3GPP TSG RAN WG1 Meeting #103-e R1-200xxxx

**e-Meeting, Oct. 26th – Nov. 13th, 2020**

**Source: Moderator (ZTE)**

Title: FL summary #3 on SRS enhancements

Agenda Item: 8.1.3

Document for: Discussion and Decision

# Introduction

In RAN#86, the Rel-17 WID of further enhancements on MIMO for NR is approved [1]. In the approved WID, a particular point is about SRS enhancements in terms of flexibility, coverage and capacity, targeting both FR1 and FR2. The detailed scope of the SRS enhancement is given as follows.

*3. Enhancement on SRS, targeting both FR1 and FR2:*

* 1. *Identify and specify enhancements on aperiodic SRS triggering to facilitate more flexible triggering and/or DCI overhead/usage reduction*
	2. *Specify SRS switching for up to 8 antennas (e.g., xTyR, x = {1, 2, 4} and y = {6, 8})*
	3. *Evaluate and, if needed, specify the following mechanism(s) to enhance SRS capacity and/or coverage: SRS time bundling, increased SRS repetition, partial sounding across frequency*

The relevant agreements made in previous RAN1 meetings are given in Appendix.

In this contribution, we summarize companies’ views on the above SRS enhancements submitted to RAN1#103e [2]-[27].

# Usage/overhead reduction

After Wednesday GTW session, the only left issue is a proposed conclusion for the discussion of Rel-17 SRS enhancement.

***Proposed conclusion:***

*For the purpose of Rel-17 SRS enhancement, the following is assumed:*

*A Rel-15/16 UE that supports nT=nR antenna switching with n={1,2,4} can be configured with an n port SRS resource that is in both an SRS resource set with usage=’codebook’ and another SRS resource set with usage=’antennaSwitching’, provided that the SRS resource sets have the same time domain behavior.*

* *The existing conclusions/agreements for Rel-15/16 is unchanged.*

Let’s focus on this nTnR case. Companies are encouraged to indicate whether the proposed conclusion is acceptable, or any suggestion to refine it.

Companies’ further views are collected as follows.

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| Companies | Views |
| Nokia/NSB | We think we need to clarify that those assumptions are valid only for the discussion of SRS resource reuse for multiple purpose. And not related with any other discussion for Rel-17 enhancement. We also want to further clarify what this conclusion may mean, whether SRS resource sharing can be supported in case of nTnR without any firther specification, or we need to specify UE behavior further in Rel-17. At least we want to clarify that those issues are still open and to be discussed. Please see our proposal below: Alt1. For further clarification: *For ~~the purpose of~~ Rel-17 SRS enhancement on reuse of SRS resources for multiple purpose, the following is assumed:** *A Rel-15/16 UE that supports nT=nR antenna switching with n={1,2,4} can be configured with an n port SRS resource that is in both an SRS resource set with usage=’codebook’ and another SRS resource set with usage=’antennaSwitching’, provided that the SRS resource sets have the same time domain behavior.*
* *It is up to Rel-15/16 UE’s implementation how to apply spatial filtering, power control parameters for overlapped SRS resource.*
* *The existing conclusions/agreements for Rel-15/16 is unchanged.*

Alt2. For further clarification: *For ~~the purpose of~~ Rel-17 SRS enhancement on reuse of SRS resources for multiple purpose, the following is assumed:**A Rel-15/16 UE that supports nT=nR antenna switching with n={1,2,4} can be configured with an n port SRS resource that is in both an SRS resource set with usage=’codebook’ and another SRS resource set with usage=’antennaSwitching’, provided that the SRS resource sets have the same time domain behavior.** *The existing conclusions/agreements for Rel-15/16 is unchanged.*
* *To be decided in RAN1 #104-e whether UE behavior needs further clarification, e.g., on applying spatial filtering or power control parameters for overlapped SRS resource(s)*
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| Apple | The whole point is that some companies do not want to support SRS resource set with multiple usage, with or without this conclusion, it will not change anything. There is no need for opponent to have a divide the conquer trick like the hack proposed in this conclusionThere are three things that is fundamentally wrong in even discussing this issue. 1. It is advertising to adopt some hack in standard to solve a practical issue at the expense of at least twice the signaling. This is not consistent at all, since we introduced many enhancement in MIMO just to reduce signalling overhead, such as MACCE enhancement in BM and eType II in CSI
2. The corresponding UE behaviour is not specified in the specification. Specification allows so many possible gNB configuration. But if UE behavior is not well specified, it does not mean it can be deployed or the spec supports the corresponding feature. There is no point to discuss some NW configuration without specified UE behavior.
3. We understand some companies do not like to allow SRS resource set with multiple usage which can make the specification clean and clear, also to well define UE behavior to support a feature in a professional way. This feature is also important in the field deployment. But making this conclusion makes no progress at all, since it is a hack with unspecified UE behavior and the increased signalling overhead.
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| OPPO | We still failed to see the necessity of such conclusion. Our task to decide whether some spec enhancement is needed in Rel-17. What’s is the consequence of the proposal? I think it is that there is no spec enhancement needed for this case. Thus, we propose to have a direct a conclusion as below *In Rel-17, no specification enhancement is needed for the SRS resource sharing between antenna switching and codebook based PUSCH*I would like to clarify a bit more on our position/understanding: The current spec has allowed SRS resource sharing for different usages. Therefore, no enhancement is needed. More details are as below.**1. Spatial filtering / virtualization**The definition for antenna port in TS 38.211 is copied as below:*An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed.* Antenna ports are configured for each SRS resource. Thus, no matter an SRS resource (e.g., A) is configured in one or two SRS resource sets, port X is always the same port X of SRS resource A, port Y is always the same port Y of the SRS A. According to the antenna port definition, the UE behavior is very clear for the spatial filtering. If UE uses different spatial filters/virtulizations for the same SRS resource A when it is trigged for different sets, it violates the above definition.**2. Power control**The power control parameters are configured for SRS resource set. Thus, if SRS resource set 0 is triggered for the UE, UE should use the parameters associated with set 0 for the transmission of SRS resource A. If SRS resource set 1 is triggered for the UE, UE should use the parameters associated with set 1 for the transmission of SRS resource A. These UE behaviors are aligned with the current specification **3. Practical deployment**In the field trial and commercial deployment of NR, we see the SRS resource sharing has been used and there is no issue so far. Thus, the commercial deployment (1T2R, 1T4R, 2T4R) also confirmed that the current spec has allowed SRS resource sharing for different usages. |
| Intel | Some comments for clarification.1. Regarding spatial filtering, we think in current spec, the spatial relation is defined at SRS resource level. So, it’s clear on how to apply the spatial filter even if the SRS resource is shared among different resource sets since the spatial relation is configured per resource.2. In the FL proposal, the condition for resource sharing is ‘*provided that the SRS resource sets have the same time domain behavior*’. This may not be accurate. For aperiodic SRS, it’s ok. But for periodic/semi-persistent SRS, there is some restriction. Below is the spec text copied from 38.214 (Section 6.2.1).Slot level periodicity and slot level offset as defined by the higher layer parameters *periodicityAndOffset-p* or *periodicityAndOffset-sp* for an SRS resource of type periodic or semi-persistent, which is configured by *SRS-Resource*, and *periodicityAndOffset-p*-*r16* or *periodicityAndOffset-sp-r16* for an SRS resource of type periodic or semi-persistent, which is configured by *SRS-PosResource-r16*. The UE is not expected to be configured with SRS resources in the same SRS resource set *SRS-ResourceSet* or *SRS-PosResourceSet-r16* with different slot level periodicities. For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a slot level offset is defined by the higher layer parameter *slotOffset.* For an *SRS-PosResourceSet-r16* configured with higher layer parameter r*esourceType-r16* set to 'aperiodic', the slot level offset is defined by the higher layer parameter *slotOffset-r16* for each SRS resource.With the highlighted spec text above, if the SRS resource set #A is configured with periodicity of every 2 slots, SRS resource set #B is configured with periodicity of every 4 slots, then SRS resource sharing can’t be applied among these two resource sets.Therefore, if we are going to take the proposed conclusion, the following modification is suggested.***Proposed conclusion:****For the purpose of Rel-17 SRS enhancement, the following is assumed:**A Rel-15/16 UE that supports nT=nR antenna switching with n={1,2,4} can be configured with an n port SRS resource that is in both an SRS resource set with usage=’codebook’ and another SRS resource set with usage=’antennaSwitching’, provided that the SRS resource sets have the same time domain behavior and for periodic/semi-persistent SRS, the SRS resources in the two resource sets should be configured with the same slot level periodicity.** *The existing conclusions/agreements for Rel-15/16 is unchanged.*
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| Huawei, HiSilicon | We have no strong view on whether the conclusion is needed or not. However, we need to clarify that SRS resource sharing is already supported from Rel-15/16 as discussed before. NW is anyway allowed to configure the same SRS resource in different SRS resource sets for different usages. We are also fine for the proposal from OPPO that directly to say “No enhancements are needed in Rel-17 for SRS resource sharing for different use cases”.  |

# Further discussion in next meeting

This section is intended to give some general guidance on further discussion points in next meeting. These aspects are either relative hot discussion points in RAN1#103e without clear conclusion, or necessary components to complete the already agreed features. Companies are encouraged to share your views on these aspects in your contribution submitted to RAN1#104e.

For further discussion in next RAN1 meeting

SRS triggering flexibility enhancement

* Detailed definition of available slot
* Down-selection between Opt. 1 and Opt. 2 for reference slot
* Detailed mechanism on DCI indication of t
* Whether/how to re-purpose unused fields in DCI format 0\_1 and 0\_2, when aperiodic SRS is triggered without data and without CSI
* Whether to support group-common DCI enhancements for SRS triggering
* Whether to support specification enhancement for SRS resource reuse between the usages of nTmR antenna switching and codebook based UL, where n<m
* Whether to support relevant enhancement for indicating a subset of Tx/Rx antennas in SRS antenna switching

SRS antenna switching for up to 8Rx

* Whether 4T6R is supported in addition
* Detailed SRS resource set configuration for each xTyR in the agreed set of {1T6R, 1T8R, 2T6R, 2T8R, 4T8R}

SRS capacity and coverage enhancements

* Down-selection from Scheme 2-0 to Scheme 2-3 in Class 2, and/or Scheme 3-1 to Scheme 3-5 in Class 3

# Conclusion

# Appendix

## Previous agreements

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| **RAN1#102e****Agreement**Enhance the determination of aperiodic SRS triggering offset, with at least one of the following alternatives* + Alt 1: Delay the SRS transmission to an available slot later than the triggering offset defined in current specification, including possible re-definition of the triggering offset
	+ Alt 2: Indicate triggering offset in DCI explicitly or implicitly
	+ Alt 3: Update triggering offset in MAC CE
	+ Further consideration aspects may include the cost v.s. the total combinations PDCCH and SRS locations for gNB to choose, DCI overhead, multi-UE SRS multiplexing, CA aspect, whether to have multiple opportunities to transmit SRS, etc.

**Agreement**Study the following two alternatives in the scope to enhance at least one DCI format for aperiodic SRS triggering * + Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1 without uplink data and without CSI
	+ Alt 2: Use group-common DCI, e.g., extending DCI 2\_3 for cases other than carrier switching
	+ Further consideration aspects may include simultaneous or CC-specific SRS triggering for multiple CCs, dynamic indication of SRS frequency resources, etc..

**Agreement**For SRS overhead reduction, study reusing same resources among multiple usages, at least for “codebook” and “antenna switching”. Study aspects include* + Whether implementation approach based on legacy SRS configuration is sufficient
		- If not, and if there are benefits other than RRC overhead reduction, study further on the case that antenna switching and PUSCH have different number of Tx antennas, whether UL BWP for different SRS usages is the same or different, whether and how to ensure UE to use same virtualization, the set of applicable usages, UE implementation complexity and overhead, etc..

**Agreement**For SRS antenna switching up to 8Rx, study the configuration of {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.* + Study points may include CSI latency, performance considering aspects like insertion loss, use cases, antenna structure, UE power saving, SRS resource configuration, etc..

**Agreement**For SRS coverage/capacity enhancements, evaluate and, if needed, specify one or more from three categories based on the following definition. * + Class 1 (Time bundling): Utilize relationship among two or more occasions of one or more SRS resources in one or more slots to enable joint processing within time domain.
		- Study aspects include the issue of phase discontinuity, interruption of SRS transmission by other UL signals, etc..
	+ Class 2 (Increase repetition): Change the legacy SRS pattern in one resource and one occasion from time domain by increasing SRS symbols for repetition.
		- Study aspects include to use TD-OCC to compensate the negative impact on SRS capacity, inter-cell interference randomization, whether these SRS symbols are in one slot or consecutive slots, etc..
	+ Class 3 (Partial frequency sounding): Support more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources.
		- Study aspects include the partial frequency resources are with RB level or subcarrier level (e.g., larger comb, partial bandwidth), PAPR issue, etc..

**RAN1#103e****Agreement**A given aperiodic SRS resource set is transmitted in the (t+1)-th available slot counting from a reference slot, where t is indicated from DCI, or RRC (if only one value of t is configured in RRC), and the candidate values of t at least include 0. Adopt at least one of the following options for the reference slot.* Opt. 1: Reference slot is the slot with the triggering DCI.
* Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.
* FFS the detailed definition of “available slot” considering UE processing complexity and timeline to determine available slot, potential co-existence with collision handling, etc., e.g.,
	+ Based on only RRC configuration, “available slot” is the slot satisfying: there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set
* FFS explicit or implicit indication of t
* FFS whether updating candidate triggering offsets in MAC CE may be beneficial

**Agreement**Support at least DCI 0\_1 and 0\_2 to trigger aperiodic SRS without data and without CSI.* FFS whether/how to re-purpose the unused fields, e.g., the triggering offset(s) and the frequency resources for triggering A-SRS on one or more component carriers, SFI-index, etc.
* FFS UL/DL DCI with data for aperiodic SRS
* FFS group common DCI

**Agreement**In Rel-17 SRS coverage and capacity enhancement, support at least one scheme from Class 2 and Class 3, and deprioritize Class 1.* Note: Extensions of Rel-15/16 frequency hopping are included in Classes 2 and 3, e.g. where UE hops once per symbol within a Rel-17 SRS resource.

**Agreement**Candidate schemes for Class 2:* Scheme 2-0: Increase the number of repetition symbols in one slot
* Scheme 2-1: Inter-slot repetition on consecutive symbols or non-consecutive symbols across slots
* Scheme 2-2: Repetition with TD-OCC
* Scheme 2-3: Repetition with CS hopping

Candidate schemes for Class 3:* Scheme 3-1: RB-level partial frequency sounding
* Scheme 3-2: Subcarrier-level partial frequency sounding
* Scheme 3-3: Subband-level partial frequency sounding
* Scheme 3-4: Partial-frequency sounding schemes assisted with CSI-RS, where SRS is transmitted in a subset of RBs of the original SRS frequency resource
* Scheme 3-5: Dynamic change of SRS bandwidth with RB-level subband size scaling
* Note: Consider issues like gNB receiver complexity, PAPR, etc., with above schemes
* Note: Joint operation between Class 2 and Class 3 schemes can be considered

**Agreement**For antenna switching up to 8Rx, support SRS resource configurations for {1T6R, 1T8R, 2T6R, 2T8R, [4T6R], 4T8R}. |

# References

[1] RP-193133, New WID: Further enhancements on MIMO for NR, Samsung

[2] R1-2007544, Enhancements on SRS flexibility, coverage and capacity, FUTUREWEI

[4] R1-2007591, Discussion on SRS enhancements for Rel-17, Huawei, HiSilicon

[5] R1-2007631, Discussion on SRS Enhancements, InterDigital, Inc.

[6] R1-2007649, Further discussion on SRS enhancement, vivo

[7] R1-2007768, Enhancements on SRS flexibility, coverage and capacity, ZTE

[8] R1-2007829, On enhancements on SRS flexibility, coverage and capacity, CATT

[9] R1-2008005, Enhancements on SRS flexibility, coverage and capacity, CMCC

[10] R1-2008153, Enhancements on SRS, Samsung

[11] R1-2008222, Enhancements on SRS flexibility, coverage and capacity, OPPO

[12] R1-2008351, Considerations on SRS flexibility, coverage and capacity, Sony

[13] R1-2008443, Views on Rel-17 SRS enhancement, Apple

[14] R1-2008578, Enhancements on SRS flexibility, coverage and capacity, LG Electronics

[15] R1-2008900, Enhancements on SRS for coverage and capacity, Fraunhofer IIS, Fraunhofer HHI

[16] R1-2008908, Enhancements on SRS flexibility, coverage and capacity, Nokia, Nokia Shanghai Bell

[17] R1-2008914, Enhancements on SRS, Lenovo, Motorola Mobility

[18] R1-2008948, Discussion on SRS enhancement, NEC

[19] R1-2008959, Enhancements on SRS flexibility, coverage and capacity, MediaTek Inc.

[20] R1-2008982, Discussion on SRS enhancements, Intel Corporation

[21] R1-2009031, Discussion on SRS enhancements, Xiaomi

[22] R1-2009131, Enhancements on SRS, Sharp

[23] R1-2009146, Considerations on SRS enhancement, Spreadtrum Communications

[24] R1-2009179, Discussion on SRS enhancement, NTT DOCOMO, INC.

[25] R1-2009211, SRS Performance and Potential Enhancements, Ericsson LM

[26] R1-2009255, Enhancements on SRS flexibility, coverage and capacity, Qualcomm Incorporated

[27] R1-2009286, Discussion on enhancement of SRS in Rel. 17 further enhanced MIMO, CEWiT