

RAN-R18-WS-crossFunc-LG Electronics - Version 0.0.4
RAN

3GPP TSG RAN Rel-18 Workshop RWS-210629

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Agenda Item: 4.3

Source: LG Electronics

Title: Email discussion summary for RAN-R18-WS-crossFunc-LG Electronics

1 Introduction

This paper summarizes pre-Rel-18 WS email discussion for LG's view on Rel-18 5G-Advanced regarding cross-function related issues.

Discussion in this paper consists of 6 sub-sections as follows based on 5 LG papers and 2 co-sourced papers.

2.1 LG's overall proposal on Rel-18 cross-function related items (RWS-210239, LG's View on Rel-18 5G-Advanced: cross-function related, LG Electronics)

2.2 Full duplex operation (RWS-210241, Motivation for new SI: Study on full duplex operation for NR, LG Electronics, RWS-210242, Proposal on the work scope of Rel-18 SI for full duplex operation, LG Electronics, KT Corp., SK Telecom, Fraunhofer, CEWiT, IITM, ETRI)

2.3 Physical layer aspects for AI/ML operation (RWS-210243, AI-based PHY Layer Enhancement for 5G-Advanced, LG Electronics)

2.4 ML-aided Predictive Mobility (RWS-210233, ML-aided predictive mobility, LG Electronics)

2.5 Enhancement for positioning (RWS-210245, Enhancement for positioning, LG Electronics)

2.6 Enhancement for device requirement (RWS-210249, Enhancement for device requirement, LG Electronics, LG Uplus)

2 Discussion

2.1 LG's overall proposal on Rel-18 cross-function related items

LG' overall proposals on Rel-18 cross-function related items are introduced in RWS-210239, where the following items are proposed

a) Full duplex operation (RWS-210241, RWS-210242)

- b) Physical layer aspects for AI/ML operation (RWS-210243)
- c) ML-aided predictive mobility (RWS-210233)
- d) AI/ML enabled NG-RAN (no separate paper)
- e) Enhancement for positioning (RWS-210245)
- f) Enhancement for device requirement (RWS-210249)
- g) Enhancement for XR operation (no separate paper)

2.1.1 First round comments/questions

Please share your comments or questions on LG's overall views on Rel-18 cross-function related items here. Especially for items a), b), c) e), f) above, you may share your comments or questions based on more detailed LG and co-sourced contributions in the subsequent individual sub-sections

Feedback Form 1: Comments/questions on LG's overall views on Rel-18 cross-function related items

1 – ROBERT BOSCH GmbH

[Bosch] Enhancement for XR operation: should this also include mobility enhancements.

2.1.2 First round replies

Re Bosch(#1)'s comments

Thanks to the question. In the ongoing Rel-17 study item on XR, the study is focusing on the basic requirements such as latency and capacity, power consumption. We think Rel-18 XR should continue focusing on supporting basic features, e.g. traffic awareness in RAN, enhancements related to XR traffic characteristics, based on the outcome of the ongoing Rel-17 study. Therefore we think mobility enhancement itself may not be a main objective for Rel-18 while mobility can be considered as a technical component as always has been in 3GPP.

2.1.3 Second round comments/questions

Please share your second round comments or questions on LG's overall views on Rel-18 cross-function related items here.

**Feedback Form 2: Second round comments or questions on
LG's overall views on Rel-18 cross-function related items**

2.2 Full duplex operation

In RWS-210241, we provide motivation, initial analysis by initial simulations/measurements and proposal for Rel-18 study item structure.

Especially in RWS-210242, multiple companies (LG Electronics, KT Corp., SK Telecom, Fraunhofer, CEWiT, IITM, ETRI) propose SI objective, which is roughly summarized as follows.

> Study feasibility of full Duplex operation in unpaired spectrum [RAN1, RAN4]

» Define/prioritize scenarios for Full Duplex operation in terms of some aspects such as:

»> Full duplex operation in gNB and/or UE, Frequency resource utilization, Frequency range, Deployment scenario, Antenna configuration

»> including potential extension to IAB, wireless backhaul, sidelink, paired spectrum

> Study standardization impacts and potential enhancements for the selected scenarios for full Duplex operation in unpaired spectrum such as: [RAN1]

» Resource allocation, Interference handling, MIMO operation, Duplex adaptation,

2.2.1 First round comments/questions

Please provide your comments/questions on full duplex operation here

Feedback Form 3: Comments/questions on full duplex operation

1 – 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?

2 – CATT

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

Q1: On page 5, why digital SIC does not apply to SB-FD? Is there a particular reason?

Q2: On page 6, what is the assumed inter-cell interference mitigation scheme in the evaluation?

Q3: On page 6, as multiple antennas are used in the simulation, how are the gNB Tx and Rx antenna arrays separated? Is the interference between each pair of Tx and RX antennas modeled?

3 – Intel Corporation (UK) Ltd

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 for their study w/o information on isolation and self-, adjacent channel interference effects, etc. that would need RAN4 expertise? Specifically, what does it mean to study "general objectives" until basic feasibility for each option (sub-band-based/spectrum-sharing-based/etc.) is established? Even for the objectives in slide 8, can RAN1 make meaningful progress without basic assumptions on possible levels of isolation, self- and adjacent channel interference, need for guard bands, etc.?

Q2. While the measurement results are very interesting and very much appreciated, these correspond to very specific choices of placement and configuration. Do you think such can establish feasibility in a general setting and especially so in multi-cellular setup?

4 – Spreadtrum Communications

Thanks for the comprehensive contribution. It is very nice for sharing SLS results and measurement results of CLI. But we have a question for further explanation:

P6: In the simulation, for small size of packet, the results show that SS-FD is not as good as SB-FD. We cannot quite get the reason. Can you explain it?

5 – SHARP Corporation

In slide 5 of RWS-210241, how long is the distance between antennas for transmission and reception to obtain 30-35 dB antenna isolation?

6 – KT Corp.

KT would like to see both Sub-band scenario and spectrum-sharing scenario considered in Rel-18 time-frame. Would like to hear more on how to progress the work on both scenarios.

7 – Nokia Corporation

What kind of performance impacts especially in DL performance do you foresee if UEs do not support full duplex? How about handling and DL performance of legacy UEs? Have you considered complexity and cost assessment of FD? Are you considering to utilize the earlier RAN4 co-existence studies for dynamic TDD as starting point to avoid repeating the same studies? We would believe that studies for gNB-2-gNB CLI problems and solutions would be important for "traditional TDD" in support of UL-heavy configurations.

8 – Fraunhofer HHI

LGE, thank you very much for the comprehensive contribution on Full Duplex schemes, complemented by simulations and interference measurements in the field.

We would appreciate further elaboration and clarification of the following aspects:

Q1: in Case of Spectrum Sharing Full Duplex (SSFD), are you considering this to be on a cell level with multiple UEs or on a per UE basis, where the latter may involve more stringent Self-Interference Cancellation capabilities at the UE side?

Q2: If on cell level (multi user view): Do you have particular preferences if Subband-wise FD and/or Spectrum-sharing FD schemes should be prioritized FFS?

Q3: on slide 3 you state that ACI may not exist or to be not severe between operators using adjacent FD spectrum. Considering no MNO specific frequency filters in TDD operation, one could expect a similar effect for ACI like in Subband-wise Full Duplex. Why is ACI expected to be very different from Subband-wise CLI?

Q4: Would a extension of the UE-2-UE CLI framework to inter-operator measurements be considered suitable to coordinate adjacent band operation similar like Subband-wise Full Duplex for one operator?

9 – LG Uplus

We do appreciate for valuable contribution and also the full duplex is one of the preferred topic in Rel-18 from our perspective. Also the point we are interested in is how to proceed this feature in 3GPP so that it can be realized in real commercial network within proper time rather than using it only as the baseline of 6G or leaving it only in the paper. So we think the sub-band full duplex from whole body of full duplex scenario can be the good starting point to proceed to normative work in Rel-18 time frame.

Q) Do you have any specific plan and open to discuss about the schedule ?

10 – KDDI Corporation

Thank you for your effort and interested contribution. We are very interested in HD + SB-FD based operation, and have some questions for clarification on system simulation results.

Q1: For guard band (i.e., 12 PRBs) on slide 14, what is the rationale for choosing this value?

Q2: On the results on bottom left figure in slide 15, it seems that the larger the DL SB#, the smaller received SINR, even without interference. What could be causing this situation?

11 – CEWIT

Thank you for your contribution. We support studying the Full-duplex operation in both sub-band and spectrum-sharing manner. One question on the simulation part specific to the packet delay analysis.

On page 6, figure 1 shows the delay reduction in DL but figure 2 does not show the same in UL for SB-FD and SS-FD. Any specific reason for this?

12 – China Mobile Com. Corporation

Thanks for the nice contribution! I have a general question. In your view, do you consider to focus on a subset of the scenarios when determining the study scope (e.g., only focus on isolated scenario for spectrum sharing FD), or you prefer to have a thorough study first and then narrow down to some of the use cases in WI phase.

2.2.2 First round replies

Re Bosch(#1)'s comments

A1: We are also thinking that Full Duplex operation can be applicable for automotive. Also, we see the possibility that both gNB FD and UE FD are studied in the study item. We think this discussion is related with study scope of study item. Depending on the SI scope discussion, we may also consider, for example, phased approach for full duplex study within a study duration.

A2: Similarly with A1, depending on the further discussion on the item scope, we think sidelink may be considered. However, it depends on how much additional efforts will be needed on top of the basic Uu study.

Re CATT(#2)'s comments

A1: One reason is to see similar level of total SIC among SB-FD and SS-FD.

A2: For only spectrum sharing (SS)-FD case, power control for downlink is applied for cross link interference (e.g., gNB to gNB) mitigation. For example, different Tx power (e.g., from 23dBm to 33dBm) is applied depending on each UE's downlink geometry. In subband (SB)-FD case and Half duplex case, no gNB to gNB CLI mitigation scheme is applied. Also, we did not apply UE to UE CLI mitigation scheme and inter-cell interference (e.g., gNB to UE, UE to gNB) mitigation scheme.

A3: We didn't assume any specific SIC receiver types (i.e., antenna separation, RF SIC, Digital SIC). Depending on the type of SIC receiver and modeling, the level of SIC is different. Also, it is hard to apply self-interference model in SLS evaluation. In this reason, we tried to see the performance degradation depending on the level of residual SIC which is used for SINR calculation. But in this simulation, we assume one specific value of SIC (i.e., 80dB) for both SB-FD and SS-FD.

Residual SI for SB-FD = Tx power – ACIR (43dB) – SIC (80dB)

Residual SI for SS-FD = Tx power – SIC (80dB)

Re Intel(#3)'s comments

A1: While we agree RAN4 feasibility study is needed in many aspects, we think RAN1 can proceed with interested scenarios and potential gains with some reasonable assumptions. This is because we think starting with detailed requirements studied by RAN4 may not be efficient so much in the study item phase. We think necessary RAN4 works can proceed in parallel and can be used during the study item in appropriate phases.

A2: We think that in-building deployment (e.g., office, factor, shopping mall, etc) is very important scenario for 5G cellular network. In this aspect, we tried to see the potential impact of CLI/ACI and Full duplex operation at in-building scenario. Also, in this scenario, we see potential operation method for gNB FD / UE HD. If multi-cell setup is required, we may see the impact on SLS evaluation.

Re Spreadtrum Communications(#4)'s comments

In case of small size of packet, we see that DL performance of SB-FD and SS-FD is same. That is, DL performance is saturated even if narrower DL bandwidth of SB-FD than that of SS-FD is used. Also, we see that the impact of UE2UE CLI assumed in this simulation is marginal. On the other hand, we see that UL performance of SB-FD and SS-FD is different. From the evaluation result, we see that narrower bandwidth of SB-FD is quite enough to deliver UL packet, and the frequency partition between DL and UL is beneficial to reduce gNB to gNB CLI in SB-FD case. On the other hand, in SS-FD case, UL performance is degraded due to higher level of gNB to gNB CLI.

In case of medium size of packet, wider bandwidth of SS-FD can provide performance benefit even though higher level of gNB to gNB CLI is existed. On the other hand, in SB-FD case, performance enhancement is not expected due to narrower bandwidth of SB-FD.

Re SHARP(#5)'s comments

In this measurement, it is applied that Tx power of gNB is 5dBm. Also, in our implementation, it is applied that antenna distance between Tx and Rx is 4 5cm.

Re KT(#6)'s comments

We see the both scenarios (i.e., SB-FD and SS-FD) are studied in Rel-18 timeframe. Depending on the study result, we may select one or both scenarios for normative work.

Re Nokia(#7)'s comments

A1: In our SLS evaluation, we assume gNB full duplex and UE half-duplex. Even if UEs do not support full duplex, it is observed that DL performance is enhanced.

A2: Depending on packet size per UE, the narrower bandwidth of SB-FD than DL bandwidth of Half duplex could impact DL performance.

A3: We need feasibility study of Full duplex implementation, if necessary.

A4: In Rel-16, we obtained a result of RAN4 co-existence study. We think the co-existence study could be a good starting point for co-existence study for Full Duplex case. For example, we can follow evaluation assumptions and deployment scenarios. But, we think that different point between SB-FD/SS-FD and previous co-existence study could be an assumption of frequency gap between DL part and UL part. When frequency gap is applied, adjacent carrier interference from aggressor to victim is reduced. So, it needs to revise the assumption of ACI for co-existence study for SB-FD/SS-FD cases. Also, we need RAN4 co-existence study for SB-FD/SS-FD cases.

A5: We are also thinking that studies for gNB-2gNB CLI problem and solution is very important for both "traditional TDD" with UL-heavy configuration and Spectrum-shared Full Duplex.

Re Fraunhofer HHI(#8)'s comments

A1: When gNB FD and UE HD is applied, we think it needs to consider self-interference cancellation capability at gNB side. In addition, we think that full duplex operation on cell level with multiple UEs or on per UE basis is a network choice.

A2: In this stage, our preference is to study a potential benefit of both subband-wise FD and spectrum sharing FD. We expect to analyze how to operate SB-FD/SS-FD in terms of multiple aspect including multi-user scheduling.

A3: We expect level of ACI is reduced when frequency gap between DL part and UL part. In our measurement, we observed that SINR at adjacent subbands is degraded due to higher level of ACI, but impact of ACI is reduced.

A4: The UE-2-UE CLI framework is composed by two parts (i.e., CLI measurement and reporting at UE side,

Exchange of intended DL/UL TDD configuration among gNBs), which is used for one operator. For RAN4 co-existence study in Rel-16, no information exchange among operators was assumed. We expect similar assumption will be applied in full duplex study.

Re LG Uplus(#9)'s comments

We also hope that full duplex operation is realized in real commercial network. We think that gNB FD and UE HD is first step for introducing FD in NR considering on implementation complexity in UE side and specification impact when UE full duplex is introduced. We think it required that two gNB Full duplex scenarios (i.e., subband-full duplex and spectrum-sharing full duplex) are studied to see the potential benefit depending on deployment scenario and traffic conditions. We may decide normative work for FD based on the result of study.

Re KDDI(#10)'s comments

A1: In this measurement, 273RBs (100MHz) are used. Because we assume about 10% of system bandwidth as a guard band, we set each 12 PRBs as a guard band at left part and right part of subbands for UL.

A2: In figure 2, we can see different level of SINR even without interference. We tried to measure the signal strength in building (i.e., parking area). Due to multi-path fading, we observed frequency selective response.

Re CEWiT(#11)'s comments

In DL case, we see the performance enhancement of SS-FD with wider bandwidth for DL transmission. And, we think that impact of UE-to-UE CLI is marginal in this evaluation.

In UL case, we see the performance enhancement of SB-FD when small packet size is assumed. The narrower bandwidth of SB-FD for UL transmission is quite enough to deliver small size of packet. Also, in case SB-FD, we think that impact of gNB-to-gNB CLI is marginal. But, when packet size is increased, we see that performance enhancement is limited due to the narrower bandwidth of UL transmission. On the other hand, in case SS-FD, UL performance enhancement can be expected using wider bandwidth for UL transmission. But, we see that the performance is degraded due to gNB-to-gNB CLI.

Re CMCC(#12)'s comments

A1: In our initial SLS result, we see the potential benefit of spectrum sharing FD even in dense urban case when DL power control is applied for gNB to gNB CLI mitigation. So, we are considering to study both Subband FD and spectrum sharing FD in general scenarios (e.g., Macro, Dense urban, Indoor, Isolated scenarios). Depending on result of study, we can decide priority for normative work in WI phase.

2.2.3 Second round comments/questions

Please provide your second round comments/questions on full duplex operation here

Feedback Form 4: Second round comments/questions on full duplex operation

1 – SK Telecom

We appreciate your hard work for the full duplex item in Rel.18. We are also interested in full duplex and look forward that full duplex study item is approved in rel.18, which can increase the system capacity. Sub-band full duplex seems good starting point of the discussion, but the discussion could be stopped in that stage if the spectrum sharing full duplex is not identified in the Rel.18 study item. For the sufficient study for the full duplex in Rel.18, large scope of full duplex should be approved.

2.2.4 Second round replies

Re SK Telecom(#1)'s comments

Thanks for your kind comment. We are aligned with your view regarding study scope for full duplex in Rel-18. We also think that both sub-band full duplex and spectrum sharing full duplex should be studied in Rel-18 in terms of potential benefit, deployment scenario, SI/CLI handling and so on.

In our initial SLS evaluation, we see that sub-band full duplex and spectrum sharing full duplex has a potential to increase system capacity. Also, we see that sub-band full duplex is applicable solution for small packet size, also SB-FD can be more attractive solution for Macro cell deployment. On the other hand, we see that spectrum sharing full duplex is more attractive solution for delivering larger size of packet, and deployment scenarios where lower Tx power is allowed (e.g., Indoor, Urban) is more appropriate for SS-FD operation.

2.3 Physical layer aspects for AI/ML operation

In RWS-210243, we share our view on the potential study item for physical layer aspects for AI/ML operation. And the proposed SI objective can be summarized as follows.

> Identify use cases, deployment scenarios, and solutions for AI based physical layer enhancements

- » Network AI based approaches (e.g. MTRP, interference management)
- » UE AI based approaches (e.g. channel prediction, UE-centric BM/link adaptation)
- » Joint operation of UE AI and NW AI (e.g. positioning)

> Study performance evaluation methodology for AI based solutions

> Evaluate potential performance gain of AI based solutions

2.3.1 First round comments/questions

Please provide your comments/questions on physical layer aspects for AI/ML operation here:

Feedback Form 5: Comments/questions on physical layer aspects for AI/ML operation

1 – ROBERT BOSCH GmbH [Bosch] We are interested to see the positioning also as an example of UE (only) AI based approaches
2 – Intel Corporation (UK) Ltd Q: what is the envisioned specification impact of NW AI based approaches – is it part of RAN3 data-collection scope or air-interface scope?
3 – CATT Thanks for the contribution, and we have following question for clarification: Q1: On page 5, what is joint operation of UE AI and network AI. Positioning is given as an example of joint operation. What is the role of UE AI in use case of positioning?
4 – Sony Corporation Thanks for the contribution. We have two questions.
- Could you clarify “ <i>Joint operation of UE AI and NW AI</i> ” mean?
- Why does joint operation of UE/NW AI may have beneficial for positioning?

2.3.2 First round replies

Re BOSCH(#1), CATT(#3), and Sony(#4)’s comments:

The categorization is just to sort out possible AI deployment scenarios since each scenario would have quite different impact on evaluation as well as specification impact. Joint operation of UE AI and NW AI means that both NW and UE have AI functions for the same feature. In this case, for example, NW and UE can exchange information for helping AI training of each other. Those use cases in our tdoc are only examples and each use case can belong to multiple categories depending on each company’s interested deployment scenario. Specifically for positioning questioned by multiple companies, either or both NW and UE can deploy AI function. Due to the fact that AI based positioning accuracy will be highly dependent on AI model/algorithm for the target scenario, we think joint operation of NW AI and UE AI has a potential, e.g. when UE enters a new cell environment. But we are open for categorization for positioning use case, including UE AI based approach as commented by BOSCH.

Re Intel’s comments(#2):

The proposal is for PHY enhancement, so it is for air-interface scope. In our view, a well-trained NW AI can provide a quick answer for complex NW optimization problem such as traffic management, interference avoidance, TRP/beam allocation, transmission scheme selection, scheduling/resource allocation, etc., so we can consider introducing new advanced L1 scheme(s) based on the analysis of possible use cases, feasibility, and performance gain. One example of NW AI approach can be found in AT&T's paper for MU-MIMO scheduling.

2.3.3 Second round comments/questions

Please provide your second round comments/questions on physical layer aspects for AI/ML operation here

Feedback Form 6: Second round comments/questions on physical layer aspects for AI/ML operation

2.4 ML-aided Predictive Mobility

In RWS-210233, we share our view on the potential study item for ML-aided predictive mobility. And the proposed SI objective is as follows.

> Identify possible scenarios that benefit from ML-aided mobility and link management.

» Consider network-centric prediction, UE-centric prediction and its hybrid form as prediction entities, based on prediction of beam and cell qualities.

» Consider utilization of UE's local real-time information as prediction input

> Evaluate potential benefits and feasibility of ML-aided mobility and link management.

» Investigate the necessity of consolidating prediction models between UE and network, including update of prediction model parameter and/or prediction model replacement.

> Study necessary enhancements to support ML-aided mobility and link management

» Establish predictive mobility procedure with a predictive RLM/RRM framework.

> Study possible methodologies for testing and evaluation of ML-aided mobility and link management procedures.

2.4.1 First round comments/questions

Please provide your comments/questions on ML-aided predictive mobility here

Feedback Form 7: Comments/questions on ML-aided predictive mobility

1 – ROBERT BOSCH GmbH

[Bosch] We support this SI in general. However, we assume it is mandatory to start with UE-centric prediction. How can this study item include predictive quality of service?

2 – Beijing Xiaomi Mobile Software

We support to introduce AI in mobility management. Especially in FR2, legacy mobility management can't adopt to the rapidly changing radio channel condition. ML-aided mobility could provide better performance from respective of throughput and ping-pong handover. UE based prediction may be more preferred, considering UE location is a key factor to improve mobility management and UE may refuse to expose location information to NW. One question is whether this AI model should be specified in 3GPP or up to UE/NW implementation?

3 – ZTE Corporation

We agree this a useful area. One question we have is what is the relationship between the proposals made here and the RAN3 follow-up WI on AI?

4 – Motorola Mobility Germany GmbH

[Lenovo, Motorola Mobility]:

-

Do you also consider predictive mobility for reducing overhead and latency for beam management?

5 – Intel Corporation (UK) Ltd

Q1) For UE-centric prediction where UE triggers handover, will network participate in this approach? What is the role of gNB?

Q2) How does the ML-aided mobility land in UE specifications? Is the plan to specify network behaviours or network requirements after enhancements with ML?

6 – NEC Corporation

NEC proposes to have WI in RAN3 as continuation of the current RAN3 SI; to have a new SI in RAN3 as continuation of the current RAN3 SI covering wider scope and use cases; to have a SI for AI/ML for radio interface. The scope of these WI and SIs looks very close to what is proposed by LG Electronics.

7 – Beijing Xiaomi Mobile Software

We see benefit to introduce AI in mobility management. Especially in FR2, legacy mobility management can't adopt to the rapidly changing radio channel condition. ML-aided mobility could provide better performance from respective of throughput and ping-pong handover. UE based prediction may be more preferred, considering UE location is a key factor to improve mobility management and UE may refuse to expose location information to NW. One question is whether this AI model should be specified in 3GPP or up to UE/NW implementation?

2.4.2 First round replies

Re Bosch(#1)'s comments

Thank you for your support. We would like scope of the study to include both UE-centric and network-centric prediction approaches, because we see relevant use cases that can benefit from respective approach. Regarding predictive QoS, we understand that this would be an ultimate goal of using ML in communication system. However, predicting QoS is indeed challenging in the real field, since QoS is affected by so many factors (internal, external) and subject to network scheduling (and each of those factors is also subject to relevant ML task). Given that, ML with such many factors, in particular for UE-centric approach, seems to raise lots of questions including feasibility. So, we think it is pragmatic to consider relatively easier prediction tasks during the study. Once ML with such easier tasks is adopted in 3GPP, then we can further extend the adoption for QoS prediction later when ML technologies are mature enough for QoS prediction.

Re Xiaomi(#2)'s comments

Thank you for your support. We also think that ML-aided mobility could increase mobility performance and hence user QoS, and the performance benefit with ML approach would be larger for mobility in higher frequency range. We would like UE-based prediction approach to be included as objectives, because real-time local information at UE side is important to improve prediction performance.

Regarding the question on ML model, we think 3GPP does not develop ML models but should be able accommodate state-of-art ML models. However, we think it may be possible that some ML models are recommended for particular use cases, and for mutual trust between UE and network, negotiation/provisioning of AI model between UE and network may be beneficial. All the relevant issues need function-wise discussion and we also need to figure out how performance requirement and test cases should be defined for ML-aided radio interface. We are quite open to discuss and hope to discuss this during initial study phase

Re ZTE(#3)'s comments

Thank you for your comment and question. In our view, the potential RAN3 follow-up WI is more about RAN intelligence enabled by network-centric ML for limited use cases and does not consider ML adoption over radio interface. The proposed study item intends to focus on ML adoption in radio interface, where we want to consider both NW-centric and UE-centric approaches. On the other hand, we see some common ground between the WI and SI in particular on the basic information flow to enable ML-based operation, which we think the study should take into account.

Re Motorola Mobility(#4)'s comments

Thank you for the question. We think prediction capabilities of ML at UE side can reduce latency for beam management. We also think ML can enable beam management with less overhead thanks to its robust reconstruction capabilities.

Re Intel(#5)'s comments

Thank for your questions. On Q1) we think that network should be able to participate in UE-triggered handover approach. For instance, UE is allowed to have a limited degree of freedom for that approach, where the level of the allowed freedom can be controlled by network. This essentially means that the overall mobility

is subject to network control, but the mobility can benefit from UE-centric ML capabilities by selecting better mobility candidate or better mobility timing.

Re NEC(#6)'s comments Thank you for your comment and information. It seems that the scope of your SI proposal seems close to what we propose, which sounds good to us, because we have common interest. What we think for Rel-18 is to have follow-up WI and a new SI. Since the SI will focus on radio interface, we think it would be better for RAN1 and RAN2 to lead the SI, but are open to discuss this

Re Xiaomi(#7)'s comments

We think we answered the same question above. Thanks :-)

2.4.3 Second round comments/questions

Please provide your second round comments/questions on ML-aided predictive mobility here

Feedback Form 8: Second round comments/questions on ML-aided predictive mobility

1 – Intel Corporation (UK) Ltd

Q1: Compared with network-based AI mobility (currently studied in RAN3), what benefit do you expect UE-based AI mobility can bring? What level of UE freedom is expected in UE-centric prediction? (i.e. without network decision on handover? Network decide handover based on UE's prediction? Etc?)

2.4.4 Second round replies

Re Intel(#1)'s comments

For network-triggered mobility (legacy handover), we think UE-centric ML inference can assist network to make better mobility decisions (better candidates/timing), given that UE's local inference can yield, for instance, predictive beam/cell quality based on its locally available measurements and context obtained by sensors, etc, and the UE's local inference is reported to network. Prediction of beam/cell quality from network side (for both serving and neighbor cells) for a concerned UE would not be straightforward. For UE-triggered handover (CHO or CPAC), we think UE-centric ML inference is also beneficial - once mobility execution condition is given to a UE, the mobility execution can be autonomously adapted based on UE-centric ML inference. Regarding the level of UE freedom, we believe that network should be able to control the degree of freedom, once allowed, so that network is still in charge of overall mobility control.

2.5 Enhancement for positioning

In RWS-210245, we share our view on the Rel-18 enhancement positioning. And the potential enhancement areas are suggested as follows.

> **Support of sidelink based positioning**

» Solution to provide absolute and relative position of a UE regardless of the network coverage

> **Support of sidelink assisted positioning**

» Measurement in sidelink can improve the positioning accuracy provided by a Uu-based solution, e.g., by additionally providing the distance and/or angle from a UE placed in a known location and used as an anchor node.

> **Enhancements for UEs equipped with distributed antenna system**

» A vehicle may be equipped with multiple antenna panels placed in different position and the distance between two panels can be several meters as shown in TR 37.885.

»> The current positioning solution may have limitation in achieving a positioning error smaller than the inter-panel distance as it is not supported to separate PRS transmission or reception in different antenna panels.

» This aspect should be considered both in Uu and sidelink positioning.

2.5.1 First round comments/questions

Please provide your comments/questions on positioning enhancement here

Feedback Form 9: Comments/questions on positioning enhancement

1 – ROBERT BOSCH GmbH

[Bosch]: We support sidelink positioning in all coverage and out-of coverage scenarios. We also support DAS for V2X communication; however, we have the following related concerns:

-

Is DAS a mandatory design factor for SL positioning if it is accepted?

-

Should we study DAS impact on RAN before considering it for SL positioning support?

2 – CATT

Comments:

In general, CATT shares the very similar views with LG on the motivations and considerations of SL positioning, and also the consideration of UEs equipped with distributed antenna system

Questions:

Q1: For Slid 9 and 10. For V2X positioning, we may take the advantage of distributed antenna system (DAS) not only for improving positioning performance, but also providing the vehicle orientation information (e.g., from the difference of the carrier phase (time) measurements between the distributed antennas). In addition, the changes of the carrier phase (time) measurements between the distributed antenna of two

UEs may be used to derive precisely the change of the relative position and orientation on the two vehicles. Thus, what is LG's view to support carrier phase/carrier phase difference measurements from DAS for V2X positioning?

3 – vivo Mobile Communication Co.

Thanks for your effort on this. We share similar views that sidelink positioning is an important complement to Uu positioning.

Questions:

Q1: In the given examples and evaluations, the scenarios are mainly related to V2X. Commercial use cases are also being studied in SA1. What's your views for study of sidelink positioning for commercial use cases?

Q2: It is also noted that you would like to consider power efficiency for UEs with limited battery. We support such considerations. One question for such consideration, which scenario do you envision for such UEs with limited battery and how much power consumption do you expect for such cases?

4 – Motorola Mobility Germany GmbH

Thank you for your contribution.

Given the varying use cases and requirements for SL positioning that have or are being discussed in 3GPP, what are your thoughts on a unified SL positioning design for Rel-18 that addresses and supports V2X & Public Safety (TR38.845), Commercial (TR22.855) and IIoT (TS22.104-relative positioning) use cases and requirements ?

5 – Sony Europe B.V.

Thanks for the contribution and we also support sidelink positioning as indicated in our contribution RWS-210301.

Q1: Will there be any specification impact of the introduction of DAS in a UE?

Q2: Which sort of UE enhancements do you foresee to separate PRS transmissions and receptions in different panels?

6 – Intel Corporation (UK) Ltd

Q: Please clarify assumption on DAS / CAS RX signal processing from multiple panels (i.e. whether independent measurements are used for each antenna panel) and antenna/array pattern assumptions. Which factor leads to performance gain of DAS vs CAS? Whether positioning is performed independently for each antenna panel or jointly for both antenna panel?

7 – InterDigital Communications

Do you expect any specification impact by DAS in positioning?

8 – Beijing Xiaomi Mobile Software

Q1: Do you think the commercial and public safety use cases and requirements identified in SA1 Ranging WI(TR22.855/TS22.261) should be taken into account?

-

Q2: According to the definition and the KPI requirements of relative positioning and ranging in TS22.261(see below), do you agree that relative positioning and ranging are different, i.e. relative positioning requires to acquire the 2D/3D coordinates(e.g. the horizontal accuracy of relative positioning set requirements on both distance accuracy and angle accuracy) while Ranging requires to acquire only one component of 2D/3D coordinates(either distance or angle) and thereby only set requirements on one component(either distance or angle)?

o relative positioning: relative positioning is to estimate position relatively to other network elements or relatively to other UEs.

o Ranging: refers to the determination of the distance between two UEs and/or the direction of one UE from the other one via direct communication connection.

-

Q3: from your material, we understand that sidelink based positioning means measurement based on sidelink S-PRS and location is calculated at vehicle side, while sidelink assisted positioning means measurement based on sidelink S-PRS but location is calculated by LMF based on the measurement report from vehicle. Is it possible that vehicle transmits S-SRS and RSUs measure S-SRS?

9 – KT Corp.

KT support this as this feature is requested from Public Safety customers.

2.5.2 First round replies

Re ROBERT BOSCH GmbH(#1)'s comments:

A1: As all kind of UEs supporting SL positioning are not expected to be equipped with DAS, it could be a UE capability.

A2: In Rel.17, multi-panel based communication is being discussed in MIMO WI. If UE is equipped with multi-panel and is involved in SL communication, positioning of multi-panel UE should also be discussed as a consequence. First of all, DAS should be considered for both Uu link and sidelink positioning. Once a vehicle is equipped with DAS, it can be used for both link. As current specification only supports to use a single panel for positioning, multi-panel based positioning solutions should be supported in order to fulfill the positioning requirement. We're open to study impact of DAS on other RAN aspect.

Re CATT(#2)'s comments:

A1: From technical point of view, the carrier phase based positioning can be a candidate for Rel.18 positioning in that it is possible to require less bandwidth than conventional time domain based positioning for high positioning accuracy.

Re vivo Mobile Communication Co.(#3)'s comments:

A1: V2X is one of the important use cases for SL positioning as positioning should be available regardless of network coverage. We're fine to investigate further to extend use cases including commercial ones.

A2: VRU is a key example of power-limited UE in V2X application. In Rel.17 SL enhancement WI, power saving is one of the important topics for improvement from Rel.16 V2X. We need to consider the output of Rel.17 in this aspect also for SL positioning.

Re Motorola Mobility Germany GmbH(#4)'s comments:

A1: It would be ideal if a unified solution can be used for all the use cases of different requirements. Considering industry inputs from 5GAA and SAE, we think it's important to ensure satisfying the requirements of V2X in Rel.18. We're open to consider other use cases with this feature.

Re Sony Europe B.V.(#5)'s comments:

A1: Current LTE/NR positioning only supports the use of a single panel for positioning. When a UE uses DAS, the positioning related attributes e.g., RSTD or AoA/AoD measurement for each panel can be different. This aspect is not addressed in the current specification, so some enhancement needs to be considered for high accuracy positioning.

A2: Taking PRS reception and measurement reporting as an example, the specification first needs to support reporting of separate measurement on each panel. In addition, location information of multiple panels needs to be available for positioning calculation in order to figure out the location of the UE based on per-panel measurement. Similar aspect also needs to be considered in PRS transmission side.

Re Intel Corporation (UK) Ltd(#6)'s comments:

A1: In our simulation, the location of each panel was separately measured and the final UE location is calculated as an average. Joint estimation across panels can be considered for further improvement. One source of performance gain of DAS is thought to come from diversity gain. The radiation pattern is quite different from each location of a vehicle, e.g. front, rear bumper or rooftop. That is one of reasons why DAS is considered for V2X communication to get better coverage. The same reason works for positioning. If DAS is used, more anchor nodes (e.g. gNB or UEs) are visible from a vehicle side, which is directly associated to the performance improvement in terms of positioning accuracy and availability.

Re InterDigital Communications(#7)'s comments:

A1: Current LTE/NR positioning only supports the use of a single panel for positioning. When a UE uses DAS, the positioning related attributes e.g., RSTD or AoA/AoD measurement for each panel can be different. This aspect is not addressed in the current specification, so some enhancement needs to be considered for high accuracy positioning.

Re Beijing Xiaomi Mobile Software(#8)'s comments:

A1: All the use cases of different requirements including commercial and public safety can be considered in SL positioning. Considering industry inputs from 5GAA and SAE, we think it's important to ensure satisfying the requirements of V2X in Rel.18. We're open to consider other use cases with this feature.

A2: We think that Rel.18 should support a solution which provides a distance and an angle/direction of UE using SL between UEs. From RAN perspective, no distinction between relative positioning and ranging is necessary as far as a radio solution serving this purpose is specified.

A3: We assume that S-SRS means S-PRS in the last sentence. If RSU is UE-type, then SL positioning can be used between RSU and vehicles. In this scenario, yes, a vehicle can transmit S-PRS and RSU can measure S-PRS. RSU can be used as an anchor node for positioning, of which the location is known in advance.

Re KT Corp.(#9)'s comments:

Thank you for support.

2.5.3 Second round comments/questions

Please provide your second round comments/questions on positioning enhancement here

Feedback Form 10: Second round comments/questions on positioning enhancement

1 – Beijing Xiaomi Mobile Software

Thank you for the response. Please see our further questions below:

Q1: As your response in the first round discussion, you are open to consider commercial use cases for V2X positioning and think DAS should be considered for sidelink positioning. So I am wondering whether DAS can be used to sidelink positioning for commercial cases, since I think the device for commercial cases couldn't provide enough distance between two antenna panels and so the expected gain couldn't be achieved.

Q2: What are your views on support RAT independent SL positioning for relative positioning/Ranging?

Q3: Do you think it is needed to support network based relative positioning? If so, why?

Q4: For relative positioning, do you think TDOA/RTOA need to be supported? If so, how? Also, please justify the scenario and explain the gain compared to RTT+AOA/AOD.

2.5.4 Second round replies

Re Xiaomi(#1)'s comments

Thank you for further interest and questions. Please see our responses below:

A1: There seems misunderstanding on positioning based on multiple panels. First, multiple panels can be used not only for sidelink but Uu link communication and positioning. Second, we're not insisting that multiple

panels should be used for positioning purpose. The proposal is that some positioning enhancement is needed for positioning of UE that is equipped with multiple panels, because the current specification only supports positioning based on a single panel. For V2X applications, some vehicles may be equipped with multiple panels for several reasons such as to overcome the blockage of the vehicle body, to provide design flexibility, etc., and multi-panel based positioning needs to be considered when high accuracy positioning is required for these vehicles. Some commercial devices may also be equipped with multiple panels but with very small inter-panel distance, but still some consideration is necessary, e.g., to deal with the difference in AoA/AoD properties in different panels.

A2: Fusion of various positioning sources generally provide better positioning performance. In this sense, RAT independent SL positioning can be combined with RAT dependent SL positioning for e.g., better positioning accuracy and availability.

A3: In general sense, high computational power of location server may be more appropriate for very high accuracy positioning based on e.g., MUSIC algorithm than UE. In addition, a UE outside the network coverage can be positioned through nearby UEs located inside the network coverage. In this case, location server can provide positioning service to the UE outside the network coverage. It can be thought of as SL-assisted positioning.

A4: TDoA/RToA-based positioning can be considered for relative positioning together with other positioning techniques including RTT and AoA/AoD. Relative distance from nearby UEs can be estimated based on RSTD measurement, for example. It can also be combined with AoA/AoD if a direction of a UE needs to be known. One of the advantage of TDoA/RToA approach is a reduced latency for positioning compared to RTT, as only a one-way positioning measurement is needed for TDoA/RToA whereas two-way measurement is needed for RTT. Considering services having very short latency requirement, TDoA/RToA can be considered as a technique to fulfill the latency requirement. Another benefit is that only anchor nodes (gNB or UEs at fixed locations) transmit PRS in TDoA/RToA and thus it can avoid resource and battery consumption required for RTT measurement.

2.6 Enhancement for device requirement

In RWS-210249, we share our view on the Rel-18 enhancement for device requirement. And the potential enhancement areas are suggested as follows.

> **Further enhancement for FR1 RF**

- » Simultaneous Rx/Tx for Intra-band non
- » contiguous CA/DC in TDD band

> **Further enhancement for FR2 RF**

- » PC2 (Vehicular UE) requirement on 39GHz(n259, n260) and inter-band DL/UL CA for PC2 in FR2 RF
- » FR2 inter-band UL CA based on CBM

> **Further enhancement for RRM**

- » Study and specify RRM requirements related to different sets of RX beams between different MOs in FR2

2.6.1 First round comments/questions

Please provide your comments/questions on enhancements for device requirements here.

Feedback Form 11: Comments/questions on enhancements for device requirements

1 – Intel Corporation (UK) Ltd

1) For RRM: How is the network supposed to cope with a UE indicating multiple sets of beams? Do we need to specify network behaviour towards that? If so what are the clear benefits brought from this enhancements in standards? Note that we have already different assumptions when we specify the existing requirements.

2 – LG Uplus

Thanks for valuable contribution and we think this "Simultaneous Rx/Tx for Intra-band NCCA in TDD band" would be the important feature and can be the bridge to full duplex. Of course in reality adjacent operators scenario might be the issue requiring significant discussion and negotiation, but anyway technically this feature can be the essential foundation to improve spectral efficiency and utilization. Just one question is following :

Q1) Do you have any plan for the schedule for specifying each feature regarding Rel-18, 19 ?

2.6.2 First round replies

Re Intel(#1)'s comments

In general, different Rx beam sets can have different Rx beam gains. If different Rx beam sets are used on cells which are configured to be measured in different MOs, the different Rx beam gain should be considered. However, so far, there is no behavior related to this in either network or UE. Therefore some related behaviors need to be specified. This can give clear benefits in the aspect of enhancement for mobility management and system throughput.

Re LG Uplus(#2)'s comments

The related work on simultaneous Rx/Tx for intra-band non-contiguous CA/DC is for Rel-18. First round comments/questions

2.6.3 Second round comments/questions

Please provide your second round comments/questions on enhancements for device requirements here.

Feedback Form 12: Second round comments/questions on enhancements for device requirements

1 – Intel Corporation (UK) Ltd

Thank you for the responses! Please see our additional questions:

Q1: For FR1 RF enhancements (simultaneous Rx/Tx), what is operation scenario among three operators, i.e., asynch or sync? Compared to n79, what is expected issue in n77 and n78?

2 – Huawei Technologies France

Thanks for the contribution.

Further enhancement for FR1 RF

Question 1: whether synchronization co-ordination would be considered for TDD intra-band NC CA/DC?

Question 2: So far there is no feasibility study to support defining the simultaneous Rx/Tx capability for intra-band NC CA/DC.

Further enhancement for FR2 RF

Question 1: Are there any deployment demand from operators for PC2 on 39GHz band?

Further enhancement for RRM

Question 1: This enhancement was discussed for Rel-17 FeRRM in RAN#88 but there was no consensus. We understand that Rx beamforming is up to UE implementation. Based on RAN1 agreement in R1-1805760, the selection of Rx beam set to perform measurement on carrier is left to the UE implementation with the limitation that the same Rx beam set is used to measure the same carrier, so it's unclear to us what additional requirements need to be specified.

2.6.4 Second round replies

Re Intel(#1)'s comments

Our target is to define simultaneous Rx/Tx capability for intra-band non-contiguous CA/DC UE in wide band e.g. n77, n78 or n79

The capability can support asynchronous operation when there is sufficient frequency gap.

For the multiple operators with adjacent carrier, RAN4 should study further how much frequency gap is needed to allow asynchronous operation. Having said that, it is currently not exactly the scope of our proposal.

Re Huawei(#2)'s comments

Further enhancement for FR1 RF

A1) RAN4 can consider both synchronous and asynchronous operation in TDD intra-band NC CA/DC depending on the frequency gap

A2) In CLI WI, RAN4 studied macro to macro interference issue with adjacent carrier. But RAN4 did not study the interference issues for intra-band NC CA/DC. That is reason to propose the work for FR1 RF enhancement. For the intra-band NC CA/DC with frequency gap between CC1 and CC2, RAN4 can allow the simultaneous Rx/Tx capability, and we can allow different UL/DL configuration in intra-band non-contiguous CA/DC.

Further enhancement for FR2 RF

A1) We can say at least a Korean operator who co-signed this proposal has interest. And we think PC2 needs to be covered in 39GHz just like the case in 47GHz (n262) where PC2 was also included. We are not sure if there was any deployment demand from operator in 47GHz for PC2.

Further enhancement for RRM

A1) For different MOs, UE can perform measurement with different Rx beam sets. One example can be inter-frequency measurement. So, we think it needs to study and specify the related behavior for network and UE.