**3GPP TSG-RAN2 Meeting #110-e *R2-2005219***

**Online, , 1st Jun 2020 - 12th Jun 2020**

**Agenda Item:** **6.19.1**

**Source: China Telecom**

**Title:** **Report of [Post109bis-e][045][NR16 Other] UL TX Switching-NR\_FR1 (China Telecom)**

**Document for: Discussion and decision**

# Introduction

In RAN2#109bis-e meeting the following conclusion for UL TX Switching-NR\_FR1 was achieved via online discussion

* In configuration indicate the UL carrier pair (a carrier on one band and another carrier on the other band) for UL Tx switching.
* In configuration indicate switching period (i.e., UL interruption) in *UplinkConfig*.
* to use UE capability filter for UL Tx switching capability reporting.
* R2 assumes that in configuration, we’d have explicit indicating that which carrier is carrier1, which carrier is carrier2.
* New or existing band combination list, under which the UE capabilities associated with UL Tx switching are reported, decide next meeting

Then it was assigned an email discussion as following

* [Post109bis-e][045][R16 Other] UL TX Switching-NR\_FR1 (China Telecom)

Scope: Make progress, pave the way for desicions needed to close this issue, take into account R1 LS (and R4 LS). Proponents could provide CR variants for review.
Intended outcome: Report
Deadline: Next meeting.

There were some fundamental issues for UE capability report remained, which would be continued in this email discussion. Besides, the RAN1 LS [3] and RAN4 LS [4] would be taken into account.

Let’s split this email discussion into 2 phases:

**Phase 1**: companies to provide the comments on the discussion paper and the draft CRs; Deadline: 2020-05-18 23:59 PST;

**Phase 2**: companies to provide the comments on the summary of the discussion paper and the updated CRs; Deadline: 2020-05-20 23:59 PST;

# Discussion

There are some questions on UE capability reporting remained after the online discussion in RAN2#109bis-e:

- to use legacy BC list or introduce a new BC list for reporting UE capability

- reporting capability on single band pair or each UL band pairs per BC that supports UL Tx switching

- whether including UL MIMO aspect in the capability parameters description.

Considering the last bullet above is a correction to TS 38.306, which has no obvious impact on the overall signalling structure, we suggest discussing it after the questions impacting ASN.1 are resolved. Thus, the first two questions are list in this round discussion for now.

For UE capability reporting, the legacy BC list or a new BC list may be used. UE capability reporting signalling structure depends on this fundamental issue. Based on previous discussion, there are some clarifications proposed for introducing new BC list as below for better understanding:

* The introduced band combination list only includes the band combination(s) that support UL Tx switching, which means it is a subset of full supported BC list.
* The capability in the introduced band combination list is only supported while UL Tx switching is enabled.
* All capability parameters that could be reported per band combination are included in the introduced band combination list.
* For one particular BC supporting UL Tx switching, the UE will report capability without UL Tx switching operation (1Tx+1Tx) in the legacy BC list, while report capability with UL Tx switching operation (1Tx+2Tx) in the new BC list. The network enables UL Tx switching by sending the UL Tx switching period location configuration to UE, thus UE monitors the DCI indicating UL transmission (using 1Tx or 2Tx) for both of the UL carriers, and performs UL Tx switching following the network scheduling. The UE behaviour of monitoring scheduling DCI is the same way as we have now.

We discussed this question for two rounds and had a majority view. So the rapporteur would suggest following the majority option, i.e, introducing a new BC list, which is used in the uploaded draft CRs. But still, companies are welcome to provide CR variants for review. Drafts are expected to remove concerns on both sides.

Q1: to use legacy BC list or introduce a new BC list for reporting UE capability

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| Company | Comments/CR examples |
| OPPO | New BC list is preferred, to avoid further discussion on the backwards compatibility. |
| MediaTek | New BC list is not our original preference but acceptable. However, the proposed change in the draft CR does not follow the above description. Please see our comment in the 38.331 CR. The new UL TX Switching capability should only be included in new BC list, not in the legacy BC list. |
| CATT | We think to have a clear manner, new BC list is preferred. |
| Nokia, Nokia Shanghai Bell | Both options can work, We slightly prefer separate BC list for these as otherwise UE may need to include several fallback band combinations in the legacy list, which may increase the capability size. |
| Huawei | We agree with rapporteur’s suggestion of introducing a new BC list. Because as OPPO and Nokia mentioned, if go with the legacy BC list, we also need to discuss backwards compatibility issue and fallback issue, which makes the problem even more complicated.So we prefer new BC list, in this way, the UE capability with UL Tx switching operation can be composed and reported in the new BC list separately from the UE capability without UL Tx switching operation in legacy BC list, which avoids misalignment between NW and UE and also avoids limitation on UE implementation of this UL Tx switching feature.  |
| CMCC | We prefer to use the new BC list. |
| Apple | New BC list is acceptable if companies are concerned on how to pick which UE capabilities should be repeated for UL switching with the extension approach. |
| ZTE | We think both can work, new BC list seems simpler, we are fine with the majority. |
| Qualcomm Incorporated | New BC list looks safer. |

Based on the above comments, both options that using legacy BC list and introducing new BC list can work. All companies can accept introducing new BC list. 9companies (including the rapporteur) in 10 prefer/slightly prefer to use the new BC list.

**Proposal 1:** to introduce a new band combination list, under which the UE capabilities associated with UL Tx switching are reported.

Q2: reporting capability on single band pair or each UL band pairs per BC that supports UL Tx switching.

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| Company | Comments/CR examples |
| OPPO | We are fine to go for majority view, i.e., each UL band pair per BC that supports UL switching. |
| MediaTek | We think that the UE should report all UL band pairs that support UL TX switching in each BC. So, there may be more than one UL band pair reported in each BC. |
| CATT | We prefer each UL band pairs per BC that supports UL Tx switching. |
| Nokia, Nokia Shanghai Bell | We think this can be indicated in BC-level via a single UL band pair as outlined below:TxSwitchingCarrierPair-r16 ::= SEQUENCE { carrier1-r16 INTEGER(1..maxSimultaneousBands), carrier2-r16 INTEGER(1..maxSimultaneousBands)}Here the carrier1/2 refer to the indexes of the bands within the band combination indicating support for the UL Tx switching. |
| Huawei | We understand it clearly should be “each UL band pairs per BC that supports UL Tx switching”. One single UL pair per BC is not aligned with RAN4’s agreement “per UL band pair per BC”.  |
| CMCC | Support report capability on each UL band pairs per BC that supports UL Tx switching |
| Apple | We also feel RAN4 LS clearly indicates that it should be “each UL band pairs per BC”. If opertors have deployment requirements for multiple UL band pairs per BC, RAN2 would better support it. |
| ZTE | We also think this should be “each UL pairs per BC” level.  |
| Qualcomm Incorporated | “each UL band pair per BC” is fine. |

Based on the above comments, 9 companies (including the rapporteur) in 10 understand the capability should be reported on “each UL pairs per BC”. Apple talked about the operators’ deployment requirement. In our understanding, for example, there may be a deployment requirement that the BC has (1.8G, 2.1G, 3.5G), the UL Tx switching is supported between 1.8G and 3.5G，while the UL Tx switching is also supported between 2.1G and 3.5G.

**Proposal 2:** reporting capability on each UL band pairs per BC that supports UL Tx switching.

In RAN1 #100b-e, for uplink Tx switching the following agreements on inter-band UL CA have been reached:

For inter-band UL CA, if UE reports via capability signalling to support uplink Tx switching, UE further reports via capability signalling which option (between Option 1 and Option 2) is supported.

­        Option 1: If uplink Tx switching is configured, UE is not expected to be scheduled or configured with UL transmission on carrier 2 for case 1.

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|   | Number of **Tx chains** in WID (carrier 1 + carrier 2) | Number of **antenna ports** for UL transmission (carrier 1 + carrier 2) |
| Case 1 | 1T+1T | 1P+0P |
| Case 2 | 0T+2T | 0P+2P, 0P+1P  |

 ­        Option 2: If uplink Tx switching is configured, UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 for case 1.

O    UE can be scheduled or configured with UL transmission on either carrier 1 or carrier 2.

O    UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 simultaneously.

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|   | Number of **Tx chains** in WID (carrier 1 + carrier 2) | Number of **antenna ports** for UL transmission (carrier 1 + carrier 2) |
| Case 1 | 1T+1T | 1P+0P, 1P+1P, 0P+1P |
| Case 2 | 0T+2T | 0P+2P, 0P+1P |

RAN1 respectfully asks RAN2 to take the above information into account.

We provide an example in the uploaded draft CR. A capability ***uplinkTxSwitching-SupportedULCAOption*** is introduced to indicate which option between option1 and option2 is supported for inter-band UL CA where UE supports uplink Tx switching. Option 1 and option 2 for inter-band UL CA case are specified in TS 38.314 [5]. This capability is defined as per UE and conditional mandatory.

Q3: whether to introduce a capability as defined per UE, which reports the supported option (between option 1 or option 2, as specified in TS 38.214) in UL CA case where UE supports UL Tx switching.

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| Company | Comments/CR examples |
| OPPO | We believe it should be per-BC capability. |
| MediaTek | This is capability for simultaneous UL TX transmission while supporting the UL TX switching. Therefore, we believe that this should be reported together with the supported UL TX switching band pair (i.e. the capability is also reported per UL band pair per BC). |
| CATT | We think this capability is needed and should be per UL band pair per BC. It should be reported together with UL Tx switching related capability. |
| Nokia, Nokia Shanghai Bell | The RAN1 LS requests RAN2 to introduce a capability and the UE behaviour for these sub-options for Case 1: Option 1 seems to be that UE can only transmit single UL on either carrier 1 or carrier 2 (in switching manner: Carrier 2 has no UL unless Carrier 1 is switched to it), whereas option 2 allows UL on both carrier 1 and carrier 2. Since the UE behaviour in each seems different, so a capability is needed. This can be simply introduced as a **per-BC capability** (which is mandatory to be provided when UL TX switching is supported) as shown below: uplinkSupport-r16 ENUMERATED {switchedUL, dualUL} |
| Huawei | Our interpretation of RAN1 LS is UE capability of option1 or option2 for CA case is per-UE level. So we do not need to introduce finer granularity of reporting e.g. per-BC. However, we are also ok to see confirmation of RAN1’s feature list which will explicitly indicate per-UE/per-BC/other types. |
| CMCC | In RAN1 LS, it does not mention whether the capability is per UE or per BC explicitly. To align with other UL Tx switching capabilities, it can be reported per UL band pair per BC, together with the other UL Tx switching capabilities. Since option2 includes option1, UE needs to report whether option 1 or option 2 is supported. |
| Apple | We are fine to put it into either one among per UE, or per BC, or per band pair per BC level. We can wait a little bit for RAN1 input on UE feature list. |
| ZTE | We are fine with per-UE or per BC level, and we also think RAN1 will make decision and inform RAN2 via UE feature list.  |
| Qualcomm Incorporated | This should be clarified by RAN1. Otherwise, RAN2 can only go for the safest approach, e.g. UE capability per band pair per BC. |

For the level of this capability, there are various views including per-UE, per BC and per band pair per BC level. RAN1 has scheduled this discussion in the RAN1 meeting next week. It would be better if we wait for RAN1’s input and then discuss the signalling.

**Proposal 3:** introducing a capability which reports the supported option (between option 1 or option 2, as specified in TS 38.214) in UL CA case where UE supports UL Tx switching. The signaling is FFS based on RAN1’s latest conclusion.

In RAN4#94e, the follow agreements on DL interruption have been reached.

* The following duplex mode combinations (carrier 1 + carrier 2) do not require DL interruption:
	+ SUL+TDD
	+ TDD+TDD CA with the same UL-DL pattern
	+ TDD+TDD EN-DC with the same UL-DL pattern

In RAN4#94e-bis, the follow agreements on DL interruption related UE capability have been reached.

* Introduce UE capability to indicate DL interruption is needed for duplex mode combinations except the above combinations agreed in RAN4#94e not requiring DL interruption
* UE capability is defined as per band per band combination for each band pair supporting UL Tx switching
* For the band where DL interruption is needed, the RRM interruption requirements defined in RAN4 shall be applied
* Whether to allow DL interruption for each band combination can be discussed later in RAN4 after the signaling for DL interruption is defined.

RAN4 asks RAN2 to take into consideration above RAN4 agreements on DL interruption related UE capability in future work to introduce UE capability signaling.

DL interruption is specified in TS 38.133 [6]. As UE capability on DL interruption is defined as per band per band combination for each band pair supporting UL Tx switching, the following example may be helpful to understand this capability:

* + - For example, if one UE supports a band combination with DL bands A+B+C+D and UL bands A+B+C, and supports Tx switching between UL band A and B as well as UL band A and C (not supports Tx switching between UL band B and C), the capability for DL interruption should be reported as follows:
			* For UL band pair A and B, the UE reports whether there is interruption on each of the DL bands, i.e., DL band A, B, C and D.
			* For UL band pair A and C, the UE reports whether there is interruption on each of the DL bands, i.e., DL band A, B, C and D.

If the capabilities for switching period and DL interruption are reported only for the band pair(s) with UL Tx switching capability, the rough example is as below (the size of “SEQUENCE OF TxSwitchingCarrierPair-r16” is FFS as Q2)

BandParameters-v16xy ::= SEQUENCE {

 uplinkTxSwitchingBandPairListNR-r16 SEQUENCE OF TxSwitchingCarrierPair-r16 OPTIONAL

}

TxSwitchingCarrierPair-r16 ::= SEQUENCE {

 bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands),

 bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands),

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us},

uplinkTxSwitching-DLInterruption-r16 BIT STRING {SIZE(2..maxSimultaneousBands)} OPTIONAL

}

If the capabilities reporting for switching period and DL interruption is ergodic as similar as *srs-SwitchingTimesListNR*’s structure, the rough example is as below

BandParameters-v16xy ::= SEQUENCE {

uplinkTxSwitchingParameterList-r16 SEQUENCE {SIZE (1..maxSimultaneousBands)) OF UplinkTxSwitchingParameter-r16 OPTIONAL

}

UplinkTxSwitchingParameter-r16 ::= SEQUENCE {

uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us} OPTIONAL

uplinkTxSwitching-DLInterruption-r16 BIT STRING {SIZE(2..maxSimultaneousBands)} OPTIONAL

}

The overhead difference of the two structures is depending on the comparison of the number of band pairs with UL Tx switching capability in the BC and the number of bands in the BC. We prefer the ergodic way for its stabilization, and its overhead is limited considering the realistic bands situation.

Q4: whether to introduce a capability reporting DL interruption, which is defined as per band per band combination for each band pair supporting UL Tx switching, as the draft CR.

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| Company | Comments/CR examples |
| OPPO | Yes DL interruption indication is needed.And we agree with the example above that* + - For example, if one UE supports a band combination with DL bands A+B+C+D and UL bands A+B+C, and supports Tx switching between UL band A and B as well as UL band A and C (not supports Tx switching between UL band B and C), the capability for DL interruption should be reported as follows:
			* For UL band pair A and B, the UE reports whether there is interruption on each of the DL bands, i.e., DL band A, B, C and D.
			* For UL band pair A and C, the UE reports whether there is interruption on each of the DL bands, i.e., DL band A, B, C and D.
 |
| MediaTek | We also have the same understanding as explained by the example. In addition, we think that the R15 SRS capability reporting is too complicate and the first alternative (report only for UL band pairs, as following) is easier and more suitable for this feature.TxSwitchingCarrierPair-r16 ::= SEQUENCE { bandIndexUL1-r16 INTEGER(1..maxSimultaneousBands), bandIndexUL2-r16 INTEGER(1..maxSimultaneousBands), uplinkTxSwitchingPeriod-r16 ENUMERATED {n35us, n140us, n210us}, uplinkTxSwitching-DLInterruption-r16 BIT STRING {SIZE(2..maxSimultaneousBands)} OPTIONAL}One small question is that why uplinkTxSwitching-DLInterruption-r16 is optional? Shouldn’t the UE always include whether there is interruption for each DL band?  |
| CATT | We agree to introduce a capability reporting DL interruption. The above two alternatives are both fine for us. We slightly prefer the first alternative ‎(report only for UL band pairs), which is more clear. |
| Nokia, Nokia Shanghai Bell | Capability is needed as it’s requested by RAN4. The RAN4 LS indicated the following:*– UE capability is defined as per band per band combination for each band pair supporting UL Tx switching*It’s a bit unclear what this means, but since the text above talks about the “*band pair supporting UL TX switching*”, we assume that the DL interruption is only allowed for bands that are involved in the UL Tx switching, Therefore, it’s sufficient to just state whether there is interruption to each of those as shown below: dl-Interruption-r16 BIT STRING {SIZE(2)} OPTIONALHere the first bit refers to the band of carrier1 and the second bit to the band of carrier2, and if the field is not present, there is no interruption to either carrier. |
| Huawei | We agree to introduce UE capability to report DL interruption. And according to RAN4 LS, apart from the duplex mode combinations (carrier 1 + carrier 2) indicated in RAN4 LS, the UE should report DL interruption per band per BC given a band pair, as the example given by rapporteur as below:* + - If one UE supports a band combination with DL bands A+B+C+D and UL bands A+B+C, and supports Tx switching between UL band A and B as well as UL band A and C (not supports Tx switching between UL band B and C), the capability for DL interruption should be reported as follows:
			* For UL band pair A and B, the UE reports whether there is interruption on each of the DL bands, i.e., DL band A, B, C and D.
			* For UL band pair A and C, the UE reports whether there is interruption on each of the DL bands, i.e., DL band A, B, C and D.

For the signalling design, we prefer to use similar structure as srs-SwitchingTimesListNR, as if we go for a new structure of sequence of UL band pair, we still need to discuss some detailed signalling, e.g. number of sequence, which may also time-consuming. |
| CMCC | Yes. DL interruption capability is needed. RAN4 already agreed to introduce DL interruption capability.We agree with the provided example. DL interruption may not only happen in the DL band involved in the UL Tx switching. And if the interruption field is not present, there is no interruption on this DL bands.We are OK with both alternatives. Slightly prefer the 1st alternative. |
| Apple | We also agree with rapporteur that UE should indicate whether DL interruption is required for each band in the BC. That is to say, it should not be limited to the band in the UL band pair.Then, regarding the signaling, either one is fine as long as it well serves the purpose. |
| ZTE | We agree the example provided by the rapporteur, according to RAN4’s LS, the DL interruption should be reported per band per BC for each UL band pair. So the length of the bit string equals to the number of band entries in the BC.Regarding the capability signaling, we prefer the first alternative. |
| Qualcomm Incorporated | Rapporteur’s suggestion is OK. (Prefer the signalling as in SRS Tx switch because it is of less signalling overhead. |

There are two issues in this question:

* Is the capability reporting DL interruption defined as “per band per band combination for each band pair supporting UL Tx switching”, or is it sufficient to just state whether there is interruption to “each of the band pair supporting UL TX switching”? Majority agreed with the example where the DL interruption is defined as “per band per band combination for each band pair supporting UL Tx switching”.
* For the signaling alternatives, 4 companies prefer/slightly prefer the first alternative and 3 companies prefer/slightly prefer the second alternative. We uploaded a draft CR according to the comments, in which the first alternative is shown. It can be revised based on further comments.

**Proposal 4:** introducing a capability reporting DL interruption, which is defined as per band per band combination for each band pair supporting UL Tx switching.

Q5: Do companies have any other issues? If so, they can be provided below.

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| Company | Issues/Comments/Solutions |
| MediaTek | We would like to clarify on the configuration part. For the IE *UplinkTxSwitching-r16*. Is it going to be configured in two uplink carrier or just one UL carrier? |
| Nokia, Nokia Shanghai Bell | Without UL Tx switching, UE behaviour for “Case1” (i.e. legacy) is unchanged regardless of its capabilities. Hence, the option 1+2 UE capability must clearly indicate that this configuration is **only** applicable when UL TX switching is configured and in all other cases, UE defaults to legacy behaviour (i.e. UE behaves in the same way as in Rel-15 when not configured with UL Tx switching). We have provided an example of this in the CR draft. |
| Apple | There are several issues we would like to discuss and we will bring a contribution. Note that these discussions are mainly to clarify things and make sure UE and NW can inter-operate with each other and probably may not impact the CR.1) Whether the case 1 UE capability is needed to carry in the new UE capability container for UL switching. This is because we are not sure whether case 1 UE capability is the same as legacy UE capability without UL switching.1a) Suppose case 1 UE capability is not reported, how does UE compose its capability, e.g., 1T+2T or 0T+2T?1b) Otherwise suppose case 1 UE capability is needed (different from legacy UE capability without UL switching), should UE compose two sets of capability, e.g., 1T+1T and 0T+2T?2) Fallback BC: For the BC with UL switching, does the lower order of this BC be considered as fallback BC? Say A+B+C where B (carrie 1) and C (carrier 2) is the UL pair, seems the A+C (with 2Tx) is not a correct fallback BC. In addition, for a higher order BC without UL switching, UE should be allowed to report a lower order BC with UL switching. This is naturally logical as we can consider the UE capability in per band feature set gets higher due to UL switching.3) For RRCReconfiguration, shall the NW side provide separate set of RRC configuration for each case respectively (different from conventional way)? Or does NW side only provide one set of RRC configuration, say only case 2? If it is the latter case, we think careful consideration is required as some parameters for 2Tx is not compliant to 1Tx, such as SRS resource.  |
| CTC | For the configuration part, we think the *UplinkTxSwitching-r16* is going to be configured in two uplink carriers. In the draft 331CR, the description for *uplinkTxSwitchingCarrier* includes the sentence “Network configures one of the two uplink carriers involved in UL TX switching as carrier1 and the other as carrier2.” |

# Summary

**Proposal 1:** to introduce a new band combination list, under which the UE capabilities associated with UL Tx switching are reported.

**Proposal 2:** reporting capability on each UL band pairs per BC that supports UL Tx switching.

**Proposal 3:** introducing a capability which reports the supported option (between option 1 or option 2, as specified in TS 38.214) in UL CA case where UE supports UL Tx switching. FFS the signaling until receiving RAN1’s conclusion on the level.

**Proposal 4:** introducing a capability reporting DL interruption, which is defined as per band per band combination for each band pair supporting UL Tx switching.

# References

[1] R2-2000043(R4-1916083), LS on UE capabilities and RRC signalling on Tx switching period delay, RAN4.

[2] [R2-2002531](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_109bis-e%5CDocs%5CR2-2002531.zip), LS on UE Tx switching period delay and DL interruption (R4-2002816; contact: Apple), RAN4

[3] R1-2003072 LS on Rel-16 RAN1 UE features lists for NR

[4] R4-2005665 LS on DL interruption UE capability for UL Tx switching

[5] R1-2003148 Introduction of switched uplink operation

[6] R4-2005421 Draft CR on DL interruption Tx switching between two uplink carriers