**3GPP TSG RAN WG1 #100bis R1-2002978**

**e-Meeting, April 20th – 30th, 2020**

Source: moderator (vivo)

Title: Feature lead summary of [100b-e-NR-eMIMO-ULFPTx-01] Email discussion

Agenda Item: 7.2.6.4

Document for: Discussion and Decision

1. Summary

TP for TS 38.214 section 6.1.1.1

Reason for change: when there are 2 port SRS and 4 port SRS in one SRS resource set and codebooksubset is configured as partialAndNonCoherent, which codebook subset is associated with 2 port SRS resource is ambiguous.

Summary of change: clarify in the specification that when there are 2 port SRS and 4 port SRS in one SRS resource set and codebooksubset is configured as partialAndNonCoherent, the associated codebook subset with 2 port SRS resource is nonCoherent.

Consequences if not approved: the codebook subset associated with 2 port SRS is ambiguous

Clauses affected: 38.214, section 6.1.1.1

#### 6.1.1.1 Codebook based UL transmission

For codebook based transmission, PUSCH can be scheduled by DCI format 0\_0, DCI format 0\_1, DCI format 0\_2 or semi-statically configured to operate according to Clause 6.1.2.3. If this PUSCH is scheduled by DCI format 0\_1, DCI format 0\_2, or semi-statically configured to operate according to Clause 6.1.2.3, the UE determines its PUSCH transmission precoder based on SRI, TPMI and the transmission rank, where the SRI, TPMI and the transmission rank are given by DCI fields of SRS resource indicator and Precoding information and number of layers in clause 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212] for DCI format 0\_1 and 0\_2 or given by *srs-ResourceIndicator* and *precodingAndNumberOfLayers* according to clause 6.1.2.3. The *SRS-ResourceSet(s)* applicable for PUSCH scheduled by DCI format 0\_1 and DCI format 0\_2 are defined by the entries of the higher layer parameter *srs-ResourceSetToAddModList* and *srs-ResourceSetToAddModList-ForDCIFormat0\_2* in *SRS-config*, respectively. The TPMI is used to indicate the precoder to be applied over the layers {0…*ν*-1} and that corresponds to the SRS resource selected by the SRI when multiple SRS resources are configured, or if a single SRS resource is configured TPMI is used to indicate the precoder to be applied over the layers {0…*ν*-1} and that corresponds to the SRS resource. The transmission precoder is selected from the uplink codebook that has a number of antenna ports equal to higher layer parameter *nrofSRS-Ports* in SRS-Config, as defined in Clause 6.3.1.5 of [4, TS 38.211]. When the UE is configured with the higher layer parameter *txConfig* set to 'codebook', the UE is configured with at least one SRS resource. The indicated SRI in slot *n* is associated with the most recent transmission of SRS resource identified by the SRI, where the SRS resource is prior to the PDCCH carrying the SRI.

For codebook based transmission, the UE determines its codebook subsets based on TPMI and upon the reception of higher layer parameter *codebookSubset* in *pusch-Config* for PUSCH associated with DCI format 0\_1 and *codebookSubset-ForDCIFormat0\_2* in *pusch-Config* for PUSCH associated with DCI format 0\_2 which may be configured with *'*fullyAndPartialAndNonCoherent*'*, or *'*partialAndNonCoherent*'*, or 'nonCoherent' depending on the UE capability. When higher layer parameter ul-FullPowerTransmission is set to ‘fullpowerMode2'and the higher layer parameter codebookSubset or the higher layer parameter codebookSubset-ForDCIFormat0\_2 is set to 'partialAndNonCoherent', and when the SRS-resourceSet with usage set to “codebook” includes at least one SRS resource with 4 ports and one SRS resource with 2 ports, the codebookSubset associated with the 2 port SRS is ‘nonCoherent’. The maximum transmission rank may be configured by the higher layer parameter *maxRank* in *pusch-Config* for PUSCH scheduled with DCI format 0\_1 and *maxRank-ForDCIFormat0\_2* for PUSCH scheduled with DCI format 0\_2*.*

A UE reporting its UE capability of 'partialAndNonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubset-ForDCIFormat0\_2* with 'fullyAndPartialAndNonCoherent*'*.

A UE reporting its UE capability of 'nonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubset-ForDCIFormat0\_2* with *'*fullyAndPartialAndNonCoherent*'* or with *'*partialAndNonCoherent'.

A UE shall not expect to be configured with the higher layer parameter *codebookSubset* or the higher layer parameter *codebookSubset-ForDCIFormat0\_2* set to *'*partialAndNonCoherent' when higher layer parameter *nrofSRS-Ports* in an *SRS-ResourceSet* with *usage* set to 'codebook' indicates that the maximum number of the configured SRS antenna ports in the *SRS-ResourceSet* is two.

For codebook based transmission, the UE may be configured with a single *SRS-ResourceSet* with *usage* set to 'codebook' and only one SRS resource can be indicated based on the SRI from within the SRS resource set. Except when higher layer parameter *ULFPTxModes* is set to 'Mode 2', the maximum number of configured SRS resources for codebook based transmission is 2. If aperiodic SRS is configured for a UE, the SRS request field in DCI triggers the transmission of aperiodic SRS resources.

The UE shall transmit PUSCH using the same antenna port(s) as the SRS port(s) in the SRS resource indicated by the DCI format 0\_1 or 0\_2 or by *configuredGrantConfig* according to clause 6.1.2.3.

The DM-RS antenna ports  in Clause 6.4.1.1.3 of [4, TS38.211] are determined according to the ordering of DM-RS port(s) given by Tables 7.3.1.1.2-6 to 7.3.1.1.2-23 in Clause 7.3.1.1.2 of [5, TS 38.212].

Except when higher layer parameter *ULFPTxModes* is set to 'Mode 2', when multiple SRS resources are configured by *SRS-ResourceSet* with *usage* set to 'codebook', the UE shall expect that higher layer parameters *nrofSRS-Ports* in *SRS-Resource* in *SRS-ResourceSet* shall be configured with the same value for all these SRS resources.

When higher layer parameter *ULFPTxModes* is set to 'Mode 2',

- the UE can be configured with one SRS resource or multiple SRS resources with same or different number of SRS ports within an SRS resource set with *usage* set to '*codebook*'.

- up to 2 different spatial relations (*maxNumberConfiguredSpatialRelations)* can be configured for all SRS resources with usage set to 'codebook'.

- subject to UE capability, a maximum of 2 or 4 SRS resources are supported in an SRS resource set with *usage* set to 'codebook'

# Annex

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| Company/organization | Comments |
| OPPO | Support Alt.21. According to the LS R1-2001513, some new RRC parameter is needed for Alt.1. Introducing non-essential new RRC parameter at a so-late stage is not a wise design, and may lead to further workload and more risk for ASN.1 frozen
2. As explained several times, it cannot be guaranteed that the 2 ports are coherent. Thus Alt.3 does not work for many UE implementations.
 |
| CMCC | We support Alt2, since we think the motivation of Alt1 or Alt3 is not clear. In our understanding, the 2 ports can be considered as coherent only when the 2 ports are virtualized from the first and third port (i.e., using [1 0 1 0]) or from the second and fourth port (i.e., using [0 1 0 1]) of the 4 ports. Let’s take the former case as an example, we can assume both the first and the third port can support 20dBm in order to support full power transmission. However, in that case, the 2-port is equivalent to the 4-port using reported TPMIs (e.g., using G4, ; ) which can support full power transmission.  |
| LG | Support Alt 2. Similar view with OPPO, in order to avoid new RRC parameter, Alt 2 or Alt 3 can be considered. Between Alt 2 and Alt 3, we think Alt 2 is more preferable, since Alt 3. may require higher UE implementation complexity/cost compared to Alt 2.  |
| Huawei, HiSilicon | Support Alt.2. Here the condition is 2-port SRS and 4 port SRS resources are both configured. For the following all three cases:If each antenna port is virtualized from a group of two coherent antennas, then after virtualization, it will be non-coherent between the two ports. If each antenna port is virtualized from a group of two non-coherent antennas, the after virtualization, the phase in each port is difficult to be guaranteed. So, it results to non-coherent between two ports.If each antenna port is virtualized from a group of two non-coherent antennas with [1 0] or [0 1], yes, the two ports will be coherent. However, the case is equivalent to non-virtualized case with [1 0 1 0] or [0 1 0 1], without any benefits.From above, only Alt.2 makes sense. Some detailed discussion also can be find in R1-2001565.  |
| Samsung | We prefer Alt 1 due to the following reason:* The virtualization of 2 ports (from 4 ports) is up to UE implementations, and the UE should have the freedom/flexibility to implement any virtualization of 2 ports. This freedom is completely lost in Alt2 since it restricts 2 ports to be non-coherent. Alt3 is also restrictive, but it is better than Alt 2, at least in the sense that TPMI can be non-coherent or full-coherent.
* Re the comment “If each antenna port is virtualized from a group of two non-coherent antennas with [1 0] or [0 1], yes, the two ports will be coherent. However, the case is equivalent to non-virtualized case with [1 0 1 0] or [0 1 0 1],” we also need to look at TPMI payload, which is certainly not the same. In particular, the TPMI payload is more in case of 4 ports than in case of 2 ports. Hence, the two cases are not equivalent operationally.

Re CMCC comment, in our view, mode 2 has two solutions: (1) based on TPMI group signaling and (2) based on multiple SRS resources with different number of SRS ports. This email discussion pertains to (2), not (1). |
| CATT | OK with alt-2 and alt-3, with slight preference on alt-2. Alt-1 is not preferred due to RRC impact. In our view this is not a critical issue to warrant RRC changes at this late stage. Last but now least, there has been no thorough evaluation on the performance gain over the other simpler alternatives.  |
| Apple | We are okay with Alt 2, slightly prefer Alt 1 |
| ZTE | We support Alt 2 with the following two reasons.1. For Mode 2, no matter whether through intra-pair or inter-pair ports combination of 4 partial-coherent ports, due to there is no guarantee of coherence between the pairs, the 2 virtualized ports are always non-coherent.
2. Some companies mentioned that that non-coherent operation loses the benefit of coherent combining gain. Based on the so-called ‘gain’, if the virtualization is only port selection of two pairs with same order/ rule, such as [1 0] or [0 1], the coherent capability of such 2 virtualized ports is coherence. But this case is same as 4 partial-coherent ports with [1 0 1 0] or [0 1 0 1]. Thus, full-coherent codebook of 2 ports SRS resource in this case is redundant.
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| Intel | We support Alt 2. For Alt 1, it requires additional RRC signaling. For Alt 3, the coherence can’t be guaranteed after antenna virtualization. |
| Spreadtrum | We are Ok with Alt1 or Alt2. |
| DOCOMO | We prefer Alt2. This is because, Alt1 requires additional RRC signaling which we think is not desirable to handle at this moment. Further, Alt3 expects coherency between ports after virtualization which is not realistic at all the time. |
| QC | We support Alt2. As mentioned by many companies, Alt 1 has RRC impact. Alt 3 forces UE to keep coherency after virtualization which is too restrictive to UE implementation.  |
| Ericsson | We prefer Alt 3, and are OK with Alt 1.* **The need for new RRC does not differentiate Alt 1 from Alt 2 or Alt 3.** According to RAN2 guidance, new RRC signaling is generally needed to enable Rel-16 capabilities. Therefore, the RRC signaling needed for Alt-1 is no different than any other capability we are introducing in this meeting.
* **Operating with e.g. [1 0 1 0] or [0 1 0 1] on 4 ports is not the same as [1 0] or [0 1] on two virtualized ports.** Virtualized 2 port SRS could be transmitted less frequently than 4 port SRS to save overhead, and UE power can be saved by turning off Tx chains (e.g. in a 4 x 20 dBm UE).
* **Our expectation is that Alt 3 is feasible for all partially coherent UEs, not just those using a subset of Tx antennas for Mode 2 with 2 port SRI.**
* UE implementations that have at least ½ power on the fully coherent pairs can clearly support Alt 3 by transmitting on ½ of the Tx chains.
* A partially coherent UE that has ¼ power PAs can map Tx chains{0,1} to two port SRS 0 and {2,3} to two port SRS 1. The two port SRSs can combine coherently, since the relative phase can be maintained across Tx chains {0,2} and {1,3}. Here, two port SRS 0 and 1 are created with non-coherent combining; using non-coherent combining is needed when this ¼ power PA UE forms one full power port that is required for Mode 2 operation. Note that this non-coherent per port combining has the normal behavior with non-coherent virtualization that the phase of a given RE on a port may vary from slot to slot, but again the relative phase across ports for the RE will be controlled from slot to slot when coherent port pairs are mapped as described above.

If UE vendors have a different understanding, I’d appreciate comments. |
| Nokia, NSB | Support Alt 2: the codebook subset is *noncoherent*. Alt 2 is the simplest solution at this moment. Also we can support Alt 1 as the second choice. |
| vivo | Slightly prefer Alt1, since it can give more flexibility for UE implementation, additionally introduce new RRC parameter may be not needed. The following descriptions can be added in TS 38.214, When the UE reports *fullyAndPartialAndNonCoherent* capability, both NW and UE shall assume *fullyAndPartialAndNonCoherent* codebook subset is used by default.If there is no consensus, we can accept Alt2. |
| InterDigital | Prefer Alt.1. In our view, PA chain numbering is a logical indexing and a UE can adopt different indexing when it comes to the use of coherent ports. Therefore, since antenna port virtualization is a UE proprietary scheme, in a partial-coherent UE, virtualization can be implemented in such a way that a transmission always occurs using the coherent ports.As for RRC parameters, similar to vivo’s comment, we may not even need a new capability signaling by agreeing that,For a 4Tx and partial-coherent UE in Mode 2, when the SRS resource set is configured with 2 ports SRS and 4 ports SRS, the codebook subset associated with 2 port SRS resource is *fullyAndPartialAndNonCoherent.* |