3GPP TSG RAN WG1 #111 R1-22xxxxx

Toulouse, France, November 14th – 18th, 2022

Agenda Item: 7.2

Source: Moderator (Apple Inc.)

Title: Summary of UL Tx switching for PUCCH with HARQ-ACK

Document for: Discussion and Decision

# Introduction

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| In this document, the inputs from companies are collected on the following email discussion:**UL Tx switching for PUCCH with HARQ-ACK (continuation of [110bis-e-NR-R16-10]) - Ankit (Apple)**Two contributions have been submitted on this Rel-16 maintenance issue of UL Tx switching for PUCCH with HARQ-ACK (proposals/observations from the two contributions are listed in Appendix section of this summary):1. R1-2211634, “*Discussion on timeline for UL Tx switching triggered by PUCCH with HARQ-ACK*”, ZTE
2. R1-2211792, “*On Rel-16 UL Tx switching for PUCCH with HARQ-ACK*”, Apple Inc.

Please provide your inputs for the 1st round of email discussions latest by Monday, November 14, 15:00 (Toulouse time) |

**Summary of issue**

In the two submitted contributions [2] and [3], for Rel-16/Rel-17 UL Tx switching, it is discussed that the duration from the end of the scheduling DCI to the start of PUCCH, for which the UL Tx switching is triggered (by the scheduling DCI), is not sufficient to perform UL Tx switching for at least some of the scheduling scenarios, if uplink switching gap is reported by UE. Furthermore, in [3], it is observed that the issue (available timeline duration) is more pronounced for following cases (shown in the table):

* When the scheduling DCI and corresponding PDSCH are partially or fully overlapping
* and/or reported switching gap value is higher
* and/or higher numerology is applied

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| μ | N1 | N1 + 4(including *)*) | N2 | N2 + ( |
|  |  |  |  | 35μs | 140μs | 210μs |
| 0 | 8 | 12 | 10 | 11 | 12 | 13 |
| 1 | 10 | 14 | 12 | 13 | 16 | 18 |
| 2 | 17 | 21 | 23 | 25 | 31 | 35 |

**Summary of proposed solution**

In the two submitted contributions [2] and [3], generally option 2b is proposed as a solution to resolve the issue. Option 2b (proposal 3) was captured in moderator’s summary in RAN1#110bis-e [1] as follows:

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| *For NR Rel-16 and Rel-17, for both CA and SUL, if UL Tx switching is triggered for PUCCH with HARQ-ACK by scheduling DCI (for PDSCH) and switching gap (Tswitch) is reported by the UE, then gNB scheduling ensures that the duration from the last symbol of the scheduling DCI to the first symbol of the PUCCH with HARQ-ACK is equal or longer than the combined duration of Tswitch and Tproc,1* |

In [2], the above proposal is slightly updated to also cover the case of SPS release by PDCCH:

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| *gNB scheduling ensures that the duration from the last symbol of the scheduling ~~DCI~~ PDCCH to the first symbol of the PUCCH with HARQ-ACK corresponding to the PDSCH scheduled by this PDCCH or SPS release indicated by this PDCCH is equal or longer than the combined duration of Tswitch and Tproc,1* |

**Moderator’s initial assessment**

In RAN1#110bis-e, the issue related to UL Tx switching triggered for PUCCH with HARQ-ACK has been discussed and the final summary from the moderator has been captured in [1].

Based on the moderator’s summary, majority of the companies agreed with the issue that, at least for some of the scheduling scenarios. In addition, one of the companies that had strong concern in RAN1#110bis-e, on whether the issue exists or not, has submitted contribution in this meeting [2] and seem to agree with the issue, at least for scenarios with higher μ such as 60kHz and for higher switching period values such as 210μs, that is supported in current specification to be reported by UE.

Furthermore, the solution to introduce scheduling restriction at the gNB seems acceptable to the majority (based on option 2b in [1]). Also, as mentioned above, the two submitted contributions propose to take option 2b for resolving the issue. Therefore, gNB scheduling restriction to resolve the issue shall be a good starting point for further discussion in this meeting.

# Email discussion – 1st round

Based on the discussions from RAN1#110bis-e in [1] and the proposals from the two companies in their contributions [2] and [3], the moderator provides the following proposal:

## *Proposal 1: For NR Rel-16 and Rel-17, if UL Tx switching is triggered for PUCCH with HARQ-ACK by scheduling PDCCH and switching gap (Tswitch) is reported by the UE, then gNB scheduling ensures that the duration from the last symbol of the scheduling PDCCH to the first symbol of the PUCCH with HARQ-ACK corresponding to the PDSCH scheduled by this PDCCH or SPS release indicated by this PDCCH is equal or longer than the combined duration of Tswitch and Tproc,1*

Companies are encouraged to provide their views on proposal 1 if it is acceptable to them or not. If not acceptable, please provide further clarifications:

|  |  |  |
| --- | --- | --- |
| **Company** | **Acceptable – Yes or No?** | **Comments, if any** |
| Samsung | Yes |  |

Furthermore, it needs to be discussed whether the gNB scheduling restriction is handled by implementation or whether it is implemented in the specification. In RAN1#110bis-e [1], it has been discussed whether the specification impact is needed or not. Based on the discussion, from the UE perspective, if the gNB scheduling restriction, as proposed in proposal 1 is not implemented in specification, then the UE cannot know for certain if gNB is actually applying the scheduling restriction or not. And in this case, UE will always need to implement with the assumption that the gNB scheduling restriction is not applied. From this perspective, implementing the gNB scheduling restriction in the specification is needed. Furthermore, majority was fine with such specification update for both Rel-16 and Rel-17.

On the need of specification updated, in contribution [2], it is proposed that the specification impact can be FFS. In contribution [3], specification impact is proposed, and the following TP is provided:

Adopt the following TP to be added to clause 5.3 of TS 38.214

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| \* Unchanged part omitted \** If this PUCCH resource is overlapping with another PUCCH or PUSCH resource, then HARQ-ACK is multiplexed following the procedure in clause 9.2.5 of [6, TS 38.213], otherwise the HARQ-ACK message is transmitted on PUCCH.
* If uplink switching gap is triggered following the procedure in clause 6.1.6, then UE is not expected to be scheduled on the first uplink symbol of the PUCCH which carries the HARQ-ACK information, if the first uplink symbol of the PUCCH starts earlier than the combined duration of { + } from the last symbol of the PDCCH scheduling the PDSCH, where is defined in clause 6.4

Otherwise the UE may not provide a valid HARQ-ACK corresponding to the scheduled PDSCH. The value of *Tproc,1* is used both in the case of normal and extended cyclic prefix. For a PDSCH that consists of two PDSCH transmission occasions in time domain in one slot, *d1,1* is calculated based on the first PDSCH transmission occasion in the slot, and as described above.\* Unchanged part omitted \* |

Based on the discussions from RAN1#110bis-e and submitted contributions in this meeting, the following is moderator’s proposal on the specification impact:

## *Proposal 2: Adopt the following TP to be added to clause 5.3 of TS 38.214 for both Rel-16 and Rel-17*

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| \* Unchanged part omitted \** If this PUCCH resource is overlapping with another PUCCH or PUSCH resource, then HARQ-ACK is multiplexed following the procedure in clause 9.2.5 of [6, TS 38.213], otherwise the HARQ-ACK message is transmitted on PUCCH.
* If uplink switching gap is triggered following the procedure in clause 6.1.6, then UE is not expected to be scheduled on the first uplink symbol of the PUCCH which carries the HARQ-ACK information, if the first uplink symbol of the PUCCH starts earlier than the combined duration of { + } from the last symbol of the PDCCH ~~scheduling the PDSCH~~, where is defined in clause 6.4

Otherwise the UE may not provide a valid HARQ-ACK corresponding to the scheduled PDSCH. The value of *Tproc,1* is used both in the case of normal and extended cyclic prefix. For a PDSCH that consists of two PDSCH transmission occasions in time domain in one slot, *d1,1* is calculated based on the first PDSCH transmission occasion in the slot, and as described above.**\* Unchanged part omitted \*** |

Companies are encouraged to provide comments on proposal 2 in the table below:

|  |  |
| --- | --- |
| **Company** | **Please provide comments** |
| Samsung | We do not think that the CR for 38.214 Section 5.3 is necessary. This can be handled by UE implementation. If desired, such a conclusion reached as outcome from the email discussion can be documented in the RAN1 Chairman’s minutes. |

# Reference

1. R1-2210641, “*Summary for [110bis-e-NR-R16-10] Discussion on UL Tx switching for PUCCH with HARQ-ACK*”, Apple Inc.
2. R1-2211634, “*Discussion on timeline for UL Tx switching triggered by PUCCH with HARQ-ACK*”, ZTE
3. R1-2211792, “*On Rel-16 UL Tx switching for PUCCH with HARQ-ACK*”, Apple Inc.

# Appendix (Submitted contributions)

In this meeting, two contributions have been submitted discussing the same issue and provided corresponding proposals in [2] and [3]. According to [2], following is proposed :

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| ***Proposal 1****: If RAN1 agrees to address the potential timeline issue for UL Tx switching triggered by PUCCH with HARQ-ACK, the following option 2b can be the starting point.* * *Option 2b: gNB scheduling ensures that the duration from the last symbol of the scheduling ~~DCI~~ PDCCH to the first symbol of the PUCCH with HARQ-ACK corresponding to the PDSCH scheduled by this PDCCH or SPS release indicated by this PDCCH is equal or longer than the combined duration of Tswitch and Tproc,1*
* *FFS: Whether any spec impact is needed.*
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According to [3], following observations/proposals are made:

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| ***Observation 1****: For Rel-16/Rel-17 UL Tx switching, the duration from the end of the scheduling DCI to the start of PUCCH, for which the UL Tx switching is triggered (by the scheduling DCI), is not sufficient to perform UL Tx switching for all the scheduling cases, if uplink switching gap is reported by UE** *Total available duration from the end of DCI of the start of PUCCH is calculated for respective numerology by taking into account the corresponding value, and the gap from the end of DCI to the end of PDSCH*

***Observation 2****: For Rel-16/Rel-17 UL Tx switching, the issue (available timeline duration) is more pronounced for following cases (shown in the table):** *When the scheduling DCI and corresponding PDSCH are partially or fully overlapping*
* *and/or reported switching gap value is higher*
* *and/or higher numerology is applied*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| μ | N1 | N1 + 4(including *)*) | N2 | N2 + ( |
|  |  |  |  | 35μs | 140μs | 210μs |
| 0 | 8 | 12 | 10 | 11 | 12 | 13 |
| 1 | 10 | 14 | 12 | 13 | 16 | 18 |
| 2 | 17 | 21 | 23 | 25 | 31 | 35 |

***Observation 3****: NR Rel-16/Rel-17 specification is not able to handle all the supported PDSCH scheduling scenarios, when UL Tx switching is triggered for PUCCH carrying HARQ-ACK (triggered by DCI that schedules corresponding PDSCH)** *It is assumed same switching gap value (as reported by UE) is needed regardless of whether it is applied for PUSCH or PUCCH*

***Proposal 1****: RAN can adopt following solution to resolve UL Tx switching issues for PUCCH with HARQ-ACK:** *if UL Tx switching is triggered for PUCCH with HARQ-ACK by scheduling DCI (for PDSCH) and switching gap () is reported by the UE, then gNB scheduling ensures that the duration from the last symbol of the scheduling DCI to the first symbol of the PUCCH with HARQ-ACK is equal or longer than the combined duration of and*

***Proposal 2****: RAN can adopt same solution (in proposal 1) for both NR Rel-16 and Rel-17 UL Tx switching.* |