3GPP TSG RAN WG1 #110 R1-2207764

**Toulouse, France, August 22nd – 26th, 2022**

**Agenda item: 8.17**

**Source: Moderator (China Telecom)**

**Title: FL summary of discussion on Rel-17 uplink Tx switching**

**Document for: Discussion**

# Introduction

Editor’s CRs have been approved in [1][2][3]. This contribution is a summary of the discussion on Rel-17 uplink Tx switching maintenance.

# Discussion

## Issue#1: Correction on TS 38.214

R1-2206262 points out that TS 38.214 uses the value “OneT”, whereas TS 38.331 uses the value “oneT”, and the ambiguity on the understanding of “the other carrier” in the case with three carriers. R1-2206262 proposes the following changes to TS 38.214.

|  |
| --- |
| 6.1.6.2 Uplink switching for carrier aggregation  For a UE indicating a capability for uplink switching with *BandCombination-UplinkTxSwitch* or *uplinkTxSwitchingPeriod2T2T* for a band combination, and if it is for that band combination configured with uplink carrier aggregation:  - If the UE is configured with uplink switching with parameter *uplinkTxSwitching*, when the UE is to transmit in the uplink based on DCI(s) received before or based on a higher layer configuration(s):  - When the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 1-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - When the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 2-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL', when the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on a carrier on the same band and the UE is under the operation state in which 2-port transmission cannot be supported in the same band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on another uplink carrier on another band and the UE is under the operation state in which 2-port transmission can be supported in the same band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', if the UE is configured with *uplinkTxSwitching-DualUL-TxState* set to 'oneT', when the UE is under the operation state in which 2-port transmission can be supported on one carrier on one band followed by no transmission on any carrier on the same band and 1-port transmission on another carrier on another band the UE shall consider this as if 1-port transmission was transmitted on both uplinks, otherwise the UE shall consider this as if 2-port transmission took place on the transmitting carrier.  - If *uplinkTxSwitching-2T-Mode* is configured, when the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 2-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - The UE is not expected to be scheduled or configured with uplink transmissions that result in simultaneous transmission on two antenna ports on one uplink carrier on one band, and any transmission on another uplink carrier on another band.  - In all other cases the UE is expected to transmit normally all uplink transmissions without interruptions.  < Unchanged parts are omitted > |

## 1st round discussion

Companies are encouraged to provide comments on the above CR.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | This change looks good to us. |
| Qualcomm | We are ok with OneT change and prefer keeping the second part as unchanged as don’t see the necessity. |
|  |  |

## Issue #2: Clarification on CA based SRS carrier switching

R1-2205771 mentions that regarding the CA based SRS carrier switching, clarification of the "prioritization rules" & "suspension" is needed. R1-2205771 thinks that the “suspending” and the determination and application procedure of prioritization rules are two non-overlapping functions of SRS carrier switching. Specifically, as shown in Figure 1, the prioritization rule is used to determine whether UE can transmit SRS transmission on carrier c1, while the “suspending” function is to determine the transmission on other carriers during SRS transmission on carrier c1. It means the “suspending” function is an independent function after the prioritization rule was applied. So, the specification related to the “suspending” function can be modified independently without impacting prioritization rules.

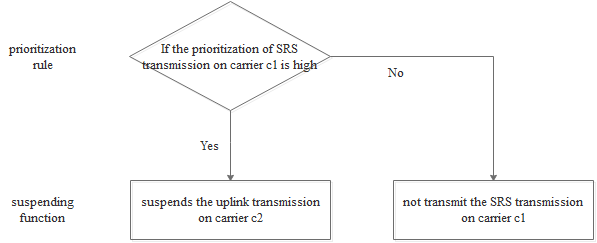


Figure 1 The relationship between the prioritization rule and the “suspending” function

R1-2205801 proposes the following changes to TS 38.214 for uplink suspension of SRS carrier switching.

|  |
| --- |
| 6.2.1.3 UE sounding procedure between component carriers **<Unchanged parts are omitted>**  A UE can be configured with SRS resource(s) on a carrier *c1* with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier *c1*, the UE is configured with higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier* the switching from carrier *c2* which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier *c1* (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR*), the UE temporarily suspends the uplink transmission on carrier *c2*, and also the uplink transmission on carrier *c3* if the UE is configured with *uplinkTxSwitching-r16* for uplink switching between uplink carrier *c2* and *c3*.  **<Unchanged parts are omitted>** |

## 1st round discussion

**FL comments:** Do you agree with the following statements? If you do not agree, please provide the reasons.

* The “suspending” and the determination and application procedure of prioritization rules are two non-overlapping functions of SRS carrier switching.
* The “suspending” function is an independent function after the prioritization rule was applied. So, the specification related to the “suspending” function can be modified independently without impacting prioritization rules.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | We agree with the intention of this CR. However, the following has been captured in the latest spec.  *For a carrier of a serving cell c1 with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, denote C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps1.jpg as the corresponding carrier of a serving cell whose UL transmissions are temporarily suspended as signalled by higher layer parameter srs-SwitchFromServCellIndex and srs-SwitchFromCarrier. Define the set C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps2.jpg as the set of carriers of serving cells that each carrier meets one of the following conditions:*  *- C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps3.jpg is in the same band and same TAG as C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps4.jpg;*  *- C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps5.jpg is a carrier of inter-band CA with C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps6.jpg and C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps7.jpg is indicated through the capability signalling ImpactedBands-SRS-CS-v17 to be affected by the SRS switch from C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps8.jpg to C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps9.jpg;*  *where C:\Users\10240317\AppData\Local\Temp\ksohtml2564\wps10.jpg.*  Thus, UE can already report the impacted bands via UE capabilities *ImpactedBands-SRS-CS-v17*. In this case, as long as UE includes carrier c3 in the impacted bands, then the issue is addressed. The only thing we need to change is the following.  *A UE can be configured with SRS resource(s) on a carrier c1 with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier c1, the UE is configured with higher layer parameter srs-SwitchFromServCellIndex and srs-SwitchFromCarrier the switching from carrier c2 which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier c1 (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters switchingTimeUL and switchingTimeDL of SRS-SwitchingTimeNR), the UE temporarily suspends the uplink transmission on carrier* ***S(****c2****)****.* |
| Qualcomm | As we commented in last several meetings, this joint feature (SRS CC switching and UL Tx switching) should at least identify below 3 issues.   * In the prioritization for SRS switching considers the state of carriers configured with UL Tx switching jointly. As an example, if SRS switching is configured between CC2 and CC3 then in the prioritization the state of CC1 also needs to be considered if CC1 and CC2 are configured with UL Tx switching. * Define requirements allowing dropping transmissions on a CC due to SRS transmission on another CC, even if this CC is not configured with SRS switching, as long as the CC is configured with UL Tx switching. * During the SRS transmission on CC3 and the interruption time caused by RF tuning, UE is not expected to be scheduled or configured with other transmission requiring UL Tx switching   The above proposal only tries to identify the second issue, while the rest two issues are not touched. To enable this joint feature, we propose to approve a whole solution. |
| Huawei, HiSilicon | OK with ZTE suggestion. A clearer version is  *“the UE temporarily suspends the uplink transmission on carriers in the set* ***S(****c2****)****.* “  @QC, regarding your bullet#1 and #3, they were agreed here to be handled in the other CR thread of SRS carrier switching. Now they have been settled with a generic solution in the other CR thread. |

Companies are encouraged to provide comments on the above CR.

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

## Issue #3: Back-to-back switching with SRS carrier switching

For Back-to-back switching with SRS carrier switching, R1-2205771 has the following proposal:

***Proposal 2:*** *For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than symbols plus the RF retuning time.*

* *In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS.*

R1-2207648 proposes the following changes to TS 38.214.

|  |
| --- |
| **< Unchanged parts are omitted >** 6.1.6 Uplink switching The UE may omit uplink transmission during the uplink switching gap if the conditions defined in this clause are met and the UE is configured with *uplinkTxSwitching*. The switching gap is indicated by UE capability *uplinkTxSwitchingPeriod2T2T* if *uplinkTxSwitching-2T-Mode* is configured, and *uplinkTxSwitchingPeriod* otherwise:  - If a UE indicated a capability for uplink switching with *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination  - Configured with a MCG using E-UTRA radio access and with a SCG using NR radio access (EN-DC), or  - Configured with uplink carrier aggregation, or  - Configured in a serving cell with two uplink carriers with higher layer parameter *supplementaryUplink*.  the conditions under which the switching gap may be present and the location of the switching gap are defined for each of the cases in clauses 6.1.6.1, 6.1.6.2, and 6.1.6.3 respectively.  If an uplink switching is triggered for an uplink transmission starting at *T0*, after *T0-Toffset*, the UE is not expected to cancel the uplink switching, or to trigger any other new uplink switching occurring before *T0* for any other uplink transmission that is scheduled after *T0-Toffset*, where *Toffset* is the UE processing procedure time defined for the uplink transmission triggering the switch given in clause 5.3, clause 5.4, clause 6.2.1, clause 6.4 and in clause 9 of [6, TS 38.213].  The UE does not expect to perform more than one uplink switching in a slot with *µUL* = max(*µUL, 1, µUL, 2*), where the *µUL, 1* corresponds to the subcarrier spacing of the active UL BWP of one uplink carrier before the switching gap and the *µUL, 2* corresponds to the subcarrier spacing of the active UL BWP of the other uplink carrier after the switching gap.  If the UE is configured with *uplinkTxSwitching-r16* for uplink switching between uplink carrier *c2* and *c3*, and it is also configured with SRS resource(s) on a carrier *c1* and the switching from carrier *c2* according to sub-clause 6.2.1.3, and if an uplink transmission is scheduled on carrier *c3* after a SRS transmission on carrier *c1* and the time interval between the first symbol of the uplink transmission on carrier *c3* and the last symbol of SRS transmission on carrier *c1* is less than or equal to an interval of 13 symbols plus the RF retuning time required by the SRS transmission, then the last symbol of PDCCH scheduling the uplink transmission on carrier *c3* should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission on carrier *c1* is larger than symbols plus the RF retuning time, where the SCS for 13 symbols is the smaller SCS between carrier *c1* and *c3*.**<Unchanged parts are omitted>** |

## 1st round discussion

**FL comments:** Do you think it is a critical issue?

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | From our perspective, this enhancement is not necessary at such a late stage. |
| Qualcomm | This is intended to solve the issue when SRS carrier switching together with UL Tx switching. In the discussion paper, proponent assumes the switching could be directly from C1 to C3 which would need UE to support an additional capability. Without this additional UE capability, this proposal could not avoid the back to back switching when SRS carrier switching is configured.  We have a proposal which could solve this issue by network scheduling and work for all the UE without any additional capability.  When SRS carrier switching is configured, a maximum of 3 switches (2 for SRS and 1 for UL Tx switching) are supported in 14 consecutive symbols. |
| Huawei, HiSilicon | @ZTE, it is not a late proposal but a proposal lasts for 6 meetings and was postponed by the group in order to wait for more stable outcome from the other CR thread on SRS carrier switching.  @QC, your proposal causes too much performance degradation and limitation on application of UL Tx switching. Therefore, alternatively, the proposal here introduces another kind of scheduling restriction to get a better balance between UE complexity and performance. The proposal does not need a new UE capability because it is just additional scheduling restriction rather than a new UE behavior. The UE is still free to implement indirect switching between C1 and C3. |

Companies are encouraged to provide comments on the above CR.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | We don’t quite understand Huawei’s argument on performance degradation and how the early scheduling without additional UE capability (direct switch from CC1 to CC3) could reduce the UE complexity.  Based on Huawei’s paper, the back to back switching is still allowed as “the time interval between the first symbol of the uplink transmission on carrier *c3* and the last symbol of SRS transmission on carrier *c1* is less than or equal to an interval of 13 symbols plus the RF retuning time required by the SRS transmission”, and the proposal is just provide earlier scheduling by “larger than symbols plus the RF retuning time”. If the UE doesn’t have direct switching capability from CC1 to CC3, this is still two-step switching as CC1 -> CC2 (SRS switching back) plus CC2 -> CC3 (Tx switching). If we count the potential two other switches (UL Tx switching from CC3 to CC2 in early part of the slot and SRS switch from CC2), there would be 4 switches (CC3 -> CC2 -> CC1 -> CC3) within a short time period (14 symbols from two consecutive slots). If the UE does have direct switching capability from CC1 to CC3, UE could anyhow switch directly by implementation. We failed to see how this early scheduling could provide better or less performance degradation.  Our proposal below is to ask network to optimize the scheduling and avoiding back to back switching within 14 symbols which is possible as SRS carrier switching is agreed.  **Proposal: When SRS carrier switching is configured, a maximum of 3 switches (2 for SRS and 1 for UL Tx switching) are supported in 14 consecutive symbols.**  We understand Infra vendor’s concern on scheduling flexibility but also believe Infra vendor would not prefer “4 switches within 14 symbols” as this would largely downgrade the network performance as too many costs by switching periods. Per our understanding, approving our above proposal would not reduce network scheduling flexibility but would certainly reduce UE implementation complexity. |
|  |  |
|  |  |

## 2nd round discussion

Companies are encouraged to continue the discussion on the above CR.

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

# Proposals for online session

**Proposal 1:** Adopt the following TP to TS 38.214.

|  |
| --- |
| < Unchanged parts are omitted > 6.1.6.2 Uplink switching for carrier aggregation For a UE indicating a capability for uplink switching with *BandCombination-UplinkTxSwitch* or *uplinkTxSwitchingPeriod2T2T* for a band combination, and if it is for that band combination configured with uplink carrier aggregation:  - If the UE is configured with uplink switching with parameter *uplinkTxSwitching*, when the UE is to transmit in the uplink based on DCI(s) received before or based on a higher layer configuration(s):  - When the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 1-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - When the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 2-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL', when the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on a carrier on the same band and the UE is under the operation state in which 2-port transmission cannot be supported in the same band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on another uplink carrier on another band and the UE is under the operation state in which 2-port transmission can be supported in the same band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', if the UE is configured with *uplinkTxSwitching-DualUL-TxState* set to ‘oneT’, when the UE is under the operation state in which 2-port transmission can be supported on one carrier on one band followed by no transmission on any carrier on the same band and 1-port transmission on the other carrier on another band the UE shall consider this as if 1-port transmission was transmitted on both uplinks, otherwise the UE shall consider this as if 2-port transmission took place on the transmitting carrier.  - If *uplinkTxSwitching-2T-Mode* is configured, when the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 2-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - The UE is not expected to be scheduled or configured with uplink transmissions that result in simultaneous transmission on two antenna ports on one uplink carrier on one band, and any transmission on another uplink carrier on another band.  - In all other cases the UE is expected to transmit normally all uplink transmissions without interruptions.  < Unchanged parts are omitted > |

**Proposal 2:** Adopt the following TP to TS 38.214.

|  |
| --- |
| < Unchanged parts are omitted > 6.2.1.3 UE sounding procedure between component carriers For a carrier of a serving cell *c1* with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, denote as the corresponding carrier of a serving cell whose UL transmissions are temporarily suspended as signalled by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*. Define the set as the set of carriers of serving cells that each carrier meets one of the following conditions:  - is in the same band and same TAG as;  - is a carrier of inter-band CA with and is indicated through the capability signalling *ImpactedBands-SRS-CS-v17* to be affected by the SRS switch from to ;  where .  A UE can be configured with SRS resource(s) on a carrier *c1* with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier *c1*, the UE is configured with higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier* the switching from carrier *c2* which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier *c1* (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR*), the UE temporarily suspends the uplink transmission on carriers in the set *S(c2)*.  < Unchanged parts are omitted > |

# References

1. RP-212983, Introduction of UL Tx Switching enhancements, RAN1, RAN#94-e, 6th -17th Dec. 2021.
2. RP-220267, Rel-17 maintenance of UL Tx Switching enhancements, RAN1, RAN#95-e, 17th – 23rd Mar. 2022.
3. RP-221615, Rel-17 maintenance of UL Tx Switching enhancements, RAN1, RAN#96, June 6th -9th, 2022.
4. R1-2205771, Discussion on remaining issues for supporting Tx switching between two uplink carriers, Huawei, HiSilicon, RAN1#110, August 22nd – 26th, 2022.
5. R1-2205801, Correction on uplink suspension for CA-based SRS carrier switching, Huawei, HiSilicon, RAN1#110, August 22nd – 26th, 2022.
6. R1-2206262, Correction on UL Tx switching, OPPO, RAN1#110, August 22nd – 26th, 2022.
7. R1-2207648, Correction on back-to-back switching with SRS switching, Huawei, HiSilicon, RAN1#110, August 22nd – 26th, 2022.