3GPP TSG-RAN WG2 Meeting #116bis electronic ***R2-220xxxx***

Online, Jan 17 – 25, 2022

**Agenda item:** 8.24.1

**Source:** China Telecom

**Title:** Draft-Summary of [AT116bis-e][036][NR17] UL TX switching Enh (China Telecom)

**WID/SID:** NR\_RF\_FR1\_enh

**Document for:** Discussion and Decision

# Introduction

This document is the report of the following email discussion:

* [AT116bis-e][036][NR17] UL TX switching Enh (China Telecom)

 Scope: Treat R2-2200120, R2-2201499, R2-2201500, R2-2201501, R2-2200516. R2-2200519, R2-2200517, R2-2200518, Take into account R2-2200095.

 1: Determine agreeable parts, parts that need CB on-line if any 2: agree updated Running CRs that reflect agreeable parts / agreements.

 Intended outcome: 1 Report, 2 endorsed running CRs

 Deadline: 1 for online CB Mon W2 if CB is needed, 2 EOM

For **Phase 1** discussion, rapporteur suggests companies provide comments **before Thursday W1 UTC 13:00 (Jan 20),** so that we can try to figure out the agreeable parts and start to discuss how to update the Running CRs earlier. The Phase 1 report will be submitted **before online CB Mon W2 (Jan 24).**

For **Phase 2** discussion, rapporteur plans to start it at **Friday W1 (Jan 21)**, which can focus on updating the Running CRs based on the agreeable parts discussed in Phase 1. For the parts that need further online discussion, we can continue the Running CRs updating work based on the online agreements afterwards.

**Contact from companies**

|  |  |
| --- | --- |
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# Phase 1 Discussion

In last RAN2 meeting, the discussion on RRC configuration of Rel-17 UL Tx switching enhancement was postponed for further RAN1 progress. Considering Rel-17 RAN1 part of RF requirements enhancement for NR frequency range 1 has completed as indicated in RAN1 status report RP-212642, RAN2 needs to discuss how to capture the RAN1 agreements and whether there are extra parameters to specify from RAN2 perspective.

Besides, in RAN4#101-e meeting, RAN4 introduced new UL MIMO coherence capabilities for Rel-17 UL Tx switching enhancements and sent an LS (R2-2200120-R4-2120039) to ask RAN2 to take into consideration the RAN4 agreements to introduce UE capability signalling.

Based on the current progress on Rel-17 UL Tx switching enhancements in RAN1 and RAN4, and the company contributions submitted in this meeting, the following issues may need further discussion.

* Regarding **RRC configuration**, the following aspects should be considered:

(1) How network indicates/UE determines 2Tx-2Tx switching is configured (with differentiation from 1Tx-2Tx switching).

(2) How network indicates/UE determines 2 CCs on band B is configured for 1Tx-2Tx switching/2Tx-2Tx switching.

(3) Other configuration introduced by RAN1

* Regarding **UE capability reporting**, the leftover includes:

(1) UL MIMO coherent capability for UL Tx switching introduced by RAN4.

(2) FFS captured in the endorsed running CR, i.e. whether switching option can be reported differently for 1Tx-2Tx and 2Tx-2Tx.

## RRC configuration

### How to indicate 1Tx-2Tx or 2Tx-2Tx switching is configured

In RAN1#107-e meeting, RAN1 reached the following agreement to introduce a new RRC parameter for 2Tx-2Tx switching.

|  |
| --- |
| **Agreement**For a UE capable of 2Tx-2Tx switching and configured with UL Tx switching via uplinkTxSwitching, to differentiate the switching delay for 1Tx-2Tx switching from that for 2Tx-2Tx switching, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.* If 1Tx-2Tx mode is derived by the new RRC parameter, then there is one uplink (or one uplink band in case of intra-band) configured with uplinkTxSwitching, on which the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources should be 1 and non-codebook based UL MIMO is not configured. RAN1 assume the uplink is configured with RRC parameter “carrier1” by RAN2.
* The default value of the new RRC parameter is 1Tx-2Tx switching mode.
* In a configured switching mode, the switching gap duration for a triggered uplink switching is equal to the switching time capability value reported for the switching mode.
* Note: This RRC parameter doesn’t imply any restriction on application of non-codebook transmission together with UL Tx switching.
 |

The above agreement is stable in RAN1 with only some remaining discussion on the detailed description of UE behaviours/NW restrictions after reception of the parameter. From RAN2 perspective the meaning of the parameter is quite straightforward, i.e. the UL Tx switching mode is 2Tx-2Tx switching to differentiate from 1Tx-2Tx switching.

Based on the above RAN1 agreement, R2-2201499 proposes to add a Rel-17 field in *CellGroupConfig* to indicate the Tx switching mode, and the existing *uplinkTxSwitchingPeriodLocation* and *uplinkTxSwitchingCarrier* within *UplinkTxSwitching* can be reused without any change.

Below is the corresponding TP to show the change to TS38.331.

CellGroupConfig ::= SEQUENCE {

 cellGroupId CellGroupId,

 rlc-BearerToAddModList SEQUENCE (SIZE(1..maxLC-ID)) OF RLC-BearerConfig OPTIONAL, -- Need N

 rlc-BearerToReleaseList SEQUENCE (SIZE(1..maxLC-ID)) OF LogicalChannelIdentity OPTIONAL, -- Need N

 mac-CellGroupConfig MAC-CellGroupConfig OPTIONAL, -- Need M

 physicalCellGroupConfig PhysicalCellGroupConfig OPTIONAL, -- Need M

 spCellConfig SpCellConfig OPTIONAL, -- Need M

 sCellToAddModList SEQUENCE (SIZE (1..maxNrofSCells)) OF SCellConfig OPTIONAL, -- Need N

 sCellToReleaseList SEQUENCE (SIZE (1..maxNrofSCells)) OF SCellIndex OPTIONAL, -- Need N

 ...,

 [[

 reportUplinkTxDirectCurrent ENUMERATED {true} OPTIONAL -- Cond BWP-Reconfig

 ]],

 [[

 bap-Address-r16 BIT STRING (SIZE (10)) OPTIONAL, -- Need M

 bh-RLC-ChannelToAddModList-r16 SEQUENCE (SIZE(1..maxBH-RLC-ChannelID-r16)) OF BH-RLC-ChannelConfig-r16 OPTIONAL, -- Need N

 bh-RLC-ChannelToReleaseList-r16 SEQUENCE (SIZE(1..maxBH-RLC-ChannelID-r16)) OF BH-RLC-ChannelID-r16 OPTIONAL, -- Need N

 f1c-TransferPath-r16 ENUMERATED {lte, nr, both} OPTIONAL, -- Need M

 simultaneousTCI-UpdateList1-r16 SEQUENCE (SIZE (1..maxNrofServingCellsTCI-r16)) OF ServCellIndex OPTIONAL, -- Need R

 simultaneousTCI-UpdateList2-r16 SEQUENCE (SIZE (1..maxNrofServingCellsTCI-r16)) OF ServCellIndex OPTIONAL, -- Need R

 simultaneousSpatial-UpdatedList1-r16 SEQUENCE (SIZE (1..maxNrofServingCellsTCI-r16)) OF ServCellIndex OPTIONAL, -- Need R

 simultaneousSpatial-UpdatedList2-r16 SEQUENCE (SIZE (1..maxNrofServingCellsTCI-r16)) OF ServCellIndex OPTIONAL, -- Need R

 uplinkTxSwitchingOption-r16 ENUMERATED {switchedUL, dualUL} OPTIONAL, -- Need R

 uplinkTxSwitchingPowerBoosting-r16 ENUMERATED {enabled} OPTIONAL -- Need R

 ]],

 [[

 reportUplinkTxDirectCurrentTwoCarrier-r16 ENUMERATED {true} OPTIONAL -- Need N

 ]]

 [[

 uplinkTxSwitching-2T2T-Mode-r17-r17 BOOLEAN OPTIONAL -- Need R

 ]]

}

|  |
| --- |
| ***uplinkTxSwitching-2T2T-Mode***Indicates 2Tx-2Tx UL Tx switching is configured for inter-band UL CA or SUL as specified in TS 38.214 [19].  |

Companies are welcome to give comments on P1 within R2-2201499 for the configuration of 2Tx-2Tx switching.

**Q1: Do companies agree P1 within R2-2201499 as it is: To configure 2Tx-2Tx switching, the new RRC parameter of 2Tx-2Tx switching mode agreed by RAN1 is included in *CellGroupConfig*, and the existing *UplinkTxSwitching* can be reused without change?**

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| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We understand that RAN1 agreement is stable and the meaning of the newly introduced parameter is quite straightforward. We support to include the new RRC parameter of 2Tx-2Tx switching mode agreed by RAN1 in *CellGroupConfig*, and the existing *UplinkTxSwitching* can be reused without change. |
| Qualcomm Incorporated | Not agree | It is not entirely clear to us why this parameter is needed if 1Tx-2Tx vs 2Tx-2Tx can be known based on the number of antenna ports.RAN1 text says “The default value of the new RRC parameter is 1Tx-2Tx switching mode”, but it is not clear from the proposed text above how 1Tx-2Tx mode is configured.NOTE: As we discussed previously, we should discourage RAN1 from defining “default” behaviour associated with RRC parameter in their specification. |
| OPPO | Agree | Although the R1 conclusion is not entirely clear (according to our R1 colleague), we understand the P1 within R2-2201499 is a clearer way-out. |
| Ericsson | Agree, but | Agree with the intention, it is safer to have it controlled via RRC rather than rely on other methods. Also, though we agree with QC that we should discourage RAN1 from defining “default” behaviour associated with RRC parameter in their specification, in this case it should be the backwards compatible way to do it, since the configuration of 1T-2Tx is also used in legacy Rel-16 case and thus cannot contain the new indication. In fact, due to that, it seems better to just have the value as ENUMERATED {enabled}, since absence of this parameter should anyway imply in 1Tx-2Tx case.  |
| Huawei, HiSilicon | Agree | Some response to Qualcomm’s comments:* About why to introduce this new parameter: in RAN1 it was discussed whether port number can be used to differentiate legacy 1T-2T switching and Rel-17 2T-2T switching, assuming existing ***UplinkTxSwitching*** is reused to configure 2T-2T switching without extra change. However, as some companies strongly prefer to introduce an explicit RRC configuration for 2T-2T case, then the new RRC parameter is agreed as a compromise. But we do agree that network configuration of Tx switching mode and port number should be aligned as emphasized in RAN1 agreement: *If 1Tx-2Tx mode is derived by the new RRC parameter, then there is one uplink (or one uplink band in case of intra-band) configured with* uplinkTxSwitching, *on which the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources should be 1 and non-codebook based UL MIMO is not configured. RAN1 assume the uplink is configured with RRC parameter “carrier1” by RAN2*. **Thus we suggest to add the RAN1 agreement to the field description of the new RRC parameter for further clarification.**
* Regarding the “default value”, we share the same view as Ericsson. Considering the legacy ***UplinkTxSwitching*** is used to configure both legacy 1T-2T switching and new 2T-2T switching, then the network and UE should have the aligned understanding that if the new parameter is present, 2T-2T is configured, otherwise 1T-2T is configured which is also the legacy Rel-16 UE behaviour.

We agree with Ericsson that the value of the parameter would better be ENUMERATED {enabled}. |
| vivo | Agree | We agree with Ericsson having the value *uplinkTxSwitching-2T2T-Mode-r17* as ENUMERATED {enabled} to capture the RAN1 intention of “The default value of the new RRC parameter is 1Tx-2Tx switching mode.”, since 1T-2T mode is the base mode of R16 uplink tx switching.Although QC have the point that we should discourage RAN1 from defining “default” behaviour associated with RRC parameter, we think it’s acceptable in this case. |
| CATT | Agree | And we agree with the suggestion of Ericsson.  |
| ZTE | Agree | We agree with Ericsson that “ENUMERATED {enabled}” is more suitable. |
| Nokia, Nokia Shanghai Bell | Agree (with clarifications) | We also had the same question as Qualcomm (i.e. is the parameter really needed?), and fully agree with QC that defining parameters with "default behaviour" is a bad practice that we have tried to discontinue through RAN2. That's why the configuration should be made very clear.However, it does seem that RAN1 agreed to go for the explicit configuration, and as Ericsson pointed out, explicit configuration will be easier to interpret. So let's just make clear what the configuration means: With this parameter, the 1Tx-2Tx and 2Tx-2Tx configurations are done as follows:1. 1Tx-2Tx operation: Only Rel-16 configuration, i.e. only the field *uplinkTxSwitchingOption-r16* is configured (regardless of what UE supports)
2. 2Tx-2Tx operation: Rel-16 + Rel-17 configuration, i.e. both the *uplinkTxSwitchingOption-r16* and *uplinkTxSwitching-2Tx-Mode-r17* are configured (which is only done for UEs supporting the 2T2T-mode)

Then some comments on the RRC aspects:* The extra -r17 suffix should be removed
* Since this parameter toggles use of 2Tx-mode, it's best to just call it that and shorten it a bit, e.g. use *uplinkTxSwitching-2Tx-Mode-r17* with type ENUMERATED{enabled} as is the normal practice (just as Ericsson commneted) .
* The field *uplinkTxSwitching-2Tx-Mode-r17* should indicate it is only configured if *uplinkTxSwitchingOption-r16* is configured, e.g. via configuration condition.

Hence, this is how the parameter should look like:  [[ uplinkTxSwitching-2Tx-Mode-r17 ENUMERATED {enabled} OPTIONAL -- Cond 2Tx ]]

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| Conditional Presence | Explanation |
| *2Tx* | The field is optionally present, Need R, if *uplinkTxSwitchingOption-r16* is configured; otherwise it is absent, Need R. |

See also Q5. |
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### UL Tx switching between 1 carrier in band A and 2 carriers in band B

Regarding the RRC configuration for UL Tx switching between 1 carrier in band A and 2 carriers in band B, R2-2201499 gives the following proposals.

Proposal 2: For UL Tx switching between 1 carrier in band A and 2 carriers in band B, 3 uplinks are configured in legacy way, i.e. one uplink band (Band A) is configured with 1 *UplinkConfig*, and the other band (Band B) is configured with 2 *UplinkConfig*.

Proposal 3: For UL Tx switching between 1 carrier in band A and 2 carriers in band B, the field *uplinkTxSwitchingPeriodLocation* is reused to configure period location. The configuration to the 2 uplinks in band B (i.e. the band capable of 2Tx) should be aligned.

Proposal 4: For UL Tx switching between 1 carrier in band A and 2 carriers in band B, the field *uplinkTxSwitchingCarrier* is reused. The configuration to the 2 uplinks in band B (i.e. the band capable of 2Tx) should be *carrier2*.

Below is the corresponding TP to show the change to TS38.331.

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| --- |
| ***uplinkTxSwitchingPeriodLocation***Indicates whether the location of UL Tx switching period is configured in this uplink carrier in case of inter-band UL CA, SUL, or (NG)EN-DC, as specified in TS 38.101-1 [15] and TS 38.101-3 [34]. In case of inter-band UL CA or SUL, network configures this field to TRUE for the uplink carrier(s) on one band ~~one of the uplink carriers~~ involved in dynamic UL TX switching and configures this field in the ~~other~~ carrier(s) on the other band to FALSE. In case of (NG)EN-DC, network always configures this field to TRUE for NR carrier (i.e. with (NG)EN-DC, the UL switching period always occurs on the NR carrier). |
| ***uplinkTxSwitchingCarrier***Indicates that the configured carrier is carrier1 or carrier2 for dynamic uplink Tx switching between 2 uplink carriers, as defined in TS 38.101-1 [15] and TS 38.101-3 [34]. In case of inter-band UL CA or SUL, network configures one of the two uplink carriers involved in dynamic UL TX switching as carrier1 and the other as carrier2. In case of (NG)EN-DC, network always configures the NR carrier as carrier 2.For dynamic uplink Tx switching between 2 bands with 3 uplink carriers as defined in TS 38.101-1 [15], the field is set to *carrier2* for the uplink carriers in the band capable of two transmit antenna connectors. |

Companies are welcome to give comments on the proposals within R2-2201499 for UL Tx switching between 1 carrier in band A and 2 carriers in band B.

**Q2: Do companies agree P2 within R2-2201499 as it is: For UL Tx switching between 1 carrier in band A and 2 carriers in band B, 3 uplinks are configured in legacy way, i.e. one uplink band (Band A) is configured with 1 *UplinkConfig*, and the other band (Band B) is configured with 2 *UplinkConfig*?**

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| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We agree with the proposal. For UL Tx switching between 1 carrier in band A and 2 carriers in band B, 3 uplinks can be configured in legacy way, and only some clarifications are needed. |
| Qualcomm Incorporated | Agree |  |
| OPPO | Agree |  |
| Ericsson | Agree |  |
| Huawei, HiSilicon | Agree |  |
| vivo | Agree |  |
| CATT | Agree |  |
| ZTE | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree |  |
|  |  |  |
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**Q3: Do companies agree P3 within R2-2201499 as it is: For UL Tx switching between 1 carrier in band A and 2 carriers in band B, the field *uplinkTxSwitchingPeriodLocation* is reused to configure period location. The configuration to the 2 uplinks in band B (i.e. the band capable of 2Tx) should be aligned?**

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| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We support this proposal. For UL Tx switching between 1 carrier in band A and 2 carriers in band B, the field *uplinkTxSwitchingPeriodLocation* can be reused to configure period location, and the configuration to the 2 uplinks in band B should be aligned. |
| Qualcomm Incorporated | Agree, but | For uplinkTxSwitchingPeriodLocation, the proposed text does not sufficiently clarify the same value is configured for all carriers on one band in case of UL Tx switching with 3 UL carriers. |
| OPPO | Agree | The issue identified by QC should be corrected. |
| Ericsson | Agree | On QC’s comment, we could probably add a clarification at the end as done for uplinkTxSwitchingCarrier? |
| Huawei, HiSilicon | Agree | We are fine to further discuss the CR details in phase II, and Ericsson’s suggestion looks good. |
| vivo | Agree | The TP needs some revise to accurately reveal rel-17 features as QC points out. |
| CATT | Agree | Agree with Huawei, we can discuss the detail text in next phase.  |
| ZTE | Agree | Regarding QC’s concern, we are fine to add more restriction in field description. |
| Nokia, Nokia Shanghai Bell | Agree (with QC clarifcation) | Agree with Qualcomm clarification |
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**Q4: Do companies agree P4 within R2-2201499 as it is: For UL Tx switching between 1 carrier in band A and 2 carriers in band B, the field *uplinkTxSwitchingCarrier* is reused. The configuration to the 2 uplinks in band B (i.e. the band capable of 2Tx) should be *carrier2*?**

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| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We support this proposal. For UL Tx switching between 1 carrier in band A and 2 carriers in band B, the field *uplinkTxSwitchingCarrier* can be reused, and the configuration to the 2 uplinks in band B should both be *carrier2*. |
| Qualcomm Incorporated | Agree |  |
| OPPO | Agree |  |
| Ericsson | Agree |  |
| Huawei, HiSilicon | Agree |  |
| vivo | Agree |  |
| CATT | Agree |  |
| ZTE | Agree, but | We want to clarify that in case of 2Tx-2Tx switching, both the carrier in band A and carrier(s) in band B will be configured with two transmit antenna connectors. Then based on the field description of *uplinkTxSwitchingCarrier*, the field for both carrier in band A and carrier(s) in band B will be set to “*carrier2*”. Is this the common understanding from companies? |
| Nokia, Nokia Shanghai Bell | Agree but | We had the same understanding as ZTE on the needed configuration for carrier A and carrier B. |
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### Other configuration introduced in RAN1

In RAN1#106bis-e meeting, one RRC parameter was agreed for determination of the state of Tx chains for 2Tx-2Tx switching and captured in RAN1 RRC parameter list R1-2112976 as below.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NR\_RF\_FR1\_enh-Core | Uplink Tx switching enhancements | *uplinkTxSwitchingdualULTxState* | new | For UL-CA option 2 and 2Tx-2Tx switching, indicate the state of Tx chains if the state of Tx chains after the UL Tx switching is not unique. | [{1T, 2T}] | [2T] | UE-specific | Agreement:Ÿ For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, introduce a new RRC parameter to configure between 1) and 2) ‐ 1) The state of Tx chains supporting 2Tx transmission on the carrier is assumed.‐ 2) 1Tx on carrier 1 and 1Tx on carrier 2 is assumed. | New stable |

Regarding the configuration of the new RRC parameter introduced by RAN1, R2-2201499 gives the following proposal*.*

Proposal 5: The new RRC parameter *uplinkTxSwitchingdualULTxState* should be included in *CellGroupConfig* to configure the state of Tx chains for UL-CA option2 in case of 2Tx-2Tx switching.

Companies are welcome to give comments on P5 within R2-2201499 for other configuration introduced by RAN1.

**Q5: Do companies agree P5 within R2-2201499 as it is: The new RRC parameter *uplinkTxSwitchingdualULTxState* should be included in *CellGroupConfig* to configure the state of Tx chains for UL-CA option2 in case of 2Tx-2Tx switching?**

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| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We support to include the new RRC parameter*uplinkTxSwitchingdualULTxState* in *CellGroupConfig* to configure the state of Tx chains for UL-CA option2 in case of 2Tx-2Tx switching. |
| Qualcomm Incorporated | Agree |  |
| OPPO | Agree |  |
| Ericsson | Agree |  |
| Huawei, HiSilicon | Agree |  |
| vivo | Agree |  |
| CATT | Agree |  |
| ZTE | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree | Since this is related to 2Tx-switching in general, it would be better to have a new IE for all the configuration parameters in that mode, e.g. as follows: [[ uplinkTxSwitching-2Tx-Mode-r17 UplinkTxSwitching-r17 OPTIONAL -- Cond 2Tx ]]UplinkTxSwitching-r17 := SEQUENCE { uplinkTxSwitching-DualUL-TxState-r17 ENUMERATED {oneTx, twoTx}}

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| --- |
| ***uplinkTxSwitching-2Tx-Mode***Indicates 2Tx-2Tx UL Tx switching is configured for inter-band UL CA or SUL as specified in TS 38.214 [19].  |

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| ***uplinkTxSwitching-DualUL-TxState***Indicates state of Tx chains after UL TX switching for 1-port transmission as specified in TS 38.214 [19]. |

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| Conditional Presence | Explanation |
| *2Tx* | The field is optionally present, Need R, if *uplinkTxSwitchingOption-r16* is configured; otherwise it is absent, Need R. |

Note that this expands upon the discussion of Q1, replacing that structure. |
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## UE capability reporting

### UL MIMO coherence capability for Tx switching

* **Baseline for the Rel-17 UL Tx switching coherence capability discussion**

In RAN2#115-e meeting, an LS (R2-2106952) from RAN4 on UL MIMO coherence for Rel-16 Tx switching was noted and the corresponding CRs on introducing UL MIMO coherence capability for Tx switching were postponed to wait for potential RAN1 progress.

In RAN2#116-e meeting, the following agreement was reached in RAN2#116-e meeting.

* [013] Both endorsed, not for RP, final version later. The CRs R2-2110483 and R2-2110484 correctly captures RAN4 request in their LS. CRs can be revisited after RAN1 discussion on the legacy MIMO coherence capability.

In RAN4#101-e meeting, RAN4 reached the following agreements on UL MIMO coherence capabilities for Rel-17 UL Tx switching enhancements and sent an LS (R2-2200120-R4-2120039) to ask RAN2 to take into consideration the RAN4 agreements to introduce UE capability signalling.

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| Regarding the UL-MIMO coherence for the above Rel-17 Tx switching scenarios, RAN4 reached the following agreements:* For 3CC (within 2 bands) 1Tx-2Tx switching
	+ The Rel-16 per BC UE capability for 2CC 1Tx-2Tx switching can be applied, i.e., the same capability applies to both Rel-16 and Rel-17 1Tx-2Tx switching.
	+ If the per BC UL-MIMO capability for 1Tx-2Tx switching is absent, the existing Rel-15 per band UE capability *pusch-TransCoherence* is applicable to each of the 2Tx-capable bands for 1Tx-2Tx switching.
* For 2CC and 3CC 2Tx-2Tx (within 2 bands) switching
	+ Introduce new per band per BC UL-MIMO coherence capability, and the same capability applies to both 2CC and 3CC (within 2 bands) 2Tx-2Tx switching.
	+ If the per band per BC UL-MIMO coherence capability is absent, the per BC UL-MIMO coherence capability for 1Tx-2Tx switching is applicable to 2Tx-2Tx switching.
	+ If both the per band per BC UL-MIMO coherence capability and per BC UL-MIMO coherence are absent, the existing Rel-15 per band UE capability *pusch-TransCoherence* is applicable to each of the bands for 2Tx-2Tx switching.
* The above UL-MIMO coherence capability for Tx switching applies when UE is configured with uplink switching, and uplink switching is triggered by the switching mechanisms specified in RAN1 between last transmitted SRS and scheduled PUSCH transmission.
 |

In RAN1#107-e meeting, RAN1 discussed on the legacy MIMO coherence capability issues, but did not reach a consensus on whether to introduce a new per-FS capability indicating UL MIMO coherence at least in Rel-16. Based on the discussion, RAN1 sent an LS (R2-2200072-R1-2112778) to inform RAN2 the following conclusion on MIMO coherence capability issues.

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| Following are some notes regarding the updates on the NR features list: (R1-2112778)* RAN1 has discussed on whether to introduce a new per-FS capability of UL MIMO coherence based on R1-2112185, but RAN1 did not reach a consensus to introduce a new per-FS capability indicating UL MIMO coherence at least in Rel-16.
 |

As per RAN1 discussion, the discussion scope is limited to 4Tx UL MIMO coherence with no impact on Rel-16 UL Tx switching, which is a different issue from RAN4 discussion on UL MIMO coherence capability for UL Tx switching. Besides, according to the RAN4 LS on Rel-17 UL Tx switching UL MIMO coherence capability, the Rel-17 capability has some relation with the Rel-16 capability.

Considering there is no plan to treat Rel-16 discussion in this RAN2 meeting, R2-2200519 suggests first taking the endoresed Rel-16 CRs as baseline, on top of which the Rel-17 capability can be discussed and formulated, and gives the following proposal*.*

Proposal 1: Taking the endorsed Rel-16 CRs R2-2110483 and R2-2110484 as baseline for the Rel-17 UL Tx switching coherence capability discussion.

Companies are welcome to give comments on P1 within R2-2200519.

**Q6: Do companies agree P1 within R2-2200519 as it is: Taking the endorsed Rel-16 CRs R2-2110483 and R2-2110484 as baseline for the Rel-17 UL Tx switching coherence capability discussion?**

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| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We support to take the endorsed Rel-16 CRs as baseline for the Rel-17 UL Tx switching coherence capability discussion. |
| Qualcomm Incorporated | Agree | This is fine for now.We understand RAN1 is discussing introducing per band per BC capability for MIMO coherence in non-Tx switching case, which may have to be taken into account later. |
| OPPO | Agree |  |
| Ericsson | Agree |  |
| Huawei, HiSilicon | Agree |  |
| vivo | Agree |  |
| CATT | Agree |  |
| ZTE | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree | Fine to start from this assumption (we can take RAN1 information into account when we receive it). |
| Intel | Agree |  |
|  |  |  |

* **For Rel-17 1Tx-2Tx switching, i.e. 3CC (within 2 bands) 1Tx-2Tx switching**

RAN4 has already agreed that the Rel-16 per BC UL MIMO coherence capability for 2CC 1Tx-2Tx switching can be applied for Rel-17 3CC (within 2 bands) 1Tx-2Tx switching.

Based on RAN4 agreement, R2-2200519 and R2-2201499 give similar proposals as below.

Proposal 2 (within R2-2200519): The Rel-16 capability *uplinkTxSwitching-PUSCH-TransCoherence-r16* endorsed in RAN2#116-e can be used to report UL MIMO coherence capability for Rel-17 3CC (within 2 bands) 1Tx-2Tx switching as well.

Proposal 8 (within R2-2201499): The Rel-16 per-BC UL MIMO coherent capability introduced for 1Tx-2Tx switching between 2 uplinks applies to Rel-17 UL Tx switching between 2 bands with 3 uplinks.

An example of TP for TS 38.306 based on the endorsed CR R2-2110483 is given below:

| ***uplinkTxSwitching-PUSCH-TransCoherence-r16***Indicates support of the uplink codebook subset for the carrier(s) on the band capable of two antenna connectors for UL 1Tx-2Tx switching, when UE is configured with uplink Tx switching with parameter *uplinkTxSwitching-r16* and uplink Tx switching is triggered between last transmitted SRS and scheduled PUSCH transmission, as specified in TS 38.101-1 [2]. UE indicated support of full coherent codebook subset shall also support non-coherent codebook subset.If the field is absent, the UE capability reported in *pusch-TransCoherence* is applied when the uplink switching is triggered between last transmitted SRS and scheduled transmission. | BC | No | N/A | FR1 only |
| --- | --- | --- | --- | --- |

Companies are welcome to give comments on the above proposals for Rel-17 1Tx-2Tx switching UL MIMO coherence capability reporting.

**Q7: Do companies agree that the Rel-16 per-BC UL MIMO coherent capability introduced for 1Tx-2Tx switching between 2 uplinks applies to Rel-17 UL 1Tx-2Tx switching between 2 bands with 3 uplinks?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | Based on RAN4 LS, the Rel-16 per-BC UL MIMO coherent capability introduced for 1Tx-2Tx switching between 2 uplinks can also apply to Rel-17 UL 1Tx-2Tx switching between 2 bands with 3 uplinks. |
| Qualcomm Incorporated | Agree | We understand the change is done only in release-17. |
| OPPO | Agree |  |
| Ericsson | Agree |  |
| Huawei, HiSilicon | Agree |  |
| vivo | Agree |  |
| CATT | Agree |  |
| ZTE | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree (as Rel-17 change) | Just to be clear: The difference between Rel-16 and Rel-17 is that Rel-16 only defined 1Tx-2Tx, whereas Rel-17 has also 2Tx-2Tx so the modification is intended to clarify that the Rel-16 capability only applies for 1Tx-2Tx mode.Therefore, the change should only be done for Rel-17 specifications as the difference between 2Tx-2Tx option doesn't exist in Rel-16.  |
| Intel | Agree |  |
|  |  |  |

* **For Rel-17 2Tx-2Tx switching, i.e. 2CC and 3CC (within 2 bands) 2Tx-2Tx switching**

Based on RAN4 agreements, a new per band per BC UL MIMO coherence capability shall be introduced for Rel-17 2Tx-2Tx switching, which can be applied to both 2CC and 3CC (within 2 bands) 2Tx-2Tx switching. Considering the potential spec maintenance work in the future, R2-2200519 gives the following proposal.

Proposal 3: Introduce a new field *UplinkTxSwitchingBandParameters-v17xx* to report the UL Tx switching specific band parameters for a given band combination, which comprises of the following parameters:

- *bandIndex-r17* indicates a band on which UE supports dynamic UL Tx switching with another band in the band combination.

- *uplinkTxSwitching2T2T-PUSCH-TransCoherence-r17* is used to report UL MIMO coherence capability for Rel-17 2Tx-2Tx switching.

An example of TP for TS 38.331 is given below:

BandCombination-UplinkTxSwitch-v17xx ::= SEQUENCE {

 supportedBandPairListNR-v17xx SEQUENCE (SIZE (1..maxULTxSwitchingBandPairs)) OF ULTxSwitchingBandPair-v17xx OPTIONAL,

 uplinkTxSwitchingBandParametersList-r17 SEQUENCE (SIZE (1.. maxSimultaneousBands)) OF ULTxSwitchingBandParameters-r17 OPTIONAL

}

ULTxSwitchingBandParameters-r17 ::= SEQUENCE {

 bandIndex-r17 INTEGER(1..maxSimultaneousBands),

 uplinkTxSwitching2T2T-PUSCH-TransCoherence-r17 ENUMERATED {nonCoherent, fullCoherent} OPTIONAL

}

R2-2201499 shares similar views and gives the following proposals.

Proposal 7: Add a new per-band per BC UE capability in *BandCombination-UplinkTxSwitch* to indicate UL MIMO coherent capability specific for 2Tx-2Tx switching.

Proposal 9: The Rel-17 per-band per-BC UL MIMO coherent capability applies to Rel-17 UL 2Tx-2Tx switching between 2 uplinks and switching between 2 bands with 3 uplinks.

Companies are welcome to give comments on the above proposals for Rel-17 2Tx-2Tx switching UL MIMO coherence capability reporting.

**Q8: Do companies agree to add a new per-band per BC UE capability in *BandCombination-UplinkTxSwitch* to indicate UL MIMO coherent capability specific for 2Tx-2Tx switching?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We support to add a new per-band per BC UE capability in *BandCombination-UplinkTxSwitch* to indicate UL MIMO coherent capability specific for 2Tx-2Tx switching. |
| Qualcomm Incorporated | Agree |  |
| OPPO | Agree |  |
| Ericsson | Agree, but | While generally we think the approach of relying on absence of a parameter to indicate a capability should be avoided (note that recursively now if the Rel-17 parameter is absent, the Rel-16 parameter is applicable, while if the Rel-16 parameter is also absent, then the Rel-15 one is applicable!), since this is already the baseline for Rel-16, it can be applied to Rel-17. |
| Huawei, HiSilicon | Agree | We agree with Ericsson that the general principle is UE should report capability instead of incapability. But here seems a special case that Rel-16/Rel-17 UE capability indicates the UE support a different capability for UL Tx switching, and the recurrence is to avoid duplicated signalling. |
| vivo | Agree | We agree with HW’s comment on that the case here is not to indicate a capability with an intentional absence of a parameter, but to avoid duplicated signalling for a similar capability. |
| CATT | Agree | Agree with Huawei. |
| ZTE | Agree |  |
| Nokia, Nokia Shanghai Bell | Agree |  |
| Intel | Agree |  |

**Q9: For the detail design of UL MIMO coherent capability reporting for 2Tx-2Tx switching, do companies agree P3 within R2-2200519 as it is: Introduce a new field *UplinkTxSwitchingBandParameters-v17xx* to report the UL Tx switching specific band parameters for a given band combination, which comprises of the following parameters:**

**- *bandIndex-r17* indicates a band on which UE supports dynamic UL Tx switching with another band in the band combination.**

**- *uplinkTxSwitching2T2T-PUSCH-TransCoherence-r17* is used to report UL MIMO coherence capability for Rel-17 2Tx-2Tx switching?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | We think the above proposals can correctly capture RAN4 agreements on UL MIMO coherence capability for Rel-17 2Tx-2Tx switching. |
| Qualcomm Incorporated | Not agree | ASN.1 detail requires more discussion. Given RAN1 is still discussing per band per BC capability for MIMO coherence in non-Tx switching case, it may be better to extend the *BandParameters* in *BandCombinationList*. |
| OPPO | See comment | We also see *BandParameters* is more a traditional way-out. |
| Ericsson |  | We are fine to wait for further RAN1 progress. |
| Huawei, HiSilicon | Agree | We understand RAN1 discussion only targeted at 4Tx and is supposed to not impact UL Tx switching. In this sense the capability for UL Tx switching will not be used for non-UL Tx switching case, it may be confusing to include it in the general band parameter. |
| vivo | Not agree | pending on RAN1 progress |
| CATT | Agree |  |
| ZTE |  | We are fine to wait for RAN1. |
| Nokia, Nokia Shanghai Bell | See comment | To our understanding nothing on this topic has been discussed in RAN1 (yet) in this meeting. So it would require RAN1 contribution from some company to even discuss. Hence, we expect RAN2 can get input from RAN1 earliest during February meeting. |
| Intel |  | It should be decided whether to put it in BandParameters or in the UplinkTxSwitchingBandParameters-v17xx. Ok to wait for RAN1 on the non-TX switching case |

### FFS captured in the endorsed running CR

In the endorsed running CR R2-2109225, there is one FFS on switching option reported for 2Tx-2Tx switching. R2-2201499 suggests that the FFS should be deleted from the running CR, since RAN1 already claimed the RAN1 work is completed and no new UE capability is agreed by RAN1.

Proposal 6: Remove the sentence of “FFS: whether switching option can be reported differently for 1T2T and 2T2T” from the running CR.

Companies are welcome to give comments on P6 within R2-2201499.

**Q10: Do companies agree P6 within R2-2201499 as it is: Remove the sentence of “FFS: whether switching option can be reported differently for 1T2T and 2T2T” from the running CR?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/ Not agree** | **Comments** |
| China Telecom | Agree | In our understanding, it is not necessary to introduce a new UE capability to report different switching option supported by the UE for 1Tx-2Tx and 2Tx-2Tx switching. If UE can support 2Tx-2Tx switching and Tx switching between 2 UL bands for Rel-17 Tx switching, it can easily support 1Tx-2Tx switching between 2 UL carriers for Rel-16 Tx switching for the same option.  |
| Qualcomm Incorporated | Not agree | This is still under discussion in RAN1. |
| OPPO | Disagree | Same observation as QC.Technically, based on the feedback from our RAN1 colleague, a separate reporting is preferred in OPPO view, yet finally we expect a conclusion from R1 first on this issue. |
| Ericsson | Agree, but | We agree with China Telecom, but we are also fine to wait for further discussion in RAN1. |
| Huawei, HiSilicon | Agree | We agree with China Telecom, but we can accept to wait for one more meeting to see if there would be further RAN1 discussion. |
| vivo | Agree | We agree with China Telecom. |
| CATT | Agree | Agree with Huawei, generally, we can push our progress based on the necessary RAN1 progress.  |
| ZTE | Disagree | Prefer to wait for RAN1. |
| Nokia, Nokia Shanghai Bell | Wait for RAN1 | Let's wait for RAN1 conclusion. |
| Intel | Agree | OK to wait for RAN1 |

## Any others issues

Moderator understand the R2-2201501 and R2-2200516 are resubmissions of the endorsed running CR ported on the latest version of TS 38.331 and TS 38.306.

If companies have any concerns on either contribution or any other issues, please comment in below table.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |
|  |  |

# Phase 2 Discussion

TBD…

# Conclusion

TBD…

# Reference

1. R2-2200120 LS on UL-MIMO coherence for Rel-17 Tx switching (R4-2120039; contact: China Telecom) RAN4 LS in Rel-17 NR\_RF\_FR1\_enh-Core To:RAN2 Cc:RAN1
2. R2-2200516 Running CR to TS 38.306 to support Tx switching enhancements China Telecom, Huawei, HiSilicon, Apple, CATT draftCR Rel-17 38.306 16.7.0 B NR\_RF\_FR1\_enh R2-2110424
3. R2-2200517 Draft CR to TS 38.306 on UE capability for UL-MIMO coherence for Rel-17 Tx switching China Telecom, Huawei, HiSilicon draftCR Rel-17 38.306 16.7.0 F NR\_RF\_FR1\_enh
4. R2-2200518 Draft CR to TS 38.331 on UE capability for UL-MIMO coherence for Rel-17 Tx switching China Telecom, Huawei, HiSilicon draftCR Rel-17 38.331 16.7.0 F NR\_RF\_FR1\_enh
5. R2-2200519 Discussion on UL MIMO coherence for UL Tx switching China Telecom, Huawei, HiSilicon discussion Rel-17 NR\_RF\_FR1\_enh
6. R2-2201499 Remaining issues to support R17 UL Tx switching enhancement Huawei, HiSilicon, China Telecom, CATT discussion Rel-17 NR\_RF\_FR1\_enh
7. R2-2201500 RRC configuration to support R17 UL Tx switching enhancements Huawei, HiSilicon, China Telecom, CATT draftCR Rel-17 38.331 16.7.0 NR\_RF\_FR1\_enh
8. R2-2201501 Running CR to TS38.331 to support Tx switching enhancements Huawei, HiSilicon, China Telecom, Apple, CATT draftCR Rel-17 38.331 16.7.0 B NR\_RF\_FR1\_enh R2-2109225
9. R2-2200095 LS on updated Rel-17 LTE and NR higher-layers parameter list (R1-2112977; contact: Ericsson) RAN1 LS in Rel-17 NR\_feMIMO, NR\_ext\_to\_71GHz, NR\_IIOT\_URLLC\_enh, NR\_NTN\_solutions, NR\_pos\_enh, NR\_redcap, NR\_UE\_pow\_sav\_enh, NR\_cov\_enh, NR\_IAB\_enh, NR\_SL\_enh, NR\_MBS, NR\_DSS, LTE\_NR\_DC\_enh2, NR\_RF\_FR1\_enh, NR\_SmallData\_INACTIVE, NB\_IOTenh4\_LTE\_eMTC6, LTE\_NBIOT\_eMTC\_NTN, LTE\_terr\_bcast\_bands\_part1 To:RAN2, RAN3 Cc:RAN4