**3GPP TSG RAN WG1 #112bis-e R1-23xxxxx**

**e-Meeting, April 17th – April 26th, 2023**

**Agenda item:** 9.16

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

**Title:** [draft] Summary #1 on Rel-18 TEIs

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the discussions and proposals in AI 9.16 for Rel-18 TEI related discussion and following email discussion.

[112bis-e-R18-TEIs-01] Email discussion on Rel-18 TEI proposals April 26 – Shinya (DOCOMO)

* Check points: April 21, April 26

Based on the discussions summarized in Section 2, following TEI proposals are identified in AI 9.16. According to the guidance in [10], 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 #1: Multi-PxSCH scheduling with single DCI**
  + Supported by Ericsson, Verizon, Qualcomm
* **TEI proposal #2: UE capability with up to 6-layer DL MIMO**
  + Supported by OPPO, CMCC, China Telecom, NTT DOCOMO, Lenovo, China Unicom, Qualcomm
* **TEI proposal #3: PUSCH antenna switching**
  + Supported by vivo, CMCC, Ericsson
* **TEI proposal #4: PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI**
  + Supported by ZTE, China Telecom, Sanechips
* **TEI proposal #5: Extensions to FR1 TRS configurations**
  + Supported by Nokia, Nokia Shanghai Bell
* **TEI proposal #6: Enhanced PDCCH reception for mDCI based mTRP**
  + Supported by Qualcomm
* **TEI proposal #7: Enhancement for scheduling request**
  + Supported by Qualcomm
* **TEI proposal #8: UE reporting of power offset for SRS antenna switching**
  + Supported by Qualcomm
* **TEI proposal #9: RAT-independent Positioning Enhancements**
  + Supported by Qualcomm
* **TEI proposal #10: Enhancement for HARQ multiplexing on PUSCH**
  + Supported by Huawei, HiSilicon, Ericsson, China Unicom, DOCOMO
* **TEI proposal #11: Enhancement of Preferred Resource Set in IUC Scheme 1 for SL**
  + Supported by Nokia, Nokia Shanghai Bell, Qualcomm
* **TEI proposal #12: Adapting drx-HARQ-RTT-TimerUL/DL for different number of PUSCH/PUCCH repetitions**
  + Supported by Nokia, Nokia Shanghai Bell
* **TEI proposal #13: Pathloss RS for Type 1 CG-PUSCH**
  + Supported by Xiaomi, China Unicom, OPPO, ZTE

1. Discussion on Rel-18 TEI proposals
   1. Multi-PxSCH scheduling with single DCI

Following proposal is made in the contribution.

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| [8] | In Rel-16, the feature multi-PUSCH scheduling was introduced whereby a single DCI 0\_1 can schedule up to 8 PUSCHs. The feature is agnostic to subcarrier spacing, frequency range, and whether or not shared spectrum access is required for the frequency band. The only restriction in Rel-16 specifications is that the multiple scheduled PUSCHs occur in contiguous slots. The corresponding Rel-16 UE feature parameter is as follows (see [3]   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ***multiPUSCH-UL-grant-r16***  Indicates whether the UE supports scheduling up to 8 PUSCH with a single DCI 0\_1. This capability is also applicable to a frequency band that does not require shared spectrum access. | Band | No | N/A | N/A |   In Rel-17, multi-PUSCH scheduling was extended to support non-contiguous slots in addition to contiguous slots. In contrast this feature is not agnostic to frequency range; it is limited to FR2 which includes sub-ranges FR2-1 (up to 52.6 GHz) and the newly introduced FR2-2 (up to 71 GHz). For FR2-1 the UE feature is limited to 120 kHz only. The corresponding Rel-17 UE feature parameter for FR2-1 is given is as follows (see [4]):   | ***multiPUSCH-SingleDCI-FR2-1-SCS-120kHz-r17***  Indicates whether the UE supports multi-PUSCH scheduling by single DCI for the operation with 120kHz SCS in FR2-1 with non-contiguous allocation. | Band | No | N/A | N/A | | --- | --- | --- | --- | --- |   In our view, it would be beneficial to extend multi-PUSCH scheduling with non-contiguous slots also to FR1. The extension is important for XR uses cases. The XR video traffic in UL includes variable and large packets, arriving in bursts. Therefore, dynamic scheduling is a reasonable approach for data transmission. Considering the large size of the packets, multiple PUSCHs are needed to be scheduled for sending the data. Hence, scheduling these PUSCHs with a single DCI has clear benefit and advantage, over scheduling each PUSCH with a single DCI. A limitation to contiguous slots would be problematic in case of transmission over TDD bands. We note there is no RAN1 specification impact from this; it is only a matter of introducing an additional UE capability. With this capability, multi-PUSCH with either contiguous or non-contiguous slots would then be available in all frequency ranges and all subcarrier spacings defined so far.  Similar to multi-PUSCH scheduling, multi-PDSCH scheduling with single DCI 1\_1 for both contiguous/non-contiguous slots was specified in Rel-17. Similarly, this feature was limited to FR2 including both sub-ranges FR2-1 and FR2-2, and for FR2-1 it is limited to 120 kHz only. The corresponding Rel-17 UE feature parameter for FR2-1 is given is as follows (see [4]):   | ***multiPDSCH-SingleDCI-FR2-1-SCS-120kHz-r17***  Indicates whether the UE supports multi-PDSCH scheduling by single DCI for the operation with 120kHz SCS in FR2-1 and HARQ enhancements for both type 1 and type 2 HARQ codebook. | Band | No | N/A | N/A | | --- | --- | --- | --- | --- |   In our view it is beneficial to also extend multi-PDSCH scheduling for contiguous/non-contiguous slots to FR1. Similarly, to UL for the case of multi-PUSCH, this extension is important for XR uses cases to serve XR video traffic in DL which includes variable and large packets, arriving in bursts. Again, there is no specification impact from this; it is only a matter of introducing an additional UE capability. With this capability, multi-PDSCH with either contiguous or non-contiguous slots would then be available for all frequency ranges and all subcarrier spacings defined so far.  **With respect to the comments raised in the previous meeting, we would like to provide the following clarifications:**  The features under discussion here, were developed during the WI for FR2-2. There is no specification impact to enable these features for other frequency ranges. Whether the features would be implemented or not, depends on the market need and vendors. When it comes to deployment scenarios, large variations are often experienced as compared to the scenarios used for the purpose of the design of the feature.  For the argument that this proposal was previously discussed and not agreed, we would like to understand the fundamental reasons for not enabling these features when there is no specification impact.  For the argument that the performance benefit should be shown to relax the restriction, we question that why to start with restriction and limitation of use cases?  Consider this example: XR traffic is to be served using a TDD band in FR1. Hence, it is sensible if PUSCHs with different SLIVs are scheduled in different UL slots. A NW vendor see the benefit to use a single DCI for this purpose for various reasons. But it is simply not possible because of FR1. Was it a correct or necessary decision to deny this possibility?  Moreover, we have experienced cases that a feature is being restricted in a release and next release the restriction is removed, consuming a lot of efforts and time.  Therefore, we make the following observations and proposals. We encourage companies to consider the benefits of lifting the current restriction thus contributing to providing enough flexibility and freedom for the market to decide when and what features to use.   1. Artificial restrictions to use the features developed by 3GPP are not beneficial. 2. The market decides when and which features to use. 3. A TEI-18 is supported to introduce the UE feature for multi-PUSCH scheduling with single DCI 0\_1 for non-contiguous slots in FR1 for all defined SCSs. Note: there is no RAN1 impact. 4. Introduce the UE feature for multi-PDSCH scheduling with single DCI 1\_1 for contiguous/non-contiguous slots in FR1 for all defined SCSs in the same TEI-18 as for multi-PUSCH with non-contiguous slots for FR1. Note: there is no RAN1 impact. |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Y | A minor comment: There seems no need to extend NR-U contiguous PUSCH scheduling design to FR1 as long as FR2-2 design (for both contiguous and non-contiguous slots) is extended to FR1. | | DOCOMO |  | This proposal was discussed in Rel-18 XR SI while no consensus was achieved because the gain is unclear. It is appreciated if proponent can show how much capacity gain can be achieved by this proposal | | CATT | N | It has achieved a conclusion in RAN1#110bis as following:  Conclusion  No further discussion in RAN1 for Rel-18 XR to extend the support of legacy single DCI scheduling multi-PDSCHs for FR2-2, to other SCS in FR1/FR2-1.  According to the conclusion, it is not necessary to extend the multi-PUSCH/PDSCH to other SCS in FR1/FR2-1 for XR service.  Moreover, for multi-PDSCH/PUSCH scheduling, the same MCS is applied to all the PDSCH/PUSCHs scheduled by a DCI. If it is extended to other SCS in FR1/FR2-1, i.e. 15kHz, using the same MCS for up to 8 PUSCH/PDSCH may affect the performance of PUSCH/PDSCH. Thus, we prefer not to extend the multi-PUSCH/PDSCH to other SCS in FR1/FR2-1. | | ZTE |  | More clarification on the motivation is needed, e.g., support of multi-PUSCH/PDSCH scheduling in non-contiguous slots for FDD. | | Nokia, NSB | N | Already concluded not to consider this further (see CATT comment) TEI18 should not be used as a second attempt for features that did not make it to a Rel-18 WI they were originally proposed for. | | vivo |  | It has been studied in Rel-18 XR, no consensus on the achieved gain | | MediaTek | N | We are skeptical about the use case for this TEI. In R17 UE feature discussion, the proposal was discussed but not agreed to extend to FR1. In R18 XR study, extending multi-slot-PxSCH scheduling by single DCI from FR2 to FR1 was again discussed and majority of companies are inclined to think there is no obvious XR capacity gain. We are hence curious what is the main benefit or application scenario for this extension to FR1 considering FR1 has a much longer slot length than FR2. | | Huawei, HiSilicon | Y | Support the proposal#2 in general.  Considering the proposal and existing FGs in NRU and above 52.6GHz, there is only 60kHz SCS in FR2-1 not supporting multiple PDSCH/PUSCH scheduling by single DCI. Not sure why it is treated differently from the other SCS and FR.  During the discussion on R17 UE features, extension of 32 HARQ processes (already supported in above 52.6GHz and NTN) to FR2-1 and FR1 were discussed together with the FGs of multiple PDSCH/PUSCHs scheduled by single DCI to solve the starvation of HARQ processes. We propose to extend support of 32 HARQ processes to FR2-1 and FR1 for all supported SCSs. | | Moderator |  | According to the above comments, this proposal is supported by Ericsson, Qualcomm, Huawei, HiSilicon, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponent is encouraged to address the concern from companies. | | OPPO | N | Agee with CATT’s comment | | Moderator |  | This proposal is supported by Ericsson, Qualcomm, Huawei, HiSilicon, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Companies can come back in next RAN1 meeting considering the comments provided in this RAN1 meeting. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #1**

* **Introduce a UE feature for multi-PUSCH scheduling with single DCI 0\_1 for non-contiguous slots in FR1 for all defined SCSs**
  + **Note: there is no RAN1 impact**
* **Introduce a UE feature for multi-PDSCH scheduling with single DCI 1\_1 for contiguous/non-contiguous slots in FR1 for all defined SCSs**
  + **Note: there is no RAN1 impact.**

This proposal is already supported by Ericsson, Verizon, Qualcomm.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO |  | This proposal was discussed in Rel-18 XR SI while no consensus was achieved because the gain for XR is unclear. For example, multi-PDSCH/PUSCHs scheduled by each DCI with different MCS/FDRA may have better performance compared to multi-PDSCH/PUSCHs scheduled by single DCI because MCS/FDRA are same to all the PDSCH/PUSCHs scheduled by a DCI for multi-PDSCH/PUSCHs scheduling. It is appreciated if proponent can show how much capacity gain can be achieved by this proposal. |
| QC | Y |  |
| CATT | N | Single DCI 1\_1 scheduling for multiple slots were introduced for FR 2\_2 with short slot interval (large SCS) to accommodate UE capability of the number of PDCCH decoding. The single DCI scheduling multiple slots in FR1 would degrade the link adaptation and HARQ performance. There is not evidence of benefit for DCI 1\_1 scheduling multi-PDSCH for FR1. |

* 1. UE capability with up to 6-layer DL MIMO

Following proposal is made in the contribution.

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| [4] | **Background**  In Rel-15 NR, the MIMO schemes with up to 8 layers were introduced to boost the DL throughput. Based on UE capability, NW may configure MIMO transmission with up to 8 layers for a UE. According to the existing RRC signaling, the number of MIMO layer can be configured as 1, 2, 3, 4, 5, 6, 7, or 8.   |  | | --- | | PDSCH-Config ::= SEQUENCE {  dataScramblingIdentityPDSCH INTEGER (0..1023) OPTIONAL, -- Need S  dmrs-DownlinkForPDSCH-MappingTypeA SetupRelease { DMRS-DownlinkConfig } OPTIONAL, -- Need M  dmrs-DownlinkForPDSCH-MappingTypeB SetupRelease { DMRS-DownlinkConfig } OPTIONAL, -- Need M  ...,  [[  maxMIMO-Layers-r16 SetupRelease { MaxMIMO-LayersDL-r16 } OPTIONAL, -- Need M  minimumSchedulingOffsetK0-r16 SetupRelease { MinSchedulingOffsetK0-Values-r16 } OPTIONAL, -- Need M  …  }  MaxMIMO-LayersDL-r16 ::= INTEGER (1..8) |   Meanwhile, the existing UE capability signaling allows a UE to report the support of up to 2-layer DL MIMO, up to 4-layer DL MIMO or up to 8-layer DL MIMO.   |  | | --- | | FeatureSetDownlinkPerCC ::= SEQUENCE {  supportedSubcarrierSpacingDL SubcarrierSpacing,  supportedBandwidthDL SupportedBandwidth,  channelBW-90mhz ENUMERATED {supported} OPTIONAL,  maxNumberMIMO-LayersPDSCH MIMO-LayersDL OPTIONAL,  supportedModulationOrderDL ModulationOrder OPTIONAL  }  MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers} |   For the practical deployment, it is common for smartphones to use 4 Rx or 2Rx antennas for typical bands. Thus, the current commercial smart phones can only support DL MIMO with up to 4 layers.  ***Observation 1: The current commercial smart phones can only support DL MIMO with up to 4 layers.***  As hardware and design improve, some advanced smartphones are starting to trend towards using more Rx antennas to improve the DL performance. For example, some foldable phones have already implemented 6 Rx antennas. That brings in the following benefits to 5G system:   * B1: A more advanced receiver exploiting more Rx antennas to mitigate interference for DL MIMO transmission with up to 4 layers that can * B2: providing higher peak data rate through supporting higher number of DL MIMO layers (e.g., 5 or 6 layers). Fig.1 illustrates the LLS performance for DL MIMO schemes. “rank4” and “rank6” in the figure refer to the dynamic rank adaptation with up to 4 layers and up to 6 layers, respectively.   ***Observation 2: Compared to 4-layer DL MIMO, 6-layer DL MIMO can offer higher data rate and better user experience.***    Figure 1. Performance comparison of up to 4-layer and up to 6-layer DL MIMO  The benefit B1 can be achieved by advanced implementation of chipset with no spec impact. But, unfortunately, the benefit B2 cannot be obtained under the current specification. According to the existing UE capability signaling, a UE not supporting 8-layer DL MIMO can only report either “twoLayers” or “fourLayers”. With reporting either one, the system is not able to configure 6-layer DL MIMO transmission to the UE, even though the UE is capable of 6-layer DL MIMO.  During the discussion in the last meeting, there was a proposal that a UE reports the support of 8-layer DL MIMO but will only report the rank with up to 6. However, this implementation-based solution has some problems. The first one is that “cheating” network is not aligned with the basic principle of UE capability in 3GPP. The second one is UE cannot meet some other requirements specified by 3GPP or regulator (e.g., the requirements of 8-layer DL MIMO peak data rate, other test use cases in RAN4/RAN5).  ***Observation 3: The current NR spec cannot allow UE to support DL MIMO with up to 6 layers if it cannot support 8-layer DL MIMO.***    Based on the above discussion, the main restriction of existing UE capability is the relatively coarse granularity, i.e., only 2-layer, 4-layer and 8-layer are supported. A finer granularity for the DL MIMO layers will encourage more advanced commercial smart phones to provide higher data rate as UE don’t need to jump from 4 layers to 8 layers directly.  ***Observation 4: Allowing smart phones to support 6-layer DL MIMO will encourage UE vendors to provide advanced commercial smart phones with higher data rates.***  **Solution**  Therefore, in order to achieve higher DL throughput by fully exploiting the capability of UE with 6-layer DL MIMO, it is proposed to introduce a new UE capability so that an advanced smart phone with 6 or more Rx antennas can report its support of up to 6-layer DL MIMO transmission.  ***Proposal 1: Introduce a new candidate value, sixLayers, for the UE capability of supported maximal number of DL MIMO layers to support up to 6-layer DL MIMO transmission***   * ***Prerequisite feature group is FG 2-1*** * ***“Need for gNB to know whether the feature is supported by the UE” is “Yes”*** * ***Reporting type is per FSPC*** * ***“Mandatory/Optional” is Optional with capability signalling*** * ***Note1: R15 NR has already supported the candidate values of twoLayers, fourLayers and eightLayers via the RRC parameter MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}. It’s up to RAN2 for the signaling design of the corresponding UE capability.*** * ***Send an LS to RAN2 for necessary signalling design***   The key point of Proposal 1 is to introduce a new candidate value of UE capability so that UE vendors can provide some new types of advanced smart phones, which is more powerful than the current commercial smart phones. All the configuration mechanisms and transmission schemes are reusing existing ones. That is to say, no new mechanism/scheme/feature is introduced.    ***Observation 5: Proposal 1 doesn’t introduce any new NR feature(s). That is to say, the smart phone will reuse NR existing mechanisms/schemes.***  During the last meeting, some companies suggested RAN4 work for this TEI. As we discussed above, the smart phone will reuse NR existing mechanisms/schemes. In our views, whether/how any RAN4 work is needed or not for legacy NR mechanism/schemes is a separate discussion.  ***Observation 6: Whether/how any RAN4 work is needed or not for legacy NR mechanism/scheme/feature is a separate discussion.*** |
| [7] | In the current UE capability signalling maxNumberMIMO-layersPDSCH for DL MIMO, there are two unnecessary limitations.   * Limitation 1: the allowed values for maxNumberMIMO-layersPDSCH are {twoLayers, fourLayers, eightLayers} where sixLayers are missing. Given that there is no product on market to support more than fourLayers for DL MIMO, the caveat is not a problem for now. But in the future, this is a problem for UE vendors to build new devices beyond 4 layers, because the new devices have to support up to 8 layers directly. It is quite challenging to build device which improves from supporting max of 4 layers to max of 8 layers directly. It is beneficial, from both market demand and UE implementation perspective, to allow UE vendors improve devices from max of 4 layers to max of 6 layers, then to max of 8 layers. * Limitation 2: In Rel-15, number of Rx and number of max layers supported for DL MIMO is unnecessary tied together. For example, a 4 Rx UE is mandated to support 4 layers DL MIMO. We don’t intend to break the coupling for existing legacy devices which are already deployed, although we don’t think the couple is necessary. However, for future devices that can support more than 4 layers, it would be beneficial to untie the coupling of number of Rx and number of max DL MIMO layers, to allow more flexible UE implementation on market.   To address the first limitation, a very simple proposal is made, which is adding value 6 in the candidate value list of maxMIMO-LayersPDSCH. In RAN1#112, several companies mentioned there is RAN4 impact due to this proposal. However, one should notice that there is RAN4 impact for other TEI proposal as well. To way to avoid RAN4 impact in Rel-18, for the following agreed TEI proposal in RAN#112 is simply adding a note “Not to define RAN4 RRM requirement, including core/performance in Rel-18”, as in the following agreement. Similar approach can be adopted for this TEI proposal on maxNumberMIMO-layersPDSCH.   |  | | --- | | **Agreement**   * Introduce 1-symbol PRS with legacy comb sizes.   + UE expects the suitable expected RSTD windows provided by LMF such that peak ambiguity is addressed. Otherwise no measurement accuracy requirements are expected to be met.   + Not to define RAN4 RRM requirement, including core/performance in Rel-18 |   With the above analysis, we make the following proposal.  Proposal 2: Add a new UE capability of maxMIMO-LayersPDSCH-r18 with candidate values {2,4,6,8}.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **Description** | **Per** |  | **Candidate values** | | **maxMIMO-LayersPDSCH-r18** | **Supported maximum number of DL MIMO layers** | **FSPC** |  | **{2,4,6,8}** |   **Note: Not to define RAN4 requirements for maxMIMO-LayersPDSCH-r18=6, including core/performance in Rel-18.**  To address the second limitation, the following proposal is made.  Proposal 3: In UE capability maxNumberMIMO-layersPDSCH-r18, a 6-Rx UE can report a capability of twoLayers, fourLayers, or sixLayers, and an 8-Rx UE can report a capability of twoLayers, fourLayers, sixLayers, or eightLayers. |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Y |  | | DOCOMO | Y (w/ update) | Support the proposal in principle, however current Note 2 has a problem.  From Rel.15, 4 layers is mandatory for the bands where 4Rx is mandatory (except for RedCap). However, the note2 is contradicting with this Rel.15 rule.  TR38.822:  *For single CC standalone NR, it is mandatory with capability signalling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE*  Hence, we suggest to update the note 2 as:  Note2: A 6Rx UE can report a capability of two, four or six layers of maximum number of DL MMO layers except for the bands where 4Rx is specified as mandatory for the given UE. A 6Rx UE can report a capability of four or six layers of maximum number of DL MMO layers for the bands where 4Rx is specified as mandatory for the given UE. An 8Rx UE can report a capability of two, four, six or eight layers of maximum number of DL MMO layer except for the bands where 4Rx is specified as mandatory for the given UE. A 8Rx UE can report a capability of four, six or eight layers of maximum number of DL MMO layers for the bands where 4Rx is specified as mandatory for the given UE. | | CATT | N | In addition to UE capability, corresponding RAN4 work is also needed to enable up to 6-layer DL MIMO in practical system. The feature has major impacts to other working group, and may not suitable for a TEI. | | ZTE | N | Firstly, in general, introducing a new UE type should be fully justified, and then a new corresponding WID rather than TEI seems much more suitable. It is not just relevant to spec impact, but also much relevant to NW implement efforts on supporting above.  Secondly, in technical, we think the following may be clarified:   * + - Besides for SU-MIMO, we are wondering whether MU-MIMO should be supported or not. If only supporting SU-MIMO, from NW perspective, SU-MIMO with up to 6 layers vs MU-MIMO with up to 8/12 layer should be evaluated.   Then, if having up to 6 layer UE, the pattern of DMRS ports should be studied in our views. | | Nokia, NSB | [Y] | In principle we’d support allowing 6-Rx UEs, but would like to understand the CATT and ZTE concerns better. The specification already supports 6-layer MIMO, so if the proposal is simply to introduce a UE that can be scheduled with 6 layers, but never more than 6 layers, on the face of it there doesn’t seem to be a need for new functionality.  We agree with DOCOMO revisions. | | vivo |  | Maybe RAN4 is the correct WG to discuss this TEI proposal | | MediaTek | N | We do not support this proposal. We believe that introducing this level of flexibility into the specifications is not justified for a device that can support 8 Rx antennas.  We also do not see the practical benefits of introducing 6 layers and 6Rx for a smartphone form factor. A similar discussion also took place when prioritizing RAN4 work items for Rel-18 at RAN plenary. So agreeing this now in RAN1 would contradict with that outcome, and does not have any solid justification as to why this flexibility is practically useful. | | Huawei, HiSilicon | See comments | We have several questions over this proposal:   * We are not clear on the benefits. For CSI reporting based transmission, 6 layers have limitations, e.g., no type-II high resolution codebook for 6-layer, coarser codebook compared with 4-layer. This can also be reflected in the simulation results that for SNR less than 30dB, there’s marginal difference between 4-layer & 6-layer. For reciprocity-based transmission, spec has supported UE reporting of 1t6r or 2t6r for antenna switching, thus in practice the 6-layer can be supported in practice. * To fully use 6R, it seems the requirement for 6R in RAN4 will be needed. Does the proposal include some RAN4 work? | | Moderator |  | According to the above comments, this proposal is supported by OPPO, CMCC, China Telecom, NTT DOCOMO, Lenovo, Qualcomm, [Nokia, NSB], and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponents are encouraged to address the concern from companies.  Proposal is updated based on the comment as follows:   * **Introduce a new candidate value, sixLayers, for the UE capability of supported maximal number of DL MIMO layers to support up to 6-layer DL MIMO transmission**   + **Prerequisite feature group is FG 2-1**   + **“Need for gNB to know whether the feature is supported by the UE” is “Yes”**   + **Reporting type is per FSPC**   + **“Mandatory/Optional” is Optional with capability signalling**   + **Note1: R15 NR has already supported the candidate values of twoLayers, fourLayers and eightLayers via the RRC parameter MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}. It’s up to RAN2 for the signaling design of the corresponding UE capability.**   + **Note2: A 6Rx UE can report a capability of two, four or six layers of maximum number of DL MMO layers except for the bands where 4Rx is specified as mandatory for the given UE. A 6Rx UE can report a capability of four or six layers of maximum number of DL MMO layers for the bands where 4Rx is specified as mandatory for the given UE. An 8Rx UE can report a capability of two, four, six or eight layers of maximum number of DL MIMO layer except for the bands where 4Rx is specified as mandatory for the given UE. A 8Rx UE can report a capability of four, six or eight layers of maximum number of DL MMO layers for the bands where 4Rx is specified as mandatory for the given UE** | | OPPO | Y | We are fine with the updated proposal.  Re CATT: We agree that RAN4 work may be needed for 6Rx. However, the RAN4 work is not necessary to be finished in Rel-18. Even 8Rx requirement was just finished in Rel-17. Once RAN1 can agree on the feature, RAN4 can finish it in future release.  Re ZTE: The TEI is only related to UE capability, while gNB can still follow legacy configuration if it doesn’t want to implement the feature. At least in scenarios where there are not so many UEs in a cell (low probability of MU), UE supporting 6 layers transmission can provide higher peek SE. Regarding DMRS, we think current DMRS design is sufficient and no enhancement is needed.  Re vivo: RAN4 work can start after the UE feature is introduced.  Re MediaTek: It is not about flexibility. For a 6Rx UE, without this UE capability, it can only down-report the capability of 4 layer transmission, which would impact the peek SE for some UE with high SINR.  Re Huawei: Since the feature is mainly applied to UE with SU-MIMO, we think type-II high resolution codebook for 6-layer may not be needed. For reciprocity-based transmission, though UE can report 1T6R or 2T6R, it can only report max layers of 4. gNB can obtain full channel information with 6RX, but it cannot schedule more than 4 layers even with high SINR. For RAN4 work, please see the response to CATT. | | Moderator |  | This proposal was discussed on Tuesday online session but could not achieve consensus. Since this proposal will not be discussed further online in this meeting due to the overlap with MIMO online session, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #2**

* **Introduce a new candidate value, sixLayers, for the UE capability of supported maximal number of DL MIMO layers to support up to 6-layer DL MIMO transmission**
  + **Prerequisite feature group is FG 2-1**
  + **“Need for gNB to know whether the feature is supported by the UE” is “Yes”**
  + **Reporting type is per FSPC**
  + **“Mandatory/Optional” is Optional with capability signalling**
  + **Note1: R15 NR has already supported the candidate values of twoLayers, fourLayers and eightLayers via the RRC parameter MIMO-LayersDL ::= ENUMERATED {twoLayers, fourLayers, eightLayers}. It’s up to RAN2 for the signaling design of the corresponding UE capability.**
  + **Send an LS to RAN2 for necessary signalling design**
  + **FFS on the following notes**
    - **Note2: A 6Rx UE can report a capability of two, four or six layers of maximum number of DL MMO layers. An 8Rx UE can report a capability of two, four, six or eight layers of maximum number of DL MMO layers.**
    - **Note3: Not to define RAN4 requirements for UE supporting up to 6-layer DL MIMO transmission, including core/performance in Rel-18.**

This proposal is already supported by OPPO, CMCC, China Telecom, NTT DOCOMO, Lenovo, Qualcomm.

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

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| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Moderator |  | Regarding the FFS in the last sub-bullet, if 6Rx is considered for 6 DL MIMO layers, RAN4 requirements may need to be defined according to the discussion in the last RAN1 meeting. Companies are also encouraged to provide their views on whether these notes 2/3 are necessary or not. |
| DOCOMO | Y | Support the proposal. We believe the proposal is useful in real network, because if we can configure up to 6 layer DL MIMO, we can improve DL peak throughput compared to up to 4 layer DL MIMO. The issue of the current spec. is that UE cannot report supporting of 6 layer DL MIMO even if UE supports 6 layers. Simple extension of the UE capability signaling to include 6 layers can solve the issue.  For the FFS part,   * We believe Note2 should be removed. From our perspective, we don’t think we should mention 6Rx or 8Rx in the proposal. Since 6 layers for 6 Rx is not supported in Rel.18 RAN4, it can be supported in future RAN4 releases. 6 layers for 8 Rx can be discussed as a part of Rel.18 RAN4 work. Even if we keep the Note2, we think the current Note2 should be updated to clarify keeping the rule that 4 layers is mandatory for the bands where 4Rx is mandatory except for RedCap (same comment as RAN1#112). * We think Note3 is not needed, but we are fine to keep the note3. |
| QC | Y | For Note2: We are open to discuss how to modify the note2 to address DCM and other companies’ comments.  To clarify on the intention of Note3: eventually, RAN4 requirements for 6-layer DL MIMO would be needed. But it is up to RAN4 to decide when to do it (e.g. in Rel-19). Just following the note added for 1-symbol PRS TEI agreement in last meeting, we are OK to not define RAN4 requirement in Rel-18. |
| CATT | N | In our view, it’s not feasible to support this without defining RAN4 requirements correspondingly. Furthermore, this feature has major impacts to other working group, and may not suitable for a TEI. |

* 1. PUSCH antenna switching

Following proposal is made in the contribution.

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| [3] | **Background**  Current NR spec supports flexible configuration of SRS resources for different purposes with usage defined as for codebook, for antenna switching etc. However, the SRS resources for different usages are configured independently and not shared. SRS resources with usage for codebook are for PUSCH transmission, while SRS resources with usage antenna switching are for PDSCH transmission (channel reciprocity, TDD). Depending on UE capability SRS for antenna switching can be configured with 1T2R, 1T4R, 2T4R etc.  gNB can configure a UE with SRS for codebook and SRS antenna switching independently, simultaneously. In the following examples, it can be noticed that PUSCH antenna switching is supported in some of the scenarios.   * example 1, a UE can be configured with same two 1/2-port SRS resources for codebook and two 1/2-port SRS resources for 1T2R or 2T4R   + PUSCH antenna switching is supported * example 2, a UE can be configured with four 1-port SRS resources for 1T4R, however configuration of four SRS resources is not supported for CB except UL full power mode 2   + PUSCH antenna switching is partially supported * example 3, a UE can be configured with one 2-port SRS resource for codebook (ID 0) and two 2-port SRS resources (ID 0, ID 1) for 2T4R antenna switching.   + PUSCH antenna switching is not supported. * example 4, in FDD, SRS antenna switching may not be supported/configured, however two (four) SRS resources for CB can be configured   + Antenna switching for SRS and hence PUSCH is partially possible   **Discussion**  Currently, antenna selection for PUSCH is UE implementation, and partially supported in spec by configuring multiple SRS resources for CB. UE implementation could vary significantly and may not be very dynamic. Network doesn’t know when and how PUSCH antenna switching is implemented at the UE which may lead to degraded network implementation. Network controlling TX antenna can improve antenna selection mechanism, dynamically selecting best antenna for SRS and PUSCH transmission, improving overall system performance.  Figure 2 shows evaluation results, the UE is equipped with 1Tx chain but 4 antennas, PUSCH antenna is switched from the antenna which is completely blocked (index 1) to another antenna which not blocked. Blocking occurs at dashed vertical line and reaction time means the time delay in switching to best antenna (not blocked) after the blocking occurs. The reaction time is the time period required for UE switching to better antenna by implementation. If the UE can instantly switch to better antenna (0ms reaction time), then the UE switches to better antenna for SRS transmission and the following PUSCH transmission. For example, for 80ms (or longer) reaction time, after antenna blocking happens (at dashed line 30ms), the UE takes 80ms to switch to better antenna, during this period the UE uses blocked antenna for SRS and the following PUSCH transmission. In this evaluation, only 1 SRS resource is assumed for CB based transmission. It can be noticed that longer the delay (reaction time) in PUSCH antenna switching performance gets worse.    Figure 2 Impact of PUSCH antenna switching delay on performance  From above discussion and evaluation results, following observations can be made   * It is beneficial to support spec based PUSCH antenna switching * If SRS for antenna switching and for codebook share same resources, only minor spec change for 1T4R is needed. * For FDD, assuming the network doesn’t configure antenna switching SRS for the UE, network can configure two 1/2-port SRS resources   + Some enhancement on SRS configuration is needed, i.e., introduce “gap symbol” between two SRS resource for codebook * For 1Tx, 4Rx UE, assuming the network doesn’t configure antenna switching SRS for the UE   + To support PUSCH antenna switching, for TDD/FDD, four 1-port SRS resources are needed with gap symbol in between, and SRI is indicated in DCI.   **Proposals and potential spec impact**  Based on the motivation and discussion above, it is proposed to support more than 2 SRS resources in a set for usage codebook. It is also proposed to introduced new a UE capability on gap symbol between SRS resources.  **Proposal 2:**   * **Support to configure maximum of 4 SRS resources for codebook based transmission for PUSCH antenna switching** * **Introduce following new UE capabilities for PUSCH antenna switching**   + **Support of max 4 SRS resources in a set for codebook based UL transmission**     - **With 1 or 2 ports in each resource, and excluding nTnR switching**   + **Support of gap symbol(s) between SRS resources in a set for usage codebook**      - **Number of gap symbol(s) are same as for SRS resources for antenna switching**   Below table shows the potential spec impact to 38.214.   |  | | --- | | 38.214 Section 6.1.1.1  ..  For codebook based transmission, only one SRS resource can be indicated based on the SRI from within the SRS resource set. ~~Except when higher layer parameter~~ *~~ul-FullPowerTransmission~~* ~~is set to 'fullpowerMode2', t~~The maximum number of configured SRS resources for codebook based transmission is ~~2~~4. If aperiodic SRS is configured for a UE, the SRS request field in DCI triggers the transmission of aperiodic SRS resources. | |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | N | We have some concerns on this proposal.   1. Current UE implementation based 1Tx sounding works fine and it offers UE some flexibility to choose antenna. Please notice some UE Tx related parameters/procedures are not aware at gNB such as SAR, accurate/instant PHR, etc. For example, for 2T case, if antenna A/B are far apart, while C/D are clsoder, then UE might prefer to use A/B more to meet SAR requirements. 2. The functionality of this new mode can be achieved with non-codebook based PUSCH already. 3. If this proposal is adopted, GAP symbol need to be introduced on back-to-back PUSCH, if gNB indicate two different antenna port for these two PUSCH. | | FUTUREWEI |  | Unclear benefit over current implementations | | vivo | Y | @QC, please find comments below   1. In current spec up to 2 SRS resources can be configured in SRS resource set for usage codebook, which allows some flexibility. For UE specific implementation as you mentioned for 2T case, the UE can map the SRS ports to corresponding antennas anyway 2. Non-codebook based PUSCH is optional in current spec 3. In the proposal GAP symbol depends on UE capability, if the UE reports the capability without GAP, gNB can configure SRS resources without GAP symbols, for the UEs without this capability gNB can choose configure GAP symbols or not to configure 4 SRS resources. In current spec, there is no GAP symbols between 2 SRS resources for codebook.   @FUTUREWEI, could you please clarify what do you mean by “current implementations”? We have shown in the simulation results that antenna switching delay has impact on PUSCH performance. | | DOCOMO |  | We understand this proposal is basically to improve the performance of a PUSCH transmission by optimizing antenna port selection while making a sacrifice of some UL symbols at least for the corresponding SRS transmissions (e.g., Y+1 symbols for additional antenna port). We are currently not sure whether/how much the proposal could be beneficial from system perspective. It may be good to clarify such “system-wise” benefit at first. | | CATT | Y | We are supportative of this TEI proposal. We have one question for clarification. When each resource is configured with 2 ports, there is no need to configure 4 SRS resources in a set. Is that correct understanding? | | ZTE |  | As mentioned by other companies, the following may need to be clarified, otherwise it is difficult for us to justify the necessity and NW-implementation impact of this TEI proposal.   * Q1: When/whether the SRS ports for CB from different resources can be different or not, for instance, if fully overlapping with SRS resource for AS, or a new RRC parameter/rule can be introduce for indicating that SRS ports for CB can be different ports from different resources. * Q2: Whether/when a gap between PUSCH scheduled by DCI format 0\_1/2 and PUCCH/PUSCH scheduled by DCI format 0\_0 is needed? How to assume the PUCCH port and PUSCH port scheduled by DCI format 0\_0  in such case.   Q3: Whether we can assume that there is a fix mapping between SRS for AS? For instance, after RRC reconfiguration, SRS for CB is fully overlapped from SRS resource #0 for AS to resource #3, can we assume that the antenna port for SRS for CB is switched from physical UL-Tx antenna port 0 to 3 accordingly. | | vivo2 |  | @DOCOMO, our initial evaluation shows the impact of switching delay. It is intuitive that more flexibile dynamic antenna selection for SRS (PUSCH) is beneficial. And, from network perspective there is flexibility in configuring number of SRS resources in a set for usage codebook  @CATT, thanks for question, current proposal is to support 4 SRS resources in a set with 2 ports each. We can discuss 1 port and 2 port SRS separatelly  @ZTE,  reply to Q1, the proposal has nothing to do with SRS for AS, current spec supports configuration of up to 2 SRS resources in a set for usage codebook, number of SRS port(s) for codebook is same. [for your information UL full power mode2 support up to 4 SRS resources with different number of ports]  reply to Q2, the proposal for SRS configuration with or without GAP is UE capability. Regarding “gap between PUSCH scheduled by DCI format 0\_1/2”, current spec allows configuring 2 SRS resources, which means SRI indicates which PUSCH follows which antenna ports are used for SRS transmission, partial PUSCH antenna switching is already supported by spec. when scheduled by DCI format 0\_0, there is no SRI/TPMI field in DCI, UE behavior is single port transmission, which same as in current spec with 2 SRS resources configured.  Reply to Q3, this proposal has nothing to do SRS for AS, according to spec PUSCH transmission follows SRS transmission for codebook. | | MediaTek | N | We do not support this proposal. The UE implementation-specific approach to Tx antenna switching works well in our understanding, and gives flexibility to the UE. We see no need to change this paradigm and believe that adding network control would make the whole procedure more cumbersome. | | Huawei, HiSilicon | N | The antenna switching for PUSCH can already be achieved to the most extent by implementation. For example, the blocked antenna can be measured by DL reference signal, and UE can choose to switch the physical antenna utilized to transmit the SRS resource based on the measurement result if necessary.  Furthermore, introduce SRS resource set with usage “codebook + antenna switching” will bring non-negligible spec. effort. | | Moderator |  | According to the above comments, this proposal is supported by vivo, CMCC, Ericsson, CATT, and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor.  Companies are encouraged to check the reply comments from proponent (vivo) and to provide further comments, if any.  Also, proponents are encouraged to address the concern from companies not answered yet. | | OPPO |  | The benefit over current implementation-based solution is not so clear to us and needs to be justified. | | vivo |  | @OPPO, yes it is possible by implementation, however we have shown in the simulations results that if there is delay in antenna switching compared to SRS periodicity, there is performance degradation. In our understanding, antenna selection by UE implementation happens in hundreds of milliseconds, it is much longer than L3-RSRP measurement.  @ MediaTek @Huawei, this proposal doesn’t reduce implementation specific flexibility. And, as I explained above nothing to do with SRS for antenna switching. Let me explain with few drawings below, assuming UE has 1Tx chain and 4 antennas.   1. UE is configured with 1 single port SRS resource, and certain periodicity,   SRS(occasion1) PUSCH SRS(occasion2)  UE selects 2nd antenna in occasion 1 by implementation for SRS transmission and following PUSCH is also transmitted using 2nd antenna. In occasion 2, the UE selects 3rd antenna by implementation and the subsequent PUSCH is also transmitted using 3rd antenna.   1. UE is configured with 2 single port SRS resources and certain periodicity,   SRS1 SRS2 SRS2 SRS1  SRS(occasion1) PUSCH(follow SRI) SRS(occasion2)  UE selects 1st and 2nd antenna in occasion 1 by implementation for SRS transmission and following PUSCH is ransmitted following SRI indication (corresponding to 1st or 2nd antenna). In occasion 2, the UE selects 3rd and 4th antenna by implementation and the subsequent PUSCH is transmitted following SRI indication (corresponding to 3rd or 4th antenna). Here SRS resource to antenna mapping is UE implementation  Above 2 cases are already supported in the spec. Now, the TEI proposal is support configuring 4 SRS resources  SRS1 SRS2 SRS3 SRS4 SRS4 SRS2 SRS1 SRS3  SRS(occasion1) PUSCH(follow SRI) SRS(occasion2)  UE selects 1st 2nd 3rd and 4th antenna in occasion 1 for SRS transmission and following PUSCH is ransmitted following SRI indication, sequence of SRS to antenna mapping is UE implementation. Similarly, in occasion 2, the UE selects 1st 2nd 3rd and 4th antenna for SRS transmission and the subsequent PUSCH is transmitted following SRI indication, sequence of SRS to antenna mapping is UE implementation. Flexibility of UE selection of antenna for SRS transmission is still there.  In case 1 above, if the antenna is blocked and selects better antenna based on DL measurement or some other UE implementation, it takes long time to make switching decision. If the switching happens in 80ms (in our evaluation SRS is configured 40ms periodicity) then performance degrades significantly. With 4 SRS resources configured, gNB can indicate SRI for PUSCH transmission. In case 2, SRI can indicated 1 out of 2 antennas. | | Moderator |  | This proposal was discussed on Tuesday online session but could not achieve consensus. Since this proposal will not be discussed further online in this meeting due to the overlap with MIMO online session, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #3**

* **Support to configure maximum of 4 SRS resources for codebook based transmission for PUSCH antenna switching**
* **Introduce following new UE capabilities for PUSCH antenna switching**
  + **Support of max 4 SRS resources in a set for codebook based UL transmission**
    - **With 1 or 2 ports in each resource, and excluding nTnR switching**
  + **Support of gap symbol(s) between SRS resources in a set for usage codebook** 
    - **Number of gap symbol(s) are same as for SRS resources for antenna switching**
* **Adopt following TP in Clause 6.1.1.1 in TS 38.214**

|  |
| --- |
| For codebook based transmission, only one SRS resource can be indicated based on the SRI from within the SRS resource set. ~~Except when higher layer parameter~~ *~~ul-FullPowerTransmission~~* ~~is set to 'fullpowerMode2', t~~The maximum number of configured SRS resources for codebook based transmission is ~~2~~4. If aperiodic SRS is configured for a UE, the SRS request field in DCI triggers the transmission of aperiodic SRS resources. |

This proposal is already supported by vivo, CMCC, Ericsson.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | N | We are still not convinced this TEI proposal is needed, based on   1. Current UE implementation based 1Tx sounding works fine and it offers UE some flexibility to choose antenna, and we like to keep such flexibility at UE side. Please notice some UE Tx related parameters/procedures are not aware at gNB such as SAR, accurate/instant PHR, etc. For example, for 2T case, if antenna A/B are far apart, while C/D are closer, then UE might prefer to use A/B more to meet SAR requirements. 2. For 1 Tx 4 Rx UE, NW can already configure 2 SRS resources, UE will autonomously sound the best two antennas, and network can use SRI to pick between the two antennas. This can already achieve most of the gain this proposal is trying to achieve. 3. The functionality of this new mode can be achieved with non-codebook based PUSCH already. 4. Another way to achieve this functionality is extending the agreement made for 8 Tx, which allow 8-ports SRS being sounded in multiple OFDM symbols, to allowing 4-ports SRS being sounded in 4 OFDM symbols.   If this proposal is adopted, GAP symbol need to be introduced on back-to-back PUSCH, if gNB indicate two different antenna port for these two PUSCH. |
| CATT | Y | We are supportative of this TEI proposal. But we prefer to clarify the configuration of the SRS resources. When 2-port SRS is configured, the UE is at a 2T4R UE. Then configuring 2 SRS resources is sufficient. When UE is a 1T4R UE, UE can be configured with 4 SRS resources, but with one port for each SRS resource. There is no use case for the configuration of 4 SRS resources and 2 SRS port per resource. |
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* 1. PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI

Following proposal is made in the contribution.

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| [5] | **Background**  In Rel-17 CE SI, most UL channels are identified as the coverage bottleneck channels in many scenarios, e.g., Rual 700MHz FDD NLOS O2I scenario [1]. Up to Rel-17, PUSCH repetition Type A is supported when transmitting PUSCH scheduled by a grant among the following cases.   * DCI format 0\_1 or 0\_2 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1; * RAR UL grant, i.e., Msg3 initial transmission; * DCI format 0\_0 with CRC scrambled by TC-RNTI, i.e., Msg3 re-transmission.   In Rel-18, PRACH repetition [2] and repetition of PUCCH carrying Msg4 HARQ-ACK [3] will be further supported. PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI is one important channel left that does NOT support repetition transmission.  In this contribution, the coverage performance of PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, e.g., Msg5 PUSCH, is evaluated. And potential issues and corresponding mechanisms to support Msg5 PUSCH repetition are also discussed.  **Coverage analysis**  As shown in Figure-1, after a UE performing 4-step RACH procedure, the network would schedule Msg5 PUSCH transmission to complete the RRC setup. Typically, the network performs the first RRC reconfiguration according to the UE capability information. Before the UE capability is reported, some functions that need to be determined based on the UE capability information cannot be configured. Therefore, before the first *RRCReconfiguration* message is received, DCI formats other than format 0\_0 cannot be used for UL scheduling. So, Msg5 PUSCH, which is scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, cannot be scheduled with repetition.  ***Observation 1****: Msg5 PUSCH, which is scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, is the only uplink channel does not support repetition transmission after a UE performing 4-step RACH procedure in Rel-18.*    Figure-1: Higher layer procedure for a UE accessing the network  It is observed that Msg5 transmission is the coverage bottleneck according to the real filed test. The situation would get worse when repetition transmission of PRACH/Msg3/Msg4 HARQ-ACK is enabled. This is because more UEs would access to the network after the RACH procedure while congested during Msg5 transmission.  ***Observation 2****:* *Msg5 PUSCH is the coverage bottleneck according to the real filed test.*  Msg5 PUSCH is now one of the few UL channels does not support repetition transmission in Rel-18. However, it may have even worse coverage than some other UL channels (e.g., Msg3 PUSCH according to the evaluation below). Therefore, no support of Msg5 PUSCH repetition would jeopardize the commercialization of other Rel-17 and Rel-18 coverage related features, especially for repetition based features including the ones for NTN.  ***Observation 3****:* *No support of Msg5 PUSCH repetition would jeopardize the commercialization of other Rel-17 and Rel-18 coverage* *enhancement related features in both TN and NTN scenarios.*  To further evaluate the transmission performance of the Msg5 PUSCH, some link-level simulations are performed. Regarding the information carried by the Msg5 PUSCH, the packet size is assumed as 118 Bytes, which contains *RRCSetupComplete* (~102 Bytes), potential PHR and BSR (10 Bytes), and sub-layer (including, PDCP, RLC and MAC) header overhead (6 Bytes). As shown in Figure-2, TDD frame structure ‘DDDDD DDSUU’ with 30kHz SCS is used in the simulation. Then, there will be at most 2 times of transmission during one radio frame. The other detail simulation assumptions can be found in the Appendix.    Figure-2: TDD frame structure used in the simulation  In the simulation, the Msg5 PUSCH transmission performances under different maximum transmission times are evaluated. For example, ‘Msg5 with max 2 (re-)transmissions’ represents that there are at most 2 transmissions for Msg5 PUSCH, including initial transmission and retransmission. The performance of Msg3 PUSCH transmissions with different repetition factors (i.e., 1, 2, 4 and 8) are taken as baseline. The simulation results are showed in Figure-3 and Table-1.  Figure-3: Performance for Msg3 and Msg5 PUSCH transmission  Table-1: Performance for Msg3 and Msg5 at BLER = 0.1   |  |  |  | | --- | --- | --- | | Simulation cases | Target SNR (dB) w/o power normalization | Target SNR (dB) w/ power normalization to one PRB | | Msg3 without repetition | -7.31 | -4.3 | | Msg3 with 2 repetitions | -11.24 | -8.23 | | Msg3 with 4 repetitions | -13.66 | -10.65 | | Msg3 with 8 repetitions | -15.91 | -12.9 | | Msg5 with max 2 (re-)transmissions | -9.21 | 5.84 | | Msg5 with max 4 (re-)transmissions | -10.25 | 4.8 | | Msg5 with max 8 (re-)transmissions | -11.18 | 3.87 |   According to the above simulation results, significant performance gap can be observed between Msg5 PUSCH and Msg3 PUSCH, even though HARQ re-transmissions are enabled for Msg5 PUSCH while not for Msg3 PUSCH. It means that Msg5 PUSCH has more severe coverage issue than Msg3 PUSCH and therefore is the coverage bottleneck.  ***Observation 4****: The performance gap between Msg5 PUSCH transmission and Msg3 PUSCH transmission is large, which is summarized in the following table.*   |  |  |  |  |  | | --- | --- | --- | --- | --- | | *Performance gap(dB) between Msg5 and Msg3 at BLER = 0.1* | *Msg3 without Repetition* | *Msg3 with 2 Repetitions* | *Msg3 with 4 Repetitions* | *Msg3 with 8 Repetitions* | | *Msg5 with max 2 (re-)transmissions* | *>10* | *>10* | *>15* | *>15* | | *Msg5 with max 4 (re-)transmissions* | *9.1* | *>10.* | *>15* | *>15* | | *Msg5 with max 8 (re-)transmissions* | *8.17* | *>10* | *>10* | *>15* |   During RAN1#112 meeting, RLC segmentation is proposed by some companies to improve Msg5 PUSCH coverage. However, the layer 2 header overhead increases significantly with the increase of the number of segmentations. For each segmented packet, an RLC header with 4 Bytes and a MAC header with 2 Bytes will be additionally added and a PDCP header with 2 Bytes is shared by all segmented packet. While for PUSCH repetition, there is always 6 Bytes layer header overhead for each repetition transmission. The payload size of Msg5 is much larger than Msg3. If segmentation is used, more than 10 segmentations are required to approach similar payload size as Msg3. Then, as given in Table-2, the ratio of layer 2 header overhead would reach 30.9% and 46.7% for 8 and 16 segmentations respectively, making it an unfeasible solution in reality.  Table-2: Layer 2 header overhead for Msg5 PUSCH transmission w/ or w/o segmentation   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Number of segmented packets (N) | Size of data (excluding header overhead) | Layer 2 header overhead | Payload size of each packet after segmentation | Ratio of layer 2 header overhead | | 1 (repetition or w/o segmentation) | 112 Bytes | 2 (PDCP header) + 2 (RLC header) + 2 (MAC header) = 6 Bytes | 118 Bytes | 5.1% | | 2 | 112 Bytes | 2 (PDCP header) + 4\*N (RLC header) + 2\*N (MAC header) = 14 Bytes | 63 Bytes | 11.1% | | 4 | 112 Bytes | 26 Bytes | 35 Bytes | 18.8% | | 8 | 112 Bytes | 50 Bytes | 21 Bytes | 30.9% | | 16 | 112 Bytes | 98 Bytes | 14 Bytes | 46.7% | | 32 | 112 Bytes | 194 Bytes | 10 Bytes | 63.4% |   ***Observation 5****: If segmentation is used, more than 10 segmentations are required to approach similar packet size as Msg3. The layer 2 header overhead increases significantly (e.g., 46.7% for 16 segmentations, 63.4% for 32 segmentations), making it an undesirable solution in reality.*  In addition, similar to other PUSCH channels supporting repetition, using a larger TBS without segmentation can provide better performance in terms of large encoding gain and small high layer overhead. This is also the reason why TBoMS transmission is supported in Rel-18 for PUSCH scheduled by DCI format 0\_1/0\_2.  ***Observation 6****: Similar to other PUSCH channels supporting repetition or TBoMS, PUSCH transmission with less segmentation can provide better performance in terms of large encoding gain and small high layer overhead.*  Except for Msg5, similar coverage issue could be observed for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI even after UE capability reporting. Thus, we propose to support PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI.  ***Proposal 1:*** *Support PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI.*  **Proposed enhancement**  Both Msg5 PUSCH and Msg3 retransmission are scheduled by DCI format 0\_0, and the only difference is the RNTIs used. That is, TC-RNTI is used to scramble CRC of the DCI format for Msg3 retransmission scheduling, while C-RNTI is used Msg5 PUSCH. Therefore, from our perspective, similar repetition mechanism can be reused to support Msg5 PUSCH repetition, and the standardization effort would be limited.  In this context, we can consider the following solution for support of PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI.   * For the transmission schemes, reuse the same approach as Msg3 re-transmission which is scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, including repetition indication, RV determination, available slot determination and frequency hopping etc. * During initial access, a UE can request repetition transmission for PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI via Msg3 PUSCH transmission. * Alternatively, using separate PRACH resources for the request can also be considered, while this would result in further PRACH partition and therefore not preferred. * Similar mechanism has been agreed/discussed in several Rel-18 topics, * It has agreed that the early indication for Rel-18 eRedCap is included in Msg3/MsgA PUSCH; * The request of PUCCH repetition for Msg4 HARQ-ACK is also proposed to be carried in Msg3 PUSCH as discussed in Rel-18 NTN WI.   ***Proposal 2****: For support of PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI, adopt the following solution.*   * *For the transmission schemes, reuse the same approach as Msg3 re-transmission which is scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, including repetition indication, RV determination, available slot determination and frequency hopping etc.* * *During initial access, a UE can request repetition transmission for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI via Msg3 PUSCH transmission.* |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | N | We don’t support this proposal for now. But we are open to discuss it. From our observation in field, msg5 reception seems not an issue. | | CATT | Y | The motivation may be good, so we are open to discuss further. | | ZTE | Y | Support.  RAN1 somehow missed the evaluation on Msg5 transmission before. Based on our observation in real field, Msg5 is the actual bottleneck channel among channels before UE capability reporting, i.e. PRACH, Msg3 and PUCCH for Msg4 HARQ-ACK, which would all support repetition transmission in Rel-18.  As the evaluation results shown in our tdoc, we found re-transmission cannot make up the performance gap between Msg3 and Msg5 due to much larger payload of Msg5.  We see it is promising to implement Rel-17/18 CE features in near future, e.g., for NTN scenarios or vertical scenarios. Thus, it is critical to make Msg5 repetition available together with other repetition-based features. | | Nokia | N | This proposal may need a substantial amount of time to work out all the details related to a possible solution to the problem. We see the technical merit of this matter ,but we prefer deferring a discussion to a later time, when sufficient time to handle it properly would be available, e.g., next release, if applicable. | | vivo |  | First of all, pusch-RepetitionMultiSlots is a UE mandatory feature with capability signalling in Rel-15 and DCI 0\_1 is also mandatory in Rel-15, which means that Msg5 repetition is already possible to be scheduled by DCI 0\_1 with repetition.  In addition, we have following comments:   1. PUSCH scheduled by RAR in CFRA, MsgA (PRACH + PUSCH) in 2-step RACH are not supported with repetition either. 🡪 observation 1 is wrong. 2. Cell coverage is determined by the worst channel. Bottleneck channel is still PUSCH eMBB even after Rel-17/18 coverage enhancement. 3. Retransmission can be used for coverage extension of Msg5 though latency is a bit larger compared to repetition.   According to above, Msg5 repetition seems not necessary. In addition, this enhancement may require early UE feature indication which has large spec. impacts. | | MediaTek | N | We would like to understand why segmentation is not sufficient to cover message 5 in case there is a coverage limitation issue. It seems strange that after 2 Releases of SI and two follow up Wis that this is a sudden realised as an important bottleneck. | | Huawei, HiSilicon | N | In our observation, the so called Msg5 reception seems not an issue in field. Additionally, since the first message after initial access is targeted in the proposal, a network may not be aware of the UE capability yet. An early identification for the new feature seems necessary and requires special RAN2 impacts which seems not a task involving only single WG. | | Moderator |  | According to the above comments, this proposal is supported by ZTE, China Telecom, Sanechips, CATT, and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor.  Proponents are encouraged to address the concern from companies. | | ZTE2 |  | Below are some follow-up comments based on companies’ input.  **Whether Msg5 has coverage issue:**  We found the coverage issue of Msg5 in field during testing Msg3 repetition, and found that the system performance is even worse after enabling Msg3 repetition because more UEs can access to the NW while congested during Msg5 transmission. We expect similar issue if enabling Rel-18 features like PRACH repetition and PUCCH repetition for Msg4 HARQ-ACK. As mentioned above, we see it is promising to implement Rel-17/18 CE features in near future, e.g., for NTN scenarios or vertical scenarios. Thus, it is critical to make Msg5 repetition available together with other repetition-based Rel-17/18 features.  @vivo, Based on Rel-17 evaluation, Msg3 is the bottleneck channels in some scnearios, e.g., Rural 700MHz FDD NLOS O2I. Furthermore, the performance of Msg5 is even worse than Msg3 due to larger payload size.  **Whether it needs large spec effort**  Our proposal intends to reuse what we defined for Msg3 re-transmission (the only difference is the RNTI used), and spec impact for this would be minimized. Regarding early UE identification, it is similar as the Rel-18 NTN discussion on PUCCH repetition for Msg4 HARQ-ACK. In our view, a simplest way is to use one bit indication in Msg3 payload, similar as UE capability reporting after RRC setup.  **Whether DCI 0\_1 can be used**   * pusch-RepetitionMultiSlots is a UE mandatory feature **with capability signaling**, our understanding is gNB cannot assume UE can support it before UE capability reporting. Similarly, the configuration of some bit fields, e.g., DAI, in DCI 0\_1 relies on UE capability reporting. Therefore, we don’t think DCI 0\_1 can be used for Msg5 transmission, and, even DCI 0\_1 can be used, it cannot schedule repetition transmission for Msg5.   **Whether segmentation can be used**  The payload size of Msg5 is much larger than Msg3. Using segmentation, e.g., more than 10 times of segmentation to reach similar payload size as Msg3, is not a practical way in reality. | | Moderator |  | This proposal was discussed on Wednesday online session but could not achieve consensus. Since this proposal will not be discussed further online in this meeting, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #4**

* **Support PUSCH repetition type A for a PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI.**
  + **For the transmission schemes, reuse the same approach as Msg3 re-transmission which is scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, including repetition indication, RV determination, available slot determination and frequency hopping etc.**
  + **During initial access, a UE can request repetition transmission for PUSCH scheduled by DCI format 0\_0 with CRC scrambled by C-RNTI via Msg3 PUSCH transmission**

This proposal is already supported by ZTE, China Telecom, Sanechips.

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

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| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | N | We are still not convinced that this proposal is needed. From our observation in field, msg5 reception seems not an issue. |
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* 1. Extensions to FR1 TRS configurations

Following proposal is made in the contribution.

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| --- | --- | --- |
| [2] | RAN1#112 discussed the initial proposal in [3] that proposed several extensions to the FR1 TRS configurations. Based on the feedback received, in this contribution we focus on just one additional configuration that appeared to be the easiest for the UEs to implement as it would be a simple time-shift on the existing configurations.  The TS 38.214 subclause 5.1.6.1.1 defines the CSI-RS for tracking to have two symbols per slot in a one or two slot configuration, but hard-codes the FR1 to always transmit the TRS in the two-slot configuration.   |  | | --- | | - **For frequency range 1, the UE may be configured with one or more NZP CSI-RS set(s), where a *NZP-CSI-RS-ResourceSet* consists of four periodic NZP CSI-RS resources in two consecutive slots with two periodic NZP CSI-RS resources in each slot**. If no two consecutive slots are indicated as downlink slots by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigDedicated*, then the UE may be configured with one or more NZP CSI-RS set(s), where a *NZP-CSI-RS-ResourceSet* consists of two periodic NZP CSI-RS resources in one slot.  […]  - the time-domain locations of the two CSI-RS resources in a slot, or of the four CSI-RS resources in two consecutive slots (which are the same across two consecutive slots), as defined by higher layer parameter *CSI-RS-resourceMapping*, is given by one of  - , , or for frequency range 1 and frequency range 2,  - , , , , ,  or  for frequency range 2. |   The symbol locations and the requirement for two-slot configuration in FR1 complicates the TRS multiplexing with PDSCHs sent before the UE has a dedicated configuration (SI, paging, RAR), and the need for two-slot config limits the network energy saving when there is only light traffic in the system.  In this TEI18 document we propose additional FR1 TRS configurations to better facilitate multiplexing with common PDSCH transmissions and increase the opportunities for network energy savings.  The currently allowed TRS configurations for FR1 are depicted in Figure 1. It is evident that UEs not aware of the TRS cannot use the PRBs with TRS except by brute-force puncturing the TRS REs, and in many cases on FR1 carriers this means that the slots cannot be used at all for paging, system info or random access response. It is also not possible to multiplex TRS in the SSB slots if more than 1 SSB is used by the network.  In low-loaded environment this means that instead of being able to concentrate the TRS transmissions with common channels, different set of slots need to be used, increasing the network’s on-time.    Figure 2: Allowed FR1 TRS configurations since Rel-15  Extending the support for configuration {9, 13} also to FR1 would help placing the TRS after a shortened PDSCH while only introducing a time-shift to the TRS.    Figure 3: Proposed new FR1 TRS configuration 2x{9,13}  **Proposal 2:** For FR1, in addition to the already supported TRS configurations 2x{4,8}, 2x{5,9}, 2x{6,10}, allow also the configuration of 2x{9,13} for FR1.   * **Note:** The 2x{9,13} TRS configuration is supported for FR2 in Rel-15: No change to configuration signalling needed. |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | N | Regarding the new entries, we have the following comments.  2x{9,13}: it might be useful. We are open to consider 2x{8,12}, 2x{7,11} as well.  Single slot TRS for FR1: We have concern on its performance. FR1 is expected to have richer scattering. With 1 slot TRS there is only 1 equation to solve both the doppler spread and CFO. So, it does not seem to be the right thing.  2x{13}: freq error pull in range will be smaller than LTE.  2x{11,13}, 2x{12,13}: The other two patterns do offer smaller pilot spacing. But they will impact freq error resolution, i.e., less accuracy on freq error estimation. | | FUTUREWEI | N | Most of the proposed patterns may have worse T/F tracking performance.{9, 13} may work. | | DOCOMO | N | If this proposal had applied to Rel.15, it may be beneficial. However, even if we introduce new TRS configuration in Rel.18, gNB cannot stop transmitting Rel.15 TRS for Rel.15-17 UEs. Hence, the proposed new TRS should be transmitted in addition to Rel.15 TRS, which causes additional resource overhead. In that sense, we thinis this proposal is not useful in real operation. | | CATT | N | The justification of the proposed enhancement is NOT convincing. | | ZTE | Y with a comment | We are wondering how to handle co-existence UEs from Rel-15 to Rel-17. | | Nokia, NSB | Y | We wanted to list all the new TRS configs that we’d see useful from the network operation’s perspective, but we’d be more than happy to narrow down the proposal to what is more generally agreeable.E.g. focusing just to 2x{9,13}, FFS if others are to be added would be fine with us  @DOCOMO, CATT, ZTE: We specifically see this beneficial for the (fairly typical) case where we have a limited number of UEs in RRC connected. If the feature gains support in Rel-18 UEs, then in those cases when new UEs are the ones active we can use the new pattern. It is true that if we have “legacy” UEs in RRC connected, then the new pattern does not give us the benefits we are after. | | vivo | - | Introducing new TRS patterns is big, could not be handled as TEI | | MediaTek | N | We believe that most of these configurations will impact on tracking performance, and impact Rx performance. Therefore they are not agreeable. We also have the same question as NTT DOCOMO in relation to how the energy saving gains can be envisaged considering the presence of legacy UEs in the system, requiring legacy TRS configurations. Thanks for Nokia’s response to DCM’s question, in this case, we are very doubtful about the useness of this proposal. | | Huawei, Hisilicon | Y(Partially) | **For the first sub-bullet:**  Don’t support configuration {11, 13} and {12, 13}.  1. Time gap between two CSI-RS resources in a slot is too short. The accuracy of doppler shift measurement cannot be guaranteed.  2. It may introduce RAN4 impact, e.g., requirement on accuracy of doppler shift measurement with time gap smaller than 4 symbols.  Configuration {9, 13} is acceptable for us as the time gap between two CSI-RS resources in a slot is still 4 (i.e., same as legacy pattern).  **For the second sub-bullet:**  Don’t support. With only one symbol in each slot, the two CSI-RS resources used for doppler shift measurement is the two CSI-RS in two slots with a 14-symbols time gap which is too large. The accuracy of doppler shift measurement will be degraded.  **For the third sub-bullet:**  One-slot TRS configuration can provide better flexibility for gNB implementation. However, it may degrade the accuracy of doppler shift measurement of UE. It should be up to UE capability to support it or not. So, we can support if a corresponding UE capability is introduced. | | Moderator |  | According to the above comments, this proposal is supported by Nokia, Nokia Shanghai Bell, ZTE, [Huawei, Hisilicon] and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Companies are encouraged to check the reply comments from proponent (Nokia, NSB) and to provide further comments, if any.  Also, proponents are encouraged to address the concern from companies not answered yet. | | Moderator |  | This proposal could not be discussed on Tuesday online session. Since this proposal will not be discussed further online in this meeting due to the overlap with MIMO online session, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #5**

* **For FR1, in addition to the already supported TRS configurations 2x{4,8}, 2x{5,9}, 2x{6,10}, allow also the configuration of 2x{9,13}.**
  + **Note: The 2x{9,13} TRS configuration is supported for FR2 in Rel-15: No change to configuration signalling needed.**

This proposal is already supported by Nokia, Nokia Shanghai Bell.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | We still think the proposal is not useful in real operation, because even if we introduce new TRS configuration in Rel.18, gNB cannot stop transmitting Rel.15 TRS for Rel.15-17 UEs.  Based on the discussion in RAN1#112, we see the target scenario is when the number of RRC connected UEs is limited (i.e. there is small number of RRC connected Rel.15-17 UEs). However, we don’t think such scenario will be typical in practical operation. |
| QC | Y | We are fine with this proposal. We are open to consider 2x{8,12}, 2x{7,11} as well. |
| CATT | N | There is no evidence of the benefit in adding new TRS configuration. |

* 1. Enhanced PDCCH reception for mDCI based mTRP

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | Multi-DCI based multi-TRP is specified in Rel-16 with the following relevant features:   * Two PDSCHs associated with different *coresetPoolIndex* values can be partially/fully overlapping in time in the same CC   + The max number of PDSCH per slot (in TDM manner) is defined per *coresetPoolIndex*, which can be indicated by UE capability. * For PDCCH monitoring in multi-DCI based multi-TRP, the following are supported:   + The maximum number of CORESETs per BWP is increased to 5 CORESETs, with a maximum of 3 CORESETs per *coresetPoolIndex* value.   + The maximum number of BDs / CCEs is doubled subject to UE capability, with a limit per *coresetPoolIndex* value that is same as a single-TRP CC.   Furthermore, in Rel-18, it is agreed that two PUSCHs associated with different *coresetPoolIndex* values can be partially/fully overlapping in time in the same CC (for simultaneous transmission in MIMO AI).  In order for the network to schedule overlapping PDSCHs / PUSCHs, the two TRPs need to transmit the two corresponding DCIs in any scheduling instance (e.g., in any slot or PDCCH monitoring occasion). As discussed above, the PDCCH monitoring capabilities (number of BDs / CCEs) are also enhanced accordingly. However, the following two issues make it practically infeasible for UE to receive two DCIs at the same time (issue 1 for FR2) or even in the same slot / PDCCH monitoring occasion (issue 2):   * **Issue 1**: This issue is related to QCL-TypeD prioritization for overlapping CORESETs, which is specific to FR2. Based on the procedure defined in 38.213 Section 10.1, the UE selects one CORESET (based on a priority rule), and only that CORESET and other CORESETs with the same QCL-TypeD priorities are monitored when multiple CORESETs overlap in time.   + During the maintenance phase of Rel-16, extending this rule for multi-DCI based mTRP (to make it per TRP) was discussed. Such discussions were postponed with the understanding that Rel-17 can potentially address the issue. However, Rel-17 only enhanced this QCL-TypeD prioritization rule for the case of PDCCH repetition and for the case of SFN PDCCH, but it was not extended for the case of multi-DCI based multi-TRP. * **Issue 2**: Even though the number of BDs / CCEs that the UE monitors is doubled (and number of CORESETs is increased to 5) in Rel-16, the capability to process DL DCIs or UL DCIs was not extended accordingly. That is, the UE can only monitor more PDCCH candidates, but cannot actually receive and process more DCIs.   + For basic PDCCH capability (FG 3-1), the UE can process one DL DCI and one UL DCI per slot for FDD, and one DL DCI and two UL DCIs per slot for TDD.   + For more advanced PDCCH monitoring capabilities such as FG 3-5a or FG 3-5b, the number of DL DCIs or UL DCIs that the UE can process is defined per PDCCH monitoring occasion or per PDCCH span. For these advanced PDCCH monitoring capabilities, it is possible to receive more than one DL DCI and more than one UL DCI per slot, but there is additional complexity associated with PDCCH monitoring as well.   + In either case, the max number of DL DCIs or UL DCIs is not extended accordingly for the case of multi-DCI based multi-TRP.   + Hence, in order to be able to receive DCIs from different TRPs in a slot in the case of multi-DCI based multi-TRP, the UE has to support one of these advanced UE capabilities, which is not reasonable. This can be a barrier for wide deployment of this feature. Effectively, the larger number of BDs / CCEs specified in Rel-16 for multi-DCI based multi-TRP cannot be utilized in practice to actually transmit more DL / UL DCIs from the two TRPs.   These two issues result in inefficient operation of multi-DCI based multi-TRP feature as they impose unnecessary restrictions on transmissions of DCIs from corresponding TRPs.  Observation 1: Multi-DCI based multi-TRP operation based on existing specifications suffers from the following two issues:   * **Issue 1: Existing QCL-TypeD prioritizations for overlapping CORESETs does not allow the UE to monitor PDCCHs with different beams from corresponding TRPs on the same / overlapping OFDM symbols.** * **Issue 2: Even though the PDCCH monitoring capabilities (number of BDs / CCEs) are increased for multi-DCI based multi-TRP, the capability related to number of DL/UL DCIs that the UE can actually receive and process is not enhanced correspondingly.**   To address Issue 1, we propose to perform the legacy QCL-TypeD prioritization rules separately for *coresetPoolIndex* value 0 and for *coresetPoolIndex* value 1. An example of the change needed in 38.213 Section 10.1 is shown in the following TP:  ============TP for 38.213 Section 10.1 ====================================  --Unchanged part omitted------------------------  If a UE  - is configured for single cell operation or for operation with carrier aggregation in a same frequency band, and  - monitors PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORESETs that have been configured with same or different *qcl-Type* set to 'typeD' properties on active DL BWP(s) of one or more cells  the UE monitors PDCCHs only in a CORESET, and in any other CORESET from the multiple CORESETs that have been configured with *qcl-Type* set to same 'typeD' properties as the CORESET, on the active DL BWP of a cell from the one or more cells  - the CORESET corresponds to the CSS set with the lowest index in the cell with the lowest index containing CSS, if any; otherwise, to the USS set with the lowest index in the cell with lowest index  - the lowest USS set index is determined over all USS sets with at least one PDCCH candidate in overlapping PDCCH monitoring occasions  If a UE  - is not provided *coresetPoolIndex* for first CORESETs, or is provided *coresetPoolIndex* with value 0 for first CORESETs, and  - is provided *coresetPoolIndex* with value 1 for second CORESETs, and  - is provided [*twoQCLTypeDforMulti-DCI*]  the UE applies procedures described above independently across the first CORESETs and the second CORESETs.  --Unchanged part omitted------------------------  ===============================================================  To address issue 2, we propose to introduce a UE capability that can indicate the UE can process more DL / UL DCIs for a CC that is configured with two *coresetPoolIndex* values. Such capability may be separately indicated for DL DCI versus UL DCI. Also, this capability may explicitly indicate a number of DL/UL Dis that the UE can monitor, or can simply indicate that the number of DL/UL DCIs per *coresetPoolIndex* for the CC is the same as the number of DL/UL DCIs for a CC that is not associated with two *coresetPoolIndex* value (which is determined based on legacy UE capabilities). These details can be discussed as part of Rel-18 UE capability sessions.  Proposal 1: For multi-DCI based multi-TRP operation, support the following:   * **QCL-TypeD prioritization rules for overlapping CORESETs is performed per *coresetPoolIndex* value. The TP above can be used for this purpose.** * **Introduce a UE capability that can indicate the UE can process more DL / UL DCIs for a CC that is configured with two *coresetPoolIndex* values.**   + **The details include whether separate FGs are needed for DL DCIs versus UL DCIs can be discussed in Rel-18 UE feature sessions.** |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Y | As we described in detail in our Tdoc (as copied above by FL), this TEI is needed to be able to benefit from multi-DCI based mTRP feature in practice. Otherwise, not only PDCCH transmissions will be the bottleneck, but also scheduling PDSCH from both TRPs in multiple consecutive slots becomes infeasible for UEs that do not support advanced (e.g., span-based) PDCCH monitoring even though the UE may already support more BDs/CCEs/CORESETs as specified in Rel-16 for multi-DCI. | | FUTUREWEI | Y |  | | CATT | Y | The issue and solution shown by QC are reasonable to us. | | ZTE | Y |  | | Nokia, NSB | Y |  | | vivo | - | To understand better, how does UE know which coresetPoolIndex while decoding PDCCH which are overlapped? | | MediaTek |  | We question the real value of this proposal compared to the flexibility already in the specifications today. Also such a proposal may also impact on existing Rel-18 mTRP work. The original MIMO WI scope was already reduced compared to the original set of proposals, so we question how we can justify adding this proposal to the R18 scope. | | Moderator |  | According to the above comments, this proposal is supported by Qualcomm, FUTUREWEI, CATT, ZTE, Nokia, NSB, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponent is encouraged to address the concern from companies. | | Moderator |  | This proposal could not be discussed on Tuesday online session. Since this proposal will not be discussed further online in this meeting due to the overlap with MIMO online session, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #6**

* **For multi-DCI based multi-TRP operation, support the following:**
  + **QCL-TypeD prioritization rules for overlapping CORESETs is performed per coresetPoolIndex value.** 
    - **Adopt following TP in Clause 10.1 in TS 38.213.**

|  |
| --- |
| --Unchanged part omitted------------------------  If a UE  - is configured for single cell operation or for operation with carrier aggregation in a same frequency band, and  - monitors PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORESETs that have been configured with same or different *qcl-Type* set to 'typeD' properties on active DL BWP(s) of one or more cells  the UE monitors PDCCHs only in a CORESET, and in any other CORESET from the multiple CORESETs that have been configured with *qcl-Type* set to same 'typeD' properties as the CORESET, on the active DL BWP of a cell from the one or more cells  - the CORESET corresponds to the CSS set with the lowest index in the cell with the lowest index containing CSS, if any; otherwise, to the USS set with the lowest index in the cell with lowest index  - the lowest USS set index is determined over all USS sets with at least one PDCCH candidate in overlapping PDCCH monitoring occasions  If a UE  - is not provided *coresetPoolIndex* for first CORESETs, or is provided *coresetPoolIndex* with value 0 for first CORESETs, and  - is provided *coresetPoolIndex* with value 1 for second CORESETs, and  - is provided [*twoQCLTypeDforMulti-DCI*]  the UE applies procedures described above independently across the first CORESETs and the second CORESETs.  --Unchanged part omitted------------------------ |

* + **Introduce a UE capability that can indicate the UE can process more DL / UL DCIs for a CC that is configured with two coresetPoolIndex values.**
    - **The details include whether separate FGs are needed for DL DCIs versus UL DCIs can be discussed in Rel-18 UE feature sessions.**

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 |
| QC | Y | In response to vivo’s comment from the previous meeting highlighted above: Decoding should be separate across different CORESETs, which is same as Rel-15. This proposal does not impact how UE decodes DCIs across different CORESETs.  In response to MediaTek’s comment from the previous meeting highlighted above: This proposal does not impact any aspect of the Rel-18 MIMO scope. This proposal is related to Rel-16 multi-DCI based mTRP operation. In the existing specification, the larger number of BDs / CCEs specified in Rel-16 for multi-DCI based multi-TRP cannot be utilized in practice to actually transmit more DL / UL DCIs from the two TRPs. |
| CATT | Y | The flexibility of M-DCI can be improved by allowing the UE to monitor PDCCHs with different beams from corresponding TRPs on the overlapped OFDM symbol(s). |
|  |  |  |

* 1. Enhancement for scheduling request

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [7] | In Rel-17, when PDCCH skipping is configured for a UE, it is allowed that an SR transmission from the UE during a PDCCH skip duration can override the previous PDCCH skipping indication and the UE resumes PDCCH monitoring. The underlying principle of this behavior is that, when an SR is pending at the UE during a PDCCH skip duration, the network can realize it only after receiving an SR transmission from the UE. By terminating PDCCH skipping after the SR transmission, the UE and network do not need to wait until the end of the indicated PDCCH skip duration and, thus, a latency benefit is achieved,  For the SR enhancement associated with the latency reduction, there are some remaining issues:   * **Issue 1**: In addition to PDCCH skipping, search space set group (SSSG) switching, which is another UE power saving feature for licensed band, has been introduced in Rel-17. For example, when a UE is configured with two SSSGs, the first SSSG may be configured with frequent PDCCH monitoring, while the second SSSG may be configured with sparse PDCCH monitoring. In a heavy traffic situation, the UE may be indicated to monitor PDCCH according to the first SSSG. Otherwise, for UE power saving, the UE may be indicated to monitor PDCCH according to the second SSSG. If an SR is pending while the UE is monitoring PDCCH according to the first (i.e., dense) SSSG, the UE would receive a PDCCH scheduling an UL transmission quite soon after the SR transmission. However, if the UE is monitoring PDCCH according to the second (i.e., sparse) SSSG, the next PDCCH monitoring occasion would be quite far apart from the SR occasion, and the latency of the first PUSCH transmission after the SR may increase. Furthermore, after the UE transmits a BSR on the first PUSCH, it will expect additional UL grants to clear out the buffer, if the first UL grant is not large enough. Thus, unless the UE is indicated to switch to the first SSSG by the PDCCH carrying the first UL grant, the latency for the entire UL traffic burst would increase. * **Issue 2**: In order to harvest the latency benefit of SR overriding PDCCH skipping and/or SSSG switching, it may be desirable for the gNB to configure SR transmission occasions frequently over time. For FR2, since gNB may not be able to receive uplink transmissions from different UEs with different beam directions on the same OFDM symbol, the gNB may align the SR resources such that UEs with the same beam are scheduled on the same set of OFDM symbols. However, in NR, the beam direction of a SR transmission (or PUCCH in general) may be changed via MAC-CE (e.g., via the PUCCH spatial relation Activation/Deactivation MAC CE). If on a set of OFDM symbols, the beam direction of one SR resource is changed, then the beams are not aligned anymore. In the current system, the only mechanism to make re-align the SR resources is to reconfigure SR resources for these users via RRC, which operates at a much lower pace. The problem is illustrated in Figure ‑1: after the beam change on the SR PUCCH resource 3, the beam alignment between PUCCH resource 1, 2, 3 (from different UEs) are not maintained anymore. As a consequence, the gNB may not be able to receive all SRs at the same time.     Figure 4‑1 Illustration of Issue 2  To address Issue 1, the feature of SR overriding PDCCH skipping should be extended for SSSG switching. That is, in order not to delay the UL transmission, it should be allowed that an SR transmission overrides SSSG switching, as well as PDCCH skipping.  Proposal 4: If a UE is indicated to monitor PDCCH according to search space sets with a group index other than a designated index, the UE stops PDCCH monitoring according to search space sets with the group index and start PDCCH monitoring according to search space sets with the designated group index from the first slot that is at least symbols after the last symbol of a PUCCH carrying an SR.  To address Issue 2, we propose to allow the MAC-CE that signals the beam change to also indicate the change/update of PUCCH resource(s) associated with an SR transmission.  Proposal 5: For each spatial relation information or TCI state associated with a PUCCH resource for SR, the gNB configures a UE with a corresponding time domain offset (in #symbols or #slots). If a UE is indicated by the Rel-15 PUCCH spatial relation Activation/Deactivation MAC-CE, or Rel-16 Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE, or the Rel-17 Unified TCI States Activation/Deactivation MAC CE to update the spatial relation/TCI state associated with a PUCCH resource used for SR transmission, the UE performs the spatial relation/TCI state update and applies the time domain offset to the PUCCH resource.   * **The gNB may additionally configure a frequency domain offset or a code domain offset (e.g., OCC offset, cyclic shift offset) for each spatial relation information or TCI state. In this case, the UE shall also apply the frequency domain offset or code domain offset to the PUCCH resource.** |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Y |  | | CATT | N | These are implementation issues, which gNB should not indicate the PDCCH skipping before completion of the UL data transmission | | ZTE | Not supportive for the first two bullets | For the third bullet, we are supportive. The benefit of re-aligning the spatial relation information associated with SR from multiple UEs can be observed.  For the second bullet, the capacity benefits from switching to e.g., a denser SSSG (with a designated group index) after transmission of PUCCH carrying SR/regular BSR, is not clear. Also, it seems there is no consensus on which SSSG is configured with dense PDCCH MO.  For the first bullet, similar with the second bullet, the benefits are not clear since PDCCH skipping will be terminated by SR. | | vivo |  | This is actually three independent TEIs, although they all somehow related to SR.  We could be open to the 1st and 2nd bullet. For 3rd bullet, we undersdand the spec impacts are significant, while it is not clear to us if sufficient gain is justified. | | MediaTek |  | We have concerns on this proposal. This TEI requires additional coordination between L2 functions (BSR, MAC-CE) and L1 functions (PDCCH skipping, SSSG switching, beam management). We want to first understand how much gain can be obtained by this TEI. If RAN1 are going to treat this TEI, at least the application delay needs to be discussed/revisited due to the additional L1/L2 coordination. | | Huawei, HiSilicon | N | For the first bullet of the proposal, it is not necessary to introduce this optimition. It was already supported in Rel-17 UE power saving to configure multiple PDCCH skipping duration lengths, which can be dynamically indicated by gNB for PDCCH skipping. If the latency of uplink scheduling matters, gNB shall configure at least one proper PDCCH skipping duration length. Meanwhile, it was already supported by Rel-17 that the PDCCH skipping shall be cancelled when a positive SR is transmitted and is pending. This could already cover the most cases, and we didn’t see the need to further optimize other corner cases where SR cannot be transmitted but BSR can be transmitted.  For the second bullet, we have similar concerns. It was already supported in Rel-17 that three SSSGs can be configured. At least one of them can be configured with a proper PDCCH monitoring periodicity which is smaller than the required latency of uplink service, if gNB thinks the latency would be important for the uplink scheduling of this UE.  For the third bullet, we are open to discuss the issue. But we don’t think it is proper to discuss it as a TEI issue as it involves big spec impact of RAN 1 (UE behavior description), RAN 2 (time/frequency/code domain offset configuration, offset indication signling, e.g., MAC-CE, DCI), RAN 4 (e.g., new requirement). Suggest to discuss in Rel-19. | | Moderator |  | According to the above comments, this proposal is supported by Qualcomm, ZTE (third bullet), and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponent is encouraged to address the concern from companies. | | Moderator |  | This proposal is supported by by Qualcomm, ZTE (third bullet), and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Companies can come back in next RAN1 meeting considering the comments provided in this RAN1 meeting. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #7**

* **If a UE is indicated to monitor PDCCH according to search space sets with a group index other than a designated index, the UE stops PDCCH monitoring according to search space sets with the group index and start PDCCH monitoring according to search space sets with the designated group index from the first slot that is at least symbols after the last symbol of a PUCCH carrying an SR.**
* **For each spatial relation information or TCI state associated with a PUCCH resource for SR, the gNB configures a UE with a corresponding time domain offset (in #symbols or #slots). If a UE is indicated by the Rel-15 PUCCH spatial relation Activation/Deactivation MAC-CE, or Rel-16 Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE, or the Rel-17 Unified TCI States Activation/Deactivation MAC CE to update the spatial relation/TCI state associated with a PUCCH resource used for SR transmission, the UE performs the spatial relation/TCI state update and applies the time domain offset to the PUCCH resource.**
  + **The gNB may additionally configure a frequency domain offset or a code domain offset (e.g., OCC offset, cyclic shift offset) for each spatial relation information or TCI state. In this case, the UE shall also apply the frequency domain offset or code domain offset to the PUCCH resource.**

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 |
| QC | Y |  |
| CATT | N | There is no benefit shown in this proposal. |
|  |  |  |

* 1. UE reporting of power offset for SRS antenna switching

Following proposal is made in the contribution.

|  |  |  |
| --- | --- | --- |
| [7] | Release 17 introduced SRS antenna switching for 6Rx and 8Rx devices, namely {1T8R, 2T8R, 4T8R, 1T6R and 2T6R} to enable DL CSI acquisition across all Rx antennas. However, antenna switching for 6/8Rx devices comes at the cost of extra RF switching circuitry that introduces insertion loss. For some UE implementation, the insertion loss may be large which causes big mismatch between the actual DL channel and the one estimated by the gNB from UL sounding. This results into different Tx power between antenna ports or equivalent power offset between SRS antenna ports. gNB is unaware of the power offset between the SRS ports which will impact channel reciprocity reducing the quality of DL-CSI and DL beamforming by the gNB. RAN4 specification allows for some relaxation of SRS transmit power for any ports other than first port and is given by a parameter, ∆TRxSRS, as shown in the text below from 38.101-1 version 17.8.0.   |  | | --- | | **6.2.4 Configured transmitted power**  The UE is allowed to set its configured maximum output power PCMAX,f,c for carrier f of serving cell c in each slot. The configured maximum output power PCMAX,f,c is set within the following bounds:  PCMAX\_L,f,c ≤ PCMAX,f,c ≤ PCMAX\_H,f,c with  PCMAX\_L,f,c = MIN {PEMAX,c– ∆TC,c, (PPowerClass – ΔPPowerClass) – MAX(MAX(MPRc+∆MPRc, A-MPRc)+ ΔTIB,c + ∆TC,c +∆TRxSRS, P-MPRc) }  PCMAX\_H,f,c = MIN {PEMAX,c, PPowerClass – ΔPPowerClass }  **…**  ∆TRxSRS is applied during SRS transmission occasions with usage in SRS-ResourceSet set as ‘antennaSwitching’ when   1. UE transmits SRS on the second SRS resource in every configured SRS resource set when the SRS-TxSwitch capability is indicated as 't1r2' or 't1r1-t1r2' 2. UE transmits SRS on the second, third and fourth SRS resources of the total 4 SRS resources from all configured SRS resource set(s) consisting of one SRS port when the SRS-TxSwitch capability is indicated as 't1r4' or, 't1r4-t2r4' or 't1r1-t1r2-t1r4' or, 't1r1-t1r2-t2r2-t1r4-t2r4' 3. UE transmits SRS from the second SRS port pair on the second SRS resource in every configured SRS resource set consisting of two SRS ports when the SRS-TxSwitch capability is indicated as ' t2r4' or ' t1r4- t2r4', or 't1r1-t1r2-t2r2-t2r4' or 't1r1-t1r2-t2r2-t1r4-t2r4', or 4. UE transmits SRS to a DL-only carrier   The value of ∆TRxSRS is 4.5dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 3 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 or power class 1.5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB, or when UE indicating txDiversity-r16.  The value of ∆TRxSRS is 7.5dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 6 dB for bands whose FUL\_high is lower than the FUL\_low of n79 during SRS transmission occasions with configured SRS resources consisting of one SRS port when the device is capable of power class 2 in the band and ΔPPowerClass = 0 dB and not indicating txDiversity-r16.  For other SRS transmissions ∆TRxSRS is zero; |   Considering 1T4R UE architecture as a baseline for extending to 8Rx antennas, an extra RF switching circuitry is needed to route the Tx path to the extra Rx antennas. An example of such architecture is shown in the Figure ‑1 below. It is important to note that there will be X1 to X2 dB extra insertion loss (i.e. power offset) for antenna ports 4-7 as compared to the first 4 antenna ports.    Figure 5‑1 Example of 8Rx UE RF architecture with single Tx chain  *To overcome this mismatch, the UE can report to the network the power offset between the antenna ports which can help the network to compensate the UL/DL channel mismatch*.  To evaluate the effectiveness of such reporting, a link-level evaluation was done for an 8Rx UE with 1T8R SRS antenna switching using CDL-C 300ns, 3km/hr and 20MHz DL/UL BW. The results are shown in Figure ‑2 in which we compare three different schemes: legacy 4Rx with 1T4R, 8Rx UE with 1T4R and 8Rx with 1T8R for both scenarios of power offset compensation enabled and disabled at the gNB. The power offset across the extra four antenna ports is assumed to be [ 1 1 2 2] dB. For the case of 1T8R with gNB reporting of power offset, the throughput performance is close to the ideal scenario of no power offset across the antenna ports.    Figure 5‑2: Power offset reporting and compensation  Observation 2: UE reporting of power offset can help the gNB to compensate of the power offset between the UL and DL channels and improve the DL throughput.  RAN1 received an LS from RAN4 on the issue of UE SRS IL imbalance [1]. The LS clarified that the insertion loss (IL) for the diversity branch might be different from the main branch. They provided the following example for better explanation of the UE RF switching for 1T4R and 1T8R.    Figure 5‑3 . Example of possible RF architecture between ‘t1r4’ (left) and ‘t1r8’ (right) AS-SRS capable UE  RAN4 thinks it is necessary to address such IL imbalance issue as it leads to inaccurate channel estimation at receiver, which could lead to incorrect PMI selection that would degrade overall system performance. The LS listed possible solutions and asked RAN1 to evaluate possible solution. *The UE reporting of the actual IL imbalance for each diversity branch was highlighted in the LS and listed as the first solution for handling this issue.*  Observation 3: RAN4 identified UE static reporting the actual IL imbalance for each diversity as the first solution for handling SRS IL imbalances across the diversity antennas.  Proposal 6: For SRS antenna switching, Support UE capability of reporting of relative power offset of SRS antenna ports with respect to the first SRS port. |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Y |  | | CATT | N | This proposal is not necessary. gNB is able to estimate the power imbalance of UE antennas through UL measurement | | ZTE | N | Besides for Tx power, our concerns are much relevant to phase consistency across different SRS ports. For instance, if there is additional phase offset for each Tx-Rx chain and also it may vary along with the change of Tx power, the DL precoding performance based on UL-DL reciprocity should be justified in such case. | | vivo | - | Power offset for SRS antenna switching should be discussed in RAN4, RAN4 has expertise in insertion loss. | | MediaTek | N | We wonder how much practical gain this proposal can bring taking power tolerance into account. We should also consult RAN4 if this TEI is to be agreed. | | Huawei, HiSilicon | Y | The performance degradation caused by the power imbalance among SRS antenna ports has been shown in our tdoc during RAN4 discussion. In order to avoid this/similar kind of performance degradation, following factors need to be considered:  1) Other potential reasons breaking the perfect channel reciprocity, e.g., power imbalance among receiving antenna ports;  2) Whether the guidance about the candidate value of power imbalance from RAN4 is needed. | | Moderator |  | According to the above comments, this proposal is supported by Qualcomm, Huawei, HiSilicon, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponent is encouraged to address the concern from companies. | | OPPO |  | To show the benefit of power offset reporting, performance of 1T8R with power offset but without reporting may be needed. | | Moderator |  | This proposal could not be discussed on Tuesday online session. Since this proposal will not be discussed further online in this meeting due to the overlap with MIMO online session, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | | Ericsson | Y | Power imbalances for SRS antenna switching lead to inaccurate CSI for reciprocity-based DL precoding as gNB can not distinguish between power difference due to channel conditions and power difference due to insertion loss. UE reporting of relative SRS power offset can mitigate this issue. We think that this can be handled in RAN1. Indeed, UE that complies with existing RAN4 requirements on relative SRS power offset can still benefit from reporting said relative SRS power offset. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #8**

* **For SRS antenna switching, Support UE capability of reporting of relative power offset of SRS antenna ports with respect to the first SRS port**

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 |
| DOCOMO |  | Now RAN4 asks RAN1 to discuss the exact same issue in R1-2302267. We suggest having the discussion in a single place to avoid duplicated discussions, i.e., under AI5. |
| Moderator |  | As announced by Chair, this discussion is put on hold until the discussions in [112bis-e-LS-04] is finalized.  R1-2302267     LS on the UE SRS IL imbalance issue    RAN4, Huawei  RAN1 is requested study UE SRS IL imbalance issue. To be handled in agenda item 5.  [112bis-e-LS-04] Email discussion on UE SRS IL imbalance issue by April 21 – Zhening (Huawei).  Relevant discussions under 9.16 to be put on hold until the discussions in [112bis-e-LS-04] is finalized. |

* 1. RAT-independent Positioning Enhancements

Following proposal is made in the contribution.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [7] | LPP protocol (TS 37.355) enables Control plane based positioning across multiple technologies, as shown in the following table:   |  |  |  |  | | --- | --- | --- | --- | |  | LPP Supported Positioning Methods | | | | Method | UE-based | UE-assisted | | LTE/NB-IoT | OTDOA | No | Yes | | E-CID | No | Yes | | RAT-Independent | A-GNSS | Yes | Yes | | Sensor | Yes | Yes | | WLAN | Yes | Yes | | Bluetooth | No | Yes | | TBS | Yes | Yes | | NR | DL-TDOA | Yes | Yes | | DL-AoD | Yes | Yes | | Multi-RTT | No | Yes | | NR E-CID | No | Yes | | UL-TDOA(1) | No(2) | No(2) | | UL-AoA(1) | No(2) | No(2) | |  | NOTE 1: Only LPP Capability Transfer  NOTE 2: NW-based method | | |   With regards to RAT-independent technologies, beyond GNSS, specification enhancements for the remaining technologies has been rather limited. Such signaling enhancements (in RAN2) can be done without the need of significant time and effort. Such enhancements will help expand the role of the multi-technology 3GPP-based positioning protocol and increase its value in the overall positioning ecosystem.   |  |  | | --- | --- | | **Potential RAT-independent Enhancement** | **Motivation** | | **UWB Ranging** | A high-bandwidth (>=500 MHz) technology that can support secure and accurate ranging capability which has received a lot of product and ecosystem attention lately. UWB Technology is not included in LPP | | **BT 5.1** | Bluetooth positioning in LPP is based on Bluetooth 4.2. Enhancements based on Bluetooth 5.1 (e.g. AoA/AoD positioning) could be introduced, along with UE-based Positioning | | **WiFi 802.11az FTM** | WiFi RTT has been added in an earlier release (Rel-13). Enhancements needed to pick up the required changes for devices supporting the latest IEEE 802.11az FTM. |   Proposal 7: Send an LS to RAN2 to add the necessary signalling enhancements for the following RAT-independent Positioning Enhancements:   * Introduction of UWB Ranging/Positioning, * update of BT positioning with Angular measurements and UE-based BT Positioning * **Updates on the WLAN Positioning for devices supporting IEEE 802.11az FTM.** |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Y |  | | FUTUREWEI | N | Not for RAN1 | | DOCOMO |  | This proposal can be discussed directly in RAN2. | | CATT | N | The proposed potential RAT-independent enhancements (UWB, Bluetoorth, WiFi RTT) mainly impact RAN2’s work, but not RAN1. The proposal should be discussed in RAN2. | | ZTE | Yes with comments | ZTE is also quite interested in this feature as UWB positioning is helpful to provide higher location accuracy because of very large bandwidth.  Becides the enhancement of LPP as Qualcomm proposed, we also prefer to enhance NRPPa to support TRP report UWB positioning results to LMF. Specifically, the function of UWB positioning can be installed at gNB side, then gNB can get UWB results and further report the results to LMF. LMF can combine the existing RAT-dependent measurement results and UWB positioning results to calculate the target UE’s location.    In short, we think it is better to introduce UWB/BT ranging/positioning in both NR PPa and LPP as the following figure    Here is our suggested update:   * **Send an LS to RAN2 and RAN3 to add the necessary signalling enhancements for the following RAT-independent Positioning Enhancements:**   **Introduction of UWB and BT Ranging/Positioning in LPP and NRPPa** | | vivo | - | we are not sure it should be discussed in RAN1 if only signaling enhance, and prefer to consider it in future release other than TEI | | MediaTek | N | It seems strange that this TEI proposal comes to RAN1 when there is actually no RAN1 spec impact claimed by the proponents, and requires mainly RAN2 work. Furthermore, the Positioning WI scope in R18 is already too heavy in our view, so do not believe it is a good practice to overload them even more. | | Huawei, HiSilicon | N | This should not be discussed by RAN1. We do not see it as RAN1 responsibility to confirm the necessity or any RAN1 spec impact. | | Moderator |  | According to the above comments, this proposal is supported by Qualcomm, ZTE, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponent is encouraged to address the concern from companies. | | Moderator |  | This proposal is supported by by Qualcomm, ZTE, and hence does not meet the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Companies can come back in next RAN1 meeting considering the comments provided in this RAN1 meeting. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112 meeting.

### **TEI proposal #9**

* **Send an LS to RAN2 to add the necessary signalling enhancements for the following RAT-independent Positioning Enhancements:** 
  + **Introduction of UWB Ranging/Positioning,**
  + **update of BT positioning with Angular measurements and UE-based BT Positioning**
  + **Updates on the WLAN Positioning for devices supporting IEEE 802.11az FTM.**

This proposal is already supported by Qualcomm.

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

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| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO |  | Same as last RAN1 meeting, we think this proposal can be discussed directly in RAN2. |
| QC | Y |  |
| CATT | N | The proposed potential RAT-independent enhancements (UWB, Bluetoorth, WiFi RTT) mainly impact RAN2’s work, but not RAN1. The proposal should be discussed in RAN2. |

* 1. Enhancement for HARQ multiplexing on PUSCH

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [1] | In Rel-15 and Rel-16, to maintain the single carrier metric of uplink transmission, UCI (except SR) from PUCCH is multiplexed on a PUSCH within the same PUCCH group, when they are overlapped in time and have same priority level. To guarantee UE and gNB have the same understanding of HARQ bits number on the PUSCH, total DAI mechanism is applied and a restriction on PDSCH scheduling is introduced, which is described in the TS 38.213 Clause 9 [1] and the restriction is copied as below:  *“A UE does not expect to detect a DCI format scheduling a PDSCH reception or having associated HARQ-ACK information report without scheduling a PDSCH reception, 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.”*  In Rel-17 TEI stage, whether/how to relax the restriction is discussed but did not reach agreement or conclusion in the end, however, the majority companies consider such restriction is not very necessary especially for the case of PUSCH repetition and dynamic scheduling PDSCH [3]. In RAN1 #112, whether/how to relax the restriction for PUSCH repetitions are discussed and majority companies think such a restriction is too limited to gNB scheduling. In this contribution, the impact of this scheduling restriction is analyzed based on the PUSCH repetition case and solution to calculate the number of HARQ information bits on the PUSCH are further discussed.  **Scheduling restriction on PDSCH**  In contribution [R1-2110856], the scheduling restriction on PDSCH is explained and can be interpreted as two ways:   * Interpretation 1: After UL DCI, gNB cannot schedule a PUCCH transmission to carry HARQ information in the slot of PUSCH transmission scheduled by the UL DCI, unless the PUSCH and PUCCH transmissions are not overlapped in time. * Interpretation 2: After UL DCI, gNB may not schedule PDSCH until all the PUSCH transmissions scheduled by the UL DCI are finished.   Following Interpretation 1, to avoid overlapping between PUCCH and PUSCH, when gNB schedules a DL data transmission after the UL grant, gNB has to indicate a PUCCH reporting corresponding HARQ information transmitted after PUSCH transmission, which results in quite large HARQ latency. Considering the case of PUSCH with repetition in TDD system, the latency could become huge and beyond the largest k1 value (i.e. 15) configured for eMBB service. Take Figure 1 as an example, a DL domain frame is configured as DDDSU. In slot 0 of frame N, UL DCI triggers PUSCH transmitted 4 times repeatedly and each repetition occupies 14 symbols. Although PDSCH is scheduled in slot 1 of frame N, the corresponding HARQ only can be reported until slot 4 of frame N+2, 22 slots between the PDSCH reception and PUCCH transmission. It should be noted, number of repetitions can be configured as 8 and for the coverage extension scenario, the number could be configured as large as 32.  ***Observation 1: If PUSCH repetition is configured, the timing restriction on scheduling PDSCH after UL grant introduces large delay for HARQ feedback.***  C:\Users\y00415751\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\7E9E5B9.tmp  Figure 1. PDSCH scheduling restriction results in large HARQ feedback delay  As interpreted in the second way, to have a short HARQ latency and smaller value of k1, gNB may postpone PDSCH scheduling after PUSCH repetitions finishing. This will cause no PDSCH can be scheduled during the period of PUSCH repetition which will decrease the spectrum efficiency dramatically. Use the same UL\_DL configuration and repetition times as above example, once gNB triggers a PUSCH transmission with repetition in slot 0, Frame N, it may wait until slot 0, Frame N+2 to schedule a new PDSCH expecting a quick HARQ feedback. Details are illustrated in Figure 2.  C:\Users\y00415751\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\896AA6CE.tmp  Figure 2. PDSCH scheduling restriction results in PDSCH blockage  ***Observation 2: If PUSCH repetition is configured, the timing restriction on scheduling PDSCH after UL grant causes PDSCH blockage for small k1 values.***  During the discussion in Rel-17, several possible solutions are proposed by companies, including configuring TDMed PUCCH resource with PUSCH in a slot, enabling parallel PUCCH and PUSCH transmissions and always enabling PUSCH repetition type B. However, these solutions cannot always fix the issue completely, on the contrary, may introduce more restrictions on gNB scheduling.  Specifically, when UE is required to repeatedly transmit a TB, it means UE may locate at edge of a cell and UL coverage is possibly constraint. Hence, gNB intends to allocate more resources, typically 14 symbols, for UE to have better UL transmission performance. Less number of PUSCH transmission might lead to more PUSCH repetitions. On the other hand, gNB cannot predict whether there will be any new PDSCH scheduling after a UL grant. If gNB always spare some symbols in UL slots for potential PUCCH transmission, a large quantity UL resource could be wasted.  Transmit PUCCH and PUSCH simultaneously within a PUCCH group is supported in Rel-17, however, such kind of transmission are only applicable PUCCH and PUSCH are in different bands and with distinguished priority index. Therefore, it cannot be feasible for typical eMBB case in same band.  PUSCH repetition type B is applicable for a small packet and repetitions can be finished as soon as possible, which is enhanced for URLLC transmission purpose. Despite type A PUSCH repetition are supported widely and latency is also a critical metric for eMBB service, so using Type B repetition might not be always suitable.  Based on the analysis in section 2.1 and considering the possible solution discussed above, relaxing the scheduling restriction on PDSCH and associated HARQ seems a more feasible way which brings more flexibility for gNB scheduling.  ***Proposal 1: The restriction on scheduling PDSCH after UL grant should be removed for the case of PUSCH with repetitions.***  From UE Side, to support the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the DCI format, a new UE capability can be introduced in Rel-18. To align the understanding between gNB and UE and avoid unnecessary ambiguity due to false alarm, an RRC parameter should be introduced as well to configure the function. When UE reports a capability to support the function, gNB can configure it and schedule 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: An RRC parameter to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the DCI format can be introduced in Rel-18.***  **DAI enhancements**  The optimization of restriction in section 2 relaxes the scheduling of PDSCH later than UL DCI and makes it possible to piggyback the associated HARQ information on the scheduled PUSCH. However, in this case total DAI in a UL grant cannot reflect the number of scheduled PDSCH(s) after the UL grant. Therefore, some enhancements are needed here.  Several solutions are discussed in previous contribution [2]. As shown in Figure 3, if the scheduling restriction is relaxed, one simple way to indicate the number of HARQ bits on PUSCH is reusing the DAI mechanism of the HARQ feedback piggybacked on CG PUSCH or a PUSCH scheduled by DCI format 0\_0, which is 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.    Figure 3. Update total DAI in UL DCI by the DAI in DL DCI  Further enhancements on total DAI mechanism taking the DL scheduling after the UL grant into account should be investigated. It should allow total DAI covers both the number of PDCCHs sent before the UL grant and the ones will 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 4. 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. Clearly, the gNB can choose a proper value for the upper bound considering different factors.    Figure 4. Total DAI in UL DCI cover all past and future DL grants  Updating total DAI by a new signaling could be discussed. For example, a new DCI is 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 used to cancel the PUSCH transmission scheduled previously. As shown in Figure 5, 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 5. New UL DCI delivered to update DAI value  As summarized in [R1-2112148], morecompanies prefer to keep total DAI usage and avoid potential misalignment due to the last DCI missing. Thus, the second option can be a way for moving forward.  ***Proposal 3: When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition case, the UL total DAI can be indicated with a large DAI value to count all HARQ bits corresponding to the PDSCHs scheduled before and after the UL grant to generate a HARQ codebook.***  Based on the discussion in RAN1 #112 [4], one company commented that the proposed DAI enhancement solution may introduce some ambiguities on HARQ codebook side due to limited bits number of DAI. For example, gNB intends to make that DAI value is equal to 5, but UE does not know what DAI value gNB exactly indicates (5, 9, 13, ….). However, this can be handled by gNB using the legacy implementation. In Rel-15, even with this scheduling restriction, the actual total DAI size is aligned between gNB and UE according to the actual PDCCH scheduled/received and the assumption that UE would not miss consecutive 4 DCI formats. For the case gNB indicates a total DAI value as 5, if 5 PDSCHs are scheduled from gNB in total and only 3 of them are received by UE, both gNB and UE will determine the HARQ codebook as 5bits on the PUSCH rather than 9 or 13. On the other hand, if more than 5 but less than 9 PDSCH are received by UE, then UE will think DAI=9 and generate codebook including potential NACKs accordingly. So does gNB side. Therefore, the understanding of codebook size is aligned between gNB and UE. |

This TEI proposal has been proposed and discussed in the last RAN1 meeting, and the discussion at the RAN1#112 meeting is shown below [9].

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| |  |  |  | | --- | --- | --- | | Company | Suppport (Y/N) | Comment | | QC | Partially No | We are open to discuss this. But before we decide support or not support it, we have a question on this part: “**a large total DAI value can be configured to count all HARQ bits corresponding to the PDSCHs scheduled before and after the UL grant**”. What is the spec impact regarding this? In our view, gNB can do this in a transparent way to spec/UE, i.e., just issue a larger total DAI than it currently needs to overbook some HARQ-ACK bits for future potential PDSCHs. We are not sure why RRC is needed to configure a large totalDAI. | | FUTUREWEI | Y |  | | DOCOMO | Y (w/ update) | We support to remove the scheduling restriction since especially when PUSCH repetition is used, the issue of delaying PUCCH timing is critical for DL data latency. Regardig the proposal details, the first sub-bullet is OK, but the second sub-bullet seems not spec-wise description, i.e., not text from UE perspective. Whether each DAI value is larger than the actual number of scheduled PDSCHs or not is not considered at UE side. Rather, from UE side, what should be clarified is whether still UL DAI is used or DAI in the last DL assignment is used, to generate HARQ-ACK CB. We think that the intention is still to use the UL DAI value for HARQ-ACK CB generation, so the second sub-bullet should be updated as follows.  **For HARQ-ACK CB generation, UE uses UL DAI value for total DAI value as in the existing specification. No spec change is assumed** | | CATT | N | These are implantation issue, which gNB should schedule PDSCH at a proper occasion. | | ZTE |  | As discussed in the tdoc, there could be other solutions to solve the concerned issue. For instance, using PUSCH repetition type B and invalid symbol pattern indication to restrict transmission of PUSCH repetition in some of the slots, which can be used for HARQ-ACK transmission in PUCCH. We are wondering why this is not suitable here.  Regarding the proposal, we are not sure whether it is for type 2 HARQ-ACK codebook or both type 1 and type 2 HARQ-ACK codebook. In addition, does the proposal impact the fallback mode of HARQ-ACK transmission. More specifically, what would be the UE behavior if UL\_DAI=0 for type-1 HARQ-ACK codebook and UL\_DAI=4 for type-2 HARQ-ACK codebook. | | vivo |  | We understand the scheduling restriction issue and would be open to discuss proper solution with less specification/implementation impacts. | | Moderator |  | According to the above comments, this proposal is supported by Huawei, HiSilicon, Ericsson, China Unicom, FUTUREWEI, DOCOMO and hence meets the condition of support by at least 1 operator, 1 infra vendor and 1 UE vendor yet.  Proponent is encouraged to address the concern from companies.  Proposal is updated based on the comment as follows:   * **The restriction on scheduling PDSCH after UL grant should be removed for the case of PUSCH with repetitions**   + **An RRC parameter to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the DCI format can be introduced in Rel-18.**   + **~~When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition case, a large total DAI value can be configured to count all HARQ bits corresponding to the PDSCHs scheduled before and after the UL grant~~**   + **For HARQ-ACK CB generation, UE uses UL DAI value for total DAI value as in the existing specification. No spec change is assumed** | | Samsung |  | It is not clear that the updated proposal is working.  This is because DAI has the limited size. For example, gNB intends to make that DAI value is equal to 5 for considering future PDSCH scheduling(s), UE doesn’t know what DAI value gNB exactly indicates (5, 9, 13, ….). Thus, it requires additional specification effort to align understanding between UE and gNB. | | Moderator |  | This proposal was discussed on Wednesday online session but could not achieve consensus. Since this proposal will not be discussed further online in this meeting, companies are encouraged to share further view and/or provide some way forward by Thursday EOB, so that we can prepare for next RAN1 meeting considering the shared views. | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112bis-e meeting.

### **TEI proposal #10**

* **The restriction on scheduling PDSCH after UL grant should be removed for the case of PUSCH with repetitions**
  + **An RRC parameter to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the DCI format can be introduced in Rel-18.**
  + **When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition case, the UL total DAI can be indicated with a large DAI value to count all HARQ bits corresponding to the PDSCHs scheduled before and after the UL grant to generate a HARQ codebook.**

This proposal is already supported by Huawei, HiSilicon, Ericsson, China Unicom.

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

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| Company | Suppport (Y/N) | Comment |
| DOCOMO | Y | We support to remove the scheduling restriction since especially when PUSCH repetition is used, the issue of delaying PUCCH timing is critical for DL data latency.  Regarding the proposal details, as commented at the last meeting, spec-wise description should be used. The current proposal seems to be a kind of gNB behavior. Whether each DAI value is larger than the actual number of scheduled PDSCHs or not is not considered at UE side. Rather, from UE side, what should be clarified is whether still UL DAI is used or DAI in the last DL assignment after UL grant is used, to generate HARQ-ACK CB. We think that the intention is still to use the UL DAI value for HARQ-ACK CB generation, so the second sub-bullet should be updated as follows.   * + **When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition case,**     - **UE generates HARQ-ACK CB as if any scheduled PDSCH after UL grant RX is scheduled before UL grant RX, and thus the UL DAI value is used for the HARQ-ACK CB generation** |
| QC |  | Question: if this restriction is removed, why not remove it even for PUSCH without repetitions? Not saying we support or not support extend this proposal to PUSCH without repetitions, but we are curious why only fix this for PUSCH with repetitions.  Also, a comment to the second sub-bullet: there seems no spec impact here. The Pseudo-code to construct HARQ-ACK codebook does not need any change. It is up to gNB to indicate whatever value in the UL total DAI, while UE just simply run current pseudo code following that DAI. Can proponents of this proposal confirm this is the correct understanding? |
| CATT | Y | After further checking, we support to release the restriction on scheduling PDSCH after UL grant for the case of PUSCH with repetition. And we think this proposal is also meaningful for the case of AP-CSI scheduling, as if the value of K2 is large during the AP-CSI scheduling, the value of K1 of PDSCH scheduling after UL grant might be increased as well. Hence, it’s better to introduce the release of restriction on scheduling PDSCH after UL grant for the case of PUSCH withouth repetions as well. we suggest update the proposal as following:   * **The restriction on scheduling PDSCH after UL grant should be removed for the case of PUSCH with/without repetitions**   + **An RRC parameter to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on the PUSCH scheduled by the DCI format can be introduced in Rel-18.**   **When the restriction on scheduling PDSCH after UL grant is released for PUSCH with repetition/without case, the UL total DAI can be indicated with a large DAI value to count all HARQ bits corresponding to the PDSCHs scheduled before and after the UL grant to generate a HARQ codebook.** |

* 1. Enhancement of Preferred Resource Set in IUC Scheme 1 for SL

Following proposal is made in the contribution.

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| [2] | TS 38.214 [1], clause 8.1.4A specifies the UE procedure for determining UE-A’s preferred or non-preferred resource set for UE-B’s transmission. As shown below, the non-preferred resource set includes not only reserved resources where high interference is expected at UE-A (i.e., RSRP higher than a threshold) (Condition 1-B-1 Option 1) but also reserved resources where UE-A is an intended destination and low received power is expected (i.e., RSRP lower than a threshold) (Condition 1-B-1 Option 2). The latter condition is meant to protect UE-A’s reception of an upcoming transmission by a third UE (e.g., UE-C) from interference caused by UE-B’s transmission. This feature, however, is currently not considered when determining a preferred resource set.   |  | | --- | | 8.1.4A UE procedure for determining a set of preferred or non-preferred resources for another UE's transmission  <omitted text>  When determining a non-preferred resource set, the UE considers any resource(s) within the resource selection window, if indicated by a received explicit request, and satisfying at least one of the following conditions as non-preferred resource(s):  - resource(s) indicated by a received [SCI format 1-A], satisfying at least one of the following criteria:  - the RSRP measurement performed, according to clause 8.4.2.1, for the received [SCI format 1-A], is higher than where is the value of the priority field in the received [SCI format 1-A]. The internal parameter is set to the corresponding value of RSRP threshold indicated by the *k*-th field in *sl-ThresholdRSRP-Condition1-B-1-Option1List*, where .  - the UE is a destination UE of a TB associated with the received [SCI format 1-A] and the RSRP measurement performed, according to clause 8.4.2.1 for the received [SCI format 1-A], is lower than where is the value of the priority field in the received [SCI format 1-A]. The internal parameter is set to the corresponding value of RSRP threshold indicated by the *k*-th field in *sl-ThresholdRSRP-Condition1-B-1-Option2List*, where .  - resources(s) in slot(s) in which the UE does not expect to perform SL reception due to half duplex operation, if the UE is a destination UE of a TB for whose transmission the non-preferred resource set is being determined. |   In this contribution, we propose to enhance the UE procedure for determining a preferred resource set in order to protect UE-A’s reception of UE-C’s transmission.  Figure 1 illustrates how UE-A’s preferred resource set determination, as currently specified, may lead UE-B to disrupt UE-A’s reception of UE-C’s transmission. Due to, e.g., UE-C being far away from UE-A, the RSRP measurement associated with UE-C’s SCI reserving resource r1 may be below the RSRP threshold for resource exclusion in step 6 of the resource selection procedure (clause 8.1.4 of TS 38.214). Thus, UE-A may include r1 in its preferred resource set for UE-B’s transmission, increasing the likelihood that UE-B selects r1, which would disrupt UE-A’s reception of UE-C’s transmission.    Figure 1. Preferred resource set according to Rel-17  In order to prevent this, we propose to enhance the UE procedure for determining a preferred resource set by including a criterion similar to Condition 1-B-1 Option 2 for the preferred resource set. Specifically, condition b) in step 6 of the resource exclusion procedure is to be enhanced as follows:   |  | | --- | | b) the RSRP measurement performed, according to clause 8.4.2.1 for the received SCI format 1-A, is higher than **OR the UE is a destination UE of a TB associated with the received SCI format 1-A and the RSRP measurement performed, according to clause 8.4.2.1 for the received SCI format 1-A, is lower than ;** |   In this way, resources such as r1 above where UE-A expects a weak received signal from a third UE (UE-C) are also excluded from the preferred resource set, thus protecting UE-A’s reception of the weak received signal.  In Appendix E of R1- 2108627 [2], reproduced below, it is observed that protecting UE-A’s reception of other UEs (based on Condition 1-B-1 Option 2 for the non-preferred resource set) significantly increases system performance. We believe this also applies for the preferred resource set, especially if a resource pool is configured with only the preferred resource set enabled (i.e., non-preferred resource set is disabled).   |  | | --- | | During the email discussion [106-e-NR-R17-Sidelink-04] in RAN1 #106-e, the following proposal was suggested:  ***Proposal****:*   * *In scheme 1, at least the following is supported to determine inter-UE coordination information of non-preferred resource set:*   + *UE-A considers any resource(s) satisfying at least one of the following condition(s) as set of resource(s) non-preferred for UE-B’s transmission*     - *Condition 1-B-1:*       * *Condition 1-B-1(a):*         + *Reserved resource(s) of other UE identified by UE-A whose RSRP measurement is HIGHER than a RSRP threshold when UE-A is an intended recipient of UE-B’s transmission*       * *Condition 1-B-1(b):*         + *Reserved resource(s) of other UE identified by UE-A whose RSRP measurement is LOWER than a RSRP threshold when UE-A is an intended recipient of other UE’s transmission*     - *FFS: Condition 1-B-2:*       * *Resource(s) (e.g., slot(s)) where UE-A, when it is intended receiver of UE-B, does not expect to perform SL reception from UE-B*         + *FFS: Other details (if any) including whether/how to consider UE-B’s traffic requirement (if available)*     - *FFS: Other condition(s)*   + *FFS: Other details (if any)*   In this appendix, we compare the performance of applying Conditions 1-B-1 (a) and 1-B-1 (b) separately and jointly. Figure 26 provides the results where it can be observed that Option 1-B-1 (b) provides significant gains compared to Option 1-B-1 (a). It can also be observed that Option 1-B-A (a) does not provide additional gain when applied together with Option 1-B-1 (b) compared to the case of Option 1-B-1 (b) alone.    Figure 26 Performance comparison of Option 1-B-1 (a) and Option 1-B-1 (b)  Observation 39 Significant performance gain is observed when using Option 1-B-1 (b): *UE-A considers as a non-preferred resource any resource(s) of other UE identified by UE-A whose RSRP measurement is LOWER than a RSRP threshold when UE-A is an intended recipient of other UE’s transmission.*  Observation 40 Applying Option 1-B-1 (b) provides larger gains than applying Option 1-B-1 (a).  Observation 41 Option 1-B-A (a) does not provide additional gain when applied together with Option 1-B-1 (b) compared to the case of Option 1-B-1 (b) alone. |   **Observation 1: The currently specified UE procedure for determining a preferred resource set for UE-B’s transmission does not consider protection of UE-A’s reception of transmissions from other UEs.**  **Proposal 1: RAN1 to discuss and decide on the following proposed modification to clause 8.1.4A:**   |  | | --- | | 8.1.4A UE procedure for determining a set of preferred or non-preferred resources for another UE's transmission  <omitted text>  When determining a preferred resource set, the UE applies the procedure described in clause 8.1.4 with the above parameters and the following modifications:  - Condition b) in Step 6 is replaced by:  b) the RSRP measurement performed, according to clause 8.4.2.1 for the received SCI format 1-A, is higher than **OR the UE is a destination UE of a TB associated with the received SCI format 1-A and the RSRP measurement performed, according to clause 8.4.2.1 for the received SCI format 1-A, is lower than ;**  - Step 6a) The UE excludes candidate single-slot resource(s) belonging to slot(s) where the UE does not expect to perform SL reception of a TB due to half-duplex operation, if all the following conditions are met:  - the UE is a destination UE of the TB for whose transmission the preferred resource set is being determined;  - the higher layer parameter *sl-Condition1-A-2* is not set to 'Disabled'.  <omitted text> | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112bis-e meeting.

### **TEI proposal #11**

* **Introduce a condition for the UE procedure for determining a preferred resource set for UE-B’s transmission in IUC Scheme 1 for SL**
  + **Adopt following TP in Clause 8.1.4A in TS 38.214.**

|  |
| --- |
| 8.1.4A UE procedure for determining a set of preferred or non-preferred resources for another UE's transmission  <omitted text>  When determining a preferred resource set, the UE applies the procedure described in clause 8.1.4 with the above parameters and the following modifications:  - Condition b) in Step 6 is replaced by:  b) the RSRP measurement performed, according to clause 8.4.2.1 for the received SCI format 1-A, is higher than or the UE is a destination UE of a TB associated with the received SCI format 1-A and the RSRP measurement performed, according to clause 8.4.2.1 for the received SCI format 1-A, is lower than ;  - Step 6a) The UE excludes candidate single-slot resource(s) belonging to slot(s) where the UE does not expect to perform SL reception of a TB due to half-duplex operation, if all the following conditions are met:  - the UE is a destination UE of the TB for whose transmission the preferred resource set is being determined;  - the higher layer parameter *sl-Condition1-A-2* is not set to 'Disabled'.  <omitted text> |

This proposal is already supported by Nokia, Nokia Shanghai Bell, Qualcomm.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| QC | Y |  |
| CATT | N | We are not sure about the benefit / necessity of the enhancement. |
|  |  |  |

* 1. Adapting drx-HARQ-RTT-TimerUL/DL for different number of PUSCH/PUCCH repetitions

Following proposal is made in the contribution.

|  |  |
| --- | --- |
| [2] | **Discontinuous reception (DRX)**  DRX defines active or inactive modes for UE, wherein UE can avoid monitoring all PDCCH occasions when it is in inactive mode. The UE is permitted to transmit on the UL during inactive mode, e.g., transmitting (a repetition) on the PUSCH. UE determines whether it is in active or inactive modes thanks to a set of timers and conditions.  In case of transmitting PUSCH or PUCCH with repetitions, the following timers are considered:   * *drx-InactivityTimer*: the duration after the PDCCH occasion in which a PDCCH indicates a new UL, DL or SL transmission for the MAC entity. * *drx-HARQ-RTT-TimerUL* (per UL HARQ process): the minimum duration before a UL HARQ retransmission grant is expected by the MAC entity; * *drx-RetransmissionTimerUL* (per UL HARQ process): the maximum duration until a grant for UL retransmission is received; * *drx-HARQ-RTT-TimerDL* (per DL HARQ process except for the broadcast process): the minimum duration before a DL assignment for HARQ retransmission is expected by the MAC entity; * *drx-RetransmissionTimerDL* (per DL HARQ process except for the broadcast process): the maximum duration until a DL retransmission is received;     Figure 4. An example of active and inactive durations in case PUSCH is transmitted with repetitions and when a) *drx-LastTransmissionUL* is not configured and b) *drx-LastTransmissionUL* is configured.  Figure 4 illustrates how the corresponding timers are used for determining active and inactive duration in case of PUSCH repetitions. For PUSCH repetitions, the starting of *drx-HARQ-RTT-TimerUL* further depends on whether *drx-LastTransmissionUL* is configured or not. Figure 1a illustrates the case when *drx-LastTransmissionUL* is not configured (disabled), wherein *drx-HARQ-RTT-TimerUL* starts after the first repetition. Figure 1b illustrates the case when *drx-LastTransmissionUL* is configured (enabled), wherein *drx-HARQ-RTT-TimerUL* starts after the last repetition.    Figure 5. An example of active and inactive durations in case where the PUCCH carrying NACK is transmitted with PUCCH repetition.  Figure 2 illustrates how the corresponding timers are used for determining active and inactive durations in case of DL transmission, wherein the PUCCH carrying NACK of the DL transmission is transmitted with PUCCH repetitions.  **PUSCH/PUCCH repetitions**  Rel-17 introduces a feature that allows counting the number of repetitions for PUSCH repetitions type A on available slots. Note also that counting on available slots already exists for PUCCH repetitions. Although this feature ensures a higher number of repetitions to be transmitted, it however increases the total latency from the first to the last repetition.  In addition, it’s worth noting that dynamic indication of number of PUSCH repetitions is introduced in Rel-16, while dynamic indication of number of PUCCH repetitions is also introduced in Rel-17.  **Observation 2:** While the number of PUSCH/PUCCH repetitions can be dynamically indicated via DCI, the DRX timers *drx-HARQ-RTT-TimerUL/ drx-HARQ-RTT-TimerDL* are semi-statically configured in RRC.  In case *drx-HARQ-RTT-TimerUL* starts after the first repetition. It can be observed from Figure 4a that, since *drx-RetransmissionTimerUL,* which starts after *drx-HARQ-RTT-TimerUL* expires, is used for UE to return to active mode for monitoring PDCCH that schedules retransmission of the PUSCH (if any), it is straightforward for gNB to configure *drx-HARQ-RTT-TimerUL* covering the whole of the PUSCH repetitions duration (i.e., until the last PUSCH repetition plus NW processing/scheduling time). However, given that the number of PUSCH repetitions can be dynamically indicated while *drx-HARQ-RTT-TimerUL* is semi-statically configured in RRC, gNB needs to configure *drx-HARQ-RTT-TimerUL* such that this timer could cover the maximum repetition duration (i.e., the repetition duration considering the maximum number of repetitions). This increases significantly the latency beyond what is needed, especially when counting on available slots is used and number of repetitions is smaller.  **Observation 3:** In case *drx-HARQ-RTT-TimerUL* starts after the first repetition, given that the number of PUSCH repetitions can be dynamically indicated while *drx-HARQ-RTT-TimerUL* is semi-statically configured in RRC, gNB needs to configure *drx-HARQ-RTT-TimerUL* such that this timer could cover the maximum repetition duration. This increases significantly the latency beyond what is needed, especially when counting on available slots is used and number of repetitions is smaller.    Figure 6. An example of active and inactive durations determination in case drx-LastTransmissionUL is configured and drx-HARQ-RTT-TimerUL is fixed for PUSCH transmission with a) one repetition and b) eight repetitions.  In case *drx-HARQ-RTT-TimerUL* starts after the last repetition. Although applying *drx-LastTransmissionUL* may partly solve the above issue of significant latency increase, this case has the following drawbacks.   * Given that *drx-HARQ-RTT-TimerUL* is fixed, the inactive duration could be very short for a smaller number of repetitions(as shown in Figure 6a)**.** However, given the smaller number of repetitions (i.e., the repetition duration is short), latency may not be so critical at the time when *drx-HARQ-RTT-TimerUL* starts. Therefore, it’s beneficial for UE to enjoy longer inactive duration for power saving (e.g., by considering longer *drx-HARQ-RTT-TimerUL)*. * In contrast, the inactive duration could be very long for a higher number of repetitions(as shown in Figure 6b)**.** In this case, given the higher number of repetitions (i.e., the repetition duration is long, especially when counting on available slots is considered), latency may be very critical at the time when *drx-HARQ-RTT-TimerUL* starts. Therefore, it’s important for UE to return to active mode faster to avoid significant latency increase in case retransmission is needed (e.g., by considering shorter *drx-HARQ-RTT-TimerUL).*   **Observation 4:** In case *drx-HARQ-RTT-TimerUL* starts after the last repetition, the inactive duration could be very short for a smaller number of repetitions. In this case, latency may not be so critical at the time when *drx-HARQ-RTT-TimerUL* starts. Therefore, increasing *drx-HARQ-RTT-TimerUL* is beneficial for power saving in this case.  **Observation 5:** In case *drx-HARQ-RTT-TimerUL* starts after the last repetition, the inactive duration could be very long for a larger number of repetitions (especially when counting on available slots is used). In this case, latency may be very critical at the time when *drx-HARQ-RTT-TimerUL* starts. Therefore, reducing *drx-HARQ-RTT-TimerUL* is crucial for avoiding significant latency increase in this case.  Similar drawbacks are observed in case PUCCH carrying NACK is transmitted with repetitions.    Figure 7. An example of active and inactive durations determination in case drx-LastTransmissionUL is configured and drx-HARQ-RTT-TimerUL is adapted with number of repetitions for PUSCH transmission with a) one repetition, b) four repetitions and c) eight repetitions.  From the above observations, and as illustrated in Figure 7, it can be deduced that adapting *drx-HARQ-RTT-TimerUL/ drx-HARQ-RTT-TimerDL* to the number of PUSCH/PUCCH repetitions is beneficial for providing a good balance between power saving and latency control, in case the number of PUSCH/PUCCH repetitions is dynamically indicated. Therefore, the following is proposed:  **Proposal 3:** RAN1 to specify that different values of *drx-HARQ-RTT-TimerUL* can be configured for different number of PUSCH repetitions and different values of *drx-HARQ-RTT-TimerDL* can be configured for different number of PUCCH repetitions. |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112bis-e meeting.

### **TEI proposal #12**

* **Different values of drx-HARQ-RTT-TimerUL can be configured for different number of PUSCH repetitions**
* **Different values of drx-HARQ-RTT-TimerDL can be configured for different number of PUCCH repetitions**

This proposal is already supported by Nokia, Nokia Shanghai Bell.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| Qualcomm | N | Per our understandings, the spec impact is in RAN2 spec only. Hence, this discussion should be in RAN2 instead. |
| CATT | N | There is no benefit shown for different timer values configured for UL and DL with different repetitions. |
|  |  |  |

* 1. Pathloss RS for Type 1 CG-PUSCH

Following proposal is made in the contribution.

|  |  |  |
| --- | --- | --- |
| [6] | In RAN1#99 [1], the following agreements were archived on the update of pathloss reference for PUSCH via MAC-CE.  ***Agreement (RRC impact)***  *On power control for PUSCH, PUCCH, and SRS, the total number of maximum configurable pathloss RSs, in including those supported in Rel-15, by RRC is 64*   * *Note: Such pathloss reference signals are for configuration purpose only, and UE is still only required to track up to 4 pathloss RSs for any PUSCH, PUCCH, and SRS transmissions.*    + *“Up to 4 pathloss RSs” applies the total number of pathloss RSs for PUSCH, PUCCH, and SRS*   ***Agreement (RRC impact)***  *For the feature of MAC CE based pathloss RS updates for PUSCH/SRS in Rel-16,*   * *Introduce one new RRC parameter to enable the feature of MAC CE based pathloss RS updates for PUSCH/SRS in Rel-16, i.e.,*   + *enablePLRSupdateForPUSCHSRS*   ***Agreement***  *When enablePLRSupdateForPUSCHSRS is configured, if a grant-based or grant-free PUSCH transmission is scheduled/activated by DCI format 0\_1 that does not include a SRI field, the RS resource index qd corresponding to the PUSCH-PathlossReferenceRS-Id mapped with sri-PUSCH-PowerControlId = 0 is used for path-loss measurement of PUSCH transmission. In this case, UE expects to be configured with sri-PUSCH-PowerControl*  While in this contribution, we give our views on the update of pathloss reference signal for Type 1 CG-PUSCH in Rel-16.  According to the agreement listed above, we can see that the pathloss reference signal for Type 2 CG-PUSCH and dynamic-grant PUSCH can be updated by the SRI field in DCI. But for Type 1 CG-PUSCH, even the spatial relation based on *srs-ResourceIndicator* configured in *rrc-ConfiguredUplinkGrant* can be updated by MAC CE, but the corresponding pathloss reference signal can’t be updated and the *pathlossReferenceIndex* configured in *rrc-ConfiguredUplinkGrant* should be used refer to the text in 38.213[2]. In this case the pathloss reference signal will be not matched with the spatial relation indicated by *srs-ResourceIndicator.*  So we propose the following text proposal.   |  | | --- | | 7.1.1 UE behaviour  ……  **<Unchanged parts are omitted>**  - For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*,   * if the UE is provided *enablePL-RS-UpdateForPUSCH-SRS,* the UE determines a RS resource index  from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the *sri-PUSCH-PowerControlId* indicated by the *srs-ResourceIndicator* value included in *rrc-ConfiguredUplinkGrant* * if the UE is not provided *enablePL-RS-UpdateForPUSCH-SRS,* a RS resource index  is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking* * ……   **<Unchanged parts are omitted>** | |

Based on the above contribution, following TEI proposal can be discussed in RAN1#112bis-e meeting.

### **TEI proposal #13**

* **Apopt following TP in Clause 7.1.1 in TS 38.213 for the pathloss RS for Type 1 CG-PUSCH**

|  |
| --- |
| 7.1.1 UE behaviour  ……  **<Unchanged parts are omitted>**  - For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*,   * if the UE is provided *enablePL-RS-UpdateForPUSCH-SRS,* the UE determines a RS resource index  from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the *sri-PUSCH-PowerControlId* indicated by the *srs-ResourceIndicator* value included in *rrc-ConfiguredUplinkGrant* * if the UE is not provided *enablePL-RS-UpdateForPUSCH-SRS,* a RS resource index  is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking* * ……   **<Unchanged parts are omitted>** |

This proposal is already supported by Xiaomi, China Unicom, OPPO, ZTE.

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

|  |  |  |
| --- | --- | --- |
| Company | Suppport (Y/N) | Comment |
| DOCOMO | N | In Rel.16, to update PL-RS by MAC CE, overlapped two features were supported.   * UE feature 1) explicit PL-RS update by MAC CE * UE feature 2) default PL-RS/spatial relation   If we use UE feature 2), PL-RS of Type1 CG-PUSCH follows to PL-RS of SRS with usage CB/NCB, by the following text. If PL-RS of SRS is updated by MAC CE (e.g. by default PL-RS/spatial relation to the SRS), PL-RS of Type 1 CG-PUSCH can be updated by MAC CE.  Hence, we think the proposal is not needed, because the existing spec. can update PL-RS for Type1 CG-PUSCH by MAC CE by using the UE feature 2).  Note that in our understanding, “the PUSCH transmission is not scheduled by DCI format 0\_0” includes Type 1 CG-PUSCH.   |  | | --- | | 7.1.1 UE behaviour (in TS 38.213)  […]  - If the PUSCH transmission is not scheduled by DCI format 0\_0, and if the UE is provided *enableDefaultBeamPL-ForSRS* and is not provided *PUSCH-PathlossReferenceRS* and *PUSCH-PathlossReferenceRS-r16,* the UE uses the same RS resource index as for an SRS resource set with an SRS resource associated with the PUSCH transmission | |
| QC | N | This one seems not a critical issue   * First, the proposal is to update the PL RS when spatial relation is updated for the SRI associated with the Type 1 CG. Our view is that this may not solve the issue completely. Because precoding, rank, MCS may all need to change if the beam changes. However, they are only updated by RRC. Dynamically changing 1 or 2 parameters may not solve the issue. Dynamically changing all parameters will have no difference from Type 2 CG.   Second, we think RRC updating PL RS is not too slow compared with actual MAC-CE latency. Indeed, RRC command latency is around 15 ms, higher than MAC-CE’s 3 ms. But up to 5 PL RS samples are needed anyway after MAC-CE command based on RAN4 requirement. This is a bigger part compared with command latency, e.g. 5 SSB samples are typically 100 ms. |
| CATT | Y | For Type 1 CG-PUSCH, it’s reasonable to address the issue with mismatched pathloss reference signal and spatial relation indicated by *srs-ResourceIndicator.* |

1. Conclusion

To be updated

Reference

[1] R1-2302385 Rel-18 TEI proposal on HARQ multiplexing on PUSCH Huawei, HiSilicon, Ericsson, China Unicom

[2] R1-2302400 RAN1 TEI proposals for Release 18 Nokia, Nokia Shanghai Bell

[3] R1-2302513 Rel-18 TEI proposals vivo

[4] R1-2302576 TEI on the introduction of a UE capability with up to 6-layer DL MIMO OPPO

[5] R1-2302762 On PUSCH repetition type A scheduled by DCI format 0-0 with CRC scrambled by C-RNTI ZTE, China Telecom, Sanechips

[6] R1-2302973 Rel-18 TEI on pathloss RS for Type 1 CG PUSCH xiaomi

[7] R1-2303620 Rel-18 RAN1 TEI proposals Qualcomm Incorporated

[8] R1-2303851 Proposals for Rel-18 TEI Ericsson, Verizon, Qualcomm

[9] R1-2302188 Summary #4 on Rel-18 TEIs Moderator (NTT DOCOMO, INC.)

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

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

Appendix: TEI guidance in [11]

**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.