**[104b-e-NR-5G\_V2X-04] Email discussion/approval on issue PP-1: How SL HARQ-ACK report is piggybacked on PUSCH till 4/15, with potential CRs till 4/19 – Hanbyul (LGE)**

## **1. 1st round discussion**

Q1: Which PUSCH can be used to convey SL HARQ-ACK report?

* Option 1: PUSCH with priority index 0
* Option 2: PUSCH with priority index 1
* Option 3: PUSCH with any priority index
* Option 4: Others (Please specify it).

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| Company | Answer | Comment |
| LG | Option 3 | When SL PUCCH is overlapping with PUSCH, SL HARQ-ACK on PUCCH could be simply piggybacked on the overlapping PUSCH regardless of priority index. There is no need to drop either SL PUCCH or PUSCH. |
| NTT DOCOMO | Option 3 | Agree with LGE. For example, in SL PUCCH vs Uu PUCCH, SL PUCCH can be prioritized based on the priority. Dropping SL PUCCH based only on PUSCH priority index is not aligned with the direction. |
| Vivo | Option 3 | All the options have further specification change, but only minimum change is foreseen from vivo perspective, i.e., spec. to describe how to assign priority index to PUCCH with SL HARQ. For 1st option, the priority index of SL HARQ is always 0; for 2nd option, the priority index of SL is always 1. For 3rd option, the priority index of SL HARQ can be 0/1 based on SL priority.  We select option 3, because we prefer to reuse Uu principle to piggyback UCI on PUSCH, i.e., URLLC UCI is piggyback on URLLC PUSCH, EMBB UCI is piggyback on EMBB PUSCH.   * PUSCH with priority index 0 is used to convey SL HARQ, only when the priority value of SL PUCCH is smaller than sl-PriorityThreshold-UL-URLLC * PUSCH with priority index 1 is used to convey SL HARQ, only when the priority value of SL PUCCH is larger than sl-PriorityThreshold-UL-URLLC |
| Huawei,  HiSilicon |  | It should be noted there are two cases when PUSCH overlaps with PUCCH with SL HARQ:   * Case 1: PUSCH with UL-SCH only overlaps with SL PUCCH. * Case 2: PUSCH with UCI overlaps with SL PUCCH.   For case 1, SL HARQ is multiplexed on the PUSCH anyway regardless of priority index.  However, for case 2, it is not allowed to multiplex UCI and SL HARQ in same PUSCH. In this case, if priority index or priority value is used for prioritization, gNB has no information which one is prioritized, SL HARQ or UCI, as a result make blind decoding for PUSCH by gNB. So case 2 should be avoided by gNB scheduling. |
| Intel |  | The direction described by vivo is preferred, but we think current formulation of Option 3 is not quite aligned with that. Current Option 3 may need to be updated “PUSCH with a priority as a function SL UCI priority”  The motivation is that multiplexing of UCI and PUSCH of different priorities is not specified in R16, and is being supported in R17 URLLC. |
| Qualcomm |  | Multiplexing of SL HARQ on a PUSCH (or a PUCCH) with Uu UCI isn’t supported as mentioned by Huawei per the conclusion from RAN1 #99:  Conclusion:   * No support of multiplexing of SL HARQ and Uu UCI on PUCCH or PUSCH in Rel-16 * Note: this reverts the agreements made during RAN1#98b email discussion   In the case of PUSCH without Uu UCI, we could go with Option 3, however our concern is the amount of changes needed to procedure and the uncertainty introduced at the gNB. There are now three different channels being considered for multiplexing/dropping: PUCCH with Uu UCI, PUCCH with SL HARQ, and PUSCH. Based on the priority of SL HARQ, one of many possibilities could occur:   * SL-HARQ is dropped, Uu UCI is multiplexed on PUSCH * SL-HARQ is dropped, Uu UCI is not multiplexed on PUSCH. * SL-HARQ is multiplexed on PUSCH, Uu UCI is dropped. * SL-HARQ is not multiplexed on PUSCH, Uu UCI is dropped. * Both SL-HARQ and Uu UCI are dropped. * There are other cases if two or more PUSCHs overlap and prioritization among them is needed.   The gNB does not know the SL HARQ priority and would have to blind decode these possibilities. Deciding to always multiplex SL-HARQ on PUSCH regardless of priority is detrimental to URLLC PUSCH transmission and we’d like to avoid that.  Our preference is to leave multiplexing SL-HARQ on PUSCH unsupported at this stage. |
| Ericsson |  | It has to be noted that based on the agreements made in RAN1#99 there is no support of multiplexing of SL HARQ and Uu UCI on PUCCH or PUSCH in Rel-16.  For other cases, in principle every PUSCH can be used regardless of the priority when reporting in PUCCH overlaps with a PUSCH transmission. |
| Apple | Option 1 | At the late stage of Rel-16 V2X, we prefer to minimize the specification impact. Based on the current specification,   1. PUCCH with sidelink HARQ-ACK, without explicit indication in DCI 3\_0 or sidelink configured grant, has the default priority index 0. 2. Only PUCCH or PUSCH of the same priority index can be multiplexed, while the PUCCH or PUSCH of smaller priority index is dropped when overlapping in time with the PUCCH or PUSCH of larger priority index.   Hence, PUCCH with sidelink HARQ-ACK is multiplexed with PUSCH of priority index 0 when overlapping, or PUCCH with sidelink HARQ-ACK is dropped when overlapping with PUSCH of priority index 1. |
| OPPO | Option 3 | To multiplex SL HARQ-ACK into PUSCH, no necessary to limit the priority of corresponding PUSCH. According to the blind detection of PUSCH commented by Huawei and Qualcomm, we think gNB’s scheduling can avoid it. If not, gNB should suffer the cost of blind detection. |
| Sharp | Option 1 | Same view with Apple. |
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Q1-1: If the answer of Q1 is Option 1 or Option 2, what is the UE behaviour for the overlapping between SL PUCCH and PUSCH that cannot support SL HARQ-ACK reporting?

* Option 1: SL PUCCH is dropped
* Option 2: PUSCH is dropped
* Option 3: Either SL PUCCH or PUSCH is dropped depending on the prioritization rule between SL PUCCH and Uu PUCCH.
* Option 4: Others (Please specify it).

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| Company | Answer | Comment |
| Apple | Option 1 | PUCCH with sidelink HARQ-ACK is multiplexed with PUSCH of priority index 0 when overlapping, or PUCCH with sidelink HARQ-ACK is dropped when overlapping with PUSCH of priority index 1. |
| Sharp | Option 1 |  |
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Q1-2: If the answer of Q1 is Option 3, how SL HARQ-ACK report is piggybacked on PUSCH?

* Option 1: UE resolve overlapping between SL PUCCH and PUSCH of priority index.
* Option 2: Priority index of PUSCH to transmit SL HARQ-ACK reporting is determined based on the priority value of the SL HARQ-ACK reporting.
* Option 3: Others (Please specify it).

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| Company | Answer | Comment |
| LG | Option 1 | Similar approach for resolving overlapping SL PUCCH and Uu PUCCH can be used.  According to the specification, HARQ-ACK information already includes both DL HARQ-ACK information and SL HARQ-ACK information. In this case, the UE procedure for resolving overlapping PUCCH/PUSCH could be captured with small changes.  In our understanding, we may need to investigate whether or how to handle following cases:  - Overlapping between SL PUCCH and PUSCH (of priority index 0 or 1) after resolving overlapping between SL PUCCH and Uu PUCCH/PUSCH for each priority index  - Non-overlapping PUSCH with different priority index and with SL HARQ-ACK information. |
| NTT DOCOMO | Comment | Firstly, we would like to understand the intention of this question.  In our understanding, if option 3 in Q1 is taken, and if one or more PUSCH with only a single priority index is overlapped with a SL PUCCH, just Rel-15 mechanism can be reused for the multiplexing.  In this sense, we guess that the question is how to handle when multiple PUSCHs with different priority indexes are overlapped with a SL PUCCH. It seems this case should be discussed. For example, after SL PUCCH is multiplexed on PUSCH with priority index 0, it could be dropped due to prioritization with channel with priority index 1.  Note that, intra-UE multiplexing of Uu channel is performed by the following order:  1. multiplexing of smaller priority index (index 0, i.e. low priority)  2. prioritization between different priority indexes, if any  3. multiplexing of larger priority index (index 1, i.e. high priority)  4. redo step 2, if any |
| vivo | Option 2 | As commented to Q1, very simple change is sufficient   * when the priority value of SL PUCCH is smaller than sl-PriorityThreshold-UL-URLLC, the priority index is 1; when the priority value of SL PUCCH is larger than sl-PriorityThreshold-UL-URLLC, the priority index is 0. * The following existing rule is applied even when PUCCH contain SL HARQ   + When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes other than PUCCH transmissions with SL HARQ-ACK reports … |
| Huawei,  HiSilicon | Option3 | As we explained in Q1, the case for SL HARQ can be piggybacked on PUSCH is the PUSCH contains UL-SCH only. When PUSCH with UL-SCH only overlaps with SL PUCCH, SL HARQ information is multiplexed on the PUSCH regardless of the priority index of PUSCH. |
| Intel |  | We assume that overlapping of different priorities should cause dropping, as per R16 URLLC. If the priorities are same, then multiplexing follows existing procedures. |
| Qualcomm |  | If Option 3 is used, then the decision on whether to multiplex SL-HARQ ACK on PUSCH should depend on the priority of PUSCH, SL HARQ, and the configured threshold. While this leads to blind decoding at the gNB, doing otherwise would degrade URLLC PUSCH any time there’s an overlapping SL HARQ-ACK. The gNB could choose to not schedule an overlap between SL PUCCH and PUSCH. |
| Ericsson |  | We would like to ask clarification about this question since if we use Option 3 in the previous question, we can simply reuse the procedures used in Rel-15 as per agreement. |
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Q2: Which option do you support for the scheduling restriction relevant to SL PUCCH? For the scheduling restriction(s), do we need to have specification update?

* Option 1: SL PUCCH does not overlap with PUSCH with aperiodic or semi-persistent CSI reports.
* Option 2: PUCCH does not overlap with PUSCH and Uu PUCCH simultaneously before resolving the overlapping between PUCCH/PUSCH(s).
* Option 3: Other (Please specify it).

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| Company | Answer | Comment |
| LG | Option 1 | If Option 1 is supported, overlapping between SL PUCCH and PUSCH with Uu UCI could be simply solved without any spec changes.  In case of BD problem at gNB side, it is up to implementation. To be specific, if gNB does not want to such BD operation, the gNB can control scheduling. Explicit restriction does not need to be captured in the spec. |
| NTT DOCOMO | Option 1 | The restriction is only on PUSCH with A/SP-CSI, which would be not so large restriction. Note that current spec allows SL HARQ-ACK + Uu UCI multiplexed on PUSCH. Small spec update will be necessary. |
| Vivo | Option 1 | None |
| Huawei, HiSilicon | Option 1 and option 2 | As we have explained in Q1, following option 1, blind decoding in gNB is avoided. Similarly, option 2 is also critical to prevent blind decoding for gNB.  It is agreed in RAN1#101-e, when PUCCH with SL HARQ reporting overlaps in time with one or more UL TX, the prioritization between PUCCHs is performed first, then followed by multiplexing/prioritization with PUSCH. If gNB configure SL PUCCH, Uu PUCCH and PUSCH simultaneously, the prioritization between Uu PUCCH and SL PUCCH is performed first, however, the output will be not aware for gNB because the prioritization is based on SL priority values which is unknown for gNB as well. If no such restrictions, gNB may blindly decode at most five cases, the details can be found in our contribution R1-2103391.  Therefore, both restrictions should be supported to avoid gNB blind decoding. |
| Qualcomm |  | If we correctly understand Option 2 as all three transmission should overlap, i.e. have at least one OFDM symbol in common across all three, then it isn’t enough to avoid the case of Uu UCI and SL HARQ being multiplexed on the same PUSCH. To cover that case, Option 2 would need to be generalized to:  SL PUCCH does not overlap with PUSCH that overlaps with a Uu PUCCH before resolving the overlapping between PUCCH/PUSCH(s).  This still wouldn’t include the cases described in Option 1, which are also not supported in the procedure.  As our first preference is to not support multiplexing of SL-HARQ on PUSCH at this point, we propose the following:   * The UE is not expected to be scheduled with an SL PUCCH that would be multiplexed on PUSCH.   If Option 3 from Q1 is adopted, then the following restrictions are needed (Option 1 and the modified Option 2):   * SL PUCCH does not overlap with PUSCH with aperiodic or semi-persistent CSI reports. * SL PUCCH does not overlap with PUSCH that overlaps with a Uu PUCCH before resolving the overlapping between PUCCH/PUSCH(s). |
| Ericsson | Option 3: Option 1 + Option 2 | In our view, it is possible that the gNB can avoid any related problems by scheduling appropriately. However, in order to avoid introducing any extra complexity to the gNB operation, e.g., blind decoding, we propose to add Option 1 and Option 2 as scheduling restrictions |
| Apple | Option 1 and Option 2 |  |
| OPPO | Option 3 | No necessary to set the scheduling restriction.  According to the agreement made in RAN1#101-e (cited by Huawei), we have defined the solutions how to handle the overlapping case with Uu UCI, SL UCI and PUSCH. The scheduling can be left to gNB’s implementation. If gNB schedules the overlapping SL UCI, Uu UCI, and PUSCH, it should experience the cost of blind detection. Otherwise, it should avoid such scheduling. |
| Sharp | Option 1 |  |
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Q3: Is there any other issue to discuss under the scope of this email thread?

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## **2. 2nd round discussion**

Q1: Do you agree following proposal?

Proposal 1:

* RAN1 confirms the following:
  + if PUCCH carrying SL HARQ-ACK information is overlapping with only a PUSCH of priority index 0 without Uu UCI that is not overlapping with any other UL channels,
    - the SL HARQ-ACK information can be mapped on the overlapping PUSCH.
  + if PUCCH carrying SL HARQ-ACK information is overlapping with only a PUSCH of priority index 1 without Uu UCI that is not overlapping with any other UL channels,
    - the SL HARQ-ACK information can be mapped on the overlapping PUSCH.

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Q2: Do you agree following proposal?

Proposal 2:

* When a UE determines overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUCCH and/or PUSCH of larger and/or smaller priority index, the UE resolves the overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUCCH and/or PUSCH of each priority index as described in Clause 9.2.5 and 9.2.6.
  + PUCCH transmission with SL HARQ-ACK reports does not overlap with PUSCH with aperiodic or semi-persistent CSI reports.
  + For each priority index, PUCCH transmission with SL HARQ-ACK reports does not overlap with PUSCH and Uu PUCCH simultaneously before resolving the overlapping between PUCCH(s)/PUSCH(s).

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