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RAN

3GPP TSG RAN Rel-18 workshop RWS-210525

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Agenda Item: 4.1

Source: Futurewei

Title: Email discussion summary for [RAN-R18-WS-eMBB-Futurewei]

1 Introduction

In RAN Rel-18 workshop, companies are sharing their views on potential Rel-18 topics. In [1], Futurewei's views on enhancements for support of eMBB+ services for Rel-18 were provided. In this document, we would like to collect companies' views/comments/questions on [1] and provide responses accordingly.

[1] RWS-210036, "Enhancements for support of eMBB+ services for Rel-18", Futurewei, RAN Rel-18 Workshop

2 Round 1 Questions/Comments: Discussions on eMBB+ Usage Scenarios, Services, and Requirements

The following usage scenarios, services, and requirements were described in [1] for eMBB+ for Rel-18:

-> XR

-> UL video

-> High data rate with high mobility

-> FWA (fixed wireless access)

[1] RWS-210036, "Enhancements for support of eMBB+ services for Rel-18", Futurewei, RAN Rel-18 Workshop

Question 1: Do you agree that these usage scenarios should be considered in R18?

Feedback Form 1: Please provide your response to Question 1 above

1 – Apple Europe Limited

Note this comment is provided over your view on XR.

BiT (Bidirectional training) is interesting and meaningful gains have been shown. It is a plus that it does not depend on fast backhaul based coordination. We agree with your assessment BiT without multiple iterations may be more realistic. Do you consider the power control aspect for BiT? How the SRS Tx power is decided? As SRS is used in the scheme, in some sense, UE power consumption is traded for higher DL capacity/throughput. UE power consumption probably can be included in your future study (it not already).

In our paper https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_AHs/2021_06_RAN_Rel18_WS/Docs/RWS-210500.zip, we suggest to investigate another approach to deal with capacity issue (besides CSI reporting/measurement aligned with XR traffic), different treatments of MAC SDUs in the same MAC PDU. That can happen when network does not have enough resources to serve all UEs' traffics, or some traffic flows' latency budgets are exceeded.

2 – Guangdong OPPO Mobile Telecom.

Thanks for the contribution. We have some questions for BiT as below

Q1: Page 12: What is (the procedure of) Bit-directional Training (BiT)?

Q2: How aboutt the gain of BiT over NZP CSI-RS based interference measurement?

3 – ZTE Corporation

Thanks for the contribution.

Would you mind how to implement BiT with flexible duplex? Which kind of interference does BiT is used to suppress? Inter/intra-cell UE-UE interference, inter/intra-cellBS-BS interference, or self-interference,?

Does any exchange information such as measurement resource etc., need to be considered to enable the BiT with flexible duplex?

4 – Qualcomm Incorporated

On page 7 for FWA enhancement, any examples or clarification for exploiting FWA distinctive properties to achieve high SE for CPE devices?

5 – Sony Europe B.V.

Thank you for the contribution.

On 'only sending CSI-RS on sub-bands that data will be sent on', does not the network need CSI measurements to determine in which sub-bands data should be sent?

Question 2: Any other eMBB+ usage scenarios important to be considered in R18?

Feedback Form 2: Please provide your response to Question 2 above

3 Round 1 Answers/Responses: Discussions on eMBB+ Usage Scenarios, Services, and Requirements

Thank you all for your good questions and comments.

Response to Apple's questions in #1:

Several power control schemes (e.g., FPC with various parameter settings, full-power tx, etc.) have been tested, and they generally provide good gains with different tradeoffs among cell center / edge UEs. With proper scheduling, increase of UE power consumption can be limited, especially considering the fact that the SRS for supporting BiT is narrowband and the DL SE is increased significantly. Note that SRS for interference probing is trigger based and used also for channel estimation of the desired UE for precoding of high precision as well as interference avoidance. This potentially reduces the need of periodic SRS with short periodicity and hence saves overhead and power. We are planning to provide evaluations with power consumption results in the future.

Response to OPPO's questions in #2:

An example procedure of BiT is as follows. After the gNB makes a scheduling decision and before it transmits the PDSCH, it triggers SRS transmission from the scheduled UEs on the scheduled PRBs, which provides interference information about that scheduling decision. The gNB can then adjust its precodings to minimize interference and transmit the PDSCH with high SE. More details can be found in our Tdoc R1-2102765 and references therein. Please feel free to try our published conceptual-level BiT simulator at GitHub - futureweiwirelesslab/bi-directionalTraining: An approach for interference probing and mitigation to achieve high spectrum efficiency (https://github.com/futureweiwirelesslab/bi-directionalTraining/) to know more details about how BiT may work in principle.

For NZP CSI-RS based interference probing scheme, it is based on DL probing to adjust MCS (but not precoding). For BiT, it is based on UL probing to adjust precoding. We think they may be combined and their gains may be partially additive.

Response to ZTE's questions in #3:

With the scheduling / interference probing step mentioned above (Please see response to OPPO's question in #2), BiT can suppress inter-/intra-cell interference, BS-BS interference, and UE-UE interference. In principle, BiT could suppress any external interference via transmitter precoding adjustment, and the gain would be higher if the transmitter precoding capability is high, in which the transmitter may be a gNB transmitter or UE transmitter. For flexible duplex, we expect good interference suppression for inter-/intra-cell interference and BS-BS interference, and some interference suppression for UE-UE interference. If the numbers of UE antennas number are high, then more UE-UE interference suppression is possible. We are not sure about self-interference cancellation, but flexible duplex should not have significant self-interference.

For inter-/intra-cell interference suppression and BS-BS interference suppression, a procedure similar to what is described in R1-2102765 can be used with little information exchange among the gNBs. For UE-UE interference suppression, the procedure is more complicated and further study is needed.

Response to Qualcomm's questions in #4:

Iterative BiT can be adopted to achieve high SE in FWA thanks to the stationarity of the CPE. The CPE may also be a "super UE" with less concerns in processing complexity / power consumption and maybe capable of more advanced MIMO / receiver / etc. schemes. We noticed the proposal of super-QAM from Qualcomm in RWS-210003. We think that proposal relies on UE processing capability and can utilize channel stationarity. Is this the right understanding of your proposal on super-QAM?

Response to Sony's questions in #5:

Wideband CSI-RS may be transmitted periodically with somewhat longer periodicity for general scheduling purposes. For accurate link adaptation, however, subband CSI-RS tied to a specific PDSCH transmission is desirable. So our suggestion is to combine longer-periodicity wideband CSI-RS and aperiodic subband CSI-RS to take full advantage of both types of CSI-RS.

4 Round 1 Questions/Comments: Discussions on eMBB+ Enhancements

The following enhancements were described in [1] for eMBB+ for Rel-18:

-> Cooperative massive MIMO (e.g., Bi-directional Training (BiT) which provides significant performance gain. Details and references can be found in Slide 8 of [1])

-> CSI enhancements for high-resolution cooperative massive MIMO (Details can be found in Slide 9 of [1])

-> TA (carryover from R16/17 M-TRP MIMO, e.g., to specify separate (TRP-specific) UL timings and separate DL timings)

-> Enhancements for high mobility channel estimation/prediction and feedback to support MU-MIMO with high mobility

-> Uplink fast carrier switching

-> Flexible duplex and IM

[1] RWS-210036, "Enhancements for support of eMBB+ services for Rel-18", Futurewei, RAN Rel-18 Workshop

Question 3: Do you agree that these enhancements should be considered in R18?

Feedback Form 3: Please provide your response to Question 3 above

1 – Intel Corporation (UK) Ltd

Thank you for the contribution. Please see our questions below:

[UL fast carrier switching]

1. What are the expected changes to support fast UL switching compared to UL CA?

2. What is the proposed timescale for switching between UL carriers?

2 – MediaTek Inc.

1) For Bi-directional training, does the UE have to be fully stationary and did you do any assessment of slightly non-stationary? It is only relevant for TDD system?

2) Co-operative MIMO: What is missing in the existing NR SRS to support cooperative massive MIMO?

3 – Spreadtrum Communications

For **Uplink fast carrier switching**, we share a similar view that it can be studied in Rel-18. Due to limited UL CA capability and limited power. The current UL carriers/Cells are semi-static activated and dis-activated, which is lack of UL load balancing and adaptation among UL cells. However, from our understanding, this UL fast carrier switching, only applies to UL carriers with PUSCH, not SRS carrier. So we don't think it can be combined with SRS carrier based switching. Or would you elaborate more for better understanding?

4 – Qualcomm communications-France

Regarding "Cooperative massive MIMO via Bi-directional Training (BiT)", based on the references provided in the contribution, our understanding is that in order to achieve the performance improvement, SRS parameters need to match that of the PDSCHs across the system in a pre-committed way. Is this understanding correct? If yes, can you please elaborate more why this cannot be achieved with existing specification given that scheduling decision / SRS configurations and triggering are up to the network? More details on specification impacts are appreciated.

5 – ZTE Corporation

For "uplink fast carrier switching", it seems the proposed solution is an enhancement following the line of Rel-17 UL Tx switching. Is the proposal trying to support UL Tx switching with more UL carriers/bands?

6 – Qualcomm communications-France

Could you please elaborate what kind of adv CSI need to be specified, implicit CSI or explicit CSI?

7 – Qualcomm Incorporated

... Continuation

On p12, any example on the application of bi-directional training to various interference mitigation in flexible duplex?

8 – Huawei Tech.(UK) Co.. Ltd

We share the same view on UL fast carrier switching. It is very important for UL capacity and operators' spectrum utilization. It can enable common UEs with limited transmission capability benefit from operators diverse spectrum.

Question 4: Any other eMBB+ enhancements important to be considered in R18?

Feedback Form 4: Please provide your response to Question 4 above

5 Round 1 Answers/Responses: Discussions on eMBB+ Enhancements

Thank you all for your good questions and comments.

Response to Intel's questions in #1:

Generally a UE has limited UL CA capability compared with its DL CA capability. For example, it may support 8 DL CCs but only 2 UL CCs at the same time. Then for UL CA with 2 CCs, only these 2 CCs can be utilized. However, with fast UL carrier switching, the UE may be configured with 8 UL CCs but can quickly switch to use 2 of the 8 UL CCs for transmission. This provides a lot more flexibility for load re-distribution, interference avoidance, and so on, than UL CA of 2 fixed CCs.

A RF retuning time is generally needed for fast UL carrier switching, which has mostly similar standard impact, e.g., UE RF retuning time reporting (ENUMERATED {n0us, n30us, n100us, n140us, n200us, n300us, n500us, n900us}), interruption, etc., as SRS carrier-based switching. The resulting time scale may be around a few OFDM symbols (for 15 kHz SCS).

Response to MediaTek's questions in #2:

One-shot BiT can work well with moderate mobility. In our Tdoc R1-2102765, one-shot BiT gain is shown for UEs with 80% indoor (3 km/h) and 20% outdoor (30 km/h). Iterative BiT would be more suitable for stationary UEs, such as FWA CPEs.

TDD has been the primary focus for BiT, but the theory has been extended to FDD (see a recent paper Bi-directional Training Methods with Frequency-Division Duplexing | IEEE Journals & Magazine | IEEE Xplore) (link: https://ieeexplore.ieee.org/document/9418520).

Existing NR SRS mechanisms still lack the full flexibility to support cooperative MIMO such as BiT. For example, significant gain can be achieved if the SRS transmission parameters in frequency domain and spatial domain are the same as the associated PDSCH transmission parameters, which we have been advocating in R17 FeMIMO WI but likely only a small part of the desired enhancements may be possible for R17.

Please feel free to try our published conceptual-level BiT simulator at GitHub - futureweiwirelesslab/bi-directionalTraining: An approach for interference probing and mitigation to achieve high spectrum efficiency (https://github.com/futureweiwirelesslab/bi-directionalTraining/) to know more details about how BiT may work in principle.

Response to Spreadtrum's questions in #3:

UL carrier switching and SRS carrier-based switching are controlled by gNB, and it is up to gNB implementation to possibly combine them for the best overall performance (may not have standard impact). One important fact is that the UE may need to perform RF retuning to switching to another UL carrier, for UL carrier switching and/or SRS carrier-based switching. With a good gNB implementation, the UE does not have to switch too often (note that RF retuning is an overhead for switching) and both UL/DL performance can be

enhanced; without a good gNB implementation, the UE may need to keep switching or some UL/DL carriers are not fully utilized (e.g., if the switching is mostly driven by UL purposes, then some DL carriers may not be able to utilize SRS for reciprocity to improve DL SE). Anyway, we think the combination may be mostly implementation but we are open to further study.

Response to Qualcomm's questions in #4:

Yes, that is generally correct understanding though it is actually up to implementation for various consideration. The results we provided in RAN1 XR capacity evaluation do not exactly follow this restriction for best tradeoff of SINR, latency, and overhead. The current standards do not allow the SRS to be transmitted with frequency/spatial-domain parameters the same as PDSCH. For example, the PDSCH may be on 10 PRBs but the SRS does not support that. The current SRS triggering mechanism also lacks sufficient flexibility to indicate the SRS transmission parameters.

Response to ZTE's questions in #5:

The UL fast carrier switching proposal is a bit different from R17 UL Tx switching. Instead of focusing on UE UL Tx antennas, this proposal is more focused on fully utilizing UL bands with limited UE CA capability. For example, a UE may support 8 DL CCs but only 2 UL CCs at the same time. Then with fast UL carrier switching, the UE may be configured with 8 UL CCs but can quickly switch to 2 of the 8 UL CCs for transmission. This provides flexibility for load re-distribution, interference avoidance, and so on.

Response to Qualcomm's questions in #6:

For advanced CSI schemes for fixed links, we noticed that if we use the conventional channel signal generation model with the speed parameter set to be close to 0 m/s, it still generate larger signal fluctuations (the red curve of the top figure in Slide 9 of RWS-210036) than the actual signal fluctuations for a fixed link (the blue curve). This means the traditional mobile channel models may not work well for fixed links. In addition, for a fixed link, the channel is long-term stationary, in the time scales of hours, days, months, and longer. No traditional mobile channel models are really applicable. Thus, we think more research should be done in this area, based on which new and advanced CSI schemes may be identified and supported.

Response to Qualcomm's questions in #7:

With the scheduling / interference probing step mentioned above (Please see response to OPPO's question in #2 in Section 2), BiT can suppress inter-/intra-cell interference, BS-BS interference, and UE-UE interference. In principle, BiT could suppress any external interference via transmitter precoding adjustment, and the gain would be higher if the transmitter precoding capability is high, in which the transmitter may be a gNB transmitter or UE transmitter. So for flexible duplex, we expect good interference suppression for inter-/intra-cell interference and BS-BS interference, and some interference suppression for UE-UE interference. If the numbers of UE antennas are high, then more UE-UE interference suppression is possible.

Response to Huawei's comments in #8:

We agree this is very important.

6 Round 2 Questions/Comments

Thank you all for the questions/comments in Round 1. We have provided our answers/responses in Sections 3 and 5. Please let us know any further questions/comments you might have on [1].

[1] RWS-210036, “Enhancements for support of eMBB+ services for Rel-18”, Futurewei, RAN Rel-18 Workshop

Feedback Form 5: Round 2 Questions/Comments on RWS-210036

1 – China Telecommunications

Thank you for the proposal about BiT.

We have some questions for better understanding the procedure.

1) When the gNB triggers SRS transmission from the scheduled UEs on the scheduled PRBs to obtain interference information about that scheduling decision, we understand it is UE to UE interference information. Since aggressor UEs may be near to the victim UE but far from the gNB, can the interference information obtained by gNB based on the probing SRS from the aggressor UEs be accurately the interference suffered by the victim UE□

2) For gNB to gNB interference suppression, is CSI -RS used for interference probing□Does scheduling information need to be exchanged between gNBs to determine the probing CSI-RS resource□

2 – Spreadtrum Communications

Many thanks for your reply. For Uplink fast carrier switching, we share same view that it would be under the control of gNB. Our concern is whether UL carrier switching should always together with an A-SRS triggering. We are open for further study in a later stage. Anyway, UL carrier switching is an important topic in Rel-18.

3 – Qualcomm Incorporated

Thank you for your clarification on the use-case of iterative BiT for achieving high SE for CPE. To further clarify on Qualcomm’s proposal: Super-QAM is motivated for high capability UEs in general. CPE and IAB are couple of examples of such use-case of high capability UEs. Regarding the channel assumptions for super-QAM, it shouldn’t be completely stationary. Some limited mobility is also acceptable and feasible.

7 Round 2 Answers/Responses

Thank you all for your good questions and comments.

Response to China Telecommunications’ questions in #1:

In general, an interference probing signal may be sent by a potential victim and received by a potential aggressor, so that the aggressor can adjust its precoding for interference avoidance. In the special case of UE-to-UE interference suppression, an SRS can be sent from the victim UE and received by the aggressor UE. Therefore, the interference information is acquired by the aggressor UE, not by the gNB. Of course, as commented before, the UE-to-UE interference avoiding benefit would be higher if the UE has more antennas for higher beamforming capability.

CSI-RS or other signals sent by one gNB and received by another gNB may be used for gNB-to-gNB interference avoidance. Detailed scheduling information exchange is not needed, but the gNBs need some semi-static coordination/information exchange for probing, such as slot format information, probing resource information (e.g., on which OFDM symbol), etc.

Response to Spreadtrum Communications' comments in #2:

We fully agree with you that uplink fast carrier switching is very important for R18 and in implementation it is controlled by the gNB. It does not have to be tied together with SRS carrier-based switching.

Response to Qualcomm Incorporated's comments in #3:

Thank you for your response to our question.

8 Summary

From June 14 – June 24, there were two rounds of Q&A email discussions conducted on RWS-210036 [1]. A total of 16 questions/comments were received and we provided answers/responses accordingly. Based on questions/comments received, it seems there is a high interest on Cooperative massive MIMO (e.g., Bi-directional Training (BiT) which provides significant performance gain) as well as Uplink fast carrier switching. This should be taken into account in RAN Rel-18 WI/SIs planning.