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

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

**Source: Moderator (ZTE)**

Title: FL summary #2 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].

# Flexibility enhancements

## SRS triggering offset

Void.

## Flexible DCI

Void.

## Usage/overhead reduction

A number of companies discuss the issue of supporting specification solution to reuse same SRS resource(s) for multiple usages explicitly. Table 2-3 summarize their views.

Table 2-3 Summary of companies’ views on SRS resource reuse enhancement

|  |  |  |
| --- | --- | --- |
|  | Number | Companies |
| Support specification solution to reuse same SRS resource(s) for multiple usages | 12 | MediaTek (for only T=R), Intel (for only T=R, and Full power mode 2 is not enabled), Spreadtrum (Using MAC CE or DCI to indicate multiple usages), NTT DOCOMO, Ericsson, vivo, CATT (for the case that ‘codebook’ and ‘antenna switching’ has same number of Tx ports), CMCC, Apple, Nokia, NSB, CEWiT |
| Do not support or need further study | 10 | Futurewei, Huawei, HiSilicon, Qualcomm, OPPO, ZTE, Xiaomi, LG, Lenovo, MotM |

It seems more input and discussion are needed to draw conclusion for this issue.

The following proposed conclusion from Ericsson in the first-round discussion can be a good start point to move forward.

***Proposed conclusion:***

*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.*

Companies are encouraged to provide feedback on this proposed conclusion, esp. on the following questions

* Whether you can agree with the proposed conclusion
	+ If no, what the missing part is in the current specification to support such configuration
	+ If yes, whether it is sufficient to support reusing same SRS resource(s) for multiple usages based on this conclusion

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
|  | Resource sharing for different usage is supported in Rel-15 not only for the case that nTnR, but also for nTmR antenna switching and codebook based PUSCH transmission. In our understanding, the current spec is sufficient for resource sharing in general cases.*A Rel-15/16 UE that supports nTnR and nTmR 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.* |
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|  |  |

## Flexible antenna switching

Companies discuss the issue of indicating a subset of antennas to support more flexible antenna switching. Their views are summarized in the following table.

Table 2-4 Summary of companies’ views on antenna switching flexibility enhancement

|  |  |  |
| --- | --- | --- |
|  | Number | Companies |
| Support indicating a subset of Tx/Rx antennas for SRS antenna switching via MAC CE or DCI | 6 | Qualcomm, ZTE, Intel, Samsung, Lenovo, Motorola Mobility |
| Not supportive | 5 | Nokia, NSB, Huawei, HiSilicon, LG, CATT |

The following proposal for further study is proposed by FL based on companies’ comments in the first round.

***FL Proposal 4****: Study on whether and the mechanism to support indicating a subset of Tx/Rx antennas for SRS antenna switching via MAC CE or DCI.*

* *Study aspects include use cases/benefits, detailed signaling design, etc..*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| Huawei, HiSilicon | Not support. There is no special use case should introduce MAC-CE and DCI. Even in power saving case mentioned by some company, the RRC configuration is sufficient since antennas activation and de-activation need a relative long time |
|  |  |
|  |  |

# Antenna switching up to 8Rx

## Supported configurations

During the first-round email and online discussions, the only controversial part on the following FL proposal is whether 4T6R should be supported.

***FL proposal 5:*** *For antenna switching up to 8Rx, support SRS resource configurations for {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.*

* *Note: companies are encouraged to evaluate directional UE antennas*

Companies are encouraged to share your views focusing on 4T6R, esp. on potential use cases, benefit or on the other hand, issues, to support 4T6R.

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| Huawei, HiSilicon | The potential physical antennas (include switches) mapping and workable switching need to be clarified before we agree the pattern. We will be not objection when the case is clear workable in practical scenarios.**A possible revision is that:** ***FL proposal 5:*** *For antenna switching up to 8Rx, support SRS resource configurations for {1T6R, 1T8R, 2T6R, 2T8R, [4T6R], 4T8R}.** *Note: companies are encouraged to evaluate directional UE antennas*
* *Study the practical physical antenna mappings and workable switching for 4T6R, and decide whether support 4T6R in RAN1#104-e.*
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# Coverage and capacity enhancements

We have agreed to support at least one scheme from Class 2 and Class 3. The following two proposals are to collect companies’ input on candidate schemes.

***FL Proposal 6A:*** *Candidate schemes for Class 2 (Increase repetition):*

* *Scheme 2-0: Increase the number of repetition symbols in one slot*
* *Scheme 2-1: Support repetition with TD-OCC*
* *Scheme 2-2: Support repetition with CS hopping*
* *Scheme 2-3: Support inter-slot repetition on consecutive symbols or non-consecutive symbols across slots*

***FL Proposal 6B:*** *Candidate schemes for Class 3 (Partial frequency sounding):*

* *Scheme 3-1: Support RB-level partial frequency sounding*
* *Scheme 3-2: Support subcarrier-level partial frequency sounding*
* *Scheme 3-3: Support subband-level partial frequency sounding*
* *Scheme 3-4: Support partial-frequency sounding schemes assisted with CSI-RS*
* *Scheme 3-5: Support dynamic change of SRS bandwidth*
* *Note: consider the PAPR issues with above schemes*

Companies are encouraged to share your further input on the above candidate schemes, esp. on the following aspects.

* Your question for better understanding of one or more particular schemes
	+ Further, suggestions to better describe one or more particular schemes to avoid misunderstanding
* Use cases/benefits of one or more particular schemes
* Concerns about one or more particular schemes

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| Huawei, HiSilicon | Questions for Scheme 2-1: TD-OCC, is it for intra-slot? What’s the mapping of TD-OCC, is that fixed in frequency domain? How to handle the collision with other channels, such as PUCCH?Questions for Scheme 3-2: how can subcarrier-level partial frequency sounding increase SRS capacity, since larger comb will reduce the orthogonality for cyclic shift?Questions for Scheme 3-4: Is that further details after partial sounding is supported?Questions for Scheme 3-5: how can dynamic change the SRS band, introduce new DCI to indicate? |
|  |  |
|  |  |

# 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.
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# 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