**3GPP TSG RAN WG1 Meeting #107-e R1-21xxxxx**

**e-Meeting, November 11th – 19th, 2021**

**Agenda Item: 7.1**

**Source: Moderator (Huawei, HiSilicon)**

**Title: Summary of [107-e-NR-7.1CRs-04] Issue#4: Discussion on SRS carrier switching**

**Document for: Discussion and Decision**

# Introduction

This document provides a summary for the following email discussion:

[107-e-NR-7.1CRs-04] Issue#4: Discussion on SRS carrier switching by Nov 17 – Keyvan (Huawei)

As the deadline for the email discussion is Nov 11, please provide your initial views by **UTC 23:59 pm, Nov. 12.**

SRS carrier switching prioritization rules have been discussed in RAN1 #104b-e [7], RAN1 #105-e [8], and RAN1 #106-e [9]. Also, issues regarding timeline and switching back to the source carrier when multiple SRS resource sets are triggered by the same DCI were discussed in RAN1 #106-e [9]. Based on companies inputs [1]-[6], above issues will be further discussed in this document. There are other issues related to SRS carrier switching that were raised by companies in their contributions to this meeting. These issues are also provided in Section 2.5.

# Discussion

## Priority rules

Following agreements were reached in RAN1 105-e:

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| Agreement: The prioritization rules of SRS carrier switching apply to at least the source CC.* FFS : Whether the specification needs to be updated or not

 Agreement: Down select one from the following two options in RAN1#106-e meeting to determine which UL CCs other than the source CC should be used for SRS carrier switching priority rules:* Option 1: The UL CCs in the same band as the source CC
* Option 2: The UL CCs can be any carriers which result in uplink transmissions beyond the UE ’s indicated uplink carrier aggregation capability.
	+ Companies should indicate how “UE’s indicated uplink CA capability” is derived based on current ASN.1 signaling.
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Companies’ views on priority rules are provided below:

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| Company | View |
| ZTE [1] | Proposal 1: The UL CCs in the same band as the source CC should be used for SRS carrier switching priority rules. |
| Vivo [2] | Observation 1: For architecture with independent Tx chains, same transmission behavior is applicable for both option 1 and option 2.Observation 2: For architecture with shared Tx chains, two carriers, i.e. SRS on CC 2 and PUSCH/PUCCH on CC 1, will be transmitted for option 1.Observation 3: For architecture with shared Tx chains, only SRS on CC 2 will be transmitted for option 2 without clear UE capability signaling.Observation 4: For architecture with shared Tx chains, simultaneous transmission between CC 2 and CC 3 can be realized for option 2 with clear UE capability signaling.Proposal 2: For SRS carrier switching, at least support priority rule applied among UL CCs in the same band as the source CC, i.e. option 1.Proposal 3: For option 2, details on how UE can indicate uplink CA capability for SRS carrier switching should be provided, whether and how uplinkTxSwitching-r16 related signaling is used or other signaling.  |
| Intel [3]:  | Snippet from [3]: “In R1-1909020, it was explained that for SRS carrier switching collision handling, besides CA-ParametersNR, other UL CA capability parameters may also need to be considered, for example, ca-BandwidthClassUL-NR. The details could be found in [8].”Proposal 1: Support Option 2 for SRS carrier switching dropping rule, i.e., the dropping rule could be applied to any UL CC which can result in uplink transmission beyond UE's capability. |
| Qualcomm [5]: | Observation 1: Under current rules for SRS carrier switching:* The UE performs prioritization between source and target CCs. RAN1 specifications define which channel the UE SHALL drop
* For CCs other than source and target, RAN4 specifications define an interruption period during which the UE MAY skip transmission.

Proposal 1: For Rel-16, define joint prioritization rules for carriers that are in the same band as the source CC, taking as baseline the CR in R1-2103759.Observation 2: There is no explicit capability in current ASN.1 indicating that, while operating in a band combination with SRS carrier switching, the UE cannot perform simultaneous transmission in the target band and a third band (other than the source and target).Observation 3: Using an implicit method (based on a separate band combination) to determine support of simultaneous transmission during SRS CS has several issues and should be avoided.Proposal 3: RAN1 concludes that current ASN.1 does not include a capability to indicate “beyond UE’s indicated uplink CA capability”* Based on current specification, UEs not supporting simultaneous transmission in the target band and a third band (other than source and target bands) are allowed to drop transmissions in the third band (per RAN4 requirements)
* FFS: RAN1 to consider discuss the need of introducing a new UE capability for indicating simultaneous transmission while switching.
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| Huawei, HiSilicon [6] | “Observation 1” [from CR cover sheet]: Because the UE Tx RF chains are shared between the two uplinks configured with uplinkTxSwitching-r16, both uplinks are impacted and suspended by a SRS transmission on the third uplink triggered by SRS carrier switching, whose corresponding UE capability for SRS carrier switching is reported via BandCombinationList-UplinkTxSwitch.”“Observation 2” [from CR cover sheet]: The UE capability container BandCombinationList-UplinkTxSwitch is dedicated to UE feature UL Tx switching. If a UE reports a support of SRS carrier switching via BandCombinationList-UplinkTxSwitch, the UE has indicated that its UE Tx RF chains are shared between uplinks configured with UL Tx switching and uplinks configured with SRS carrier switching. Therefore, “the UE's indicated uplink carrier aggregation capability” in sub-clause 6.2.1.3 of TS 38.214 can refer to this existing UE capability for this case.“Proposal 1” [extracted from CR]: For SRS carrier switching, priority rule applies to CCs in the same band as the source CC or to CCs that, together with the source CC, are configured with *uplinkTxSwitching-r16*. In either of the cases, the CC should be in the same tag as the source CC. |

### First round of discussion:

The issue of SRS CS priority rules have been discussed for 3 RAN1 meetings without much of progress. 5 companies have discussed this issue again in this meeting. 4 of these 5 companies seem to agree that for SRS carrier switching, other than the source CC, priority rule applies at least to UL CCs in the same band [and the same TAG] as the source CC. One company, while not disagreeing with the above understanding, prefers to discuss priority rules in a more general setup. Moderator’s understanding is that such Rel-15 CR discussion cannot continue indefinitely and will eventually be stopped even if there is no conclusion. As such, Moderator would like to urge companies to consider if they can live with the following proposal 2.1.1-1 which seems to be the common denominator of all views.

***Proposal 2.1.1-1:*** *For SRS carrier switching, other than the source CC, priority rule applies at least to UL CCs in the same band and the same TAG as the source CC.*

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| Company | View |
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Other than the UL CCs in the same band [and the same TAG] as the source CC, [6] suggests that priority rule applies to CCs that, together with the source CC, are configured with *uplinkTxSwitching-r16* because UE Tx RF chains are shared between the two CCs and the UE capability for such sharing is indicated by its dedicated container *BandCombinationList-UplinkTxSwitch* which is independent of container *BandCombinationList* for normal UL-CA. In turn, [3] suggests that UL CCs which result in uplink transmissions beyond the UE ’s indicated uplink carrier aggregation capability are derived at least from *CA-ParametersNR* and *ca-BandwidthClassUL-NR* [within *BandCombinationList*] while [5] suggests that UL CCs which result in uplink transmissions beyond the UE’s indicated uplink carrier aggregation capability cannot be derived based on any current ASN.1 signaling and, therefore, RAN1 should consider discussing the need of introducing a new UE capability for indicating simultaneous transmission while switching.

Based on the above views, moderator provide the following proposal.

***Proposal 2.1.1-2:*** *For SRS carrier switching, other than the source CC, priority rule applies to UL CCs which result in uplink transmissions beyond the UE ’s indicated uplink carrier aggregation capability derived by one of the following alternatives*

*Alt 1) UL CCs that, together with the source CC, are configured with uplinkTxSwitching-r16, whose UE capability is derived from BandCombinationList-UplinkTxSwitch.*

*Alt 2) UL CCs that are derived at least from CA-ParametersNR and ca-BandwidthClassUL-NR within BandCombinationList*

*Alt 3) Other UL CCs that cannot be derived based on any current ASN.1 signaling. RAN1 should consider discussing the need of introducing a new UE capability for indicating simultaneous transmission while switching.*

Please provide your views on Proposal 2.1.1-2:

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| Company | View |
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## Suspending rules

In TS 38.214, a UE behavior about suspending rules is specified as below.

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| 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*. |

In RAN1#105-e, according to the discussion under Question 1 in summary [8], there seems to be the majority view that the suspending rules are different from prioritization rules because the former is about the UE behavior after SRS transmission is determined while the latter discusses how to determine the SRS transmission in case of any collision.

### First round of discussion:

In [6], a change to the current suspending rules in TS 38.214 is proposed for the case of UL Tx switching where the third CC is sharing UE RF chains with the carrier *c2*. If carrier *c2* is suspended because its UE RF chain is occupied by carrier *c1* for SRS carrier switching, the third CC has also no sufficient UE RF chain for any transmission and should be suspended as well:

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| Company | View |
| Huawei, HiSilicon [6] | A UE can be configured with SRS resource(s) on a carrier *d* with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier *d*, the UE is configured with higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier* the switching from carrier *s*0(*d*) which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier *d*(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*(*d*). |

In case of no collision scheduled by a gNB, an SRS transmission is determined regardless the outcome of Section 2.1, but it is still possible that after the SRS transmission determination the UE is scheduled with a late received DCI; causing some collision. In this case, suspending rules should be applied and be clarified. Similarly, for any received DCI that does not comply with the timeline, the DCI is not taken into account in the priority rules and suspending rules should be also applied.

Based on the above discussion and the discussions on priority rules in Section 2.1, moderator provide the following proposal.

***Proposal 2.2.1-1:*** *For SRS carrier switching, in addition to the source CC,*

*Alt 1) the third CC is also suspended if both the source CC and the third CC are configured with uplinkTxSwitching-r16, or if the concurrent transmission between source CC and the third CC are not expected according to at least CA-ParametersNR and ca-BandwidthClassUL-NR within BandCombinationList*

*Alt 2) the third CC is also suspended on condition that new UE capability is introduced to indicate it.*

*Alt 3) it is up to UE implementation on whether a third CC is also suspended.*

Please provide your views on Proposal 2.2.1-1:

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| Company | View |
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## Timeline

Following agreement was reached in RAN1 106-e:

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| Agreement:For a target CC, In the case that multiple SRS resource sets are triggered by the same DCI, regarding the applicable timeline(s), further discuss the following alternatives:* Alt 1) Individual timeline is applied to each triggered SRS resource set
	+ “Individual timeline” means that for each SRS resource set, the deadline to consider DCI triggering the SRS resource set or other uplink signals is applied and decision is made independently amongst the SRS resource sets.
* Alt 2) The same timeline is applied to all the triggered SRS resource sets

“Same timeline” means that the deadline to consider DCI triggering the SRS resource sets or other uplink signals is applied considering the multiple SRS resource sets as a whole so that a single decision on collision handling is made for these SRS resource sets. |

Companies’ views on timeline are provide below:

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| Company | View |
| ZTE [1] | Proposal 3: For a target CC, In the case that multiple SRS resource sets are triggered by the same DCI, regarding the applicable timeline(s), the same timeline should be applied to all the triggered SRS resource sets. |
| Vivo [2] | Proposal 5: Individual timeline may be overly optimized and we prefer same timeline applied to multiple SRS resource sets triggered by single DCI for carrier switching. |
| Intel [3] | Proposal 3: When multiple SRS resource sets for carrier switching are triggered by the same DCI, the same timeline is applied to all the triggered SRS resource sets. |
| Qualcomm [5] | Proposal 4: For the case of multiple SRS resource sets being triggered in the same CC, the current specification describes the following behavior:* UE switches back to source CC between the SRS resource sets (Alt 4)
* Individual timeline is applied to each triggered SRS resource set (Alt 1)

RAN1 to further discuss whether and how to enhance this behavior under TEI. |

### First round of discussion:

Three companies prefer that when multiple SRS resource sets for carrier switching are triggered by the same DCI, the same timeline to be applied to all the triggered SRS resource sets. One company believes that although the current specification support applying individual timeline to each triggered SRS resource set, this behavior may need to be enhanced. Given companies views, Moderator provides the following proposal:

***Proposal 2.3.1-1:*** *When multiple SRS resource sets for carrier switching are triggered by the same DCI, the same timeline is applied to all the triggered SRS resource sets.*

Please provide your views on Proposal 2.3.1-1

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| Company | View |
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## Switching to source CC

Following agreement was reached in RAN1 106-e:

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| Agreement:For a target CC, when multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behaviour on switching back to the source CC after transmitting one SRS resource set, further discuss the following alternatives:* Alt 1) The behavior depends on the UE implementation
* Alt 2) UE stays in the target CC in the period between the SRS resource sets.
* Alt 3) If the time period between the SRS resource sets is smaller than the total required RF switching time to the source CC and back to the target CC and a higher priority UL transmission and/or DL reception is not scheduled on the source CC in the time period between the two SRS resources sets, the UE stays in the target CC in the period between the SRS resource sets; otherwise, the UE switches back to the source CC after transmitting each SRS resource set.
* Alt 4) UE switches back to source CC between the SRS resource sets
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Companies views on whether or not to switch back to the source CC when multiple SRS resource sets are triggered by the same DCI are provide below:

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| Company | View |
| ZTE [1] | Proposal 2: For a target CC, when multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behavior after transmitting one SRS resource set, Support Alt 2, i.e. UE stays in the target CC in the period between the SRS resource sets. |
| Vivo [2] | Proposal 4: UE stays in the target CC or switches back to source CC in the period between the SRS resource sets is up to UE implementation when multiple SRS resource sets for carrier switching are triggered by single DCI, i.e. support Alt 1. |
| Intel [3] | Proposal 2: When multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, if the time period between the SRS resource sets is smaller than the required RF switching time, the UE stays in the target CC in the period between the SRS resource sets; otherwise, the UE switches back to the source CC after transmitting the first SRS resource set. |
| Qualcomm [5] | Proposal 4: For the case of multiple SRS resource sets being triggered in the same CC, the current specification describes the following behavior:* UE switches back to source CC between the SRS resource sets (Alt 4)
* Individual timeline is applied to each triggered SRS resource set (Alt 1)

RAN1 to further discuss whether and how to enhance this behavior under TEI. |

### First round of discussion:

When multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behavior after transmitting one SRS resource set, one company support UE to stay in the target CC in the period between the SRS resource sets (Alt 2), one company suggest to leave it to implementation (Alt 1), one company support staying on the target CC or switching back to the source CC depending on the time period between the SRS resource sets (Alt 3), and one company suggests that the current specification indicates that UE should switch back to the source CC (Alt 4), however, this behavior may be sub-optimal and can be improved.

Four companies have provided four different views about this issue. Moderator tends to agree with [5] that the current specification implies Alt 4 and this behavior may need to be enhanced. As Alt 4 is already implied in specification, supporting Alt 1 (based on implementation) does not seem to be the best way forward. However, since there is no majority view on how to enhance UE behavior, Moderator would like to provide the following conclusion and proposal:

***Conclusion 2.3.1-1:*** *When multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behavior after transmitting one SRS resource set, current specification supports Alt 4.*

Please provide your views on Conclusion 2.3.1-1.

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| Company | View |
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***Proposal 2.3.1-2:*** *Support at least one of Alt 2, Alt 3, or Alt 4 as the UE behavior after transmitting one SRS resource set for the case that multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule.*

Please provide your views on Proposal 2.3.1-2 along with your supported alternative and/or to which alternative you have a strong objection:

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| Company | View |
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## Other issues

Other issues discussed by companies are provided below:

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| Issue # | Company | View |
| Issue 1 | Vivo [2] | 1. To avoid misunderstanding in application scenario of collision handling rule, we can support the following modified version for updating the specification of 38.214.

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| 38.214 section 6.2.1.3When SRS transmission on carrier c1 is performed according to the prioritization/dropping rules in this subclause, 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. |

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| Issue 2 | Intel [3] | Observation 1: From RAN1 spec perspective, DCI 2\_3 could be used for a CC without PUSCH/PUCCH or for a CC on which SRS power control is not tied with PUSCH.* DCI 2\_3 could be configured as Type A or Type B.

Observation 2: According to RRC spec, Type A or Type B for DCI 2\_3 is only for a CC without PUSCH.Observation 3: RAN1 spec and RRC spec are not fully aligned on the configuration of DCI 2\_3.Proposal 4: RAN1 to clarify how to use DCI 2\_3 for a CC according to the current RRC spec, wherein over the CC SRS is configured with separate power control state as PUSCH. |
| Issue 3 | Samsung [4] | Observation 1: If the UE supports half-duplex TDD CA and SRS carrier switching, and if the UE should handle the directional collision and overlapping between SRS carrier switching on target CC and other UL transmission on source CC together, ambiguity of UE behavior can occur according to the application order between directional collision handling and priority check for SRS carrier switching.Proposal 1: Need discussion related to ambiguity according to the application order between directional collision handling and priority check for SRS carrier switching.Proposal 2: As a simple method to solve the ambiguity, we can consider that the application order follows the order of transmission or reception from the UE side in timeline. |

### First round of discussion:

Please provide your views on the priority of these issues. Moderator suggests that, due to the limited time, only high priority issues in this section be further discussed in this meeting. In the comment section, please also provide your views about the proposed solution by proponent for each issue. Provide alternative or modified solution if necessary.

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| **Company** | **Priority: High/Medium/Low** | **Comment** |
|  | Issue 1:Issue 2: Issue 3:  | Issue 1:Issue 2:Issue 3: |
|  | Issue 1:Issue 2: Issue 3:  | Issue 1:Issue 2:Issue 3: |

# Discussion outcome

# References

1. R1-2110965, Discussion on SRS carrier switching, ZTE
2. R1- 2111206, Discussion on SRS carrier switching, vivo
3. R1-2111474, Discussion on SRS carrier switching, Intel Corporation
4. R1-2111712, Discussion on ambiguity for SRS carrier switching, Samsung
5. R1-2112191, Discussion on SRS carrier switching, Qualcomm Incorporated
6. R1-2112413, Correction on prioritization rules of SRS carrier switching, Huawei, HiSilicon
7. [R1-2104067](file:///C%3A%5CUsers%5CK00903651%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2104067.zip) Summary of [104b-e-NR-7.1CRs-02] Correction on prioritization rules of SRS carrier switching, Moderator (Huawei, HiSilicon)
8. [R1-2106100](file:///D%3A%5CRAN1%20106-e%5CAgreements%20and%20SR%20and%20LS%20prior%20to%20106-e%5CDocs%5CR1-2106100.zip), Summary of [105-e-NR-7.1CRs-12] Issue#26 SRS carrier switching, Moderator (ZTE)
9. R1-2108320, Summary of [106-e-NR-7.1CRs-02] Issue#2: Correction on prioritization rules of SRS carrier switching, Moderator (Huawei, HiSilicon)