RAN-R18-WS-crossFunc-Fraunhofer - Version 0.0.5
RAN

3GPP TSG RAN Rel-18 workshop **RWS-210619**

Electronic Meeting, June 28 - July 2, 2021

Agenda Item: 4.3

Source: Fraunhofer HHI, Fraunhofer IIS

Title: Email discussion summary for [RAN-R18-WS-crossFunc-Fraunhofer]

1 Introduction

This document is used for email discussion before the workshop to collect comments/questions from companies for the submitted contribution of Fraunhofer under agenda item 4.3 and provide answers.

Fraunhofer submitted 1 contributions under agenda item 4.3 (Full Duplex RWS-210326), and one overview document in agenda item 4.0 (RWS-210318). The following sections are structured as following:

Section 2 is used for collecting comments/questions/answers in a 1st round of email discussion, in which section 2.1 is to collect the general comments and questions regarding full duplex.

Section 3 is used for providing answers to the comments/questions in 1st round under 2.1.

Section 4 is used for collecting comments/answers/questions in 2nd round of email discussion, and section 5 is used for providing answers to the comments/questions collected in in 2nd round. They are structured in a similar way as section 2 and 3.

2 [1st Round] Comments/Questions/Answers

2.1 General Comments and Questions wrt Full Duplex

Feedback Form 1: General comments and questions wrt Full Duplex in 1st round

1 – CATT

Thanks for the contribution and we have following questions for clarification:

Q1: On page 3, flexible UL and DL band allocation within the shared band seems to imply that DL and UL are separated in frequency domain. Is that the intention?

Q2: From UE perspective, since TX and Rx will not happen at the same time, why is partial self-interference cancellation still needed?

Q3: In order to facilitate proactive UE-UE interference avoidance, any enhancement to Rel-16 CLI measurement needed?

2 – ROBERT BOSCH GmbH

[Bosch]:

1- FD operation may be interesting for automotive as well if the enhancements include UE FD capability, at least for vehicle type UE. Is it possible to consider UE FD capability in the study item?

2- Same question applies for sidelink; should FD capability enhancements include sidelink, i.e., at least for vehicular-based UE?

3 – LG Electronics Inc.

In general, we think the scope and objectives of FDR study item is reasonable. For standardization-impact study, we have small question for our clarification regarding 'legacy sounding reference signals' for self-interference channel estimation and tracking in the sub-bullet.

Q1) Does the 'legacy sounding reference signal' mean SRS for UL reception at gNB?

4 – Intel Corporation (UK) Ltd

Thanks for the contribution. We have the following questions:

Q1. Given that basic feasibility of FD @ gNB needs to be determined by RAN4 as a first step, what is your view on managing the studies across RAN1 and RAN4? Specifically, under what assumptions should RAN1 proceed with their study w/o information on isolation and self-, adjacent channel, intermodulation interference effects that would need RAN4 expertise?

Q2. Have you considered the significantly added UE complexity (even w/o FD support @ UE) to support "TDD in FDD bands" as UE would need to receive in the UL carrier, while the applicability may be rather limited considering regulations?

Q3. For FD at UE, have you considered practical feasibility and challenges for the isolation and interference filtering/cancelation methods, even for "partial self-interference cancelation" and it's effectiveness considering (1) form-factor limitations; (2) # of antennas/antenna elements/panels, e.g., to realize isolation or to realize nulling at another UE while still effectively steering a strong-enough beam to the gNB; (3) device complexity, etc.?

5 – Fraunhofer HHI

CATT, Bosch, LGE, Intel, thank you very much for leaving comments and asking questions.

3 [1st Round] Answers

Thank you very much for commenting on Fraunhofer's contribution RWS-210326. Our responses are structured with referral to the companies having posted their questions.

Answers to CATT:

Q1: On page 3, flexible UL and DL band allocation within the shared band seems to imply that DL and UL are separated in frequency domain. Is that the intention?

AW-2-Q1: Indeed, the figure in page 3 is referring to active full duplex, where the UE can receive DL data, while transmitting in UL. To relax the reuirements for SIC at the UE-side, the UL and DL resources are separated in frequency domain, maybe a few MHz, depending on the receive signal strength and the required

UL power. The closer the UE to the gNB, the better, is the effective UL-DL- decoupling by SIC.

Q2: From UE perspective, since TX and Rx will not happen at the same time, why is partial self-interference cancellation still needed?

AW-2-Q2: See answer Q1: We assume simultaneous UL and DL at a UE.

Q3: In order to facilitate proactive UE-UE interference avoidance, any enhancement to Rel-16 CLI measurement needed?

AW-2-Q3: We see a room for enhancements, e.g. CLI measurements across multiple operators and with spatial and spectral and temporal resolution, when CLI is e.g. limited to a BWP or particular slots.

Answers to LGE:

In general, we think the scope and objectives of FDR study item is reasonable. For standardization-impact study, we have small question for our clarification regarding 'legacy sounding reference signals' for self-interference channel estimation and tracking in the sub-bullet.

Q1) Does the 'legacy sounding reference signal' mean SRS for UL reception at gNB?

AW-2-Q1: Indeed, legacy sounding reference signal means SRS originally designed for the UL towards the gNB. The same SRS can be reused to identify CLI betweed UEs and ICI towards another gNB. Furthermore, the UE can use additional signals, similar to Digital predistortion (DPD) these signals can be chosen flexibly up to implementers preference.

Along the same line of thought we assume DL RS by the gNBs to be used for CLI estimation and for SIC DL RS and additional signals (including data signals) can be used.

Answers to Bosch:

Q1- FD operation may be interesting for automotive as well if the enhancements include UE FD capability, at least for vehicle type UE. Is it possible to consider UE FD capability in the study item?

AW-2-Q1: Fraunhofer is open to study FD capabilities@UE side as well, if scope and time budget permits. In particular, this would enable many applications like "listen while talking" (LWT) for radio environment observation and broadcast message reception at the same time when signals are transmitted.

Q2- Same question applies for sidelink; should FD capability enhancements include sidelink, i.e., at least for vehicular-based UE?

AW-2-Q2: See answer above. Furthermore, when extending FD capabilities at UE to include SL, Uu and SL can be operated at the same time without further coordination of UL and DL slots at the UE. Therefore, FD@UE (Uu&SL) capability enables new features for SL-relaying.

Answers to Intel:

Q1. Given that basic feasibility of FD @ gNB needs to be determined by RAN4 as a first step, what is your view on managing the studies across RAN1 and RAN4? Specifically, under what assumptions should RAN1 proceed with their study w/o information on isolation and self-, adjacent channel, intermodulation interference effects that would need RAN4 expertise?

AW-2-Q1: RAN1 can potentially focus on a phased approach to identify the standardization impact on RAN1, RAN2, RAN4 and provide a prioritized list scenarios using FD and required capabilities of involved gNB and UEs. Given some initial input from RAN1 as outcome of a first study phase RAN4 can start to identify a basic set of requirements to be met and study feasibility.

Q2. Have you considered the significantly added UE complexity (even w/o FD support @ UE) to support ”TDD in FDD bands” as UE would need to receive in the UL carrier, while the applicability may be rather limited considering regulations?

AW-2-Q2: I am not sure if I fully got the essence of the question. When considering FD capability at gNB a UE could be scheduled on DL and UL resources, which are distributed across TDD and/or FDD carriers such that half-duplex operation can be maintained. Therefore, complexity can be shifted between UE and gNB depending on capability of UE.

Q3. For FD at UE, have you considered practical feasibility and challenges for the isolation and interference filtering/cancelation methods, even for ”partial self-interference cancelation” and it’s effectiveness considering (1) form-factor limitations; (2) # of antennas/antenna elements/panels, e.g., to realize isolation or to realize nulling at another UE while still effectively steering a strong-enough beam to the gNB; (3) device complexity, etc.?

AW-2 Q3: Thanks for this very relevant question. We can confirm that spatial CLI suppression performance is a function of number and distribution of antennas, channel knowledge etc. therefore, depending on the number of simultaneous nulls to be placed the performance of spatial nulling can degrade significantly with limited no of antennas in the UE. In cases of close proximity inter-UE CLI can be mitigated by a combination of proximity awareness and subband-wise resource scheduling. Therefore, spatial nulling for CLI mitigation is a feasible option to be implemented at choice of a UE vendor.

4 [2nd Round] Comments/Questions

Feedback Form 2: Specific Questions and Comments in Round 2

1 – Intel Corporation (UK) Ltd

Follow-up to round #1:

On the second question related to UE complexity for support of flexible duplex in FDD bands, to clarify our previous question further, we expect that, for support of “TDD in FDD” a FDD UE would need to have RF support for reception in the UL bands and/or transmission in the DL bands respectively, which call for additional implementation efforts. In addition, there would be likely additional requirements on emissions, ACLR for UL transmissions in DL bands, etc. On the other hand, the applicability remains very limited – from regulations as well as practical use-cases. Additionally, we are also wondering on impact to legacy UEs (or UEs not supporting flexible duplex) in such FDD systems – e.g., how does such a UE account for potential UL transmissions within the DL carrier? Only via scheduling-based solutions?

5 [2nd Round] Answers

Thank you Intel for responding to the provided answers from round 1 and asking further questions.

Answers to Intel:

Follow-up to round #1:

Q1(2) related to Q2(1): On the second question related to UE complexity for support of flexible duplex in FDD bands, to clarify our previous question further, we expect that, for support of "TDD in FDD" a FDD UE would need to have RF support for reception in the UL bands and/or transmission in the DL bands respectively, which call for additional implementation efforts.

AW-2-Q1(2): In case of HD-FDD operation for a UE the duplex filter could potentially be reused in reverse configuration. Simply switching the UL frequency is not expected to add significant complexity.

When operating without or tunable filters, access to a DL band to be used as UL band would be more feasible.

Indeed, it is to be expected that novel UEs only will be able to exploit such band combinations, while legacy UEs are operated in traditional FDD or TDD fashion.

Q2(2): In addition, there would be likely additional requirements on emissions, ACLR for UL transmissions in DL bands, etc. On the other hand, the applicability remains very limited – from regulations as well as practical use-cases.

AW-2-Q2(2): That's a very good point. Since FD creates CLI, where the current systems were not optimized for, CLI awareness is to be considered similarly like ICI in DL or UL where there is no protection like ACLR at all. Therefore, suitable extension of the CLI framework allows to identify relevant ACLR issues and allows to schedule UEs who may create significant ACLR due to proximity to resources inside the band further away from the resources experiencing ACLR. Likewise the victim UE my indicate that certain part of its DL spectrum is less suitable for DL reception. All this, to our understanding falls under the current framework of CQI feedback for ICI and CLI.

Q3(2): Additionally, we are also wondering on impact to legacy UEs (or UEs not supporting flexible duplex) in such FDD systems – e.g., how does such a UE account for potential UL transmissions within the DL carrier? Only via scheduling-based solutions?

AW-2-Q3(2): Indeed scheduling-only is one option out of many. Some slots may be used as pure DL therefore creating protected resources for legacy UEs which are in close proximity to UEs using the FDD DL-band for UL. Furthermore, if CLI feedback is incorporated into the CQI feedback mechanism then UEs can determine if they are experiencing severe CLI by other UEs nearby being scheduled in UL. The provided CQI feedback allows the gNB to identify victim and aggressor UEs which can be entangles by scheduling these onto other resources.

6 Summary

We thank all companies for the constructive questions and comments in the first and second round of the discussions of our TDoc on Full Duplex RWS-210326. We welcome further offline discussions and clarifications.

Within the first and second round we received questions for further clarification and comments by 4 companies which expressed interest and support of the topic in general and requested particular clarifications on technical details with respect to the generality of the framework involved with Full Duplex, crossing technical boundaries of classical TDD and FDD which results in implications on potential implementation

complexity and spectrum utilization.

Discussions were focused on support of legacy HD-UEs and initial introduction of FD capabilities at the gNB side.

A phased approach starting with FD at gNB side followed by FD capabilities at UE side was favored by several companies while others expressed no explicit preference.