**3GPP TSG RAN WG1 Meeting #100bis-E R1-200xxxx**

**e-Meeting, April 20 – 30, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Summary of email discussions for NR Mobility Enhancements**

**Agenda item: 7.2.9**

**Document for:** [Status]

# Introduction

In this contribution, we summarize the email discussion approved for discussion during RAN1 #100bis-E. Chairman has approved three email discussion threads for RAN1 #100bis-E. The following are the approved email discussions:

* [100b-e-NR-Mob-Enh-01] Email discussion/approval on UL cancellation in UL DAPS-HO by 4/24; if necessary, followed by endorsing the corresponding TP by 4/30 – Daewon (Intel)
* [100b-e-NR-Mob-Enh-02] Email discussion/approval on power sharing mode for UL DAPS-HO by 4/23; if necessary, followed by endorsing the corresponding TP by 4/29 – Daewon (Intel)
* [100b-e-NR-Mob-Enh-03] Email discussion/approval on PDCCH/PDSCH restrictions for DL DAPS-HO by 4/22; if necessary, followed by endorsing the corresponding TP by 4/28 – Daewon (Intel)

# Email Discussion [100b-e-NR-Mob-Enh-01]

This discussion is regarding the uplink cancellation in UL DAPS-HO (Issue #2 from [11]).

**Issue and Proposal Summary:**

The DAPS-HO allows for UEs that support dynamic power sharing to drop (or cancel) transmissions of less-prioritized transmission, namely transmission from the source cell. However, UE may not be completely aware of the transmission collision of source and target until a specific time before the transmission is about to occur. This issue has been identified during RAN1 #99 and was not completely resolved. A note was captured as part of an agreement to allow investigation further into this issue.

Several companies have provided input on this issue. The following is a summary of proposals from contributions.

* Proposal by Huawei [1]: For UL cancellation to source cell, the time interval between the end of scheduling DCI from target cell and the start of UL transmission to source cell should be at least Toffset symbols.
  + Toffset = Tproc,2, where Tproc,2 is determined according to Section 6.4 of TS 38.214, assuming d2,1 = 1, d2,2 = 0, µ corresponds to the smallest SCS between the SCS of the PDCCH in target cell and the SCS of the UL transmission to the target cell, and N2 corresponds to a PUSCH preparation time for UE processing capability 1 in Section 6.4 of TS 38.214.
  + The following is the proposed TP:

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| **15 Dual active protocol stack based handover**  < Unchanged parts are omitted >  If  - the UE does not provide *UplinkPowerSharingDAPS-HO*, and  - UE transmissions on the target cell and the source cell overlap  the UE transmits only on the target cell  If a UE indicates support of cancelling uplink transmission to the source MCG, the UE shall cancel an uplink transmission to source cell started from *Toffset* symbols after the end of PDCCH which schedules/triggers an uplink transmission to target cell that collides with the uplink transmission to source cell, where *Toffset* = *Tproc,2*, where *Tproc,2* is determined according to [6, TS 38.214] assuming *d2,1 = 1*, *d2,2**= 0*, *µ* corresponds to the smallest SCS between the SCS of the PDCCH and the SCS of the uplink transmission on the target cell, and *N2* corresponds to a PUSCH preparation time for UE processing capability 1 [6, TS 38.214]. |

* Proposal by ZTE [2]: For collision between an ongoing UL transmission to one cell and an upcoming UL transmission to the other cell, no cancellation timeline is needed and when to stop source cell transmission in case of resource collision should be up to implementation.
* Proposal by Intel [3]: A UE does not expect to receive scheduling grant for transmission that requires cancelling a transmission for scenarios which UE cannot fully know overlapping of source and target cell transmission would happen in advance.
  + The following is proposed TP:

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| 15 Dual active protocol stack based handover *< Unchanged parts are omitted >*  UE transmissions on the target cell and the source cell overlap if they are in  - overlapping time resources if the carrier frequencies for the target MCG and the source MCG are intra-frequency and intra-band  - overlapping time resources and overlapping frequency resources if the carrier frequencies for the target MCG and the source MCG are not intra-frequency and intra-band  A UE does not expect to receive scheduling of a transmission that requires canceling the transmission on the source cell in symbols from the set of symbols that occur, relative to a last symbol of a CORESET where the UE detects a DCI format scheduling a transmission on the target cell, after a number of symbols that is smaller than the PUSCH preparation time  for the corresponding PUSCH processing capability [6, TS 38.214] assuming  and  corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format and the SCS configuration of the UE transmission on the source cell. If the UE transmits PRACH using 1.25 kHz or 5 kHz SCS on the source cell, the UE determines  assuming SCS configuration .  A UE does not expect receive scheduling of a transmission that requires canceling the transmission on the source cell in symbols from the set of symbols that occur, relative to a last symbol of a PDSCH reception conveying a RAR message with a RAR UL grant on the target cell, after a number of symbols that is smaller than msec, where  is a time duration of  symbols corresponding to a PDSCH processing time for UE processing capability 1 when additional PDSCH DM-RS is configured,  is a time duration of  symbols corresponding to a PUSCH preparation time for UE processing capability 1 [6, TS 38.214] and the UE considers that  and  correspond to the smaller of the SCS configurations for the PDSCH on the target cell and the transmission on the source cell. For , the UE assumes  [6, TS 38.214]. |

* Proposal by Samsung [4] : The timeline based on Rel-15 uplink cancellation due to SFI (clause 11.1.1 of TS38.213) is more adequate for DAPS-HO. For the cancellation due to target cell msg3, we follows similar logic with the gap between msg2 and msg3 (clause 8.3 of TS38.213) to ensure enough processing time.
  + Uplink cancellation rule is applied to all UEs supporting DAPS-HO, including UEs provide no or semi-static power sharing capability. Asking a UE cannot do dynamic power sharing to follow a timeline based on other dynamic power sharing option feature does not make sense. This implies UplinkPowerSharingDAPS-HO=dynamic is mandated capability in DAPS-HO.
  + Depending on UE implementation, cancellation and power control may require different mechanism in the uplink transmission process. Also, T\_offset is still under discussion in NR/DC WI and it involves the time dealing with overlapping transmission among two cell groups. Since RAN2 already agreed DAPS HO involves only PCells in source and target cell, we are looking at two very different procedures here.
  + The following is the proposed TP:

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| 15 Dual active protocol stack based handover ----omitted----  UE transmissions on the target cell and the source cell overlap if they are in  - overlapping time resources if the carrier frequencies for the target MCG and the source MCG are intra-frequency and intra-band  - overlapping time resources and overlapping frequency resources if the carrier frequencies for the target MCG and the source MCG are not intra-frequency and intra-band  A UE does not expect to cancel a transmission on the source cell in symbols from the set of symbols that occur, relative to a last symbol of a CORESET where the UE detects a DCI format scheduling a transmission on the target cell, after a number of symbols that is smaller than the PUSCH preparation time  for the corresponding PUSCH processing capability [6, TS 38.214] assuming  and  corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format and the SCS configuration of the UE transmission on the source cell. If the UE transmits PRACH using 1.25 kHz or 5 kHz SCS on the source cell, the UE determines  assuming SCS configuration .  A UE does not expect to cancel a transmission on the source cell in symbols from the set of symbols that occur, relative to a last symbol of a PDSCH reception conveying a RAR message with a RAR UL grant on the target cell, after a number of symbols that is smaller than msec, where  is a time duration of  symbols corresponding to a PDSCH processing time for UE processing capability 1 when additional PDSCH DM-RS is configured,  is a time duration of  symbols corresponding to a PUSCH preparation time for UE processing capability 1 [6, TS 38.214] and the UE considers that  and  correspond to the smaller of the SCS configurations for the PDSCH on the target cell and the transmission on the source cell. For , the UE assumes  [6, TS 38.214].  ----omitted---- |

* Proposal by Apple [6]: After the UL cancellation schemes are completed, then to determine which scheme is adopted by DAPS HO.
  + For NR-DC based scheme, it is applied to UE with dynamic power sharing capability. To compute the transmission power for SCG UL transmission starting at time T0, the UE would check the PDCH received before the T0-T\_offset that trigger an overlapping MCG UL transmission. How to determine the T\_offset is still open. If the scheme is re-used, before the source cell transmit the UL, i.e., configured grant PUSCH or dynamic grant PUSCH, it would check the target cell PDCCH scheduled PUSCH whether it is colliding with source cell transmission.
  + For eURLLC based scheme, UL transmission cancellation timeline is defined, UE will cancel the low priority UL transmission starting from Tproc, 2+d1 after end of the last symbol of the PDCCH scheduling the high priority transmission. The minimum processing time of the high priority channel is Tproc,2 +d2. Current agreements only focus on the case that high priority dynamic grant PUSCH transmission is colliding with low priority PUSCH/PUCCH. If the scheme is re-used, for DAPS HO, the open issue is the timeline of PUCCH transmission to target cell colliding with the PUSCH/PUCCH transmission to the source cell.

**Discussion Summary:**

Companies are encouraged to provide comments on the proposal above. Comments should include views on whether proposal by Huawei [1], ZTE [2], Intel [3], Samsung [4], and/or Apple [6] is/are acceptable or not. Also, if companies have a merged proposal based on proposal from above companies, please do provide them below as well.

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| Company Name | Comments/Views |
| Huawei/HiSilicon | We think Tproc,2 with N2 corresponds to a PUSCH preparation time for UE processing capability 1 would be efficient to cancel the uplink to source cell. No need to define additional timeline to address the MSG3 transmission to target cell. |
| Ericsson | We cannot leave this up to UE implementation – that could lead to that the UE never cancels the transmission to target.  We are not comfortable saying that the UE does not expect to receive a certain scheduling grant: the NW will try its best to avoid a collision and the rule is to give OK behavior also in case a collision does occur.  We believe we should have special behavior for Msg3.  The difference between the proposals in [1] and [4] is if the SCS of the source or target is used to calculate the offset. But in order to reuse something that is already in R15 of the spec, we slightly prefer the solution in [4]. We could still improve on the TP – we think the statement “last symbol of a CORESET” is imprecise, since the CORESET does not have a starting position, only a length. |
| Qualcomm | We think proposals in [3] and [4] could be starting point.  We agree some timeline should be specified for UL cancellation. However, whether UE should follow the timeline or not should be UE capability as discussed in FG 21-2a. Again, we would like to quote RAN2#107bis agreement that it is up to UE to select transmission to either source or target:   |  | | --- | | **Agreements for NR**   1. We do not support TDM pattern. 2. We leave it up to network implementation how to coordinate UL scheduling. 3. For single UL transmission, we will not specify rules how UE handles which link to transmit if UL should be sent to both source and target. |   Hence, we would like to add “For a UE indicating support of cancelling transmission to the source cell, the ~~A~~ UE does not expect to …” in the beginning of both paragraphs in proposals [3] and [4].  Furthermore, “DCI format scheduling a transmission” is mentioned in [3] and [4] – we prefer to clearly specify concrete format here e.g., either format 0\_0 or 0\_1 or both. |
| Samsung | We want to share our understanding for the differences of available TPs associated with timeline. Let’s focus on the cancellation due to dynamic transmissions other than msg3 first.  The described UE behavior from Huawei’s TP is very similar to our TP, which can deal with cancelation of part of transmission to source cell which satisfying the timeline. The differences between two TPs are mostly wording. For reference, our TP is sourced from the timeline based on Rel-15 uplink cancellation due to SFI (clause 11.1.1 of TS38.213), which has very similar uplink cancellation behavior from our view.  The description from Intel looks very similar but the UE behavior can be quite different.  Intel’s TP:  “A UE does not expect to receive scheduling of a transmission that requires canceling the transmission on the source cell in symbols from the set of symbols that occur, relative to a last symbol of a CORESET where the UE detects a DCI format scheduling a transmission on the target cell, after a number of symbols that is smaller than the PUSCH preparation time  for the corresponding PUSCH processing capability [6, TS 38.214] …”  Samsung’s TP:  “A UE does not expect to cancel a transmission on the source cell in symbols from the set of symbols that occur, relative to a last symbol of a CORESET where the UE detects a DCI format scheduling a transmission on the target cell, after a number of symbols that is smaller than the PUSCH preparation time  for the corresponding PUSCH processing capability [6, TS 38.214]…..”  Intel’s TP sounds like UE is not required to cancel the transmission unless it receives the target cell DCI T2 symbols before the start of the source cell transmission. i.e., this corresponds to full-cancellation scheme. We chose partial cancellation since it could benefit the overall system performance during DAPS HO. Also, since partial cancellation behavior already exists in SFI handling, it does not require more complexity than Rel-15 UE. We are fine with full-cancellation as well, but the wording can be discussed further.  For Huawei’s comments regarding msg3, we are open to discuss whether this is needed. In our view, msg3 is an important component during HO so it is hard to be ignored in a WI for mobility. |
| Nokia | Firstly, we also think that RAN1 should specify the UE behavior in this aspect. The RAN2 agreement quoted by Qualcomm is just saying that RAN2 shall not specify any UE behavior in this aspect. (Thus in our view RAN1 should specify the behavior and this should be the minimum baseline capability for the UE, but that is FG discussion).  As per TP, we think proposal in [4] would be a good starting point to determine the timeline (including Msg3). |
| ZTE | We don’t see clear motivation to specify this timeline. The main reason is summarized as follows:   * **No benefit from network side.** For UL dropping due to SFI in Rel-15 and intra-UE multiplexing in URLLC, two overlapped UL transmissions belong to the same cell. It means that the gNB can know the exactly ending symbol of the dropped UL transmission according to the defined timeline. Therefore, gNB can still attempt to decode the dropped UL transmission based on the transmitted symbols and re-schedule another transmission for the same or different UE on the symbols being canceled. However, it is not the case for DAPS handover since two overlapped UL transmissions belong to different CGs. That is, the source cell cannot exactly know when the UE may stop UL transmission. Therefore, defining timeline may not bring any benefit for network. * **No benefit from UE side.** From the perspective of the UE, it can stop source transmission at any time before the UL transmission of target cell if the timeline is not defined. This is beneficial for UE implementation compared to defining timeline for cancellation since there is no restriction for cancellation time. Therefore, when to stop source cell transmission in case of resource collision can be up to UE implementation. * **Such collision should be a corner case.** It is RAN2 understanding that coordination between the source cell and the target cell is needed before performing DAPS handover in order to ensure the configuration of source cell and target cell will not exceed the UE capability. The coordination includes the UL transmission resources coordination such as the information of slots/subframes that the source cell may use to schedule for UL transmission. It can skip these slots when scheduling, i.e. target cell may not schedule UL transmission on these slots/subframes. It is very similar as the network coordination for UL subframes allocation for MCG and SCG for the UE with single UL transmission scheme in MR-DC. In addition, it would be a very short time for a UE completing DAPS handover. It make such collision really a corner case. |
| MTK | It seems majority of companies prefer to specify the timeline and corresponding UE behavior. If this is the case, we prefer the TP proposed by Intel [3]. |

**Feature lead observation and summary (based on feedback received until 4/22 3pm UTC-7):**

* Based on feedback so far, we may want to first focus on the question on whether we should specify a timeline for UE to perform UL cancellation for source cell transmission during collision cases or not.
* Once we conclude to either specify or not specify, the details of the TP could be work on further.
* Please provide 2nd round of feedback on the following questions.

**Suggested Focus for 2nd round of discussion:**

* **Part 1)** Let’s first focus on how to deal with the issue in principle:
  + **ALT A)** RAN1 to specify timing offset and related UE behavior on the UL transmission cancellation for UL DAPS for the problematic cases (e.g. intra-frequency cases, or intra-band cases, or inter-frequency cases when UE does not support simultaneous UL transmission, etc)
  + **ALT B)** RAN1 to specify a generic UE behavior and have the UE handle problematic cases by implementation
  + **ALT C)** No need to specify any additional UE behavior on UL transmission cancellation beyond what is available in current spec.
* Companies are

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| Company Name | Answer to Part 1  (Alt A/B/C) | Comments/Views for Part 1 |
| Apple | Alt B | In Rel.15, the basic UL cancel capability was already defined, i.e., Tproc, 2. UE can perform the cancellation without defining the new timeline. The cancellation is left to UE implementation is enough. Such as, when UL transmissions are collided, the UL transmission to source is dropped or cancelled. |
| Ericsson | Alt A | Alt A is our first preference, and we could probably reuse some timeline that is already in the specification.  We do not understand Alt B.  We could be open to Alt C also, but the implications for the UE behavior is unclear. |
| Nokia | Alt A | In my understanding, even if we follow the Rel-15 timeline (based on Tproc2) we would need to define something in Section 15 for the time line. |
| ZTE | Alt C | For Alt A, a UE has to stop transmission at a certain point.  For Alt C, a UE can stop source transmission at any time before the UL transmission of target cell. This is beneficial for UE implementation. Since we don’t identify any benefits to define this timeline also at network side, we think Alt C should be the way to go. |
| Samsung | ALT A) | In order to cancel the uplink transmission of source cell on time, UE needs to be aware of the potential overlapping target cell transmission a certain time before the start of source transmission cancellation. In Rel-15, solution for similar procedure is to define a timing offset associated to the cancellation processing time after the scheduling DCI which causes the cancellation behavior. After the timing offset UE is required to perform the cancellation. Before the timing offset UE behavior is not specified. This is the general UE behavior in the TP from [4].  Regarding ZTE’s statement “a UE can stop source transmission at any time before the UL transmission of target cell.” We believe this statement is based on the fact that UL transmission to target cell couldn’t be scheduled before Tproc,2 after target scheduling DCI, so source cell cancellation can always happens before that. However, Tproc,2 is depended on the SCS of scheduling and scheduled cells. The above statement is only true if the associated Tproc,2 is more relaxed in target cell than source cell. |
| Huawei, HiSilicon | Alt A | Alt A. RAN1 spec defines, when uplink to source and targets collides, UE transmit only target. However, in some cases, transmitting only target cannot always be guaranteed, which needs to be subject to a timeline. For example, before UE obtaining the scheduling of uplink to target, UE does not know the collision will happen so that still transmit the uplink. Then there might be problem for conformance test because UE behavior is not compliant with the spec. In this sense, we think the timeline is needed to be defined in spec as well as the corresponding UE behavior.  The thing related to UE feature which is more urgent is whether UE just report support/not support or can report a specific value for defining the timeline just as URLLC does. In general, we would like to have a good system-wise performance for DAPS with less scheduling restriction and less stringent UE implementation requirement, though frankly longer timeline may be more friendly to UE implementation. We would like to hear other companies’ views. |

* **Part 2-A)** Assuming that RAN1 agrees to specify timing offset and related UE behaviors on the UL transmission cancellation for UL DAPS, is there a need to specify on how to handle Msg 3?
  + **Option 1) Yes,** need to specify in RAN1 spec
  + **Option 2) No,** can be handled with generic text description for nominal cases
  + For both options above, what is the required text proposal? (or which of the proposed TP provide above is acceptable?)

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| Company Name | Answer to Part 2-A  (Yes/No) | Comments & suggested/acceptable TP for Part 2-A |
| Apple | No | The same offset can be applied to Msg3 as well, the gap between RAR and Msg3 is larger than Tproc, 2. So Msg3 transmission will not be impacted. |
| Ericsson | No | It would be preferable to reuse the same solution, but that assumes that the preparation time is sufficient also for Msg3.  We are open to define a different timeline as well |
| Nokia | [Tentative no] | If we can agree the Tproc2 (from the end of PDSCH) applies also for Msg3 we are OK with it, but if this is not sufficient, then we need a separate timeline. |
| Samsung | Yes | We think msg3 is an important transmission during handover so it needs to be included. msg3 has very different process time from Tproc2 since it involves interpreting msg2 which requires higher layer processing. This consideration is already in Rel-15. In TP from [4], we took the Rel-15 gap between msg2 and msg3 as the process time. We think it is a valid candidate. |
| Huawei, HiSilicon | Yes or No | Depends on the timeline to be defined. Open to more discussion. The gap between RAR and MSG3 defined in Rel-15 is a bit conservative, for example, the capability only corresponds to capability 1 that is because it is general RACH stage for which UE capability has not been reported to NW. This is not the case for DAPS in which duration UE has connected to source gNB and reported capability to source gNB and the capability has transferred to target gNB before handover. Therefore, reusing the gap between RAR and MSG3 may not be necessary. We can take care of this case when defining the timeline for other dynamic scheduling cases. |

* **Part 2-B)** Assuming specific timing offset description is not needed, what is needed to be corrected in the current specification to make sure UE is adequately handling problematic cases?

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| Company Name | suggested/acceptable TP for Part 2-B |
| Apple | The possible TP could like below with the red text.  If  - the UE does not provide *UplinkPowerSharingDAPS-HO*, and  - UE transmissions on the target cell and the source cell overlap  the UE transmits only on the target cell, the transmission to source cell is dropped or cancelled.  UE transmissions on the target cell and the source cell overlap if they are in  - overlapping time resources if the carrier frequencies for the target MCG and the source MCG are intra-frequency and intra-band  - overlapping time resources and overlapping frequency resources if the carrier frequencies for the target MCG and the source MCG are not intra-frequency and intra-band |
| Ericsson | If no timeline is defined, we do not realize that anything is needed. |
| ZTE | We don’t see any spec impact if no timeline is defined. |
| Samsung | Current spec is mandated UE to “transmit only on the target cell” under overlapping/colliding conditions between UL transmissions to source and target cell. This is something UE cannot do if violating the timeline based on cancellation processing time. If no timeline is defined, the last sentence below needs to be relaxed.  “If  - the UE does not provide *UplinkPowerSharingDAPS-HO*, and  - UE transmissions on the target cell and the source cell overlap  the UE may transmit only on the target cell “ |
| Huawei, HiSilicon | N.A. because we think the timeline is needed to be defined. But can be revisited if the conclusion to part 1 is clear. |

# Email Discussion [100b-e-NR-Mob-Enh-02]

[Copy discussion from the document for email thread-02]

# Email Discussion [100b-e-NR-Mob-Enh-03]

[Copy discussion from the document for email thread-03]

# Reference

1. R1-2001530, “Remaining issues on DAPS-HO,” Huawei, HiSilicon
2. R1-2001624, “Remaining issues on NR mobility enhancements in physical layer,” ZTE
3. R1-2002011, “Corrections to Physical layer aspects of NR mobility enhancement,” Intel Corporation
4. R1-2002148, “Remaining issues for NR Mobility Enhancement,” Samsung
5. R1-2002221, “Remaining physical layer aspects of dual active protocol stack based HO,” Nokia, Nokia Shanghai Bell
6. R1-2002344, “On remaining issues on NR mobility enhancements,” Apple
7. R1-2002490, “Correction to UL power sharing for DAPS HO,” Ericsson
8. R1-2002558, “Maintenance for NR mobility enhancements,” Qualcomm Incorporated
9. R1-2001531, “Remaining PHY aspects for CHO,” Huawei, HiSilicon
10. R1-2001625, “Discussion on FR2 mobility interruption enhancements,” ZTE
11. R1-2002010, “Issue Summary for NR Mobility Enhancements,” Moderator (Intel Corporation)