

3GPP TSG RAN Release 18 Workshop RWS-210574

Electronic Meeting, 28th June – 2nd July 2021

Agenda Item: 4.1

Source: Email discussion moderator (Intel)

Title: Report from Email Discussion RAN-R18-WS-non-eMBB-Intel

Document for: Information

1 Introduction

This document is the report from the email discussion prior to the Rel-18 Workshop of the contributions submitted by Intel to agenda item 4.2 'Non-eMBB-driven Functional Evolution'. As instructed by the chair [RWS-210002], the purpose of the pre workshop email discussions is to provide an opportunity for questions and answers to help better understanding of the proposals among companies.

Intel submitted the following contribution to agenda item 4.2

RWS-210367 Rel-18 NR Positioning, Intel

RWS-210371 Rel-18 NR Sidelink, Intel

RWS-210372 Rel-18 NR XR, Intel

RWS-210374 Rel-18 NR MBS enhancements, Intel

RWS-210377 Rel-18 URLLC/IIOT, Intel

RWS-210378 Rel-18 RedCap Enhancement, Intel

2 General questions/comments

In addition to the 6 contributions submitted to agenda item 4.2, Intel submitted an overview of Rel-18 to agenda item 4 [RWS-210376]. General questions/comment to Intel related to non-eMBB functional evolution may be raised in this section.

2.1 Round 1 Questions

Feedback Form 1: General questions/comment related to non eMBB functional evolution

1 – FGI

Thank you for sharing the contributions. Please find some questions to RWS-210377 below.

1. Regarding the proposal about “overlap of multiple dynamically scheduled PUSCHs with different priorities”, could Intel elaborate more about the required enhancements in this case and the intended outcome benefited from the corresponding enhancement? From our understanding, such a scheduling is not allowed in Rel-17. Do Intel intend to support this type of scheduling in Rel-18, and prioritizes one of the overlapping PUSCHs for transmission?
2. Regarding the proposal to achieve “More reliable & faster channel access for both LBE and FBE”, could Intel elaborate more about the required enhancements to achieve this?
3. Regarding the proposal to support “survival time aware scheduling”, does Intel foresee some enhancements required at the UE side, i.e., not purely based on gNB implementation?

2.2 Round 1 Answers

Please refer to our responses on URLLC in section 7.2 below.

2.3 Round 2 Questions

2.4 Round 2 Answers

3 Rel-18 NR Positioning

Questions related to RWS-210367 ‘Rel-18 NR Positioning’ may be raised in this section.

3.1 Round 1 Questions

Feedback Form 2: Questions related to RWS-210367 ‘Rel-18 NR Positioning’

1 – ETRI

On page 8, suggested release-18 priority,...

- 1) Machine learning for positioning is an interesting topic. However, please specify which work group is main leadership. Unlike other topics, this does not seem to be the scope of RAN1.
- 2) Carrier phase-based positioning is still supported by many companies. Page 4 mentioned this, but is it missing from page 8 ? what’s the priority ?

2 – CATT

In general CATT shares the similar views with Intel on the potential work for R18 in Page 3. Our view is to have two separate SIs/WIs: one for SL positioning, and one for R18 further positioning enhancements. We

think the positioning enhancement with carrier phase measurements and also the difference of the carrier phase measurements should be studied in R18.

3 – ZTE Corporation

We have several comments as below:

(1) We are also very interested in machine learning for positioning. However, it is more natural to discuss machine learning related topics in section 4.3. You can also find our proposal for AI based positioning in RWS-210478

(2) On page 4, regarding positioning in unlicensed spectrum for Uu, what spec impact is expected?

(3) Regarding SL positioning on unlicensed spectrums, since unlicensed spectrums are not supported for Rel-17 sidelink, but may be considered in Rel-18. Does this sidelink positioning on unlicensed spectrums rely on Rel-18 sidelink discussion? How to handle the collision between two topics? We actually prefer to prioritize ITS and licensed spectrums for SL positioning in Rel-18.

4 – ROBERT BOSCH GmbH

[Bosch]:

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Regarding pos. enhancements (RWS-210367):

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We support Uu Enhancements to be extended to RedCap. However, does Intel see a chance to combine RedCap Uu and SL positioning?

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I see Intel uses SL-assisted positioning, in our understanding, this may mean mean SL assisting Uu and/or GNSS positioning. Thus, does Intel support "standalone" Sidelink positioning regardless of coverage or existing positioning scenarios (i.e., at least for ranging) ?

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Note: we support ML/AI-based positioning study to consider possible UE-centric approaches, e.g., including vehicular-UE type with ML/AI-based sensor fusion.

5 – Guangdong OPPO Mobile Telecom.

Q1

For "Sidelink-aided positioning", does it mean SL positioning mechanism is introduced as a supplementary scheme rather than a dominant positioning scheme on licensed spectrum?

Comment on 2

Proposal 2 and the observation in 7 about unlicensed spectrum consideration seems supportable.

6 – Sony Europe B.V.

Thanks for the contribution, in principle, we also support sidelink positioning for Rel-18 as we mentioned in our contribution RWS-210301.

1) Why licensed spectrum may not be enabled for sidelink? e.g. What do you mean by impact on Uu-interface?

- 2) Would you also consider FR2 sidelink as important as FR1?
- 3) Would there be any RAN1 work on supporting machine learning for positioning?

7 – Qualcomm Incorporated

8 – Huawei Tech.(UK) Co.. Ltd

Thank you for the contribution. By "sidelink-aided", do you mean that sidelink positioning does not work standalone?

9 – Beijing Xiaomi Mobile Software

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For sidelink positioning

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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?

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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)?

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

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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.

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Q3: For the V2X KPIs, we want to clarify that whether it applies for the case of Uu+sidelink or standalone sidelink? We think it is better to differentiate the latency requirement between positioning methods with Uu+sidelink and standalone sidelink. For example, lower latency should be required for positioning method with standalone sidelink, compared to that of positioning method with Uu+sidelink.

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Q4: Based on the description of 'Integration of sidelink-aided positioning to NR RAT-dependent solutions', does it mean only to study sidelink-aided positioning in Rel-18 but don't study standalone sidelink based positioning?

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For Redcap positioning

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Q5: Do you think is there a need to define new accuracy requirement for RedCap positioning or just reuse the requirement defined for eMBB?

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Q6: Do you think is there a need to have a short study phase to clarify the requirement for RedCap and perform the evaluation to see if there is gap to reach that requirement?

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Q7: For machine learning positioning, in your opinion, which aspects should be specified in the 3GPP since there are many aspects can be left to implementation?

10 – MediaTek Inc.

Q1: What exactly is the proposed optimization for UEs with reduced BW? It is to enhance the receiver algorithm?

Q2: Integrity: How do you see the work split between RAN1 and RAN2 on integrity for RAT-dependent methods, considering that RAN2 previously concluded that they needed input from RAN1 on the error sources? Would this be a study phase first?

11 – MediaTek Inc.

Q3: An ML study on positioning might be quite open-ended. Do you have anything specific in mind?

12 – Samsung Electronics Co.

1. Do you support positioning in unlicensed spectrum in FR1 and FR2?

13 – MediaTek Inc.

What issues do you see exactly preventing unlicensed positioning? Is it due to LBT, un-managed interference, or both? Note that short control signals are typically allowed to be sent with no LBT in some regulations.

14 – Lenovo (Beijing) Ltd

Machine learning mainly based on data and algorithms to generate results, what's the potential specification impact or RAN impact by introducing machine learning to positioning enhancements from intel's veiw?

15 – LG Electronics Inc.

Q1: Which aspects can be considered for using machine learning for positioning? Can machine learning be used for both Uu link and SL positioning?

Q2: For supporting positioning in unlicensed BW, we will be appreciated if you explain further details about use cases and target requirement.

16 – KT Corp.

Slide 4 is mentioning carrier phase-based positioning and it seems that you forgot to mention this in slide 8. We also support having carrier phase-based positioning included in Rel-18 scope.

3.2 Round 1 Answers

1 – ETRI

On page 8, suggested release-18 priority,...

Machine learning for positioning is an interesting topic. However, please specify which work group is main leadership. Unlike other topics, this does not seem to be the scope of RAN1.

Answer: In our view positioning performance analysis is overall in RAN1 scope, no matter whether it is ML based positioning or positioning based on traditional algorithms, etc. If the question is about specification work for support of ML-based positioning framework, then we think more discussion is needed in terms whether/what/when needs to be specified and what are the benefits from specification work. We believe that at this stage (R18 timeframe) evaluation/study of ML frameworks can at least be used to justify support of new signalling / measurements that are beneficial for RAT-dependent positioning. For instance, ML based frameworks can be used to classify the links on LOS / NLOS types as being discussed in R17. Going forward, we think that NR positioning and ML frameworks can evolve more that may require more sophisticated efforts and measurements including coordinate estimates, but we do not see strong motivation to reconsider current approach for NR positioning of specification work at this stage.

Carrier phase-based positioning is still supported by many companies. Page 4 mentioned this, but is it missing from page 8 ? what's the priority ?

Answer: In our view, this topic requires 1) further feasibility study 2) comparative analysis with R16/R17 methods. In addition, we expect many implications on current design. For Rel.18 work, it is not in our priority list.

2 – CATT

In general CATT shares the similar views with Intel on the potential work for R18 in Page 3. Our view is to have two separate SIs/WIs: one for SL positioning, and one for R18 further positioning enhancements. We think the positioning enhancement with carrier phase measurements and also the difference of the carrier phase measurements should be studied in R18.

Answer: Thanks for sharing your views. It is good to see alignment on many items. Regarding SI/WI organization, we do not think that increasing number of SI/WIs is a good idea. The organization of SI/WI can be further discussed separately.

3 – ZTE Corporation

We have several comments as below:

We are also very interested in machine learning for positioning. However, it is more natural to discuss machine learning related topics in section 4.3. You can also find our proposal for AI based positioning in RWS-210478

Answer: Thanks for feedback and sharing your views. One aspect we need to consider is that if sophisticated ML based positioning work is planned then we will need to perform comparative analysis with baseline solutions. From this perspective, we are not so sure that having all ML topics in one place is the best option.

On page 4, regarding positioning in unlicensed spectrum for Uu, what spec impact is expected?

Answer: We expect impact on procedures for transmission of positioning reference signals, measurements and

potential modifications of physical structure of positioning reference signals.

Regarding SL positioning on unlicensed spectrums, since unlicensed spectrums are not supported for Rel-17 sidelink, but may be considered in Rel-18. Does this sidelink positioning on unlicensed spectrums rely on Rel-18 sidelink discussion? How to handle the collision between two topics? We actually prefer to prioritize ITS and licensed spectrums for SL positioning in Rel-18.

Answer: This aspect requires more discussion and may be also dependent on design options/operation scenarios. Overall, we think that if both frameworks (positioning and communication) are jointly considered from the beginning, it can be mutually beneficial for overall sidelink operation in unlicensed spectrum.

4 – ROBERT BOSCH GmbH

We support Uu Enhancements to be extended to RedCap. However, does Intel see a chance to combine RedCap Uu and SL positioning?

Answer: Please clarify whether you assume RedCap SL positioning in the question (which is not supported at this stage) or R16/R17 sidelink design. Overall, our view, is that all NR positioning enhancements should be discussed together in the same framework.

I see Intel uses SL-assisted positioning, in our understanding, this may mean mean SL assisting Uu and/or GNSS positioning. Thus, does Intel support "standalone" Sidelink positioning regardless of coverage or existing positioning scenarios (i.e., at least for ranging) ?

Answer: We do consider standalone sidelink.

Note: we support ML/AI-based positioning study to consider possible UE-centric approaches, e.g., including vehicular-UE type with ML/AI-based sensor fusion.

Answer: We are open to discuss this, but we are not so sure if it really requires additional specification work. Could you clarify what do you mean by UE-centric approaches and what specification efforts you foresee for sensor fusion?

5 – Guangdong OPPO Mobile Telecom.

For "Sidelink-aided positioning", does it mean SL positioning mechanism is introduced as a supplementary scheme rather than a dominant positioning scheme on licensed spectrum?

Answer: We do not consider sidelink positioning as a dominant solution in licensed spectrum. At the same time, we assume it can be complementary to Uu positioning solution, if both are enabled. We also consider unlicensed spectrum for sidelink and Uu positioning.

Comment on Proposal 2 and the observation in 7 about unlicensed spectrum consideration seems supportable.

Answer: Thank you for feedback.

6 – Sony Europe B.V.

Thanks for the contribution, in principle, we also support sidelink positioning for Rel-18 as we mentioned in our contribution RWS-210301.

Why licensed spectrum may not be enabled for sidelink? e.g. What do you mean by impact on Uu interface?

Answer: In RAN4, sidelink support is defined for very limited number of licensed band(s) and overall, it is up to operator control. Regarding impact on Uu, we refer to sidelink interference on DL reception.

Would you also consider FR2 sidelink as important as FR1?

Answer: Overall, we consider it as important going forward. We are not sure, if both FR1 and FR2 can be completed in one release especially considering V2X scenarios and the fact that sidelink positioning has not been supported before in previous RAT dependent positioning frameworks.

Would there be any RAN1 work on supporting machine learning for positioning?

Answer: It depends on the actual context of the work. We already in R17 provided multiple results how ML may be useful for positioning (e.g., LOS/NLOS link classification). Overall, our view is that RAN1 should be in charge of ML evaluation studies for positioning and debates on specification work if any is selected for R18.

7 – Qualcomm Incorporated

Question 1: How do you see the different bands being used? Will coordination signaling and PRS be sent in different bands?

Answer: This is one of the possible design directions. In our view, design details can be discussed later when the overall picture on the scope of R18 in terms of sidelink / NR positioning is clear (e.g. sidelink communication support in unlicensed band, Uu positioning in unlicensed band, etc.)

Question 2: Do you consider ML for Positioning as part of a Positioning-specific SI, or within the scope of a general SI on ML/AI applications?

Answer: In our view, sophisticated (positioning centric) work on ML should be done in Positioning-specific SI. Note that we do not envision such work as a high priority in a near term (i.e. for R18). Sophisticated work may require additional preparation phase (work/study) in 3GPP for channel modelling and probably even architectural considerations. For R18 positioning, we see that there are already quite many remaining items on the table that need to be completed. Regarding ML scope for positioning in R18, we think it should be rather limited in terms of specification efforts/impact. The details of ML positioning scope need to be further discussed to answer the question more precisely. Our initial consideration for R18 is that we can use ML frameworks for positioning to justify new signalling and measurements but not reconsider baseline solutions introduced in R16/R17.

8 – Huawei Tech.(UK) Co.. Ltd

Thank you for the contribution. By "sidelink-aided", do you mean that sidelink positioning does not work standalone?

Answer: We assume that NR RAT dependent positioning will be aided by sidelink based positioning capabilities, including standalone sidelink positioning.

9 – Beijing Xiaomi Mobile Software

For sidelink positioning

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

Answer: We are open for discussion, considering that we do see some similarity in requirements and radio-layer solutions / functionality.

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)?

- *Relative positioning: relative positioning is to estimate position relatively to other network elements or relatively to other UEs.*

- *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.*

Answer: Our view is that relative positioning implies requirement on coordinate accuracy and ranging implies requirement on measurement accuracy (distance/angle).

Q3: For the V2X KPIs, we want to clarify that whether it applies for the case of Uu+sidelink or standalone sidelink? We think it is better to differentiate the latency requirement between positioning methods with Uu+sidelink and standalone sidelink. For example, lower latency should be required for positioning method with standalone sidelink, compared to that of positioning method with Uu+sidelink.

Answer: In our view requirement is determined by the provided service. The latency of positioning is dependent on utilized methods / radio-interfaces.

Q4: Based on the description of 'Integration of sidelink-aided positioning to NR RAT-dependent solutions', does it mean only to study sidelink-aided positioning in Rel-18 but don't study standalone sidelink based positioning?

Answer: The intention is to analyse/support both mentioned options.

For Redcap positioning

Q5: Do you think is there a need to define new accuracy requirement for RedCap positioning or just reuse the requirement defined for eMBB?

Answer: If we are talking about 3GPP / RAN4 requirements then we assume that new requirement may need to be defined for RedCap UE.

Q6: Do you think is there a need to have a short study phase to clarify the requirement for RedCap and perform the evaluation to see if there is gap to reach that requirement?

Answer: We do not think it is necessary given that positioning requirements are typically interpreted as a target numbers for evaluation and design.

Q7: For machine learning positioning, in your opinion, which aspects should be specified in the 3GPP since there are many aspects can be left to implementation?

Answer: It needs further study, overall, we agree with the observation made. One example is that ML can be used to justify additional signalling / measurements.

10 – MediaTek Inc.

Q1: What exactly is the proposed optimization for UEs with reduced BW? It is to enhance the receiver algorithm?

Answer: Our motivation is to improve accuracy of positioning under constraint of the limited bandwidth at RX processing.

Q2: Integrity: How do you see the work split between RAN1 and RAN2 on integrity for RAT-dependent methods, considering that RAN2 previously concluded that they needed input from RAN1 on the error sources? Would this be a study phase first?

Answer: For the mentioned reason, we think it should be in RAN1 scope. We slightly prefer study phase.

Q3: An ML study on positioning might be quite open-ended. Do you have anything specific in mind?

Answer: We agree with this observation and open-ended study is not our preference. Study on ML based positioning is not our top priority. In addition, we think detailed studies may require modification of channel modelling framework.

12 – Samsung Electronics Co.

1. Do you support positioning in unlicensed spectrum in FR1 and FR2?

Answer: We think both frequency ranges are important for Uu link. We are open to consider phased approach and start from FR1 given that unlicensed spectrum is also considered for sidelink.

13 – MediaTek Inc.

What issues do you see exactly preventing unlicensed positioning? Is it due to LBT, un-managed interference, or both? Note that short control signals are typically allowed to be sent with no LBT in some regulations.

Answer: We have the same considerations as you have mentioned (need for LBT, robust to un-managed interference).

14 – Lenovo (Beijing) Ltd

Machine learning mainly based on data and algorithms to generate results, what's the potential specification impact or RAN impact by introducing machine learning to positioning enhancements from Intel's view?

Answer: We do not think that reconsideration of positioning frameworks defined in R16/R17 is a right direction in a near term. The sophisticated ML based study for positioning is not our priority for specification work in R18 since many problems can be addressed by implementation already.

15 – LG Electronics Inc.

Q1: Which aspects can be considered for using machine learning for positioning? Can machine learning be used for both Uu link and SL positioning?

Answer: Regarding aspects, indoor positioning in NLOS heavy scenarios. Implementation-wise it can be used for both Uu and SL.

Q2: For supporting positioning in unlicensed BW, we will be appreciated if you explain further details about use cases and target requirement.

Answer: We target I-IoT and V2X/PS requirements for Uu / SL.

16 – KT Corp.

Slide 4 is mentioning carrier phase-based positioning and it seems that you forgot to mention this in slide8. We also support having carrier phase-based positioning included in Rel-18 scope.

Answer: We are currently not considering it as a top priority given that many other frameworks are already in place.

3.3 Round 2 Questions

Feedback Form 3: Round 2 questions related to RWS-210367 'Rel-18 NR Positioning'

1 – ZTE Corporation

Thanks for the first round reply. Regarding the ML/AI based positioning, we still think it is more proper to put the discussion in a SI dedicated for ML/AI+physical layer where how to align evaluation methodology among companies for ML/AI should be discussed first.

Regarding SL positioning on unlicensed spectrums, we see the benefit. However, doing the much related enhancements parallel in two topics (V2X and positioning) is very risk and may cause unnecessary standard efforts. We still think it is better to discuss regular V2X transmission in unlicensed spectrums first, then following by SL positioning.

2 – CATT

We'd thank Intel for sharing their view on SI/WI organization, at this stage we could first discuss on requirements and potential technical scopes, and then discuss organization aspects in a later stage.

Q1: About carrier phase-based positioning, we saw Intel provided the following responses: "In our view, this topic requires 1) further feasibility study 2) comparative analysis with R16/R17 methods", could Intel explain what is covered by the "comparative analysis with R16/R17 methods"?

Note: In our understanding there is dependency of carrier phase-based positioning on the existing R16/R17 positioning methods, e.g., the search space of the integer ambiguity in carrier phase measurement is basically determined by the accuracy of initial UE position, which is determined by the use of the existing R16/R17 positioning methods.

3 – Huawei Tech.(UK) Co.. Ltd

Q1: Based on the feedback, it seems like Intel is interested in Uu positioning enhancements in unlicensed spectrum. Just clarify, it was discussed during Rel-16 UE feature that Uu positioning in unlicensed spectrum has already been supported, and in Rel-17 there is also ongoing discussion on LBT exemption for PRS in 52.6-71GHz. Is there any particular enhancement Intel has mind that can be further specified in Rel-18 with respect to Uu positioning in unlicensed spectrum?

Q2: Regarding integrity support for Uu and PC5, we would like to understand the use case to support the protection level calculation that has such high confidence as e.g. 99.9999% (IR<0.0001%).

4 – ROBERT BOSCH GmbH

- - In our understanding, when RedCap includes SL (in addition to Uu), we can then specify Uu-positioning and SL-positioning to it. Is it what intel sees as well?

- - Regarding sensor fusion. In V2X use cases, a vehicle includes a sensor fusion will be able to integrate all positioning sensors (including 5G Uu and SL positioning). This sensor fusion is an AI entity, will detect whether GNSS needs to be assisted by Uu-based positioning, or Uu-based positioning needs to be supported by SL-positioning, etc.. It is also assumed that the sensor fusion will be integrated near to the UE in a CCU/ECU.

Hence, do you think that the sensor fusion need to be considered if we study AI-based positioning? (i.e., specifically for UE-centric approaches)

5 – LG Electronics Inc.

Thank you for clarification.

Q1: Could you explain/provide your ideas about what to consider in terms of RAN1 if positioning is supported for RedCap UEs.

3.4 Round 2 Answers

To ZTE:

Thanks a lot for the comments. We think the mentioned aspects need further analysis and can be further discussed given that there are quite many proposals on the table.

To CATT:

Answer to Q1: Thanks a lot for the feedback. Assuming feasibility study is completed, by comparative analysis we mean performance benefits in terms of positioning accuracy, UE/NW power consumption, latency vs R16/17 solutions, in NLOS-centric and LOS-centric deployment scenarios. Based on your note, it seems you assume R16/R17 positioning should be used before applying carrier phase positioning. Do we have correct understanding that you do not envision support of standalone carrier phase-based positioning?

To Huawei:

Answer to Q1: Thanks a lot for the question. Our motivation is to mainly study/enable the following procedures related to channel access in low and high frequency bands in unlicensed spectrum (it relates to LBT mechanism):

- 1) Impact on NW/gNB behavior for DL-PRS transmission and UE DL PRS processing
- 2) Impact on UE behavior for UL SRS for positioning transmission and gNB reception

Our understanding it is likely to have impact on physical structure of transmitted DL PRS and UL SRS for positioning. In addition, subject to further discussion we may need to consider support of sidelink positioning in the same frequency bands.

Answer to Q2: On integrity part, our understanding is that framework is currently missing for RAT dependent NR positioning methods. We think integrity framework can be useful for V2X/I-IoT/PS use cases. The specific targets can be further discussed/studied.

To Bosch:

Answer to Q1: Assuming RedCap for SL is supported, we are open to consider it for SL positioning as well.

Answer to Q2: On sensor fusion, so far, we have been considering it primarily as an implementation issue. We are not so sure about 3GPP evaluation efforts / specification support. Our view is that AI+fusion is a bit separate topic for discussion. We may need to discuss the exchange of information shared by UE at radio-layers.

To LGE:

Answer to Q1: Our understanding is that 3GPP may consider solutions for accuracy enhancements under UE bandwidth constraints.

4 Rel-18 NR Sidelink

Questions related to RWS-210371 'Rel-18 NR Sidelink' may be raised in this section.

4.1 Round 1 Questions

Feedback Form 4: Questions related to RWS-210371 'Rel-18 NR Sidelink'

1 – LG Electronics Inc.

Q1: Can you elaborate on the motivation of the local Uu or PC5 forwarding? Is it to improve the reliability by packet duplication?

Q2: Can you explain more about "sub-pooling" in slide 8? Is this to configure a small resource pool separately for RedCap SL operations? If so, is it something different from usual SL resource pool except its size?

2 – HuaWei Technologies Co.

Q1: What will be performance impact on both LTE-V and NR-V in coexistence, can LTE-V and NR-V service requirement can be satisfied by using the same band by LTE-V and NR-V?

Q2: On page 7, for local PC5 data forwarding (right figure), do you feel it is like multi-path for SL relay (see RWS-210451)?

Q3: On Page 7, for local Uu forwarding (left figure), in our understanding if gNB is involved in the transmission, the data should be anyway forwarded to the CN. What is your considered scenario here?

3 – ROBERT BOSCH GmbH

[Bosch]:

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Regarding Rel-18 NR Sidelink:

- Regarding leftovers from R17, can Intel prioritize among the list in slide-6: power-saving, co-channel co-existence, and sidelink CA ? (sidelink positioning in our understanding is separate topic).
- Sidelink-aided support in your slides is only for IIoT, can you elaborate more on the use-cases? does this include sidelink data transmission as well or only control, positioning, etc.?
- RedCap sidelink: do you see this feature is extendable to V2X use cases (as you excluded it in slide 8)? e.g., eBike, u-mobility, etc. ?

4 – Guangdong OPPO Mobile Telecom.

Comment on 1.1

It is proposed that SL positioning is included in NR positioning framework rather than in Rel-18 SL enh. framework. The work of SL positioning should not have significant impact on SL design including structure, procedure, etc.

Comment on 1.2 / 1.3 / 1.4

It seems reasonable to capture Co-channel, CA and Rel-17 leftover as a part of Rel-18 SL enh. since many other companies also proposed these three items.

Comment on 2.1 and 2.2

Besides latency and reliability, high data rate is another non-ignorable KPI, since I-IoT may require extremely high data rate in some scenarios.

Q2.3

Does sub-slot SL Tx need change the current NR SL PHY structure / procedures? If yes, some unexpected work / impact on existing NR SL mechanism may be introduced.

Comment on 2.4

SL in unlicensed spectrum should not be restricted in I-IoT scenarios, but also other SL related scenarios.

Comment on 2.5

For intra-UE service prioritization, the follow-up design can be considered, e.g. dropping mechanism when there are not enough resources for all the TBs; how to fulfil latency requirement when TBs with low priorities are postponed by a UE.

5 – InterDigital Communications

What is sub-pooling in slide 8 under RedCap sidelink?

6 – Lenovo (Beijing) Ltd

Q1: What's the benefit for co-channel coexistence between LTE-PC5 and NR-PC5? If co-channel coexistence was supported whether only NR-PC5 will be enhanced/modified, e.g., no spec impact on LTE-PC5?

Q2: On "Sidelink carrier aggregation and/or BWP adaptation" in Page 6, whether SL CA and BWP adaptation are proposed for the same motivation, e.g., data rate/reliability? In our view SL CA may be benefit for data rate/reliability, however BWP adaptation targets for power saving.

7 – CATT

Can we consider Redcap sidelink and URLLC sidelink two separate enhancements on top of NR-redcap and NR-URLLC respectively, instead of two enhancements for sidelink?

8 – Samsung Electronics Co.

Q1: What URLLC requirement target is considered for URLLC sidelink? Is it same as Uu URLLC requirement?

Q2: Do you consider throughput as a key KPI?

9 – MediaTek Inc.

Thanks for the contribution. For RedCap sidelink, a couple of questions:

- Do you consider the primary target as low cost, low complexity, or power saving? (We understand that SL BWP adaptation and SL WUS may be more for low power).
- What is the target for the reduced SL bandwidth?

4.2 Round 1 Answers

1 – LG Electronics Inc.

Q1: Can you elaborate on the motivation of the local Uu or PC5 forwarding? Is it to improve the reliability by packet duplication?

Answer: The motivation is to increase reliability through redundant transmission over uncorrelated links. Packet duplication is a good example.

Q2: Can you explain more about "sub-pooling" in slide 8? Is this to configure a small resource pool separately for RedCap SL operations? If so, is it something different from usual SL resource pool except its size?

Answer: Our motivation is to support operation in a reduced bandwidth without using separate pool configurations. We do not assume dedicated resource pool with smaller size, rather than a shared pool.

2 – HuaWei Technologies Co.

Q1: What will be performance impact on both LTE-V and NR-V in coexistence, can LTE-V and NR-V service requirement can be satisfied by using the same band by LTE-V and NR-V?

Answer: Performance impact depends on the reference scenario and solutions in mind. What needs to be analysed is whether performance of LTE-V and NR-V in shared resources is better than 1) performance of

LTE-V + LTE-V in shared resources and/or 2) LTE-V + NR-V in orthogonal resources. We assume that requirements can be met and think that some study is useful/needed.

Q2: On page 7, for local PC5 data forwarding (right figure), do you feel it is like multi-path for SL relay (see RWS-210451)?

Answer: Thanks. It seems to be the case / similar direction.

Q3: On Page 7, for local Uu forwarding (left figure), in our understanding if gNB is involved in the transmission, the data should be anyway forwarded to the CN. What is your considered scenario here?

Answer: We assume in a baseline scenario the data is first transmitted to gNB in UL and then transmitted to the destination UE in DL. This data is not necessarily needed by core network. Then in the enhanced scenario, it is transmitted directly to the UE in SL bypassing the core network. If the scenario of forwarding to CN is valid, then additional path can be added in UL, while resulting in the same performance from perspective of destination UE.

3 – ROBERT BOSCH GmbH

Regarding leftovers from R17, can Intel prioritize among the list in slide-6: power-saving, cochannel co-existence, and sidelink CA ? (sidelink positioning in our understanding is separate topic).

Answer: Our view in descending order of priority would be cochannel co-existence > power saving > sidelink CA.

Sidelink-aided support in your slides is only for IIoT, can you elaborate more on the use-cases?oes this include sidelink data transmission as well or only control, positioning, etc.?

Answer: The target use case is factory automation, motion control and other I-IOT/URLLC scenarios that can benefit from adding sidelink in addition to Uu. It mainly aims to improve latency and reliability by either providing a better route among possible Uu and PC5 or by creating redundant routes.

RedCap sidelink: do you see this feature is extendable to V2X use cases (as you excluded it in slide 8)? e.g., eBike, u-mobility, etc. ?

Answer: We agree that this is extendable to V2X use cases, especially for VRU types of devices.

4 – Guangdong OPPO Mobile Telecom.

Comment on 1.1

It is proposed that SL positioning is included in NR positioning framework rather than in Rel-18 SL enh. framework. The work of SL positioning should not have significant impact on SL design including structure, procedure, etc.

Comment on 1.2 / 1.3 / 1.4

It seems reasonable to capture Co-channel, CA and Rel-17 leftover as a part of Rel-18 SL enh. since many other companies also proposed these three items.

Comment on 2.1 and 2.2

Besides latency and reliability, high data rate is another non-ignorable KPI, since I-IoT may require extremely high data rate in some scenarios.

Q2.3

Does sub-slot SL Tx need change the current NR SL PHY structure / procedures? If yes, some unexpected work / impact on existing NR SL mechanism may be introduced.

Answer: We expect changes to current NR SL PHY structure and procedures. The work can assume both (1) green-field deployment w/o co-existence with R16-R17 devices and other devices not supporting sub-slots, and (2) common spectrum with R16-17 devices and other devices not supporting sub-slots which does not seem to us as a baseline assumption. These aspects can be further discussed.

Comment on 2.4

SL in unlicensed spectrum should not be restricted in I-IoT scenarios, but also other SL related scenarios.

Comment on 2.5

For intra-UE service prioritization, the follow-up design can be considered, e.g. dropping mechanism when there are not enough resources for all the TBs; how to fulfil latency requirement when TBs with low priorities are postponed by a UE.

Response: Thanks for comments. We think that operation scenario/use case will guide certain design features / design direction.

5 – InterDigital Communications

What is sub-pooling in slide 8 under RedCap sidelink?

Answer: Our motivation is to support operation in a reduced bandwidth without using separate pool configurations. We do not assume dedicated resource pool with smaller size, rather than a shared pool.

6 – Lenovo (Beijing) Ltd

Q1: What's the benefit for co-channel coexistence between LTE-PC5 and NR-PC5 If co-channel coexistence was supported whether only NR-PC5 will be enhanced/modified, e.g., no spec impact on LTE-PC5?

Answer: Going forward we consider important to have flexible mechanism for phasing out sidelink technologies in scenarios with spectrum limitations. We suggest avoiding spec impact on LTE-PC5.

Q2: On "Sidelink carrier aggregation and/or BWP adaptation" in Page 6, whether SL CA and BWP adaptation are proposed for the same motivation, e.g., data rate/reliability? In our view SL CA may be benefit for data rete/reliability, however BWP adaptation targets for power saving.

Answer: Overall, we agree but we are open to study application of SL-BWPs for various KPIs. For example, using BWPs may help reducing in-band emissions within a carrier on top of power consumption, improve flexibility in terms of service mapping, etc.

7 – CATT

Can we consider Redcap sidelink and URLLC sidelink two separate enhancements on top of NR-redcap and

NR-URLLC respectively, instead of two enhancements for sidelink?

Answer: You can view it as two design tracks for sidelink evolution. We are focusing on I-IoT demands/KPIs. We prefer keeping sidelink related enhancements for other verticals within Sidelink enhancements scope, although it is up to further discussion where to finally put related objectives.

8 – Samsung Electronics Co.

Q1: What URLLC requirement target is considered for URLLC sidelink? Is it same as Uu URLLC requirement?

Answer: Right, we assume similar target requirement as for Uu URLLC aiming to further improve performance for factory automation and motion control scenarios.

Q2: Do you consider throughput as a key KPI?

Answer: At this point we are mainly concerned about latency and reliability performance for IIoT use cases.

9 – MediaTek Inc.

Thanks for the contribution. For RedCap sidelink, a couple of questions:

Do you consider the primary target as low cost, low complexity, or power saving? (We understand that SL BWP adaptation and SL WUS may be more for low power).

Answer: We think it can be beneficial for all targets, the primary one is power saving / complexity reduction.

What is the target for the reduced SL bandwidth?

Answer: power saving / bandwidth adaptation

4.3 Round 2 Questions

Feedback Form 5: Round 2 questions related to RWS-210371 'Rel-18 NR Sidelink'

1 – LG Electronics Inc.

Q1: We have a follow-up question about the sub-pooling. From the resource dimensioning viewpoint, “sub-pooling” seems the same as configuring small but normal resource pools over a big resource pool such that resources can be shared between normal and RedCap SL operations. What additional difference do you envision in sub-pooling?

4.4 Round 2 Answers

Response to LG

Q1: We are thinking that it is useful to discuss sub-pooling together with SL BWP for transmission /reception that may imply adaptation of the TX/RX processing bandwidth at the RF/BB at UE side.

5 Rel-18 NR XR

Questions related to RWS-210372 'Rel-18 NR XR' may be raised in this section.

5.1 Round 1 Questions

Feedback Form 6: Questions related to RWS-210372 'Rel-18 NR XR'

1 – CATT

Thanks for sharing the idea of NR enhancement for XR. The proposed schemes of capacity enhancement, traffic awareness at RAN, power saving technique and mobility enhancement with DAPs are quite interesting. However, we believe the aspects of NR enhancements should be discussed in the working group first with conclusion in the XR study before further discussion of the scope of XR work item.

2 – HuaWei Technologies Co.

Q1: We share the similar view that application related assistance information may be helpful for RAN scheduling. In terms of application related assistance information, do you think procedure wise CN needs to be involved, and SA2/SA4 should be involved to determine which information is helpful as in our understanding this is rather an E2E mechanism?

Q2: Regarding to additional QoS from application layer, do you think there can be multiple data streams with different QoS requirements and there is a need to have association with these streams? And we also understand this aspect requires SA2 involvement as QoS management is E2E.

Q3: For "measure and report the QoS of application based data transmission", do you understand "multiple packets" are multiple correlated packets for one XR video frame? We also think that the that measure and report the frame level QoS may be helpful for XR services.

3 – HuaWei Technologies Co.

Just to clarify that the above Q1 and Q2 applies to the proposal on traffic awareness at RAN. Please ignore Q3, it was a copy-paste error. We also think DAPS HO is a generic enhancements which are better to be discussed in mobility, which are no specific to XR, do you agree?

4 – Spreadtrum Communications

How to indicate gNB whether a packet is critical or not? Which node is responsible to generate this indication?

5 – LG Electronics Inc.

Regarding traffic awareness at RAN, we have a same view that one QoS flow can contain different packet streams with different QoS requirements. I-frame/P-frame or RTP/RTCP is one example, and TCP/TCP ACK is another example. Our paper for TCP boosting (RWS-210226) touches issues of TCP ACK, but essentially similar to what proposed in RWS-210372. With this in mind, we have following questions:

1. Which layer do you think is suitable for packet inspection? PDCP? SDAP? or other layer?
2. UL scheduling for critical packet is important, but head-of-line blocking problem is also important. What do you think about head-of-line blocking problem? Your paper does not address this problem.

6 – ROBERT BOSCH GmbH

[Bosch]

regarding NR XR RWS-210372:

-

Do you agree to support "Traffic awareness at RAN" within ML/AL-based study?

7 – ZTE Corporation

You mentioned methods for RAN traffic awareness are needed in you paper. Would you please introduce what kind of methods, or just take some examples for us?

8 – MediaTek Inc.

Thanks for the good contribution. We have some questions below to know more about the enhancements.

-

For enhanced SPS and CG to match XR DL/UL periodicity, dynamic grant should be sufficient for DL (low overhead and high efficiency). UL traffic can also utilize flexible CG type-2. What are the expected additional enhancement and benefit?

-

For Enhanced CDRX to match XR frame rate, DCI-based power saving is able to achieve the best dynamic and fine-granularity power saving. What is expected addition enhancement w.r.t. R17 PDCCH monitoring reduction and benefit, considering very dense UL (Ex. 4ms) in XR assumed in SA4?

-

For cross-layer enhancement, RAN1 can first conclude the benefit of RAN awareness of application and application awareness of RAN first (Ex. packet dropping, packet prioritization), and then the work can be led by SA4 since QoS requirements are currently under study in SA4. How is it planned to progress the work in SA4 and RAN for RAN awareness of application and application awareness of RAN?

9 – Lenovo Information Technology

thanks for the nice contribution. Regarding Traffic awareness at RAN, do you think RAN assisted codec adaptation, TCP related optimization should be considered?

10 – Apple Europe Limited

It seems we share quite some common interest. On the RAN awareness part, how latency information is utilized by the gNB?

11 – LG Electronics Inc.

Regarding mobility, we have the following additional question for clarification.

Q) For the summary in your paper (RWS-210372) including the following bullet for mobility,

-

Mobility

○

DAPs HO enhancements to support consistent data rate during mobility (handled separately)

is it your intention that the work on mobility is done in a relevant Rel-18 WI other than XR WI?

5.2 Round 1 Answers

1 – CATT

Thanks for sharing the idea of NR enhancement for XR. The proposed schemes of capacity enhancement, traffic awareness at RAN, power saving technique and mobility enhancement with DAPs are quite interesting. However, we believe the aspects of NR enhancements should be discussed in the working group first with conclusion in the XR study before further discussion of the scope of XR work item.

Answer: Thanks for the comment. We generally agree that an enhancement focussed study is needed to determine specification in Rel-18, we think such study can be conducted in Rel-18 – is this aligned with your view ?

2 – HuaWei Technologies Co.

Q1: We share the similar view that application related assistance information may be helpful for RAN scheduling. In terms of application related assistance information, do you think procedure wise CN needs to be involved, and SA2/SA4 should be involved to determine which information is helpful as in our understanding this is rather an E2E mechanism?

Q2: Regarding to additional QoS from application layer, do you think there can be multiple data streams with different QoS requirements and there is a need to have association with these streams? And we also understand this aspect requires SA2 involvement as QoS management is E2E.

Q3: For "measure and report the QoS of application based data transmission", do you understand "multiple packets" are multiple correlated packets for one XR video frame? We also think that the that measure and report the frame level QoS may be helpful for XR services.

Answer: Thanks for the questions. We understand that SA4 needs to be involved (to ask or check) on the relevant XR information to be provided or changed. Regarding CN and SA2, this may depend on which mechanisms (e.g. enhancement of current QoS) are considered and whether CN nodes are or not involved (e.g. AMF, UPF). As Q2 explains, QoS framework may need to be enhanced. Regarding "data strand with different QoS requirements", we share the view that different handling is desirable (e.g. critical vs non-critical video data), however further discussion may be required to determine whether they can all be associated within an specific stream.

Just to clarify that the above Q1 and Q2 applies to the proposal on traffic awareness at RAN. Please ignore Q3, it was a copy-paste error. We also think DAPS HO is a generic enhancements which are better to be discussed in mobility, which are no specific to XR, do you agree?

Answer: Thanks for the question. Yes, we share the same view that DAPS should be handled under mobility topics although XR requirement could be one of the motivations for the Rel-18 mobility enhancements.

3 - Spreadtrum Communications

How to indicate gNB whether a packet is critical or not? Which node is responsible to generate this indication?

Answer: Thanks for the question. This may require some coordination with SA4/SA2 and might also be different depending on the actual solution. E.g. this can be determine via deep packet inspection or how to determine this information might be left up to UE (or network) implementation, or its knowledge might be based on information provided by the actual application (or application server) or maybe the RAN is aware of this based on enhanced QoS framework.

4 – LG Electronics Inc.

Regarding traffic awareness at RAN, we have a same view that one QoS flow can contain different packet streams with different QoS requirements. I-frame/P-frame or RTP/RTCP is one example, and TCP/TCP ACK is another example. Our paper for TCP boosting (RWS-210226) touches issues of TCP ACK, but essentially similar to what proposed in RWS-210372. With this in mind, we have following questions:

Which layer do you think is suitable for packet inspection? PDCP? SDAP? or other layer?

UL scheduling for critical packet is important, but head-of-line blocking problem is also important. What do you think about head-of-line blocking problem? Your paper does not address this problem.

Answer: Thanks for the questions. For the 1st point, if the identification of the packet is done within 3GPP layers, which layer may be the most suitable should be discussed during SI phase taken into consideration to the end to end solution proposed. For the 2nd point, we understand that WGs would 1st need to agree to the issues that want to be solved/discussed in Rel-18. Therefore during this time, companies can explained the problems and if confirmed/prioritized, potential solutions could be discussed. On “head-of-line blocking by UL TCP transmission”, we understand from your TDoc that this targets improvement of TCP performance to avoid degradations when TCP ACKs are delayed. This may be an issue although the question should be if it is one that 3GPP needs to prioritize understanding that TCP protocol already has its own enhancements targeting to improve its own TCP specific performance.

5 – ROBERT BOSCH GmbH

Do you agree to support "Traffic awareness at RAN" within ML/AL-based study?

Answer: Thanks for the question. Could you pls. clarify the use-case and whether the use-case is primarily related to physical layer (RAN1) or higher layer (for e.g. use-case discussion in RAN3 Rel-17)

6 – ZTE Corporation

You mentioned methods for RAN traffic awareness are needed in you paper. Would you please introduce what kind of methods, or just take some examples for us?

Answer: Thanks for the question. If RAN is aware of XR traffic characteristics (e.g. periodicity) or the different kind of XR packets (e.g. critical vs non-critical), it could adjust applicable configurations (e.g. CDRX, SPS) and/or perform better scheduling techniques and/or determine when dropping of a given packet may be most beneficial among other actions.

7 – MediaTek Inc.

Thanks for the good contribution. We have some questions below to know more about the enhancements.

- For enhanced SPS and CG to match XR DL/UL periodicity, dynamic grant should be sufficient for DL (low overhead and high efficiency). UL traffic can also utilize flexible CG type-2. What are the expected additional enhancement and benefit?

Answer: Thanks for the question. As mentioned in slide-4, yes combination of DG and SPS/CG can be considered as an existing method and benefits should be analysed before specification of a particular solution – we are proposing “study and specify if needed”. Having said that we think that if SPS/CG can be enhanced to be more flexible, it can be a cleaner design by avoiding very tight interaction between SPS/CG scheduling and DG scheduling (perhaps some control overhead/latency savings).

- For Enhanced CDRX to match XR frame rate, DCI-based power saving is able to achieve the best dynamic and fine-granularity power saving. What is expected addition enhancement w.r.t. R17 PDCCH monitoring reduction and benefit, considering very dense UL (Ex. 4ms) in XR assumed in SA4?

Answer: Thanks for the question. If UL transmission is expected for a certain use-case at 4 ms periodicity, it's true that optimising CDRX may not be very useful. Enhanced CDRX is targeting use-cases where UL is not such frequent.

- For cross-layer enhancement, RAN1 can first conclude the benefit of RAN awareness of application and application awareness of RAN first (Ex. packet dropping, packet prioritization), and then the work can be led by SA4 since QoS requirements are currently under study in SA4. How is it planned to progress the work in SA4 and RAN for RAN awareness of application and application awareness of RAN?

Answer: Thanks for the question. Other WGs e.g. RAN2 could also discuss potential issues and corresponding solutions to be addressed in parallel as RAN1 (i.e. RAN1 may not be the leading WG for all the areas/solutions under discussion). Regarding SA4 and RAN WGs, we understand that coordination between them would be required for this work (similarly as it has been done in previous inter-related topics e.g. LTE eViLTE or eVoLTE).

8 – Lenovo Information Technology

thanks for the nice contribution. Regarding Traffic awareness at RAN, do you think RAN assisted codec adaptation, TCP related optimization should be considered?

Answer: Thanks for the question. “RAN assisted coded adaptation” might be a good optimization to introduce considering related work done in LTE, regarding TCP, please see response to LG’s related question (point 5 above)

9 – Apple Europe Limited

It seems we share quite some common interest. On the RAN awareness part, how latency information is utilized by the gNB?

Answer: Thanks for the question. Latency may be relevant for example, if gNB is allowed to discard specific packets that will not meet those latency requirements or to determine its optimum scheduling.

10 – LG Electronics Inc.

Regarding mobility, we have the following additional question for clarification.

Q) For the summary in your paper (RWS-210372) including the following bullet for mobility,

- Mobility

- DAPs HO enhancements to support consistent data rate during mobility (handled separately)

Is it your intention that the work on mobility is done in a relevant Rel-18 WI other than XR WI?

Answer: Thanks for the question. Yes, our preference is to keep mobility related enhancements handled within its own SI/WI although XR requirement could be one of motivations for Rel-18 mobility enhancements.

5.3 Round 2 Questions

Feedback Form 7: Round 2 questions related to RWS-210372 'Rel-18 NR XR'

1 – Fujitsu Limited

Thank you for the contribution.

We have interest in this proposal. One question would be the methods for the gNB to be made aware that the UE has upper layer critical data. The existing SR procedure (SR PUCCH and SR RACH) may not be so fast to inform the gNB of the critical data arrival. To transmit the critical data, SR procedure needs to be also fast. Do you have any faster SR procedure than the current one in mind?

2 – MediaTek Inc.

Thanks for the detailed reply.

So the planned WG in Rel-18 to work on XR cross-layer enhancement would be RAN1, RAN2, and SA4, is this correct understanding?

3 – ROBERT BOSCH GmbH

Thank you for your answer. Traffic awareness may consider cyclic traffic changes (e.g., changing periodicity, changing time arrival, and rate) to enhance configured grants (type 1/2), or traffic changes after failure, or certain reliability enhancements (e.g., dictates how to use duplication/CA/DC) etc.. In our understanding the traffic awareness may include two possibilities, 1- the traffic is perfectly known at the RAN or 2- the traffic parameters are known and a prediction can be conducted accordingly. The latter includes prediction and this may be studied in AL/ML-based framework.

5.4 Round 2 Answers

Response to Fujitsu

Yes, this is a challenge, we think that gNB could be provided with some prior information on such traffic arrival parameters (e.g., for approximately periodic cases) but we don't have a specific solution in mind. For timely feedback from UE, e.g. UE indicates the critical data in the buffer, We are open on how fast the indication should be and the corresponding solutions.

Response to MediaTek

Yes, this understanding is correct, although we might also need to consider whether SA2 should be involved, e.g. to evaluate whether QoS should be enhanced to support XR.

Response to Bosch

Thanks for the response. As we indicated, we are supportive to provide more traffic information to the scheduler (probably parameterized). Clearly this motivates AI/ML based techniques at the scheduler for optimizing PHY configuration/signalling. We are open to discuss enhancements to L1 configuration/signalling motivated by AI/ML based traffic prediction.

6 Rel-18 NR MBS enhancements

Questions related to RWS-210374 'Rel-18 NR MBS enhancements' may be raised in this section.

6.1 Round 1 Questions

Feedback Form 8: Questions related to RWS-210374 'Rel-18 NR MBS enhancements'

1 – ZTE Corporation

Thanks for the contribution. We share the same view that
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Multicast reception in RRC_INACTIVE which had been de-prioritized shall be one of the study target considering clear SA1 need.
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MBSFN shall not bring large spec impacts, e.g., cross gNB or DU coordination.

Other than that. we also have the following questions:
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For RLC AM of PTM, do you agree that the concern raised in Rel-17 discussion about the complexity issues still applies future releases?

-

If Multicast in RRC_INACTIVE is supported, how to guarantee the reliability/QoS of Multicast in RRC_INACTIVE?

-

Can you elaborate more on the power saving mechanisms?
--

-

Is it possible to have Multicast reception for UE in RRC_IDLE based on current SA2 assumption that UE has to be in CM-CONNECTED?
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<p>2 – HUAWEI TECHNOLOGIES Co. Ltd.</p> <p>[Huawei, HiSilicon] Thank you for the paper. Comment: for SFN part, EnTV and NR MBS might be deployed by different operators or anyway separately. The NR MBS enhancement should allow operators not deploying EnTV to improve the spectrum efficiency for larger transmission area.</p>
<p>3 – BBC</p> <p>BBC supports the evolution of NR MBS under Rel-18 and the topics you propose seem relevant to us as potential enhancements for NR MBS.</p>
<p>4 – MediaTek Inc.</p> <p>Thanks for the proposal. The mobility enhancement aspect may depend on how much we can progress it during Rel-17 for MBS.</p> <p>By the way, we have a bit different view on the need of SFN for NR. We think LTE SFN alike mechanism can be also introduced to NR MBS in order to boost the throughput for the UE</p>
<p>5 – CATT</p> <p>Thanks for the contribution. We support NR MBS enhancements in Rel-18, based on strong market and technical requirements that have been observed.</p> <p>One question for clarification. You mentioned mobility enhancements for MBS, so we would like to understand better what needs to be further enhanced for MBS services, on top of what we have done for unicast in the R16/17? It would be useful to clarify a bit the requirement and gap. Thanks.</p>
<p>6 – Qualcomm Incorporated</p> <p>We share similar views on mobility, power saving and on (no need of) SFN support. On the UL feedback in IDLE/INACTIVE, as it increases UE complexity and power consumption, we do not see a motivation/need to improve reliability in IDLE/INACTIVE. (We support improving reliability in CONNECTED.)</p>
<p>7 – LG Electronics Polska</p> <p>For mobility enhancements, would you please clarify more on the enhancements, e.g. data forwarding or other?</p>

6.2 Round 1 Answers

L2 reliability:

Answer to ZTE’s question “*For RLC AM of PTM, do you agree that the concern raised in Rel-17 discussion about the complexity issues still applies future releases?*”. As analyzed in Intel contribution R2-2009197 as well as joint contribution R2-2106008, we don’t think there is additional standardization complexity to support RLC AM for PTM, compared with RLC AM for PTP. Our understanding is that one of the main reasons to not consider RLC AM for PTM in Rel-17 is due to the limited time (similar to deprioritized items like multicast support in RRC_INACTIVE). Therefore the reliability enhancement scheme like RLC AM for PTM can be considered for Rel-18.

Multicast support in RRC_INACTIVE:

Answer to ZTE’s question “*If Multicast in RRC_INACTIVE is supported, how to guarantee the reliability/QoS*”

of Multicast in RRC_INACTIVE?”. In RAN2#112-e meeting, following was agreed: “For Rel-17, R2 specifies two modes: 1: One delivery mode for high QoS (reliability, latency) requirement, to be available in CONNECTED (possibly the UE can switch to other states when there is no data reception TBD); 2: One delivery mode for “low” QoS requirement, where the UE can also receive data in INACTIVE/IDLE (details TBD).” We think delivery mode 2 can be used for multicast in RRC_INACTIVE, and the reliability/QoS of multicast in RRC_INACTIVE is the same as that of broadcast session.

Answer to ZTE’s question “Is it possible to have Multicast reception for UE in RRC_IDLE based on current SA2 assumption that UE has to be in CM-CONNECTED?”. CM-CONNECTED corresponds to RRC_CONNECTED and RRC_INACTIVE. Therefore we don’t think it is possible to have multicast reception in RRC_IDLE, according to SA2’s assumption.

Power saving enhancements:

Answer to ZTE’s question “Can you elaborate more on the power saving mechanisms?”. This depends on the progress of Rel-17 MBS discussion as only very initial agreements regarding power saving was decided (e.g. use LTE SC-PTM DRX scheme as baseline for NR MBS).

Mobility enhancements:

Answer to LG, MediaTek and CATT’s questions/comments on mobility enhancements. This depends on the progress of Rel-17 MBS discussion as only very initial agreements regarding mobility was decided. If some mobility aspects (e.g. mobility related features supported in unicast) are not agreed for Rel-17 MBS, they can be considered further in Rel-18.

SFN

Regarding Huawei and MediaTek’s comment on the explicit support of SFN in NR MBS, our preference is to have separate track for terrestrial broadcast (as in LTE MBSFN) and mixed mode (as in NR MBS). Given that LTE based 5G terrestrial broadcast technology already supports SFN (named as MBSFN), we don’t see the need to further develop standardized solution for NR SFN.

UL feedback in IDLE/INACTIVE

Regarding Qualcomm’s comment on UL feedback in IDLE/INACTIVE, we’d like to note that the motivation of such feedback is not only to improve the reliability, but also to improve the spectrum efficiency. The spectrum efficiency gain of UL feedback is evaluated in LTE TR 36.890.

6.3 Round 2 Questions

Feedback Form 9: Round 2 questions related to RWS-210374 'Rel-18 NR MBS enhancements'

1 – Futurewei Technologies

We have similar concern of UL feedback in Idle/Inactive states. What’d be benefit of keeping UE in Idle/Inactive states vs. in Connected state, if UL feedback is needed? How would mobility work if UE is in Idle/Inactive states, but with UL feedback? UE based or network based?

2 – ZTE Corporation

Thanks for the reply and clarifications.

We'd like to share our view on this two topic (RRC_INACTIVE reception and RLC AM for PTM):

- RRC_INACTIVE reception was driven by explicit need and supported by majority.
- While for RLC AM for PTM, the concern was about both standard and implementation complexity, which could erase the gain from it in real implementation. (we agree that the complexity is not on the UE side)

Therefore we doubt if companies will change their views even in later releases.

As for the power saving mechanism, could you share more details on possible solutions of power saving other than DRX?

6.4 Round 2 Answers

Answer to Futurewei's questions on UL feedback in IDLE/INACTIVE states.

We're considering a NACK only feedback mode for IDLE/INACTIVE states. PUCCH resource for feedback is based on cell specific PUCCH, similar to the mechanism used for HARQ ACK/NACK feedback in initial access.

Regarding the main benefits of keeping UEs in IDLE / INACTIVE, our understanding is that the question is what is the benefit from UE power consumption's perspective, as other benefits of keeping UE in IDLE / INACTIVE (e.g. less network resource consumption) are obvious. Although UL feedback is sent by UE, the power consumption in IDLE/INACTIVE is still less compared with that in CONNECTED. For example, UEs in CONNECTED need to monitor PDCCH continuously if DRX is not configured, or in Active time if DRX is configured; UEs in CONNECTED also need to perform Radio Link Monitoring.

There is no impact to IDLE / INACTIVE state mobility (cell reselection) with UL feedback as the feedback resource is on cell specific PUCCH, not UE specific. The mobility in IDLE / INACTIVE is still UE based.

Answer to ZTE's questions on RLC AM for PTM.

Regarding the complexity, as analyzed in Intel contribution R2-2009197 as well as joint contribution R2-2106008, we don't think there is additional standardization complexity to support RLC AM for PTM, as the existing RLC AM for PTP specification can be mostly reused for RLC AM for PTM. As for implementation complexity, the gNB needs to take the aggregated feedback into account, and we think such complexity increase is manageable. In our view, in any L2 reliability solution for MBS, gNB needs to take into account UE's status when making scheduling decisions, therefore there is no additional implementation complexity specific for RLC AM for PTM.

Answer to ZTE's questions on power saving.

For Rel-18, we mainly consider potential enhancements for DRX based power saving solution, and exact detail would depend on what is eventually agreed in Rel-17 MBS.

7 Rel-18 URLLC/IIOT

Questions related to RWS-210377 'Rel-18 URLLC/IIOT' may be raised in this section.

7.1 Round 1 Questions

Feedback Form 10: Questions related to RWS-210377 'Rel-18 URLLC/IOT'

1 – ZTE Corporation

- 1 Could you please clarify what objectives are considered for "More reliable & faster channel access for both LBE and FBE"?
- 2) We are positive for the "enhanced resource allocation and WB operation" to enhance the URLLC transmission from multiple frequency domain resources perspective.
- 3) Could you clarify more on the Survival time aware scheduling?

2 – ROBERT BOSCH GmbH

[Bosch]

-
Regarding URLLC/IIoT RWS-210377:

- Survival time aware scheduling: do you think needs safety aware-RAN or (at least) CSA-aware RAN design? Should we include burst spread as well?
- Survival time aware design means also you have monitoring at RX:
 - do you mean all transmission of URLLC traffic are subject to survival time monitoring and adaption? (i.e., for both safe and quality management traffic?).
 - If answer is no, should we identify grants (SPS/CG) for Survival time monitoring specifically?
- Feedback: should CSI statistic include, e.g., burst spread, Survival time distribution ?

3 – ROBERT BOSCH GmbH

[Bosch]

-
Regarding RedCap Enhancement RWS-210378:

- BW reduced from 20 MHz: does this include some possible values larger than 5 MHz as well, e.g., 15,10, 5? If yes, we are also interested in 10 MHz for sidelink Redcap
- For Sidelink RedCap, should this include 10 Mhz as well? it is very important for VRU use cases

4 – Nokia Germany

On NR-U (slide 3):

-

How to enable more reliable and faster channel access? Is this related to wideband/multi-channel operation?

-

Is the intention to enable other modes than “all or nothing” for UL wideband operation?

-

Harmonization with URLLC is being discussed in Rel-17 (e.g. DCI x_2). Maybe too early to discuss further harmonization?

On slide 4:

-

out of order operation, this was discussed during R16 eURLLC WI without success. Do you think this could be discussed again with a positive outcome?

-

RAN1 already concluded in Rel-16 that not supporting overlapping dynamically scheduled PUSCHs, any strong motivation to come back this topic again?

-

Survival time related enhancements are still under discussion in RAN2, does the proposal have any dependency on the Rel-17 work?

On slide 6, UE-based PDCP duplication – reacting to change in channel condition: How do we define “change in channel condition” in specification? This may be UE-implementation and therefore we may not have a deterministic behavior.

5 – Apple Italia S.R.L.

-

For unlicensed enhancements, can you elaborate on “More reliable & faster channel access for both LBE and FBE”? If we understand correctly, the scheme shown in the figure was discussed in R16 and was not agreed due to various concerns. We do not see the need to repeat the discussion.

-

Further UE processing time reduction was discussed in Rel-16 and was not agreed. We do not see the need to discuss it again.

-

Can you elaborate more on “survival time aware scheduling”, e.g. how to use it to avoid persistent collisions for CG & SPS?

-

For sidelink related enhancements, we think it is better to discuss it in sideline WI.

6 – Qualcomm Incorporated

For URLLC sidelink, you mention augmentation of Uu with sidelink. Is this referring to a duplication of packets on Uu (UL+DL) and sidelink, or is there a different interpretation of augmentation?

7 – Samsung Electronics Co.

1. What are the necessity and target deployments for URLLC on shared spectrum beyond what is considered in R17?
2. What is the need for tighter UE processing requirements for FR2 and what is the suggested reduction?
3. What is the likelihood of overlapped PUSCHs with different priorities compared to the BLER of a PUSCH with smallest priority? What is the application scenario?
4. Is it not possible for a network implementation to avoid persistent interference/collisions for SPS/CG transmissions?
5. Shouldn't SL aspects be proposed as part of a SL WI?

8 – LG Electronics Inc.

Thanks for the contribution. We have the following questions.

- 1) Could you explain bit more about survival time-aware scheduling?
- 2) For the out-of-order scenarios with tighter processing time, it is assumed different processing pipelines are used between eMBB and URLLC?

9 – Lenovo Mobile Com. Technology

Thanks for the contribution! we have few questions in the below

- 1) For “UE based PDCP duplication: reduce delay in reacting to the change in radio conditions”, do you mean the PDCP duplication is triggered by the change in radio conditions?
- 2) Could you elaborate a bit more on “QoS continuity”? for example which use cases are included, which QoS parameters should be considered, etc.
- 3) For sidelink part, we understand currently sidelink with unlicensed band is not supported yet, and is better be studied independently, but also would like to hear your choice on this part. For augmentation of Uu, we would like to further understand whether it means aggregation of Uu and sidelink for the UE, or use sidelink to transmit data instead of Uu?

10 – HUAWEI TECHNOLOGIES Co. Ltd.

Thank you very much for the contribution. We have one question for clarification as below:

- Q1. For tighter processing time for FR2, what is the target E2E latency and how much reduction expected?

11 – FGI

Thank you for sharing the contributions. Please find some questions to RWS-210377 below.

1. Regarding the proposal about “overlap of multiple dynamically scheduled PUSCHs with different priorities”, could Intel elaborate more about the required enhancements in this case and the intended outcome benefited from the corresponding enhancement? From our understanding, such a scheduling is not allowed in Rel-17. Do Intel intend to support this type of scheduling in Rel-18, and prioritizes one of the overlapping PUSCHs for transmission?

2. Regarding the proposal to achieve “More reliable & faster channel access for both LBE and FBE”, could Intel elaborate more about the required enhancements to achieve this?
3. Regarding the proposal to support “survival time aware scheduling”, does Intel foresee some enhancements required at the UE side, i.e., not purely based on gNB implementation?

7.2 Round 1 Answers

Regarding questions on unlicensed URLLC enhancements

For the FBE frame structure, the CCA procedure to initiate a COT can be performed only in a periodic manner, where the periodicity depends on the FFP, and this is irrespective on whether the initiating device is a UE or a gNB. By enabling both the UE and the gNB as initiating device, in Rel.17 we are solving only one of the root causes of latency, which is the single point of failure. However, both UE and gNB cannot acquire a COT at any time, but only based on their FFPs. So, if both devices fail to acquire the channel, there is no chance for both of them to try again the LBT until their next FFP. If LBE framework is used, this issue could be mitigated, since the CCA procedure is not tied to a specific timing and periodicity but could be performed as early as a specific device needs it. This could therefore help mitigating further the latency deriving from the LBT procedure in scenarios where there may be some consistent collisions or sporadic presence of other incumbent technology (not ideal controlled environment). In this case, the drawback would be that if LBE operation is used, CAT-2 LBT (which is 25us long) will be no longer used, but CAT-4 LBT with the smallest priority class could be used which is only 43us long. This would add very little additional overhead in the LBT procedure, while allowing any device more flexibility in when to acquire the channel. Furthermore, by using the LBE framework we could potentially increase system performance for URLLC/IIOT use cases which are not necessarily within a strict controlled environment. It has been shown in the past during SLS evaluations that have been done during LAA study, that the LBE framework starts performing much better than the FBE framework once collisions/blocking start to occur mainly due to the issues highlighted above (i.e., single point of failure, and strict periodic opportunity to reperform CCA). Therefore, the target scenarios are similar to R17 assumption of controlled environment, but with a more general assumption on presence of other incumbent technologies which may impact the performance, thus further enhancements are needed.

Regarding enhanced wideband operation, we confirm that it is intended to specify transmission in UL only on partial bandwidth, i.e. only on LBT BW units which pass CCA. Both contiguous and non-contiguous allocations could be considered. In Release 16 there was little motivation to introduce partial transmission regimes, since there was no strict latency/reliability requirement. Here, allowing partial transmission greatly improves chances to access the channel if LBT failure probability is non-zero.

We still expect further harmonization of URLLC and NR-U features may be required e.g. multi-PUSCH and repetition type B operation. With respect to x₂ DCI formats support, it is uncertain at this point whether all functionalities will be supported in R17.

Regarding survival time aware scheduling

Currently RAN2/RAN3 is in process of specifying survival time assistance information for radio layer. In our assessment, RAN1 analysis of how survival time awareness can be used for improved Communication Service Availability (CSA) is required, while RAN1 was not included as responsible WG in R17. There are multiple radio-layer level approaches to avoid consecutive packet dropping, which could be classified as proactive or reactive. In case of SPS/CG, usually the cycle time is very tight (0.5-2ms) so that gNB may not know the feedback result before preparing the next transmission, thus it may be important to minimize the probability of consecutive packet dropping proactively. Furthermore, SPS/CG resources are repeated and are lacking any collision randomization. We think that at least some randomization (e.g. frequency hopping) in SPS/CG

resources can greatly help reducing consecutive packet drop probability. There could be other enhancements to improve CSA with non-zero survival time.

Burst spread is not considered for specification in R17, but in our view it can be useful to realize enhanced survival time aware scheduling and can be added in R18.

We did not consider survival time adaptation and monitoring, but we think it can be a useful addition towards the paradigm of functional safety and QoS adaptation.

We don't think CSI is a good framework to signal survival time distribution, burst spread. Higher layer exchange would be enough.

Out-of-order operation and overlap of DG PUSCH

Although Release 16 did not successfully conclude OOO study, to us there is no doubts that out-of-order operation in DL and UL is still useful for handling scenarios with different services in the UE. It allows to achieve much better scheduling flexibility, where eMBB and URLLC traffic can be handled using their suitable timelines, while allowing different UE implementations to handle it. Both separate pipeline and common pipeline architectures may be considered, with details up to UE capability and implementation.

Regarding the overlap of dynamically scheduled PUSCH with different priorities, we consider it as a special case of out-of-order operation. When different services with different latency and/or reliability targets are allowed at the UE, there will be a non-negligible probability of scheduling lower priority PUSCH and then overriding it with another urgent PUSCH. RAN1 considered similar scenarios for inter-UE multiplexing and introduced UL cancellation indication, which is an overkill for situations of intra-UE prioritization. Thus, DG & DG PUSCH prioritization is considered an important scenario from our point of view.

Processing time reduction

For very tight latency numbers of 0.5-1ms it is well known that FR1 could not accommodate HARQ retransmissions. In the same time, HARQ retransmissions greatly improve system performance. And recently it was confirmed as part of R17 study that CSI accuracy is very important for single-shot scheduling, while HARQ retransmission aided system can largely sustain CSI inaccuracies. Having this in mind, further reduction in processing times to allow HARQ retransmissions is crucial. While in FR1 the limits are already tight, in FR2 the numbers are quite loose and do not represent achievable implementations.

In addition, for systems with non-zero survival time, the fast HARQ feedback can help to reactively (re-)schedule the next packet/TB and avoid consecutive drops when a timely NACK is received for a previous packet.

While it was discussed previously w/o success, the issue of faster HARQ turnaround times as concluded above is still very valid and requires further consideration in RAN, with the high level target of allowing to schedule a retransmission or change allocation for very tight latency numbers of 0.5-1 ms in unpaired spectrum.

Higher layer aspects

Regarding PDCP duplication, in MAC CE based approach (specified in Rel-16), gNB sends the MAC CE mainly based on channel condition. gNB's assessment of channel condition is based on the measurement of SRS and/or CSI/measurement report sent by UE. There are various delays incurred: SRS periodicity, delay of sending CSI/measurement report and associated gNB processing time, as well as delay of MAC CE processing at UE side. If the channel condition is assessed at the UE and switching is performed by the UE, these latency components could be avoided. The specification would at least require introduction of the UL PDCP

duplication triggering at the UE, while it can be discussed further the exact channel condition triggering for PDCP duplication. It is expected that the enabling/disabling of UE based PDCP duplication activation/deactivation and the triggering condition are configured by the gNB.

On QoS continuity, the main idea is to introduce DAPS+CA/DC in order to keep the same latency as R16 and also maintain the data rate. This affects most of major QoS parameters in our understanding.

Sidelink URLLC

Regarding where to handle sidelink URLLC – as part of URLLC enhancements or as part of sidelink enhancements – our preference is also SL. However, since it targets improving IIOT/URLLC system performance with addition of redundant PC5 links, it may be also classified as a component of further enhanced URLLC/IIOT. Anyway, it is up to further discussion where to include such a scope.

The augmentation here mainly refers to duplication of packets on Uu (DL, UL) and PC5 (SL). We consider different scenarios, such as local forwarding from UE-A to UE-B, and UE forwarding from/to gNB to/from UE.

7.3 Round 2 Questions

Feedback Form 11: Round 2 questions related to RWS-210377 'Rel-18 URLLC/IIOT'

1 – Nokia Germany

Thanks for the detailed 1st round answers. Some small follow-up from our side:

1. As part of our R18 related proposals, you have asked us whether inter-UE CG/SPS collisions could also be handled/enhanced in addition to the intra-UE collisions. Could you elaborate a bit more on what is the problem and/or solutions you have in mind for inter-UE collisions?
2. Randomization/FH for SPS /CG: Do you have in mind FH within a SPS/CG repetition bundle or between transmissions of different packets? If this is envisioned between transmission of different packets / TBs / PDUs, couldn't this be done already by using multiple SPS / CG configurations which are interlaced in time and having different FDRA?

2 – LG Electronics Inc.

Thanks for the detail explanation. There are some additional questions.

-
Q1: Regarding out-of-order, there was some opinions that OoO operation may not needed if UE uses single processing capabilities for different service in Rel-16 discussion. Is there Intel's view on whether UE manages two processing capability in a serving cell, especially when UE is with common pipeline architectures?

-
Q2: Regarding overlapping overlap of DG PUSCH, we understands that it is basically canceling previous scheduling and reschedule new PUSCH resource via DCI. Considering use case, it may be necessary to consider canceling multiple PUSCH or canceling non-overlapping PUSCHs. Those are included in DG & DG PUSCH prioritization?

7.4 Round 2 Answers

Response to Nokia

For inter-UE CG/SPS collision, we mainly refer to the issues of consecutive packet dropping when persistent CG/SPS interference exists between cells/UEs. In this case the communication service availability (CSA) for non-zero survival times may suffer the probability of consecutive packet errors. If the collisions of CG/SPS configuration can be randomized, improvement of CSA is expected.

For randomization/FH, yes we have in mind hopping between packets, but hopping between repetitions can also be included. We admit that a similar result could be achieved with multiple configurations, however we think that the purpose of different configurations is mainly to cover different services, and there may be not enough total configurations to also realize the randomization feature. In general, the collision between SPS/CG configurations is one aspect that may be improved for better CSA, and we consider that all potential enhancements towards better CSA with non-zero survival time may be discussed in this potential objective.

Response to LGE

We are open to considerations of multiple processing capabilities within a UE for different services, either with single or with multiple processing pipelines. Such implementations are definitely possible, and specification should not limit these.

On DG&DG, indeed there may be sub-cases of cancellation of multiple PUSCH and non-overlapping PUSCH, which can be considered in potential study/work.

8 Rel-18 RedCap Enhancement

Questions related to RWS-210378 'Rel-18 RedCap Enhancement' may be raised in this section.

8.1 Round 1 Questions

Feedback Form 12: Questions related to RWS-210378 'Rel-18 RedCap Enhancement'

1 – Classon Consulting

FUTUREWEI supports studying redcap positioning, but should be in positioning not redcap

2 – MediaTek Inc.

Thank you for sharing your views. We share your view that accurate positioning, Sidelink and unlicensed spectrum operation should be supported by RedCap. However, we prefer that positioning and sidelink topics are discussed in an associated work item to have all the relevant experts in the same room.

We also have the following questions:

Q1: As highlighted by 3GPP in the Rel-17 discussions, economies of scale is an important factor for reducing cost. Has the impact of market fragmentation been taken into consideration when suggesting multiple BWs? Also have the limited cost benefits associated with lower bandwidths as outlined in RWS-210313 and RWS-210409 been considered?

Q2: What gaps do you see regarding RedCap operation in unlicensed spectrum in Rel-17?

Q3: What gaps do you see regarding RedCap Sidelink operation in Rel-17?

3 – Sony Europe B.V.

Bandwidth: The R17 study determined that 20MHz BW was a sweetspot for UE redcap bandwidth capability. What percentage further complexity reduction do you expect with a 5/10MHz UE bandwidth? Are there other motivations for supporting a narrower bandwidth?

Further complexity reduction: you state that complexity reduction is commensurate with the BW reduction. Why not reduce the peak data rate independent of the bandwidth? Why not just specify a maximum data rate for Redcap-nextgen (we did this in eMTC, where we defined a max data rate of 1Mbps).

Power consumption: what traffic model would you consider when looking at a battery lifetime of multiple weeks? Are you considering MO or MT traffic?

4 – Ericsson LM

Regarding further reduced UE bandwidth (RWS-210378), we would like to ask what potential UE cost reduction you expect from reduction from 20 MHz to 5-10 MHz? The estimates from CATT (RWS-210409) and Ericsson (RWS-210313) indicate that according to the established cost evaluation methodology (TR 38.875), there may not be a very significant further cost reduction compared to 20 MHz.

Also, regarding the potential UE power saving from further UE bandwidth reduction, we would like to ask what potential gain there might be from hardcoded UE bandwidth reduction to 5-10 MHz compared to what can be achieved from simply configuring the UE-specific bandwidth part to 5-10 MHz?

5 – Lenovo (Beijing) Ltd

Thanks Intel for the contribution. We share similar views to introduce lower BW RedCap UEs, for both complexity/cost reduction and power saving. One question is that do you expect further BW reduction for FR2? If so, what's the target UE BW to be supported? Another question is for the DL spectral efficiency recovery, what's your high level solutions?

6 – CATT

Thanks for the contribution. We have the following comments/questions.

1. Further cost reduction due to reduced BW seems small but lead to market fragmentation and potential impact on initial access. How much cost/complexity reduction is expected by BW reduction smaller than 20MHz based on your evaluation?
2. If the UE BW is reduced to 5MHz, SSB with 30kHz SCS cannot be accommodated within 5MHz BW. Then there will be big spec/implementation impact. Otherwise if 30kHz SCS SSB is not supported, the usefulness in the real deployment is quite limited.
3. By default, RedCap UE supports all non-RedCap UE features except those due to reduced L1 capability. What additional enhancements do you have in mind for RedCap UE to support SL and NRU?

7 – LG Electronics Inc.

Thanks for the contribution. We have the following questions.

Q1) In your views on the potential evolution in Rel-18, the class of RedCap UEs with low cost/complexity/power is only targeted for FR1 bands when there may be more concerns on the cost/complexity/power for RedCap UEs in FR2? Is it just a priority given the timeline, or is there any other reason?

Q2) What is the motivations of sidelink support for RedCap UEs from your perspective?

8 – Samsung Electronics Co.

1. With 10MHz or 5MHz BW, how much additional cost reduction do you expect compared with current RedCap, and simple restriction, e.g. restrict BW for PDSCH or restrict TBS? In the annex A, it seems like SSB/CORESET 0 are expected to be reused, is this correct? However, for PDCCH in CORESET 0, the coverage might have more serious issue compared with 20MHz DL BW. Do you think some coverage recovery is expected?

2. What kind of necessary spec change had been identified to support Pos and/or SL for Redcap?

3. What kind of technique is expected for further power saving for RedCap, e.g., ZP-WUS? why such techniques are specific to RedCap to be discussed in RedCap WI other than general power saving for all type of device?

9 – Apple Poland Sp. z.o.o.

<Apple> Thanks Intel for nice paper.

1) On support unlicensed band, what's the gap that disallows Redcap UE supporting Rel-16 NRU features. In our view, Rel-17 Redcap UE can indicate the support of unlicensed band/CC as part of UE capability signaling if it implements LBT operation.

2) What's solutions in Intel's mind to achieve several weeks battery life? As commented by other company, is specific traffic model assumed on this statement? Whether something like 'low-power wake Up radio' is considered here?

3) Can you please clarify a bit about 'spectral efficiency recovery'?

8.2 Round 1 Answers

Potential cost/complexity reduction from further BW reduction compared to 20 MHz RedCap

While the modelling of TR 38.875 indicates cost/complexity savings from reduction in max UE BW from 20 MHz to 5 MHz to around 9-10 %, the Rel-17 RedCap design offers a significant overdesign for most low-to-mid tier cellular IoT use-cases requiring peak rates of a few Mbps. As elaborated below, additional complexity reduction schemes, e.g., processing time simplifications, BB procedure simplifications (that should be better-justified for low-to-mid tier IoT) can further reduce the cost/complexity, preferably to around one-third of a regular NR modem.

To clarify on UE power savings, while UE max BW reduction would straightforwardly help in UE power savings, the motivation is primarily cost and complexity reduction. It is understood that if only targeting UE power savings, most of what reduced max BW can offer may be achieved with proper configuration.

SONY: "Further complexity reduction: you state that complexity reduction is commensurate with the BW reduction. Why not reduce the peak data rate independent of the bandwidth? Why not just specify a maximum data rate for Redcap-nextgen (we did this in eMTC, where we defined a max data rate of 1Mbps)."

To the above, first, we would like to clarify that the related proposal in RWS-210378 is to pursue additional complexity reduction features (beyond further BW reduction) that would be commensurate to the simplifications to performance requirements associated with the BW reduction, e.g., from 20 MHz to 5 MHz. As such, explicit cap on peak rates may be considered if such may be justified in addition to the already-available throughput scaling factor. However, just limiting the peak rate (e.g., via a max TBS constraint) as an alternative to BW reduction would not benefit from the complexity reduction, beyond soft-buffer and decoder, that is offered by reducing the max BW at RF and BB, when a BW of 20 MHz would be a significant overdesign for data rates of the order of few Mbps.

Regarding possible impact from market fragmentation, while we are open to additional considerations, a single new max UE BW of 5 MHz is preferred. If properly designed, there can be a significant separation between Rel-17 20 MHz RedCap and a potential Rel-18 5 MHz RedCap solution that can cater to two segments of the rather wide cellular IoT market.

While Rel-17 RedCap with 20 MHz BW can cater to relatively more demanding “high-end” use-cases, a potential 5 MHz RedCap can address low-to-mid tier cellular IoT use-cases, and pave the path for an eventual migration of LTE-based cellular IoT solutions of the present (e.g., Cat 1, Cat 1bis, Cat M) to NR.

Further UE max BW reduction for FR2

At this point, it is not clear to us if a very low-cost solution, one that expects to rely on economies of scale, is feasible in the near term for FR2. Thus, we think the Rel-17 solution of 100 MHz RedCap in FR2 is sufficient for the near-to-mid-term. Hence, we would like to focus on FR1 in the context of introducing further reduced UE BW.

On DL coverage and spectral efficiency recovery for further reduced max UE BW

If introduced, a 5 MHz UE, coupled with 1Rx, would suffer from further degradation in DL coverage and spectral efficiency due to reduction in diversity options (frequency and spatial), and thus, means to recover some of these losses may need to be considered.

With 5 MHz, certainly, PDCCH can be expected to be a channel affected in terms of DL coverage. For PDSCH, exact coverage gap depends on target data rates considered.

In terms of solutions, although this depends on design choices, means of improving DL coverage and spectral efficiency may include techniques: (1) utilizing frequency-hopping for DL channels, (2) that enable efficient frequency-selective scheduling, etc.

Samsung: “1. In the annex A, it seems like SSB/CORESET 0 are expected to be reused, is this correct? However, for PDCCH in CORESET 0, the coverage might have more serious issue compared with 20MHz DL BW. Do you think some coverage recovery is expected?”

Kindly note that there may be some “cross-connection” with some other paper as our tdoc in RWS-210378 does not have an Annex A. On the topic itself, while we are open to considering reuse of SSB/CORESET #0, this would need further considerations due to the coverage aspect you’ve highlighted.

Potential UE PS schemes, including C-WUR support, etc., and why specific to RedCap

UE battery lifetime is a critical consideration for RedCap use-cases. Thus, we are open to investigating further into potential options for further UE power savings for RedCap. This can possibly include enhancements for support of low-power WUR.

As a first step, it would be valuable to evaluate expected battery lifetimes for certain example use-cases and associated traffic profiles and use-cases to ascertain whether existing (up until Rel-17) features are sufficient.

To the question on applicability of solutions as low power WUR to non-RedCap, this is not yet clear to us; in particular, if non-RedCap (eMBB/URLLC) use-cases can accommodate the expected impact to paging latency from support of separate WUR and turning off of the main radio to realize meaningful gains. However, for some of the RedCap use-cases with higher tolerance to latency

Traffic models (incl. MO or MT traffic) associated with multiple weeks/years of battery lifetime

The reference to “multiple weeks” of battery lifetime follows from the Rel-17 RedCap target for wearables. On this, it would be necessary for WGs to determine appropriate traffic models that correspond to such battery lifetimes, using the models RAN1 agreed to during the Rel-17 SI phase as a starting point. A similar exercise may be warranted for IWSN use-cases that quoted a battery lifetime target of multiple years.

While for IWSN use-case, the traffic profile may be primarily modelled considering MO traffic (periodic reporting of sensor data), for wearables, further discussions may be necessary to identify specific use-case, likely involving a combination of MO and MT traffic.

Target use-cases for SL for RedCap

Some of the use-cases we envision for SL for RedCap include smart homes/building/factories and personal IoT use-cases. Considering that the current SL design is common between V2X and public safety use-cases, there is room to further simplify the requirements and operations to reduce UE complexity/cost/power consumption further via RedCap UEs.

Spec impact/gaps for support of SL for RedCap

While the basic SL framework may be supported by 20 MHz RedCap UEs, further considerations are necessary at least on support of SL between RedCap UEs only and support of SL between RedCap and non-RedCap UEs considering the limitations for RedCap UEs. Also, as mentioned in response to above, considering the common design currently specified for demanding use cases like V2X and public safety, there is room for further reduction in device cost/complexity/power consumption for SL that can be facilitated with appropriate adaptations suitable for RedCap device types.

If further reduced BW is introduced for RedCap (e.g., 5 MHz), the need for such considerations becomes more evident.

Spec impact/gaps for support of RedCap in unlicensed bands

While 20 MHz UEs may be able to support Rel-16 NR-U, it needs to be considered whether at least some of the “basic set of features” for NR-U support can be relaxed/adapted for RedCap UEs in consideration of cost/complexity.

If further reduced BW is introduced for RedCap (e.g., 5 MHz), the need for enhancements becomes more evident.

Spec impact/gaps for support of positioning for RedCap

Although existing solutions for positioning can apply to at least 20 MHz/100 MHz RedCap, the limits on the achievable accuracy due to BW limitation needs further studies (including possible consideration of the target accuracy), and depending on this, enhancements may/may not be necessary. If further reduced BW is

introduced for RedCap (e.g., 5 MHz), the need for positioning enhancements may be more apparent.

Target WI(s) for positioning and SL support for RedCap

At this stage, we are open to further considerations on most appropriate WI to cover positioning and SL support for RedCap. It may be more appropriate to address such questions in future discussions.

8.3 Round 2 Questions

Feedback Form 13: Round 2 questions related to RWS-210378 'Rel-18 RedCap Enhancement'

1 – Ericsson LM

To our understanding, the cost/complexity for FR1 RedCap modem is already reduced to around one-third of a regular NR modem according to the evaluation results described in TR 38.875 Tables 7.8.2-1 and 7.8.2-2. Do you share the same understanding about Rel-17 RedCap?

2 – Samsung Electronics Polska

Q1: As analyzed by other companies, reducing RF from 20MHz to 5MHz might only provide very limited gain. With carefully design of restriction TBS or buffer for PDSCH, the cost saving doesn't expect to be much. What is your exception on the cost reduction for RedCap with 5MHz?

8.4 Round 2 Answers

Response to Ericsson and Samsung:

The “one-third” quote was somewhat of a rough approximation. While it is true that for some configurations, R17 RedCap can get us to around one-third of reference NR device, this is not the case for “FR1 FDD” which would be of high interest in the context low-to-mid-end cellular IoT.

To be more precise, Rel-17 RedCap does get us close to 30% of reference NR device for FR1 TDD, while for FR1 FDD, it's close to 40%.

Based on rough estimates, it can be expected that these numbers can be brought down in Rel-18: to around 21 24% for FR1 TDD and to 27 30% for FR1 FDD with further BW reduction and other relevant complexity reduction features.

Although the reduction, based on the framework of TR 38.875, may appear modest, at the low cost segment, a 20 25% reduction in cost/complexity compared to Rel-17 RedCap can be significant and in the right direction in terms of facilitating migration of low-to-mid-end cellular IoT use-cases (except for LPWA) from Cat 1, Cat1bis, and Cat M to NR.