**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: Discussion**

# 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]

[Copy discussion from the document for email thread-01]

# 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]

This discussion is regarding the PDCCH/PDSCH restrictions for DL DAPS-HO (Issue #1 from [11]).

**Issue and Proposal Summary:**

Proposal from [1] is to define a separate capability for UE that can process overlapping resources from source and target cell in intra-frequency DAPS HO. The motivation for introducing a new capability is not force certain UEs to be able to process DL signals that overlap in time and frequency resources, which can be difficult in some scenarios without SIC techniques. The following are the proposals made:

* Proposal by Huawei [1]: Restrict the minimum UE capability of DAPS-HO to FDMed simultaneous reception from source and target cells on overlapping OFDM symbols.
* Proposal by Huawei [1]: Introduce additional UE feature simultaneousRxOnOverlappedfreqAndtime to indicate the support of simultaneous reception from source and target cells on overlapped time and frequency resources.
* Adopt the following TP [1]:

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| --- |
| **15 Dual active protocol stack based handover**If a UE indicates a capability for dual active protocol stack based handover (DAPS HO), the UE can be provided with a source MCG and a target MCG. The UE may expect to receive one PDCCH associated to one MCG to schedule one PDSCH, where the full scheduling information for receiving a PDSCH is indicated and carried only by the corresponding PDCCH.If a UE does not indicate a capability *simultaneousRxOnOverlappedfreqAndtime* for simultaneous reception on overlapped frequency resources and is configured with a source MCG and a target MCG, the UE does not expect:* the set of frequency resources provided by higher layer parameter *frequencyDomainResources* in a *ControlResourceSet* in a source MCG to overlap with the set of frequency resources provided by *frequencyDomainResources* in a *ControlResourceSet* in a target MCG and,
* to receive a PDSCH scheduled by a corresponding PDCCH sent by the source MCG to be located in frequency resources overlapping with a PDSCH scheduled by a corresponding PDCCH sent by the target MCG.

If the PDCCHs that schedule corresponding PDSCHs are associated to different MCGs, the UE procedure for receiving the PDSCH upon detection of a PDCCH follows Clause 5.1 in [5, TS 38.214]. |

**Discussion Summary:**

Companies are encouraged to provide comments on the proposal above. Comments should include views on whether proposals by Huawei [1] are acceptable or not. Also, if companies have a modified/reformulated proposal based on proposals from above companies, please do provide them below as well.

|  |  |
| --- | --- |
| Company Name | Comments/Views |
| Huawei/HiSilicon | We support this proposal.  |
| Ericsson | We would like to understand the motivation for the proposal. On one hand, less complex UE implementations are beneficial, but this proposal would lead to increased signaling load on the NW side.We understand that demodulating PDCCH/PDSCH in overlapping time/frequency resources would impact performance, but that is always the case on the cell border. To avoid the performance degradation, the NW may choose to configure non-overlapping frequency resources, but we do not see why the specification should prevent overlapping allocations from a performance point of view.From a complexity point of view, the UE would still have to perform two channel estimations, and two decodes even when the transmissions are non-overlapping, so we do not directly see the impact on complexity.Based on the information at hand, we are not supportive of the proposal. |
| MTK | We support this proposal.To our understanding, demodulating two PDCCHs/PDSCHs simultaneously in overlapping time/frequency resources is different from the case of cell border. On cell border, UE only demodulates the data from the source cell before the handover, and only demodulates the data from the target cell after the handover. UE is not required to demodulate two PDCCHs/PDSCHs simultaneously on cell border. To demodulate two PDCCHs/PDSCHs simultaneously on cell border in overlapping time/frequency resources, in additional to performing two channel estimations, UE also has to handle severe interference between source and target cells. The complexity falls on the interference cancellation rather than the channel estimation. To my understanding, this is discussed in multi-TRP session and some related techniques are discussed there to solve this problem. For a UE supporting DAPS HO, it may not support multi-TRP and demodulating two PDCCHs/PDSCHs simultaneously in overlapping time/frequency resources can impose prohibitively high complexity in UE implementation. NW may choose to configure non-overlapping frequency resources to help UE, but if this is not guaranteed, UE still needs to take the worst case into consideration for implementation. |
| Intel | We would like to get some clarification from the supporting companies on the matter.From our understanding, the receiver complexity between receiving and processing two PDCCH/PDSCH that are not overlapping in frequency but overlapping in time for the intra-frequency DAPS and receiving and processing two PDCCH/PDSCH that are overlapping in time/frequency for the intra-frequency DAPS are more or less the same.Unless successive interference cancellation processing is involved in both cases, UE need to perform channel estimation twice, equalization and demodulation twice, and decoding twice. Of course there will be implementation challenges to process both signals simultaneously, but as long they are to be processed at the same time (i.e. overlapping in time domain), the complexity should be comparable (if not the same).From our opinion, RAN4 will not define minimum performance requirement for this case with the understanding the UE need to implement a SIC receiver. This would be far from the baseline requirements needed for intra-frequency DAPS.Of course, we acknowledge that with SIC, the performance for intra-frequency DAPS would be bad. However, this would not be any better any regular HO, where UEs need to decode signals at cell-edge in the presence of interference from neighbor cells. The NW would need to ensure that lower code rates and modulation schemes are used such that it can combat the interference in such scenario.With this said, assuming RAN4 does not use SIC as the requirements for intra-frequency DAPS, what is the motivation to separate out capability for cases where UE needs to handle signals that overlap in time but not in frequency vs UE needs to handle signals that overlap in time and in frequency in the same carrier frequency (i.e. intra-frequency DAPS)? |
| Samsung | We share similar views from Ericsson and Intel. We well recognize the performance impact for demodulation/decoding PDCCH/PDSCH in overlapping time/frequency resource. However, as long as this is understood by NW, it is NW’s choice how to trade-off system performance and functionality. We do not see the need of creating a capability signaling for this which may potentially imply interference cancellation. We do not agree that a UE does something like that to handle this scenario as baseline. Base on the above reasons, we are not supportive of the proposal. |
| Huawei, HiSilicon | As requested by companies, we will provide some further views to help clarify our intention.The primary goal of DAPS-HO is to help meet the 0ms interruption time requirement. In our understanding: DAPS-HO should be designed in a way that strikes the right balance between the UE being to receive PDCCH/PDSCH transmissions in reasonably good conditions while keeping the UE’s implementation complexity reasonable.As correctly pointed out by Ericsson and Samsung: it is the NW’s choice to carry out DAPS-HO in a way that satisfies system performance. However a UE implementation’s complexity would still be based on having to accommodate PDCCH/PDSCH in overlapping time and frequency resources. Effectively a UE implementing DAPS-HO would have to take necessary methods to combat the interference, which goes against the goal of keeping the UE implementation complexity reasonable.Regarding increased load on the NW side, we have a different understanding from Ericsson. Source and target cells don’t need to dynamically exchange PDSCH scheduling information, resource partitioning between source and target cells for PDSCHs can be carried out on a slow basis (e.g. in the order of several tens of ms). |
| Nokia | We don’t support this proposal, and in short share the view as Ericsson. In any case in cell edge conditions, the UE reception from one cell may be interfered by a transmission from a neighboring cell(s), irrespective of DAPS. Whether UE implements an advanced receiver to combat this, is subject to UE implementation and minimum baseline is set by RAN4 requirements. Thus we don’t see a need for this capability. |
| ZTE | We don’t think such reporting is needed. The performance improvement by reducing interference is always an implementation issue. As Intel mentioned above, the NW can schedule lower code rates and modulation schemes to compensate the interference. It will not increase UE complexity since UE still use the same way as the case of overlapping only in time for decoding two DL transmissions. From UE side, we think all UEs should implement some ways to reduce interference since interference from other cells is not exclusive for DAPS HO. If a UE is not expected to receive PDSCH receptions overlapping in time and frequency, NW has to have frequent and dynamic exchange for the dynamic PDSCH scheduling information to avoid the dynamic collision. In an order of several tens of ms would not solve the problem. In addition, if such exchange is agreed, we think RAN2/3 may also need to specify the details for the exchange rules.  |
| Apple | We agree a new UE capability is necessary, i.e., simultaneous DL reception in overlapped time and frequency domain resource, otherwise, if RAN4 defines the DAPS HO performance requirement, if the network configured overlapped resource in time and frequency, the UE without advanced receiver could not fulfill the requirements. I don’t think we agreed all DPAS UE have this capability have the interference cancellation capability. Considering the concerns on the RAN1 impacts, maybe we can agree the UE capability, then RAN4 will define the different requirements for normal DPSA UE and advanced DPAS (simultaneous reception in overlapped time and frequency domain), then the network can sustain the performance loss for the normal DAPS UE.  |

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

* 4 companies support the proposal from [1]
	+ Huawei, HiSilicon, MediaTek, Apple
* 5 companies do not support the proposal from [1]
	+ Ericsson, Samsung, Intel, Nokia, ZTE
* Summary of motivation for support of the proposal from [1]
	+ In order to reliability receive DL signals from source and target that are overlapping in time and frequency, interference cancellation (IC) techniques need to be implemented by the UE, which is costly and complex.
	+ Additional UE complexity is envisioned to effectively combat interference for DL signal that overlap in time and frequency.
	+ The gNB partitioning of the UE that can support or cannot support the feature can be long term basis and no dynamic signaling overhead is created.
	+ Concern for RAN4 to define strict requirements when the feature is not supported, which will mandate all UE that support intra-frequency DAPS to support strict requirements that may require advanced receivers.
* Summary of reasons for not supporting proposal from [1]
	+ Results in additional signaling and complexity at the gNB to differentiate UE that are able to process signals differently for intra-frequency DAPS
	+ UE complexity for receiving source and target in the same carrier is the same regardless of whether DL signals overlap in time and frequency or overlap just in time.
* FL notes:
	+ The main different seems to boil down to what is the baseline RAN4 receiver performance for the cases where DL signal overlap in time and frequency for intra-frequency DAPS.
	+ Some companies worry without the capability/feature, it would force complicated receiver designs in order to support intra-frequency DAPS.
	+ Some companies argue the receiver performance should be the same as those cases that do not support DAPS, and it is up to gNB to correctly configure MCS and resources to combat for interference in receiving signals (which is what has always been done by gNB).

# 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)