**3GPP TSG-RAN4 Meeting #109 R4-2318144**

**Chicago, US, November 13 – 17, 2023**

**Agenda item:** 8.23.5

**Source:** Moderator (China Telecom)

**Title:** Topic summary for [109][138] NR\_MC\_enh\_UERF

**Document for:** Information

# Introduction

This thread discusses the UE RF aspects for Rel-18 Multi-carrier enhancements WI, including the following topics:

* Topic #1: Tx switching across 3/4 bands with single TAG
* Topic #2: Tx switching with dual TAGs

# Topic #1: Tx switching with single TAG

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318248 | Qualcomm Incorporated | Title: UE capability clarifications  Proposal: We discussed some ideas for simplification of the capabilities for the TX switching objective of MC\_enh WI. |
| R4-2318416 | Apple | Title: On the remaining issues for UL Tx switching  **Proposal #1**: Two potential options are available to address the ambiguity issue:   * ***Option #1****:* The UE can use the maximum switching period capability for each band pair between A+B+C+D and A+B+C+E. This is the Alternative #3 solution that was proposed in the original LS (R4-2137611) * ***Option #2****:* The UE declares its switching period capability for the UL band pair A+B and uses the same switching period value regardless of which higher combo it comes from (A+B+C+D or A+B+C+D). This option could be an improvement of Option #1 since the switching period for A+B may not necessary be the maximum switching period, depending on the UE implementation.   **Proposal #2:** UL Tx switching with dual-TAG should be a release independent feature from Release 18 and is not applicable for Release 16 and 17. |
| R4-2318491 | NTT DOCOMO INC. | Title: Remaining issues and UE feature list for Rel-18 Tx switching  **Observation 1: To avoid any conflict between RAN2 and RAN4, RAN4 needs to take care about the progress in RAN2 during RAN4#109.**  **Proposal 1: Take Alt 2-1. Alt3 also can be acceptable.**  **Proposal 2: RAN4#109 discusses the following table as a baseline for the UE feature list for Rel-18 multi-carrier enhancements WI.** |
| R4-2318956 | vivo | Title: [Draft] Reply LS on Response LS on determination of switching period location in frequency domain based on band priority  RAN4 thanks RAN1 for the Response LS on the determination of switching period location in the frequency domain based on band priority.  Up to now, RAN4 has defined the selection of switching period location between band/carriers by reference to RAN2 signaling, and actual transmission was assumed on each band involved in the Tx switching in the requirements. An example case (Time mask for switching between two uplink carriers) has been provided below:  The switching periods described in Figure 6.3A.3.3.2-1a and Figure 6.3A.3.3.2-1b are located in either NR carrier 1 or carrier 2 as indicated in RRC signalling *uplinkTxSwitchingPeriodLocation* [7], and the length of uplink switching period *X* is less than the value indicated by UE capability *uplinkTxSwitchingPeriod*.  If a more detailed scheme or criteria is needed, e.g. in 3/4 band cases, to confirm priorities, it is suggested to define such scheme or criteria in RAN1 spec, since it could be complicated for RAN4. |
| R4-2319032 | vivo | Title: Remaining issues for Rel-18 UL Tx switching  **Observation 1:** Choosing maximum switching period capability between different BCs for each pair may be a simpler and workable way.  **Observation 2:** The problem itself may be a corner case, and even not consider it may bring not much degradation.  **Proposal 1:** If a dedicated solution is set, choosing maximum switching period capability between different BCs for each pair.  **Proposal 2:** On determination of switching period location in frequency domain based on band priority, it is suggested to be captured into RAN1 spec rather in RAN4.  A draft reply LS was submitted separately.  **Proposal 3:** Regarding conditions for triggering switch and descriptions on determination of the length of switching period in specifications, no reply LS or RAN4 further action is needed. |
| R4-2319110 | China Telecom, Huawei, Hisilicon, CMCC, Xiaomi, China Unicom, vivo, CATT, ZTE | Title: CR for 38.101-1: Time mask for switching across three or four uplink bands  Abstract: Resubmit the CR R4-2317608 endorsed in RAN4#108bis, |
| R4-2319447 | MediaTek Inc. | Title: [NR\_MC\_enh-Core]CR for DL interruption note improvement  Abstract: This is re-submission formal CR for the endorsed draft CR R4-2315546 in RAN4#108-bis |
| R4-2319448 | MediaTek Inc. | Title: [NR\_MC\_enh-Core]Discussion on the UE feature list for MC\_enh  Abstract: In last RAN4#108-bis meeting, the LS for advanced UE capability for parallel Tx switching on four different bands and draft CR were agreed[1][2]. To complete the work item, the contribution propose UE feature list for the advanced capability |
| R4-2319507 | Huawei, HiSilicon | Title: Discussion on the length of switching period for the fallback band combinations  ***Observation 1: Normally, a UE supports the corresponding capability of parent band combination in the fallback band combination from the perspective of UE architecture, i.e., the same switching period for the band pair.***  **Observation 2: *Alt.2 with UE indicating preferred capability is not aligned with the fallback rule in RAN2.***  ***Observation 3: It is the typical solution to such ambiguity that the network informs of the exact configuration when multiple capabilities are reported.***  ***Observation 4: Alt.3 with maximum switching period for each band pair when there is ambiguity with multiple capability for fallback combination, requires too high complexity from network implementation to be feasible.***  ***Proposal 1: Considering the solutions is related to not only UE architecture and RF implementation, but also RAN2 signaling rules, we need get the feedback from RAN2 based on the LS sent in October meeting before drawing any conclusion in RAN4 in case of the violation of RAN2 fundamental signalling structures.*** |
| R4-2319906 | OPPO | Title: R18 Tx switch capability for low order band combination  **Observation 1: Current RAN2 fallback band combination capability reporting rule is that when the fallback band combination has same capability of “another band combination” then it can be skipped which doesn’t require the low band combination capability to be same as all high order band combinations’ capabilities.**  **Observation 2: The fallback band combination ambiguity issue seems only happen in the Tx switching feature and it is more like a corner case. For other features, no such issue is observed up to now.**  **Observation 3: In gNB indicate high order band combination/Tx switch period approach, UE needs to implement with many capability/configuration groups to prepare for the possible gNB indications which makes the UE implementation complexity is very high.**  **Observation 4: One problem might happen is the gNB indicated Tx switch period is smaller than UE real capability in A+B+C, which makes UE cannot complete the Tx switching considering the Tx switching period is just one of the factors in determining the RF configurations in UE design.**  **Observation 5: UE indicate Tx switch period of low order band combinations** **will be much easier with best performance and it doesn’t violate RAN2 fallback rule.**  **Observation 6: No matter gNB indication or UE reporting, both are optional features, when these optional approaches are not supported by gNB or UE then some default behavior might be needed to align the understanding between gNB and UE.**  **Proposal 1: UE is allowed not to support all the Tx switch period capabilities of high order band combinations in a low order band combination due to possible different implementation choices.**  **Proposal 2: UE can indicate the applicable Tx switch period for the low order band combination to gNB.**  **Observation 7: Use 210us as the default value is simple though performance is worst. If default behavior is let gNB to decide Tx switch period, it can give gNB scheduling freedom but only applicable to UEs which support all the parent BCs.**  **Proposal 3: When UE doesn’t indicate the applicable Tx switch period to gNB, the applicable Tx switch period is determined by gNB.** |
| R4-2320095 | ZTE Corporation | Title: Remaining issues for Tx switching  ***Proposal 1. In case the UE has different switching periods for different super band combination, the UE can report a separate band combination A+B+C with corresponding switching periods in UE capability.*** |

## Open issues summary

### Sub-topic 1-1: LS related topics

Topics are related to the LS out in last RAN4 #108bis meeting:

* R4-2317774 for Length of switching period for the fallback band combinations

and two incoming LS in this meeting:

* R4-2318016 Response LS on determination of switching period location in frequency domain based on band priority
* R4-2318010 LS on conditions for triggering switch and descriptions on determination of the length of switching period in specifications.

#### Issue 1-1-1: Length of switching period for the fallback band combinations

* **Background:** LS R4-2317774 is approved to asks RAN2 a question about signalling perspective, and does not list any solutions. Meanwhile, possible solutions proposed by companies during the discussion are captured in R4-2317761, which was not approved in RAN4#108bis. The possible solutions are listed as

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| Alt.1: Network configuration   * Alt.1-1: Network configures if ABC was a fallback of ABCD or ABCE thus UE knows from which higher order combination the switching periods are inherited from * Alt.1-2: Network configures the switching periods for band pair explicitly respecting the UE capability indication, i.e. either the [AB:35, BC:140] or [AB:140, BC:35]   Alt.2: UE reports preferred capability in addition   * Alt.2-1: UE additionally reports the switch period capability for A+B+C and override the switch period capability inherited from the parent band combination A+B+C+D or A+B+C+E. * Alt.2-2: UE additionally indicate network which switch period capability is applied, i.e. either the [A+B:35us, B+C:140us] or [A+B:140us, B+C:35us]. * Alt.2-3: UE is allowed not to support all the Tx switch period capabilities of high order band combinations in a low order band combination due to possible different implementation choices.   Alt.3: The maximum switch period capability is applied for each band pair between A+B+C+D and A+B+C+E.   * Alt 3-1: 210us is applied for each band pair between A+B+C+D and A+B+C+E. |

* **Proposals:**

**Proposal #1 (Apple)**: Two potential options are available to address the ambiguity issue:

* ***Option #1****:* The UE can use the maximum switching period capability for each band pair between A+B+C+D and A+B+C+E. This is the Alternative #3 solution that was proposed in the original LS (R4-2137611)
* ***Option #2****:* The UE declares its switching period capability for the UL band pair A+B and uses the same switching period value regardless of which higher combo it comes from (A+B+C+D or A+B+C+D). This option could be an improvement of Option #1 since the switching period for A+B may not necessary be the maximum switching period, depending on the UE implementation.

**Proposal #2 (NTT DoCoMo):** Take Alt 2-1. Alt3 also can be acceptable.

**Proposal #3 (vivo):** If a dedicated solution is set, choosing maximum switching period capability between different BCs for each pair.

**Proposal #4 (Huawei):** Considering the solutions is related to not only UE architecture and RF implementation, but also RAN2 signaling rules, we need get the feedback from RAN2 based on the LS sent in October meeting before drawing any conclusion in RAN4 in case of the violation of RAN2 fundamental signalling structures.

**Proposal #5 (OPPO):**

* ***Proposal 5-1:*** UE is allowed not to support all the Tx switch period capabilities of high order band combinations in a low order band combination due to possible different implementation choices.
* ***Proposal 5-2:*** UE can indicate the applicable Tx switch period for the low order band combination to gNB.
* ***Proposal 5-3:*** When UE doesn’t indicate the applicable Tx switch period to gNB, the applicable Tx switch period is determined by gNB.

**Proposal #6 (ZTE):** In case the UE has different switching periods for different super band combination, the UE can report a separate band combination A+B+C with corresponding switching periods in UE capability.

* **Recommended WF:**
  + TBA

OPPO: We can try proposal 5-1 and then 5-2.

Huawei: According to our analysis, we see the fallback band combination can support the capability of parent band combinations. The proposal from OPPO should be exception to the current RAN2 fall back rule. Considering we have sent LS to RAN2, we need wait for RAN2.

Ericsson: We agree that some of questions are still open. In our understanding regarding the parent band combinations, the fall back should be determined by one of parent band combinations.

NTT DOCOMO: This discussion happens in RAN2 also. But as sending the previous LS, RAN4 can continue discussion on the solutions and suggest to RAN2. We are open to discuss.

Apple: We also believe it should be addressed by RAN4. We support Option 1 from Apple (Alt.3)

OPPO: the switching period should belong to UE.

Ericsson: We have no intention to stop discussion in RAN4. Is it possible for gNB to tell UE?

Qualcomm: UE declares the configure capability and network can tell UE which one is chosen. If network is involved, then more work in RAN2 is needed.

Huawei: alt 3 is not acceptable due to big burden for network to go through all the band combinations. It is a big burden for network implementation.

OPPO: We can modify the alt 3 by changing max value to 210us.

Ericsson: UE band combinations with fallback needs to configure with consistent values.

Huawei: To OPPO, it is just one implantation. 210us is not acceptable for UE supporting 35us.

Qualcomm: we are OK with 210 proposal.

#### Issue 1-1-2: R4-2318016, Response LS on determination of switching period location in frequency domain based on band priority

* **Background:** Theincoming LS R4-2318016 captures RAN1 agreement as shown below

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| **Agreement**  Update the RAN1 agreement made at RAN1#112 meeting as below and send LS to RAN4/2 to inform the updated agreement.  *Alt.5: gNB configures priorities to each carrier/band.*   * *The gNB configures priority for each band. The UE determines the switching period location on either switching-from band(s) or switching-to band(s) that is involved in the UL Tx switching and is not with the highest priority band* among set of bands, where each band in the set satisfies the following condition:   + (for switched UL) is contained in either switching-from band(s) or switching-to band(s) (not both) with actual transmission.   + (for dual UL) is contained in either switching-from band(s) or switching-to band(s) (not both) with or without actual transmission |

* **Proposals:**

**Proposal 1 (vivo):** On determination of switching period location in frequency domain based on band priority, it is suggested to be captured into RAN1 spec rather in RAN4. A draft reply LS was submitted separately.

* **Recommended WF:**
  + **Proposal 1**

OPPO: from RAN1 LS, there is no action.

Vivo: RAN1 LS has no clear action. RAN1 is discussing the rule which is very complex. RAN4 has already had the CR. We do not need further detailed explanation.

Qualcomm: support VIVO. It is not clear what we should do for this priority.

NTT DOCOMO: support vivo.

OPPO: OK with this.

Apple: OK with this proposal to capture it in RAN1 spec.

Ericsson: Agree to capture it in RAN1 spec. We can refer to it in RAN4 spec. We want to add RAN4 has also specified the behaviour when RAN1 provides the gap …as the additional information to RAN1.

Huawei: The LS is related to specify the location of switching period. For the priority index, we have concern that RAN4 asks RAN1 to capture for the rest of part. Then the priority may be captured in the different specifications. We may ask RAN1 what RAN4 should do.

Ericsson: there is discussion in RAN1 where it should be specified. Since it is UE behaviour, RAN1 spec is the proper place. We can refer to this.

Vivo: at least we should reply what we should do.

Conclusions: There is no consensus in RAN4 to capture the agreement in RAN4 specification.

#### Issue 1-1-3: R4-2318010, LS on conditions for triggering switch and descriptions on determination of the length of switching period in specifications

* **Background:** Theincoming LS R4-2318010 captures RAN1 agreement as shown below

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| Agreement   * For the TS38.214, conditions for triggering switch and descriptions on determination of the length of switching period for different switching cases with dual uplink with more than two bands involved in one uplink TX switching,   + Alt.3: it is kept in both TS38.214 and TS38.101-1 (TS38.214 refers TS38.101-1 and vice versa)     - From RAN1 point of view, conditions for triggering switching is in TS38.214, and the length determination of switching period should be in TS38.101-1     - Send an LS to RAN4 to reflect the above in their specification |

* **Proposals:**

**Proposal 1 (vivo):** Regarding conditions for triggering switch and descriptions on determination of the length of switching period in specifications, no reply LS or RAN4 further action is needed.

* **Recommended WF:**
  + **Proposal 1**

**Agreement: Agree on proposal 1.**

### Sub-topic 1-2: UE feature list

* **Background:**

Per chairman guidance:

* Please submit one contribution per companies to the dedicated AI for feature list, i.e., AI 10, which can include the previous agreed UE capabilities and the newly proposed UE capabilities to facilitate the moderator to collect them. If the newly proposed UE capability is for closed Rel-18 WI, the technique discussion can be held under AI 10 and corresponding topic thread.
* Please submit discussion papers with details for newly proposed UE capability under the individual agenda for different WIs. The UE capabilities are expected to be discussed in details and agreed under the agenda for each WIs.
* The detailed information can be found in the meeting arrangement & guideline document. And the approach is the same as for Rel-17.

Thus, one UE capability of ***Preferred switching band pairs*** is highlighted from Media Tek, other views from companies are also captured in the following proposals

#### Issue 1-2-1: UE capability of Preferred switching band pairs

* **Proposals:**

**Proposal 1 (MTK):** In last RAN4#108-bis meeting, the LS for advanced UE capability for parallel Tx switching on four different bands and draft CR were agreed R4-2317608/9. To complete the work item, the contribution propose UE feature list for the advanced capability

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| ***Features*** | ***Index*** | ***Feature group*** | ***Components*** | ***Prerequisite feature groups*** | ***Need for the gNB to know if the feature is supported*** | ***Applicable to the capability signalling exchange between UEs (V2X WI only)”.*** | ***Consequence if the feature is not supported by the UE*** | ***Type***  ***(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)*** | ***Need of FDD/TDD differentiation*** | ***Need of FR1/FR2 differentiation*** | ***Capability interpretation for mixture of FDD/TDD and/or FR1/FR2*** | ***Note*** | ***Mandatory/Optional*** |
| ***38.***  ***NR\_MC\_enh*** | ***38-x*** | ***Preferred switching band pairs*** | ***Support the indication of UE’s preferred (switched-from, switched-to) band pairs for parallel UL transmission switching for a band combination consisting of four different bands*** | ***38-1 [Rel-18 Tx switching]*** | ***Yes*** | ***No*** | ***Network can only assume the maximum switching period*** | ***Per BC*** | ***No*** | ***FR1 only*** | ***N.A*** |  | ***Optional with capability signalling*** |

**Proposal 2 (Qualcomm):** Proposal Capabilities for switching period in four band switching case {1T,1T,0,0} to {0,0,1T,1T} could be merged to be one feature group since they are used to declare switching period for the same switching case.

* **Recommended WF:**
  + TBA

**Huawei: we can wait for RAN2 conclusion and postpone to next meeting.**

**Mediatek: the LS was agreed. Why do we need to postpone?**

#### Issue 1-2-2: On-going capabilities

**• Proposals:**

**Proposal 1 (NTT DoCoMo):** RAN4#109 discusses the following table as a baseline for the UE feature list for Rel-18 multi-carrier enhancements WI.

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| **Features** | | **Index** | | **Feature group** | | **Components** | | **Prerequisite feature groups** | | **Need for the gNB to know if the feature is supported** | | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | | **Consequence if the feature is not supported by the UE** | | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | | **Need of FDD/TDD differentiation** | | **Need of FR1/FR2 differentiation** | | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | | **Note** | | **Mandatory/Optional** |
| 38.  NR\_MC\_enh | | 38-1 | | Switching period for dynamic UL Tx switching across up to 4 bands in case of inter-band CA, SUL | | [switchingPeriodFor2T-r18 indicates the length of 2Tx-2Tx switching period. switchingPeriodFor1T-r18 indicates the length of 1Tx-2Tx switching and/or 1Tx-1Tx switching period, as specified in TS 38.101-1. n35us represents 35 us, n140us represents 140us, and so on, as specified in TS 38.101-1.] | |  | | Yes | |  | | UL Tx switching across more than 2 bands cannot be supported for the band pair in the band combination | | [Per BC, details are up to RAN2] | | No need | | Applicable only to FR1 | |  | |  | | Optional with capability signaling |
| 38.  NR\_MC\_enh | 38-2 | | Application of DL interruptions due to dynamic UL Tx switching | | [uplinkTxSwitching-DL-Interruption-r18 indicates that DL interruption on the band will occur during UL Tx switching, as specified in TS 38.133. UE is not allowed to set this field for the band combination of SUL band+TDD band, for which no DL interruption is allowed.  Field encoded as a bit map, where bit N is set to "1" if DL interruption on band N will occur during uplink Tx switching as specified in TS 38.133 [5]. The leading / leftmost bit (bit 0) corresponds to the first band of this band combination, the next bit corresponds to the second band of this band combination and so on. The capability is not applicable to the following band combinations, in which DL reception interruption is not allowed:  - TDD+TDD CA with the same UL-DL pattern] | | 38-1 | | Yes | |  | |  | | [Per BC, details are up to RAN2] | | No need | | Applicable only to FR1 | |  | |  | | Optional with capability signaling | |
| 38.  NR\_MC\_enh | 38-3 | | Switching Period for unaffected Band for Dual UL | | *[SwitchingPeriodUnaffectedBandDualUL-r18* indicates for a given band pair {band X and band Y}, whether/how the switching period is to be applied on band X, Y, Z, when a UL Tx switching is triggered from band pair {band X and band Z} to band pair {band Y and band Z}, as defined in 38.101-1. If absent for band Z, the UE is not required to transmit on any UL bands, if switching period is located on X, during the switching period reported for the band pair of band X and band Y.  - *maintainedUL-Trans-r18* indicates that if the switching period is located on band X, the UE is capable of uplink transmission on band Z and is not required to transmit on band X and Y during the switching period reported for the band pair of band X and band, as specified in 38.101-1.  -  - *periodOnULBands-r18* indicates the switching period to be applied on any UL bands as specified in 38.101-1. N35us represents 35 us, n140us represents 140us, and so on.  - Band Z corresponds to the zth entry in the *uplinkTxSwitchingPeriodUnaffectedBandDualUL-List-r18*, which includes the UL band of this band combination excluding band X and band Y listed in the same order of the band combination.] | | 38-1 | | Yes | |  | |  | | [Per BC, details are up to RAN2] | | No need | | Applicable only to FR1 | |  | |  | | Optional with capability signaling | |
| 38.  NR\_MC\_enh | 38-4 | | Additional switching Period for Dual UL | | [Indicates the UL Tx switching period for switching between a band pair and another band pair or another band, when Rel-18 UL Tx switching is configured by *uplinkTxSwitchingMoreBands-r18*. If the capability is not reported, the switching period reported in *switchingPeriodFor2T-r18* or *switchingPeriodFor1T-r18* applies, as specified in TS 38.214 and TS 38.101-1.  - *bandPairIndex1-r18*/*bandPairIndex2-r18* xx refers to the xxth band pair entry in the band pair list indicated by *ULTxSwitchingBandPair-r18.*  - *bandIndex-r18* xx refers to the xxth band entry in this band combination.  - *switchingAdditionalPeriodDualUL-r18* indicateds the length of switching period for switching between one band pair indicated by *bandPairIndex1-r18* and another band pair indicated by *bandPairIndex2-r18* or another band indicated by *bandIndex-r18.*  - n35us represents 35 us, n140us represents 140us, and so on, as specified in TS 38.101-1.  A UE supporting this feature shall also indicate the support of *dualUL* switching option for the band pair(s) indicated in *bandPairIndex1-r18*/*bandPairIndex2-r18*.] | | 38-1 | | Yes | |  | |  | | [Per BC, details are up to RAN2] | | No need | | Applicable only to FR1 | |  | |  | | Optional with capability signaling | |
| 38.  NR\_MC\_enh | 38-5 | | [Switching band pair indication approach] | | [TBD] | | 38-1 | | Yes | |  | |  | | [Per BC, details are up to RAN2] | | No need | | Applicable only to FR1 | |  | |  | | Optional with capability signaling | |

* **Proposal 2 (Huawei):**

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| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
| 38.NR\_MC\_enh | 38-1 | Dynamic Tx switching between 2 bands in 3-band or 4-band combination 1Tx-1Tx switching | Indicate the supported switching period for dynamic UL Tx switching between two bands both with one transmit antenna connectors in 3-band or 4-band band combination with inter-band UL CA or SUL |  | Yes | N/A | UE does not support Tx switching among 3 or 4 bands 1Tx-1Tx switching for inter-band UL CA and SUL band combinations | UE signals supported switching period per band pair per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Candidate value set: {35us, 140 us, 210us}  Detailed information can refer to the LS to RAN2 in R4-2303507 and R4-2310271. | Optional with capability signalling |
| 38.NR\_MC\_enh | 38-2 | Dynamic Tx switching between 2 bands in 3-band or 4-band combination 1Tx-2Tx switching | Indicate the supported switching period for dynamic UL Tx switching between one band capable of one transmit antenna connector and the other band capable of two transmit antenna connectors in 3-band or 4-band band combination with inter-band UL CA or SUL |  | Yes | N/A | UE does not support Tx switching among 3 or 4 bands 1Tx-2Tx switching for inter-band UL CA and SUL band combinations | UE signals supported switching period per band pair per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Candidate value set: {35us, 140 us, 210us}  Detailed information can refer to the LS to RAN2 in R4-2214464. | Optional with capability signalling |
| 38.NR\_MC\_enh | 38-3 | Dynamic Tx switching between 2 bands in 3-band or 4-band combination 2Tx-2Tx switching | Indicate the supported switching period for dynamic UL Tx switching between two bands both with two transmit antenna connectors in 3-band or 4-band band combination with inter-band UL CA or SUL. |  | Yes | N/A | UE does not support Tx switching among 3 or 4 bands 2Tx-2Tx switching for inter-band UL CA and SUL band combinations | UE signals supported switching period per band pair per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Candidate value set: {35us, 140 us, 210us}  Detailed information can refer to the LS to RAN2 in R4-2214464. | Optional with capability signalling |
| 38.NR\_MC\_enh | 38-4 | Continuation of uplink transmission on the band with number of Tx chain unchanged | When dynamic UL Tx switching happens between two bands both with one transmit antenna connectors, and there is another band in the band combination with number of Tx chain unchanged, this capability indicates UE support of continuation of uplink transmission on the band with number of Tx chain unchanged during the switching period of the Tx switching between other two bands  If this capability is not supported, the switching period of the two bands applies to the band with number of Tx chain unchanged. | 38-1 | Yes | N/A | The switching period of the two bands applies to the band with number of Tx chain unchanged. | Per band per band pair per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Detailed information can refer to the LS to RAN2 in R4-2303507 | Optional with capability signalling |
| 38.NR\_MC\_enh | 38-5 | Dynamic Tx switching of two band pairs among 3 bands 1Tx-1Tx switching | Indicate the switching period for dynamic UL Tx switching of two band pair in three bands all with one transmit antenna connector. | 38-1 | Yes | N/A | The switching period applied to the two band pairs in the three bands is shorter. | UE signals supported switching period per band(with the number of Tx chains unchanged) per band pair per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Candidate value set: {35us, 140 us, 210us}  Detailed information can refer to the LS to RAN2 in R4-2317610 | Optional with capability signalling |
| 38.NR\_MC\_enh | 38-6 | Dynamic Tx switching with additional period of two band pairs among 3 bands 1Tx-2Tx switching | Indicate the additional switching period for dynamic UL Tx switching of two band pair in three bands including one band with two transmit antenna connectors. | 38-2 | Yes | N/A | The switching period applied to the two band pairs in the three bands is shorter. | UE signals supported switching period per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Candidate value set: {35us, 140 us, 210us}  Detailed information can refer to the LS to RAN2 in R4-2310495 | Optional with capability signalling |
| 38.NR\_MC\_enh | 38-7 | Dynamic Tx switching of two Tx chains with additional period among 4 bands 1Tx-1Tx switching | Indicate the additional switching period for two Tx chains switching among 4 bands. | 38-1 | Yes | N/A | The switching period applied to the two band pairs in the four bands is shorter | UE signals supported switching period per band combination | N/A | Applicable only to FR1 | Support mixture of FDD/TDD | Candidate value set: {35us, 140 us, 210us}  Detailed information can refer to the LS to RAN2 in R4-2310495 | Optional with capability signalling |

* **Recommended WF:**
  + TBA

**Apple: 210us is missing in NTT DOCOMO’s proposal.**

**OPPO: what is the 38-4.**

**Huawei: one capability for coherent is missing.**

### Sub-topic 1-3: CRs

**Background:** These two CRs are resubmitted based on corresponding endorsed CRs in RAN4#108bit meeting.

#### Issue 1-3-1: R4-2319110 CR for 38.101-1: Time mask for switching across three or four uplink bands

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| --- | --- | --- |
| R4-2319110 | China Telecom, Huawei, Hisilicon, CMCC, Xiaomi, China Unicom, vivo, CATT, ZTE | Title: CR for 38.101-1: Time mask for switching across three or four uplink bands  Abstract: Resubmit the CR R4-2317608 endorsed in RAN4#108bis, |

* **Recommended WF:**
  + CR R4-2319110 is agreeable

#### Issue 1-3-2: R4-2319447 CR for DL interruption note improvement

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| --- | --- | --- |
| R4-2319447 | MediaTek Inc. | Title: [NR\_MC\_enh-Core]CR for DL interruption note improvement  Abstract: This is re-submission formal CR for the endorsed draft CR R4-2315546 in RAN4#108-bis |

* **Recommended WF:**
  + CR R4-2319447 is agreeable

### Sub-topic 1-4: LS

**Background:** The LS is related to Issue 1-1-2: R4-2318016, Response LS on determination of switching period location in frequency domain based on band priority

|  |  |  |
| --- | --- | --- |
| R4-2318956 | vivo | Title: [Draft] Reply LS on Response LS on determination of switching period location in frequency domain based on band priority  RAN4 thanks RAN1 for the Response LS on the determination of switching period location in the frequency domain based on band priority.  Up to now, RAN4 has defined the selection of switching period location between band/carriers by reference to RAN2 signaling, and actual transmission was assumed on each band involved in the Tx switching in the requirements. An example case (Time mask for switching between two uplink carriers) has been provided below:  The switching periods described in Figure 6.3A.3.3.2-1a and Figure 6.3A.3.3.2-1b are located in either NR carrier 1 or carrier 2 as indicated in RRC signalling *uplinkTxSwitchingPeriodLocation* [7], and the length of uplink switching period *X* is less than the value indicated by UE capability *uplinkTxSwitchingPeriod*.  If a more detailed scheme or criteria is needed, e.g. in 3/4 band cases, to confirm priorities, it is suggested to define such scheme or criteria in RAN1 spec, since it could be complicated for RAN4. |

* **Recommended WF:** 
  + TBA

# Topic #2: Tx switching with dual TAGs

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318416 | Apple | Title: On the remaining issues for UL Tx switching  **Proposal #1**: Two potential options are available to address the ambiguity issue:   * ***Option #1****:* The UE can use the maximum switching period capability for each band pair between A+B+C+D and A+B+C+E. This is the Alternative #3 solution that was proposed in the original LS (R4-2137611) * ***Option #2****:* The UE declares its switching period capability for the UL band pair A+B and uses the same switching period value regardless of which higher combo it comes from (A+B+C+D or A+B+C+D). This option could be an improvement of Option #1 since the switching period for A+B may not necessary be the maximum switching period, depending on the UE implementation.   **Proposal #2:** UL Tx switching with dual-TAG should be a release independent feature from Release 18 and is not applicable for Release 16 and 17. |
| R4-2318234 | Qualcomm Incorporated | Title: Release independence of DualTAG with TX switching  **Observation 1: Using two TAGs enables network to ensure better alignment of the transmissions between different UE when TX Switching is deployed**  **Observation 2: In conclusion, there are no open issues from specifications point of view to support > 1 TAG with TX switching from Rel-16**. |
| R4-2319435 | Ericsson | Title: 3-4 band switching with dual TAG  **Proposal 1: include time masks for ‘simultaneous’ switching on two band pairs complete with transient time locations for the case when the network provides a transmission gap between the last symbol on any switch-from carrier and the first symbol on any switched-to carrier longer than the maximum of the switching periods indicated for the two band pairs also for dual TAG:**  **If the UE is configured with dual TAG and not configured or scheduled with uplink transmissions for a duration of at least the maximum of the lengths of uplink switching periods indicated by UE capability [*uplinkTxSwitchingPeriodForBandPair-r18*] on any of the carriers in band X, band Y and band Z including any timing difference between the uplink carriers before the first *T0* on any switched-to carrier,**  **- the configuration of the location of the switching period and the priority of bands in the *uplinkTxSwitchingBandList* are ignored by the UE**  **- transient periods of 10 s are located at the end of the last symbol(s) configured or scheduled on the switched-from carrier(s) before any *T0* and at the start of the first symbol(s) configured or scheduled at *T0* on any switch-to carrier(s)**  **for both CA and SUL (with a NUL in a different TAG).** |
| R4-2320680 | Ericsson | Title: Implementation of two-band Tx switching with dual TAG in an earlier release  Abstract: UL Tx switching with dual TAG can be supported in earlier releases without inter-operability problems for Tx switching between two carriers/bands (no change of 38.214 and no new RRC signaling required for support of band combinations with Tx switching and dual TAG). The applicable requirements for UEs implementing Tx swtiching and dual TAG in an earlier release should be made clear. |

## Open issues summary

### Sub-topic 2-1: Tx switching with dual TAGs

#### Issue 2-1-1: Release independence

* **Proposals:**

**Proposal 1 (Apple):** UL Tx switching with dual-TAG should be a release independent feature from Release 18 and is not applicable for Release 16 and 17.

**Proposal 2 (Qualcomm):** In conclusion, there are no open issues from specifications point of view to support > 1 TAG with TX switching from Rel-16.

**Proposal 3 (Ericsson):** Requirements for Rel-16 and Rel-17 UEs for NR inter-band CA configurations with UL Tx switching and dual TAG compared to the respective Rel-16 and Rel-17 versions of TS 38.101-1 are introduced in 38307

* **Recommended WF:**
  + TBA

**Ericsson: we have provided the CR. It is possible for UE to implement two band switching with multiple TAG. This CR will tell which release requirement will be applied for the UEs.**

**Apple: Rel-16 Tx switching between 2 bands was not within the original WID. It should be for single TAG only.**

**OPPO: Dual TAG in Rel-16 and Rel-17 we follow the requirement with single TAG. Is it optional or mandatory?**

**Ericsson: this is like for other features. It is optional capability. It is possible for Rel-16 UE to implement it.**

**Qualcomm: Tx switching is based on CA capability. UE can even declare the dual TAG for UL CA.**

**Mediatek: Tx switching is involved for each release. Looking at Rel-16. Tx switching is independent feature. We should not link Tx switching to release independent at all.**

**Ericsson: Rel-16 capable device can implement Rel-16 cases.**

#### Issue 2-1-2: Time mask

* **Proposals:**

**Proposal 1 (Ericssion):** **include time masks for ‘simultaneous’ switching on two band pairs complete with transient time locations for the case when the network provides a transmission gap between the last symbol on any switch-from carrier and the first symbol on any switched-to carrier longer than the maximum of the switching periods indicated for the two band pairs also for dual TAG:**

**If the UE is configured with dual TAG and not configured or scheduled with uplink transmissions for a duration of at least the maximum of the lengths of uplink switching periods indicated by UE capability [*uplinkTxSwitchingPeriodForBandPair-r18*] on any of the carriers in band X, band Y and band Z including any timing difference between the uplink carriers before the first *T0* on any switched-to carrier,**

**- the configuration of the location of the switching period and the priority of bands in the *uplinkTxSwitchingBandList* are ignored by the UE**

**- transient periods of 10 s are located at the end of the last symbol(s) configured or scheduled on the switched-from carrier(s) before any *T0* and at the start of the first symbol(s) configured or scheduled at *T0* on any switch-to carrier(s)**

**for both CA and SUL (with a NUL in a different TAG).**

* **Recommended WF:**
  + TBA

**Agreement: agree on proposal 1.**

### Sub-topic 2-2: CR

#### Issue 2-2-1: R4-2320680 CR Implementation of two-band Tx switching with dual TAG in an earlier release

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| --- | --- | --- |
| R4-2320680 | Ericsson | Title: Implementation of two-band Tx switching with dual TAG in an earlier release  Abstract: UL Tx switching with dual TAG can be supported in earlier releases without inter-operability problems for Tx switching between two carriers/bands (no change of 38.214 and no new RRC signaling required for support of band combinations with Tx switching and dual TAG). The applicable requirements for UEs implementing Tx swtiching and dual TAG in an earlier release should be made clear. |

* **Recommended WF:** 
  + TBA