[102-e-NR-5G\_V2X\_NRSL-PHYstructure-02] Email discussion/approval w.r.t. “max data rate for SL and TBS”: 2A, 3A, 3B (as in the summary) by 08/20, with potential TPs by 8/25 – Jeongho (Samsung)

This document has the following questions.

A. Max data rate definition for SL

B. 2nd SCI overhead for TBS determination

C. MCS restriction for TBS determination

# **A. Max data rate definition for SL**

This is to handle the LS from RAN2, which is found in R1-2003258. The related contributions submitted to RAN1#102-e are [vivo], [LGE], [Huawei, HiSilicon], [Samsung], [Apple], [OPPO, R1-2006001].

In TS38,306, the max data rate for NR is defined. For the max data rate for sidelink, can the existing data rate formula be reused? That is to reuse the following formula and modification:

(2)

wherein

Rmax = 948/1024

is the maximum number of supported layers by higher layer parameter.

is the maximum supported modulation order by higher layer parameter.

is the scaling factor, which is 1.

is the numerology (as defined in TS 38.211).

is the average OFDM symbol duration in a subframe for numerology , i.e. .

Note that normal cyclic prefix is assumed.

is the maximum RB allocation in bandwidth with numerology , as defined in TS 38.101-1 and TS 38.101-2, where is the UE supported maximum bandwidth for a given band.

is the overhead and takes the following values

x, for frequency range FR1 for SL

y, for frequency range FR2 for SL

The modifications from NR Uu are as below:

* The max number of layers is depending on UE capability.
* Qm is depending on UE capability.
* f is fixed as 1.
* OH is as x for FR1 and y for FR2.

Please provide the above definition for the max data rate for SL and also provide the values of x and y for OH in sidelink.

If further modification is needed, please provide the views and reason.

If other alternative is needed, please provide the views and reason.

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| **Company** | **Views** |
| Qualcomm | An important issue is how to handle data rate in the case of UL Tx and SL Tx and in the case of DL Rx and SL Rx. The simplest way to handle this is to have sidelink reception and transmission capabilities be reported per band combination, then the UE can manage data rate for the band combination. This could avoid the need to introduce an equation that incorporates these cases.  We think that the equation from Uu should be reused with only necessary changes. With this in mind, we should keep the following unchanged from Uu:   * Qm should be according to reported higher layer parameter, one that is independent from the supported modulation order, as is the case for Uu. * f should keep all 4 values {1, 0.8, 0.75, 0.4} as is the case for Uu.   The case of maximum data rate occurs when there is a single allocated PSSCH with one PSCCH in the slot, not when there is a PSCCH+PSSCH in every sub-channel in the slot. In this case, we need a separate overhead parameter for PSCCH that does not scale with bandwidth:  The bandwidth itself, should be the maximum PSSCH that can be allocated in the band, not the band size in RBs. For example, the equation should use 105 RBs instead of 106 RBs for 40 MHz BW with 30 kHz SCS:   * is the maximum number of RBs that can be allocated for a PSSCH in a resource pool inside bandwidth BW with numerology μ, where BW is the UE supported maximum bandwidth for a given band as defined in TS 38.101-1 and TS 38.101-2.   We agree that there should be a single value x for FR1 and a single value y for FR2 as proposed but think that the above points need to be addressed first before the exact values of x and y are defined. |
| Huawei, HiSilicon | Yes, the Uu formula can be re-used.  Assumptions:   * DMRS: Average value of all possible numbers of DMRS symbols in a slot * 1st-stage SCI: {Average number of PRBs over all possible PSCCH formats} / {max. number of PRBs in 40 MHz} * OH for 1st SCI = OH for 2nd SCI * PSFCH averaged over sl-PSFCH-Period * Neglect CSI-RS (max 2 RE/PRD) and PT-RS (max 5 RE/PRB)   Full calculations are in our paper (R1-2005796), and lead to the following OH values:  OH = {0.28, 0.33, 0.38, 0.49} for sl-PSFCH-Period = {0, 4, 2, 1} respectively for NCP  OH = {0.32, 0.39, 0.45, 0.57} for sl-PSFCH-Period = {0, 4, 2, 1} respectively for ECP |
| ZTE, Sanechips | Re-use Uu formula with necessary changes on value range for some parameters   * The max number of layers depends on UE capability. * Qm depends on UE capability. * f is fixed as 1. * OH is defined as a fixed value for FR1 and FR2, regardless of the PSFCH period. |
| LG Electronics | In NR Uu link, non-slot based scheduling can be used. In other words, it is assumed that more than one PDSCH or PUSCH can be TDMed in a slot. However, NR sidelink always uses slot-based scheduling. In this case, it is not necessary to use the formula for the NR Uu link.  According to TS38.306, there exists another formula for LTE in case of MR-DC as follows:  Data rate (in Mbps) =  wherein  J is the number of aggregated EUTRA component carriers in MR-DC band combination  is the total maximum number of DL-SCH transport block bits received or the total maximum number of UL-SCH transport block bits transmitted, within a 1ms TTI for j-th CC, as derived from TS36.213 [19] based on the UE supported maximum MIMO layers for the j-th CC, and based on the maximum modulation order for the j-th CC and number of PRBs based on the bandwidth of the j-th CC according to indicated UE capabilities.  As we know, LTE (except for s-TTI) only supports subframe-based scheduling. So, **we suggest to reuse this formula for LTE rather than the formula for NR Uu link**.  Regarding the assumption on the overhead to derive max TBS, it needs to remember that it is **to calculate max data rate, but not average data rate**. In other words, to calculate max TBS or data rate, **the smallest overheads shall be taken into account**.  For each parameter setting, we suggest   * maximum MIMO layers, the maximum modulation order, number of PRBs based on the bandwidth of the SL carrier according to indicated UE capabilities * the minimum PSCCH overhead, and the minimum PSSCH DMRS density of the SL carrier according to (pre)configuration(s) of resource pool(s) in the SL carrier * no 2nd SCI overhead   Next step would be whether or how to use it in physical layer. According to NR Uu link, as mentioned earlier, more than one PDSCH or PUSCH could be scheduled in a slot. At that time, the UE is not required to handle these PDSCH or PUSCH transmissions when the scheduled data rate exceeds the max data rate. In the TX perspective, a UE can transmit a single PSCCH/PSSCH in a slot, so the max data rate would not be needed. On the other hand, in the RX perspective, a UE can receive more than one PSCCH/PSSCH. In this case, the similar approach could be reused for NR sidelink. |
| NTT DOCOMO | Basically we support to reuse the Uu formula with the above presented modification. But PSCCH is not occupied with full bandwidth, hence some update is necessary.  Regarding OH, in NR-Uu, it includes any other overhead like DM-RS. The same direction should be reused. For PSFCH overhead, NR-SL can be (pre-)configured as no PSFCH resource. Therefore, the overhead could be ignored from this discussion. |
| Apple | We think the formula for NR Uu link can be reused for sidelink as well, with the following modifications:   1. J=1 since in Release 16 NR V2X, only a single sidelink carrier is supported. 2. Overhead for sidelink is 0.27. Considering the overhead from AGC symbol, GAP symbol, PSCCH, SCI stage 2 and PSSCH DMRS, we think the overhead is around 0.27. Here, we do not count PSFCH overhead since it is not always existing, depending on resource pool configuration. |
| OPPO | It is also our understanding that the Uu formula can be reused without CA as shown in FL’s equation (2) above. All of the subsequent parameter descriptions are fine with us also. Although our preference is to set the maximum supported layers to 2 and modulation order to 8 for 256QAM, it could be fine to set them based on UE’s capability.  For the OH calculation, we also agree that it is sufficient to define a single value x for FR1 and a single value y for FR2. In calculating the OH, we made the following assumptions:   * Only a single allocation of PSCCH and PSSCH in the slot * Minimum allocation of PSCCH symbols * No PSFCH is configured (assuming maximum possible data rate) * Minimum allocation of PSSCH-DMRS symbols * Minimum overhead for the 2nd stage SCI is 36 REs (based on 38.212 rate matching calculation) * Higher layer parameter sl-X-Overhead is absent in FR1 (no CSI-RS and PT-RS in FR1) and n=3 in FR2 (considering only PT-RS of 3 REs per PRB) * Maximum number of REs in a SL slot:   + FR1: 14 symbols x 12 REs/RB x 270 RBs = 45360 total REs   + FR2: 14 symbols x 12 REs/RB x 264 RBs = 44352 total REs   Given there is also one AGC symbol at the beginning and one gap symbol at the end of the slot, the total overhead should be 0.22 for FR1 and 0.238 for FR2. Detail calculations for these OH values are provided in our paper R1-2006001. |
| vivo | We are fine to reuse the NR Uu formula as the baseline, but have the following comments on the modifications:   1. In Uu, the gNB knows the and of the UE, so that it can ensure not exceeding the max data rate. But in SL, the Tx and Rx UE may not know the capability of each other, e.g., in groupcast or broadcast case. So the and should depend on the RRC parameters configured in the SL BWP. 2. In the case of more than one resource pool is configured in the SL BWP, is the maximum number of layers configured for all the resource pools, and is the maximum modulation order configured by higher layer parameter for all the resource pools. 3. We are OK to fix f as 1. 4. We are OK to define x and y, respectively for FR1 and FR2 overhead. Based on our analysis, x and y can be 2.3 and 2.8, respectively. |
| Sharp | Reuse NR Uu formula, assuming minimum PSCCH overhead and PSSCH DM-RS overhead, with no PSFCH configured in the resource pool. |
| Ericsson | We are also fine with reusing NR Uu formula with the following modifications as explained in our contributions (R1-2006442, R1-2006432 – which are not captured in the above list of contributioons):   * Maximum data rate formula should be modified considered single carrier operation. * Number of layers should be fixed to 2 (i.e. maximum layer supported in Rel. 16) * Modulation order should be fixed to 256QAM (i.e. Qm = 8) * Overhead for SL should be specified to calculate the maximum data rate for FR1 and FR2 operation, considering following assumptions: * PSCCH overhead corresponds to 2 symbols and 10 PRBs (i.e. not scaled with BW) * PSFCH resource in a slot is zero. * 2 symbols DMRS overhead in a slot, no CSI-RS and PT-RS overhead. |
| Samsung | Agree to reuse the max data rate calculation of NR Uu as much as possible.  The scaling factor = 0 can be assumed.  The max layers and the max modulation order are given by UE capability parameter.  x=y=0.21 is proposed by considering the AGC symbol and gap symbol in the end of the slot. |
| Intel | In our understanding the Uu formula can be reused with SL specific modifications.  The modifications that need to be considered are:   * Include considerations that no data is transmitted in reminder PRBs. This means based on the number of available PRBs the value of for SL available PRBs is calculated assuming the sub-channel size resulting in the minimum amount of reminder PRBs * 1st and 2nd stage PSCCH REs are independent of the number of allocated sub-channels for the case of a single PSCCH + PSSCH transmission.   We think to reflect to increase the accuracy of the maximum data rate calculation the following parameter need to be considered for the calculation of the x and y values:   * DMRS configuration with minimum time density * Configured 2nd stage PSCCH beta values (considering single PSCCH + PSSCH allocation) * Number of 1st stage PSCCH OFDM symbols (considering single PSCCH + PSSCH allocation) * No PSFCH configured   To fix the problem of an allocation independent PSCCH overhead there are two options:   * Introduce an overhead value that is bandwidth independent * Introduce bandwidth dependent overhead value   Both solutions would solve this problem. As the calculation of x and y depends on the discussions of these sidelink related maximum data rate calculation changes, we would like to wait for decisions how to deal with these problems before proposing values for x and y. |
| Futurewei | Agree with reusing the proposal of reusing the Uu formula. RAN1 needs to discuss how to determine OH |

**Summary**

Slot-based scheduling and non-slot based scheduling does not matter to determine the formula and also NR sidelink supports PSSCH having not only 13 symbols but also 6 symbols. Therefore, as Majority views, it seems NR data rate formula can be reused.

When considering the comments above, it should be discussed first what “Supported max data rate” means. In TS38.306, the statement is as “The DL and UL max data rate supported by the UE is calculated by band or band combinations supported by the UE.” As Qualcomm mentioned, it can be defined the supported max data rate can be defined based on UE capability signaling per band or per band combinations.

Then, how to consider the parameters should be discussed.

**Formula baseline**

* Alt A1-1: based on NR’s formula (based on BW, layer..) in Clause 4.1.2 of TS38.306
* Alt A1-2: based on EUTRA’s formula (based on TBS) in Clause 4.1.2 of TS38.306

**Calculation baseline**

* Alt A2-1: The supported max data rate for SL is based on UE capability per band or per band combinations.
* Alt A2-2: The supported max data rate for SL is based on (pre-)configuration of a resource pool.

**Parameter: Qm**

* Alt A3-1: between 64QAM and 256QAM (based on the existing UE capability)
* Alt A3-2: among BPSK, QPSK, …, 256QAM (based on new UE capability)

**Parameter: f**

* Alt A4-1: Fixed as 1
* Alt A4-2: Allow to report one of {1, 0.8, 0.75, 0.4}

**Parameter: OH (including PSCCH/PSFCH overhead)**

* Wait for the discussion above

**Proposal (Not consensus)**

* Take Alt A1-1 and A2-1 above.
* Further discuss Qm, f, OH value(s)

# **B. 2nd SCI overhead for TBS determination**

From the agreement in RAN1#101-e, the actual number of REs for 2nd SCI is considered for TBS determination with having the following:

- is the number of coded modulation symbols generated for 2nd-stage SCI transmission (prior to duplication for the 2nd layer, if present) according to Clause 8.4.4 of [5, TS 38.212].

A number of contributions [ZTE, Sanechips], [vivo], [CATT], [Huawei, HiSilicon], [Intel], [InterDigital], [Samsung], [Ericsson], [Apple], [Panasonic], [NTT DCM] proposed some modifications for the overhead consideration of 2nd SCI.

Please provide your views on the following alternatives:

* Alt 1. No changes
* Alt 2. Assuming the gamma as zero for the 2nd SCI
* Alt 3. Other modification(s), if any.

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| **Company** | **Views** |
| Qualcomm | We support Alt 2, but with the clarification that this is only for the purpose of TBS determination. |
| Huawei, HiSilicon | Alt. 2, clarified as being for the purpose of TBS determination.  It’s clear that the value of γ can lead to different TBS between re-transmissions, without the TX UE being able to prevent it, mainly due to PT-RS and DMRS changes, and PSFCH presence/absence. It can cause different quantization branches in the TBS calculation procedure. The TX UE does not always know the decoding success/failure of the RX UE (due to blind re-tx, and NACK-only groupcast), and this means assumptions are not always the same between TX and RX, unlike in Uu where the gNB has a precise understanding. This leads to loss of HARQ combining in sidelink, despite this not being the intention of any RAN1 agreement. |
| ZTE,Sanechips | Alt 2. |
| LG Electronics | We are supportive of Alt 1. It means that agreement on 2nd SCI overhead for TBS determination shall be kept.  First of all, Alt 2 cannot be used to ensure the same TBS if the number of REs for 2nd SCI before applying gamma is different across (re)transmissions for a TB. As we know, beta offset value could be changed across (re)transmission. To be specific, since 2nd SCI cannot enjoy HARQ combining gain, it would be too restrictive beta offset value always is fixed across (re)transmissions for a TB. Next, MCS table is originally designed to support changing only modulation order while spectral efficiency is kept constant. In a MCS table, some entries with different modulation order have the same spectral efficiency by using different coding rate. In this case, the number of REs for 2nd SCI will be different across (re)transmission. It reduces scheduling flexibility to use the same MCS entry across (re)transmissions for a TB. Next, considering upper limit of 2nd SCI mapping, DMRS pattern and PT-RS pattern needs to be fixed to keep the number of REs for 2nd SCI before applying gamma constant across (re)transmissions for a TB. However, we assume that DMRS overhead will be different across (re)transmissions, so we use average DMRS overhead for TBS determination. Next, since PT-RS pattern will be randomized based on PSCCH CRC, it is difficult to fix the PT-RS overhead across (re)transmissions.  In short, in most cases, the number of REs for 2nd SCI before applying gamma is different across (re)transmissions for a TB. In this case, **even though gamma=0 is assumed for TBS determination, the final 2nd SCI overhead is already different across (re)transmissions for a TB.**  Next, according to our analysis, **even though (re)transmissions for a TB have different value of gamma, in most cases, the value of TBS is not changed**. To be specific, for a number of combinations of DMRS pattern, PT-RS pattern, CSI-RS existence, beta offset, number of sub-channels, MCS, PSFCH indication, more than 80% cases have the same TBS across different value of gamma from 0 to 11.  At last, TBS formula is designed to ensure the same TBS between initial transmission and retransmission with different number of PRBs, with different number of symbols, different MCS, and so on. |
| Panasonic | Alt 2 for TBS determination. In addition, we propose the number of overlapped/non-overlapped PT-RS and DMRS with 2nd SCI are not taken into account and for for TBS determination. As PT-RS RE location is determined by PRB position in the frequency, the number of overlapped REs are different depending on where PSSCH is assigned in the frequency even when the number of sub-channel assignment is same between initial and retransmissions. Not only to take into account the number of subchannel but also to take into account the frequency position to determine the number of overlap between PT-RS and DMRS increases UE calculation complexity for TBS determination. |
| NTT DOCOMO | Alt 3: Assuming as fixed value  This discussion is to get the same TBS for transmissions of a TB. Even if Alt 2 is agreed, it is not achieved since is variable in the current spec. Once is fixed, γ is fixed as well. Therefore, we think that this Alt 3 is necessary instead of Alt 2. |
| Apple | Alt 2. This sidelink TBS mis-alignment between (re)transmissions issue exists. Alt 2 provides a simple fix to that issue. |
| OPPO | Alt 2 with clarification that this assumption is for TBS determination only. |
| vivo | Alt 2 is acceptable to us.  This is not the perfect one but the simplest one on the tables. We understand DCM’s comment, but fixing may require to change an existing agreement which is not preferred. |
| Ericsson | We sympathize with LG’s point of view and our priority is Alt. 1. However, if majority of the group wants to go with Alt. 2, we could be fine with it as well. |
| Samsung | Support Alt 1 or, Alt 2+Alt 3.  (Alt 3. Define the reference DMRS pattern to calculate )  If the different DMRS patterns are used for initial transmission and retransmission of a given TB, the mapping of the 2nd SCI becomes different and also becomes different.  So, despite Alt 2 (assuming gamma=0), there could be possibility to change .  So, we propose to take Alt 1 or, Alt 2+Alt 3. |
| Intel | Alt 2. In our opinion this enables more cases where the same TBS is used for initial and retransmission.  Regarding the discussion about the possibility of different DMRS pattern, beta offset, sub-channel allocation, and other configuration between transmissions of the same TB: In principle we agree that the standard allows such configuration. However, as the resulting TBS would be different, HARQ combining would not be possible for these cases. To enable the additional performance of HARQ combining a transmitter device needs to ensure that the resulting TBS is the same. |
| Futurewei | Alt. 2 for TBS determination only |

**Summary**

Majority prefers to assume gamma=0 in calculation of N^SCI,2\_RE only for TBS calculation. So, the following is proposed.

Proposal

In calculation of N^SCI,2\_RE of TBS calculation, gamma is assumed to be zero.

# **C. MCS restriction for TBS determination**

There are two contributions [Intel], [Sharp] for MCS restriction: one is proposing not to use the code point only indicating Qm, and another is proposing not to change MCS table between initial transmission and retransmission.

Please provide your views on the following alternatives:

Alt 1. No need to restrict

Alt 2. Not use the MCS code point only indicating the modulation order

Alt 3. Not change MCS table between initial transmission and retransmission.

Alt 4. Other restriction(s), if any.

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| **Company** | **Views** |
| Qualcomm | We support Alt 2; otherwise, specifications would indicate impossible UE behavior of using the unavailable target coding rate to determine SCI-2 rate-matching |
| Huawei, HiSilicon | Alt. 2.  At. 1 leaves a problem that RX UE cannot know which original transmission the re-transmission is for until after decoding the 2nd-stage SCI, and thus cannot know what the re-indicated MCS to be used is. But to decode the 2nd-stage SCI, it needs to have a priori the MCS information.  Alt. 3 imposes an avoidable restriction which is not intended by any RAN1 agreement. |
| ZTE, Sanechips | Alt 2 |
| LG Electronics | We can accept Alt 2 to avoid additional issue including 2nd SCI mapping and PT-RS density in Rel-16.  In our understanding, Alt 3 is already supported in NR Uu link. There is no need to have special handling for NR sidelink. |
| Panasonic | We support Alt 2. It is not required to mandate the same MCS between initial transmission and retransmissions like Alt 3. The soft combining is supported by Rx UE only when the same TB is indicated. |
| NTT DOCOMO | Alt 2.  To decode 2nd-stage SCI by any UE. |
| Apple | To enable the sidelink TBS derivation from each (re)transmission, it is preferred to not use the MCS code point indicating the modulation order. Hence, we support Alt. 2. |
| OPPO | Alt 2, R is not indicated by these MCS indices, 2nd SCI cannot be decoded. |
| vivo | Our understanding is that current spec already implies Alt 2 (as copied from section 8.1.3.2), **the UE cannot determine the TBS for code point only indicating Qm, which means that the UE can never use these code points according to the current spec**.  For the PSSCH assigned by SCI, if Table 5.1.3.1-2 is used and *,* or a table other than Table 5.1.3.1-2 is usedand *,* the UE shall first determine the TBS as specified below |
| Sharp | Alt 2 and Alt 3.  In our understanding, restrictions in Alt 3 and Alt 2 do not conflict, and are both necessary. Regarding LGE’s comment, unlike in NR Uu the adopted MCS table is RRC configured by the higher layer parameter *mcs-Table*, the used MCS table in NR SL is indicated dynamically via SCI. Therefore, we think it is necessary to include such a restriction. |
| Ericsson | Alt. 2. Otherwise, it leads to an error case. |
| Samsung | Alt 2 to calculate the rate matching of 2nd SCI. |
| Intel | Alt 2. |
| Futurewei | Alt 2. |

**Summary**

Majority prefers Alt 2. So, the following is proposed. The TP can be discussed after a high-level agreement.

Proposal

For NR SL, do not use the MCS code points only indicating the modulation order.

Reference

1. R1-2005292 Remaining details on physical layer structure for the sidelink FUTUREWEI
2. R1-2005307 Remaining issues of NR sidelink physical layer structure ZTE, Sanechips
3. R1-2005338 Remaining issues on physical layer structure for NR sidelink vivo
4. R1-2005646 Discussion on sidelink physical layer structure MediaTek Inc.
5. R1-2005667 Remaining issues on physical layer structure for NR sidelink CATT
6. R1-2005740 Discussion on essential corrections in physical layer structure LG Electronics
7. R1-2005761 TP on 1st symbol duplication for AGC NEC
8. R1-2005786 Remaining issues of V2X PHY layer structure Mitsubishi Electric RCE
9. R1-2005796 Remaining details of sidelink physical layer structure Huawei, HiSilicon
10. R1-2005846 Remaining opens for NR-V2X sidelink physical layer structure Intel Corporation
11. R1-2005997 Remaining issues on physical structure for NR sidelink OPPO
12. R1-2006074 Remaining issues on PHY structure for NR V2X InterDigital, Inc.
13. R1-2006099 On Physical Layer Structures for NR Sidelink Samsung
14. R1-2006254 Remaining issues for sidelink physical layer structure Spreadtrum Communications
15. R1-2006433 TPs related to PHY structures Ericsson
16. R1-2006484 On Remaining Issues of Sidelink Physical Layer Structure Apple
17. R1-2006535 Remaining issue on physical layer structure for sidelink in NR V2X Panasonic Corporation
18. R1-2006557 Remaining issues on physical layer structure for NR sidelink Sharp
19. R1-2006584 Remaining issues on sidelink physical layer structure on NR V2X ASUSTeK
20. R1-2006693 Maintenance for sidelink physical layer structure NTT DOCOMO, INC.
21. R1-2006768 Sidelink Physical Layer Structure Qualcomm Incorporated