DCI, close loop index *l*=0 and *l*=1 should be respectively applied to PUSCHs associated with *CORESETPoolIndex*=0 *and CORESETPoolIndex*=1.It also avoids the same close loop index for PUSCHs targeting different TRPs and allows TRP specific closed loop power control. The mechanism can be directly extended to PUCCH to avoid similar issue considering *PUCCH-SpatialRelationInfo* is optional.  ***Proposal: Support TRP specific default close loop index for PUSCH associated with different values of CORESETPoolIndex.***   * ***If the PUSCH is scheduled by a DCI format that does not include an SRI field, or if an SRI-PUSCH-PowerControl is not provided to the UE, close loop index l = 0 and 1 are respectively applied to PUSCHs scheduled by PDCCHs associated with CORESETPoolIndex=0 and CORESETPoolIndex=1.***   ***Proposal:*** ***As a second step, consider TRP specific default close loop index for PUCCH associated with different values of CORESETPoolIndex if time allows.***   * ***If the UE is not provided PUCCH-SpatialRelationInfo, close loop index l = 0 and 1 are respectively applied to PUCCHs scheduled by PDCCHs associated with CORESETPoolIndex=0 and CORESETPoolIndex=1.***   Default pathloss RS, P0 and alpha for different CORESETPoolIndex  Based on 38.213 [1], if *SRI-PUSCH-PowerControl* is not provided to a UE or SRI is not included in a DCI, a default pathloss RS, the pathloss RS with *PUSCH-PathlossReferenceRS-Id=0* configured by RRC, will be used for pathloss measurement of PUSCH. If multiple values of *CORESETPoolIndex* are configured, PUSCHs targeting different TRPs will share the same pathloss RS, which would lead to mismatched pathloss estimation for PUSCH. Similar issue should also be considered for PUCCH associated with different *CORESETPoolIndex* when *PUCCH-SpatialRelationInfo* is not configured and for open loop power control parameters {P0, alpha}. Considering that a PUSCH without indication of *SRI-PUSCH-PowerControl* or SRI and a PUCCH without *PUCCH-SpatialRelationInfo* are common cases in FR1, we propose to support TRP specific pathloss RS, P0 and alpha for PUSCH/PUCCH, e.g. apply two pathloss RS with different *PUSCH-PathlossReferenceRS-Id* for different TRPs (*CORESETPoolIndex*), as shown in Fig.1.    Fig.1: Default pathloss RS for different TRPs  ***Proposal: Support TRP specific default pathloss RS, P0 and alpha for PUSCH associated with different values of CORESETPoolIndex.***  ***Proposal: As a second step, consider TRP specific default pathloss RS and P0 for PUCCH associated with different values of CORESETPoolIndex if time allows.*** |

This TEI proposal has been proposed and discussed in the previous meetings, and the discussion at the RAN1#106bis-e meeting is shown below [8].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Company | Comment | | Huawei, HiSilicon | May wait a bit to see how the relevant discussion in UE feature goes. | | NTT DOCOMO | TEI proposal#16 discusses the case with CORESETPoolIndex configured.  For PUSCH, based on Rel-16 spec., if CORESETPoolIndex is configured, a DCI can schedule a normal S-TRP PUSCH. Without the support of FG 16-2a-3, there is no restriction/association on TRP (e.g., CORESETPoolIndex) of the DCI and its scheduled PUSCH. Hence, there is no need to enhance two sets of TPC parameters for PUSCH. On the other hand, with the support of FG 16-2a-3, it implies the restriction/association on TRP of the DCI and its scheduled PUSCH, since different close loop index for TPC should be configured. Therefore, with FG 16-2a-3 as prerequisite feature, we’re open to introduce new UE feature to support two sets of default TPC related parameters and two default close loop indexes.  For PUCCH, we think it is too early to discuss such enhancement. Because in current spec., there is no association configuration between a PUCCH resource and a CORESETPoolIndex. In addition, if joint ACK/NACK feedback mode is configured for mDCI based MTRP, it is possible that the PUCCH is intended for 1st TRP only and two sets of TPC parameters are not needed. Therefore, we do not support the enhancement for PUCCH for now. We may further discuss it after there is progress on association configuration between a PUCCH resource and a CORESETPoolIndex in Rel-17. | | LGE | For M-DCI based MTRP, TRP specific power control is already supported with gNB implementation. We fail to find a strong need to support TRP specific default power control in Rel-17 | | QC | Based on the analysis in the table above (RAN1#106-e meeting), we still think that the issue is not high priority or critical.  Furthermore, we would like to point out that in Rel-16 multi-DCI based mTRP, we only have one SRS resource set for CB or NCB based UL (the issue is fixed in Rel-17 for single-DCI, but not for multi-DCI based mTRP). A proper (i.e., optimized) multi-DCI based PUSCH scheme may require enhacements (such as allowing for two SRS resource sets associated with the two CORESETPoolIndex values) that are beyond the scope of TEI. Hence, the issue of default power control params for PUSCH can be discussed together with other relevant enhacements in Rel-18. | | Ericsson | We do not see the need to take up this TEI proposal.  It should be noted that per-TRP power control is agreed to be specified in Rel-17 for single-DCI based multi-TRP schemes. We can develop rel-17 specifications first based on the agreed per-TRP power control first.  Whether/how to extend the per-TRP power control to Multi-DCI can be discussed later once rel-17 specifications are complete. | | Moderator | Thank you very much for the feedbacks and discussion!  Although the proposal is supported by multiple companies, it seems we should continue discussion on this proposal since there are some companies not supporting this proposal as highlighted in yellow. Also, it seems this proposal has not yet met the criteria that the proposal is supported by at least 1 operator, 1 infra vendor and 1 UE vendor.  Thererfore, moderator recommends continuing discussion on this proposal. Proponent is encouraged to address concerns from companies. | | OPPO | @Huawei @DOCOMO Considering there is no RAN1 dicussion on this issue in Rel-17, we don’t think there would be something related in UE feature discussion (If there will be, we will also be happy to see it). We are also fine to start from PUSCH.  @LGE Yes but that cannot be applied to default power control parateter. gNB always needs to explicitly indicate the power control parameter. That is not the motivation to introduce default power control parateter.  @Qualcomm @Ericssion We are fine to discuss it in Rel-18. Anyway, we have many issues to be solved in Rel-18. It would be more efficient to deal with it in TEI with minimal specification impact. | | NTT DOCOMO | Per-TRP default power control for S-DCI based MTRP PUSCH is discussed in Rel-17. Whether such feature is also supported for M-DCI can be discussed later after Rel-17 S-DCI based MTRP design is complete.  If there is no related discussion for PUSCH in Rel-17 feMIMO UE feature, we are open to consider it in either TEI17 or Rel-18. We should wait for Rel-17 feMIMO progress for now.  For PUCCH, it is important to support the association configuration between a PUCCH resource and a CORESETPoolIndex in Rel-17 mTRP BFR first. | | Moderator | Moderator would like to ask proponent to reply to the objection/concern in this round and provide updated proposal, if necessary | |

Based on the above contribution and the discussion so far, following TEI proposal can be discussed in RAN1#107-e meeting.

### **TEI proposal #16**

* **Support TRP specific default close loop index for PUSCH associated with different values of CORESETPoolIndex**
  + **If the PUSCH is scheduled by a DCI format that does not include an SRI field, or if an SRI-PUSCH-PowerControl is not provided to the UE, close loop index l = 0 and 1 are respectively applied to PUSCHs scheduled by PDCCHs associated with CORESETPoolIndex=0 and CORESETPoolIndex=1.**
* **As a second step, consider TRP specific default close loop index for PUCCH associated with different values of CORESETPoolIndex if time allows.**
  + **If the UE is not provided PUCCH-SpatialRelationInfo, close loop index l = 0 and 1 are respectively applied to PUCCHs scheduled by PDCCHs associated with CORESETPoolIndex=0 and CORESETPoolIndex=1.**
* **Support TRP specific default pathloss RS, P0 and alpha for PUSCH associated with different values of CORESETPoolIndex.**
* **As a second step, consider TRP specific default pathloss RS and P0 for PUCCH associated with different values of CORESETPoolIndex if time allows**

This proposal is already supported by OPPO, ZTE.

Companies are encouraged to check above TEI proposal and to provide feedback if any in below.

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | No | Same comments/concerns as last meeting. |
| Samsung | Y | We tend to agree with the proposal. Without this proposal, although multiple values of CORESETPoolIndexes are configured, PUSCHs targeting different TRPs will share the same default power control parameters, e.g., pathloss RS and closed loop index, which would lead to have mismatched pathloss estimation and closed loop power control. |
| Ericsson | No | As we commented in the previous meeting, we do not see the need to take up this TEI proposal in Rel-17.  In Rel-17, we introduced per-TRP power control for single-DCI based multi-TRP schemes. For Rel-18, many companies are proposing to extend the Rel-17 unified TCI framework to multi-TRP schemes. Furthermore, there are also multi-DCI multi-TRP related proposals in Rel-18 (e.g., multi-TA and simultaneous UL transmission which will be relevant to multi-DCI multi-TRP). In our view, we can discuss this issue as part of Rel-18 MIMO work item. |
| NTT DOCOMO | Not object, but: | First, for PUCCH, we think it is important to support the association configuration between a PUCCH resource and a CORESETPoolIndex in Rel-17 mTRP BFR first. With above agreed in Rel-17, this TEI proposal could eventually be discussed and supported in Rel-17 to enhance TRP-specific UL operation.  Second, for PUSCH, we’re open to further discuss the enhanced TPC for PUSCH per TRP/CORESETPoolIndex for M-DCI based MTRP. On the other hand, as QC analyzed in previous meeting, enhancement on two SRS resource sets for two TRPs may be required to support TRP specific power control. We believe the spec. impact caused by this TEI enhancement should be carefully considered. Anyway, since TRP specific power control is agreed for Rel-17 S-DCI based MTRP, we’re open to discuss this feature for M-DCI based MTRP in Rel-17 UE feature, where we think FG 16-2a-3 should be prerequisite feature of TRP specific power control for M-DCI based MTRP, as we analyzed in previous meeting. But if there is no related discussion for PUSCH in Rel-17 UE feature, we are also open to consider it in either TEI17 or Rel-18. |
| Moderator |  | Given that this proposal has not met the requirement (supported by at least one operator, one NW vendor and one UE/device vendor) by the quiet period, this proposal will not be treated in this RAN1 meeting anymore. |

1. Conclusion

TBD

Reference

[1] R1-2110856 Enhancements on the scheduling of PUSCH Huawei, HiSilicon, Ericsson, China Unicom

[2] R1-2111061 Rel-17 TEI proposal vivo

[3] R1-2111174 TEI-17 proposal targeting the false PMI reporting issue Ericsson

[4] R1-2111287 Support of default power control parameter per TRP OPPO

[5] R1-2111538 Rel-17 TEI proposal for mitigating half-duplex issue in NR V2X groupcast NACK-only case Intel Corporation, NTT DOCOMO, Qualcomm, Ericsson, Bosch

[6] R1-2112000 Rel-17 TEI proposals on SSB resource for RLM and HARQ-ACK feedback enhancements for TDD-FDD CA CATT

[7] R1-2112263 Rel-17 TEI Qualcomm Incorporated

[8] R1-2109722 Summary on Rel-17 TEIs Moderator (NTT DOCOMO, INC.)

[9] RP-191602 Handling of TEI & contribution submission in RAN WGs for NR and LTE 3GPP RAN TSG and WG1/2/3/4 Chairmen

[10] RP-210826 Handling of TEI CRs ETSI MCC

Appendix: TEI guidance in [10]

**A. TEI Work Item codes shall only be used for small technical enhancements and improvements.**

This is how TEI was and is defined and it means that bigger topics should be done in an own WI.

**B. A TEI CR set shall be fully completed within one TSG cycle/quarter in all affected WGs.**

This requirement from TR 21.900 was never challenged. It also clarifies that only complete sets can be approved.

**C. TEI Work Item codes shall not be used where another appropriate Work Item code exists.**

This repeats the rule from TR 21.900 and it means that TEI cat.F CRs shall be an exception. Note: The CR author is supposed to find out which former CR introduced an error in the spec and the cat.F correction should then use the same WI code. So in theory, cat.F TEI CRs should only be needed to correct cat.B/C TEI CRs of the past.

D. Inter-TSG aspect:

**D1. Normally, for TSG SA/CT work that requires cat.B/C CRs from RAN WGs a RAN WI is required..**

This is what RAN applied in the last decade (if not longer). This also covers the strong discouragement of cross TSG TEI CRs expressed in RP-191602 slide 3.

**D2. In case the RAN work triggered via a TSG SA/CT WI\* is small and it affects only one RAN WG, then the RAN WG CR(s) shall use the WI code\* of the TSG SA/CT WI that triggered this work.   
NOTE: \*: provisional WI codes, companion WIDs/"mini-WIDs" are not meant here but already TSG approved proper WIs.**

This is what RAN applied in the last decade. Note: As TSG RAN has no agenda items for all SA/CT WIs, this sort of CRs were usually submitted under a TEI agenda item but for traceability we shall not use a TEI WI code on such a CR.  
(Note: D2. could work also in the other direction, i.e. if there is a RAN WI for which is turns out that only a small change would be needed in one SA WG or one CT WG. But you better consult TSG SA/CT before trying this approach.)

**D3. It is not possible to trigger work in RAN WGs via TEI CRs coming from TSG SA/CT or SA/CT WGs. The same applies for the reverse direction.**

Otherwise "small" (TEI) but affecting multiple TSGs would contradict each other. (Apart from this, inter-TSG TEI CRs would also not work well together for cat.B/C CRs if SA/CT use a companion WID but RAN does not.).

E. Inter-RAN WG aspects:

Section E. is addressing the problem that multiple RAN WGs work on the same feature but it is still intended to not have an own WI for this but to cover this feature under cat.B/C TEIxx (this is challenging time-wise and coordination-wise and therefore not a recommended approach but it is not forbidden). As RAN5 has introduced specific rules regarding the testing of TEI CRs, see RP-200931 [5] and since they use a different WI code (TEIxx\_Test) and testing work is usually coming at a later stage, this section E. is considering linked TEI CRs of RAN1/2/3/4.

In a similar way: RAN1/2/3/4 Core part work happens usually in the same time interval while RAN4 Perf. part work usually happens at the end of or after the RAN4 Core part work. In other words, having a TEI CR package that combines Core and Perf. part work requires a very careful timing to not violate requirement B.

RP-191602 [2] provided some guidance on Cross-WG TEI CRs in RAN WGs:

- Cross WG TEI CRs are strongly discouraged

- RAN1/2 TEI proposals with RAN4 impact to core requirements are strongly discouraged

- **RAN2 impact of RAN1/4-led TEI CRs shall be limited to RRC signalling of configuration parameters and UE capabilities (no MAC impact, no RRC procedural impact, etc.)**

Note: Ideally one RAN WG would take the decision about whether a TEI feature should be introduced or not and other RAN WGs then accept this decision and contribute their TEI CRs.

But as this guidance was not forbidding Cross-WG TEI CRs in RAN WGs some more requirements had to be defined how to guarantee traceability, consistency and visibility of this sort of CRs.

The basic requirements discussed in section E. were endorsed by TSG RAN in RP-202867 [7] but further clarification/guidance is provided here.

**E.1 It is mandatory to fill out the "other specs affected" for all CRs, i.e. either Yes or No shall be ticked and  
 if Yes is ticked at least the TS/TR shall be indicated and this for the present WG and all other WGs that have CRs linked to the present CR.  
 TEI CRs missing this information or having wrong information shall not be approved.**

These requirements were always there. But some clarification is required.

- "other specs affected" is used to link CRs that belong together which is essential for cat.F CRs and for cat.B/C TEI CRs to guarantee that a complete set of CRs is approved. Note: For cat.B CRs of other WIs, we have an extra RAN agenda item for each of them and we usually approve all stage 3 CRs together. But for closed WIs or TEI CRs we have normally just one agenda item collecting a larger number of CRs and then the relation of the CRs becomes unclear if "other specs affected" is not filled out properly.  
 NOTE: Other specs affected should also list inter-TSG related CRs if it is clear that these CRs can only be applied together. This usually involves a conditional approval at TSG level

- "Other core specifications" under "Other specs affected" on the CR cover: Going back to RAN #46 of Dec.2009 where TSG RAN decided to have separate Core part WIs and Perf. part WIs (in RP-091374) you can see from comparing with CR form v9.6 that the term "Other core specifications" is only intended to distinguish those specs from "Test specifications" and "O&M specifications" but not to exclude Perf. part related specs from "Other specs affected": This means as long as CR form is not updated "Other core specifications" should cover Core part specifications AND Perf. part specifications as defined in TSG RAN.

- "Test specifications" under "Other specs affected" on the CR cover: Testing under TSG RAN is either done in RAN4 or in RAN5. Since RAN5 has separate WIs for testing that usually are also just started after RAN4 work is completed, it would not make much sense to reference RAN5 specs on a RAN4 CR as it is clear that the RAN5 CR will just follow later (here it is more appropriate to review the corresponding RAN5 WI when it becomes available).  
 Examples where it could make sense to fill out this field: For RAN4 CRs to a WI that involve BS testing for the same WI/a linked CR. For CRs to SI TRs to which RAN4 and RAN5 contribute together with CRs. For a cat.B/C TEI CR of RAN1/2/3/4 that has a corresponding CR in RAN5 under TEIx\_Test.

- "O&M Specifications" under "Other specs affected" on the CR cover: O&M specifications are handled by SA5. SA5 has usually separate WIs for their changes and RAN CRs are not submitted to TSG SA or SA5, therefore the benefit of this field is higher within TSG SA. Nevertheless, there may be cases of tighter cooperation of RAN WGs with SA5 (like Minimization of drive tests) where it will be beneficial to indicate a related SA5 change coming to the same TSG meeting.

- What needs to be done if WGx is assuming that TS/TR ab.cde of WGy is affected but they are not sure?  
 WGx should list under "other comments" on the CR cover: "WGx thinks that also TS/TR ab.cde of WGy could be impacted by this CR." Depending on the probability WGx would tick Yes (and mention the spec) or No.  
 CR proponents shall check this with WGy (e.g. by sending an LS from WGx to WGy, submitting a Tdoc in WGy, talking to the chairman of WGy) so that at the TSG meeting where WGx submits this CR for approval it is either clear that there is no impact or that the WGy CR is available as well for approval.  
 NOTE: MCC has the possibility to correct CR covers before RAN submission (e.g. remove a potential impact comment if it turned out that there is no impact). But CR proponents need to inform MCC about this.  
 Incomplete CR sets (i.e. WGx CR there but linked WGy CR not available) can not be approved at TSG level and since cat.B/C TEI CRs have to be completed within one quarter, this is time critical.   
 Therefore very good preparation of cat.B/C TEI CRs which affect multiple WGs is essential.

**E.2 Each TEI cat.B/C CR and each TEI cat.F/A CR that corrects functionality related to an earlier TEI cat.B/C CR shall have a unique TEI identifier in square brackets [ ] at the end of the CR title on the CR cover sheet.  
 TEI cat.B/C CRs without such a unique TEI identifier cannot be approved at RAN.**

This principle was endorsed in RP-202867 [7] and further guidance for this approach is provided here:

- The TEI identifier should be short (4 to 18 characters using letters and/or digits or using \_ or - but avoiding blanks or other special characters which will complicate searches) and characterize the CR.

- The originating company takes care that related CRs in other WGs use the same TEI identifier.

- Unique identifiers are not added retroactively: Cat.F/A CRs for TEIs which did not have a unique identifier by RAN #91e will not get a unique identifier.

- Apart from plain TEI CRs, the unique TEI identifiers shall also be applied to NR\_newRAT-Core, TEIxx CRs because NR\_newRAT-Core was the huge WI for 5G.

- As the unique idendifiers are part of the CR title, they will be automatically stored in the CR database. Therefore CR authors have to make sure that the complete CR title in 3GU is in line with the title on the CR cover.

- For cases where it is not 100% clear whether a linked CR was agreed in another WG, it is the task of the CR author to double-check the situation in the week after the WG meeting and to inform MCC in case any updates of CR titles are required otherwise they risk that not properly linked CRs are rejected at RAN level.

**E.3 WG chairman reports report to TSG RAN about all agreed and technically endorsed cat.B/C TEI CRs of the last quarter. For each unique TEI identifier all related CRs of the considered WG are listed plus the corresponding CRs in the other WGs (if there are any) or the potential impacts on other WGs.**

How this is done is up to the chairman (e.g. it can be a slide with a table like the examples below, it can be an extra Excel table included in the zip file of the WG status report). The WG chairman could request inputs from MCC (Tdoc list filtered for agreed/endorsed TEI CRs) and all CR authors of the WG who had agreed/endorsed TEI CRs (to clarify whether there were related CRs in other WGs) and this could be condensed in such an overview.

Examples:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [HDUPLEX\_unpaired] | Modification to half duplex in unpaired spectrum | Rel-16 | R1-211234 (38.213, cat.C) | R2-2112345 (38.331 cat.C) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [intRAT\_HO\_NR\_ENDC] | Introduction of inter-RAT handover NR to ENDC | Rel-16 | R2-2123456 (38.306, cat.B)  R2-2123457 (38.331, cat.B) | potential impact on 38.133 for .... ? |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [E2E\_delay\_meas] | E2E delay measurement for QoS monitoring for URLLC | Rel-16 | R3-211234 (38.413, cat.B)  R3-211235 (38.423, cat.B)  R3-211236 (38.463, cat.B) | none |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **unique TEI identifier** | **feature** | **Rel** | **CRs in own WG** | **CRs in/impacts on other WGs** |
| [DRX\_coord] | Introduction of DRX coordination | Rel-16 | R4-2123456 (38.133, cat.B) | R2-2112345 (38.331, cat.B) |

- what's the main goal of this activity? To have a checkpoint in each WG (RAN1/2/3/4) where after the WG meeting it is checked whether a complete CR set is available for all cat.B/C TEI features for TSG RAN; by comparing the tables of different WGs a cross-check is possible.

- should this activity be limited to cat.B/C TEI CRs only? It would be useful to also list cat.F/A TEI CRs to correct formerly as cat.B/C TEI introduced features (corresponding CRs will have [ ] at the end of the Tdoc title and CR proponents will inform the WG chairman if there were any agreed/endorsed CRs lile this)

- what about CRs for WI code combinations like "<WI code>, TEIxx"?  
 These CRs appear when <WI code> was a WI of a Rel-yy with yy<xx.  
 These CRs are usually well identified via <WI code> and would therefore not need any more tracking.  
 But one exception should be made for <WI code> = NR\_newRAT-Core as this was the generic NR WI that introduced the whole 5G and if we do not track "NR\_newRAT-Core, TEIxx" as well, it could be used as a way to bypass this tracking activity.

- How big is the expected effort: Double-checking TEI16 CRs of 2020, we had about 110 cat.B/C CRs from RAN1/2/3/4 together with ~50% TEI16, ~25% "NR\_newRAT-Core, TEIxx" and ~25% other WI code, TEI16 CRs. So this means ~20 CRs per TSG RAN meeting plus a few cat.F/A corrections to former cat.B/C TEIxx CRs.

- What is TSG RAN supposed to do with the tables of TEI CRs from the WG chairmen? The impacts on other WGs have to be carefully reviewed (the earlier the tables from the WG chairmen are available the better, ideally at latest 1 week after the WG meeting): If WGx expected a CR from WGy but WGy did not provide such a CR, then there are 2 possibilities: The CR from WGy was not needed (then this will be documented e.g. in the RAN minutes or in a revised WG chairman's report) or WGy did not manage to conclude on a CR which means we have an incomplete CR set that cannot be approved. It is then up to TSG RAN to discard the incomplete CR set or to request a company CR for the WGy spec (if it is easy to solve) or to consider the start of a new WI (if the problem is more complex).

**E.4 MCC will support this tracking activity with a list of TEI CRs for a considered release that were handled at RAN and that have the unique TEI identifier.**

- The resulting Tdoc list of each RAN meeting includes already a complete list of all CRs handled in this meeting. An additional list will be added after RAN #92e listing the TEI CRs with unique TEI identifiers in [ ].  
 After RAN #93e, a further list will be appended to the TEI CR list so that in the end a list for all TEI cat.B/C CRs (and their corresponding cat.F/A corrections) will develop that allows easy search and filtering for new TEI features.

- Such a list could be generated per release and will allow an improved visibility and tracing of new TEI features.  
 Note: Due to the unique TEI identifiers and the proper documentation as outcome of the RAN meetings, also 3GU will allow to search for TEI CR sets.