Email discussion summary for [RAN-R18-WS-non-eMBB-Ericsson] - Version 0.0.6
RAN

3GPP TSG RAN Rel-18 workshop RWS-210565

Electronic Meeting, June 28 - July 2, 2021

Agenda Item: 4.2

Source: Ericsson

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

1 Introduction

This email discussion summary covers the first 2 rounds of Q&A of the following Ericsson documents:

Table 1: Ericsson tdocs covering features/enhancements driven by non-eMBB use cases

tdoc number	tdoc title
RWS-210189	New WID on Enhanced NR Support for Aerial Vehicles
RWS-210190	Motivation for Rel-18 UAV
RWS-210313	Motivation for Rel-18 WI on Enhanced RedCap
RWS-210314	New WID on enhanced support of reduced capability NR devices
RWS-210328	Development of Mission Critical Communication
RWS-210330	MBS and related spectrum bands in Rel-18
RWS-210380	On Rel-18 URLLC and IIoT enhancements
RWS-210381	Discussion on Rel-18 XR
RWS-210394	Considerations on NTN for Rel-18

2 Reduced Capability Devices (RedCap)

2.1 1st round questions to the proposals on RedCap

Please provide your 1st round questions to RWS-210313 and RWS-210314 in the below feedback form:

Feedback Form 1: 1st round questions to the proposals on RedCap

1 – Classon Consulting

FUTUREWEI supports studying redcap positioning, but should be in positioning not redcap.
Good analysis on BW, we believe no need to revisit 40MHz or to consider sub 20MHz for ultra-low end wearables (see p6 of RWS-210037 and https://nwm-trial.etsi.org/#/documents/4714)
Harvesting energy is interesting

2 – vivo Communication Technology

Thanks Ericsson for the nice proposal on eRedCap, please find our questions and comments as below.

1. For lower UE power class, we are in general supportive. As discussed in our paper RWS-210171, we are considering the power level of 20dBm or 14dBm so that CMOS PA can be utilized rather than GaAs therefore better PA efficiency. We wonder what power level Ericsson is considering for devices with harvested energy?

2. Regarding L2/L3 protocol optimizations for devices with harvest energy (P6 of RWS-210313), we wonder what are the potential optimizations does Ericsson have in mind?

3. What issue is expected to be solved for inter-RAT mobility from/to LTE?

4. Regarding the wake-up radio, based our assessment, significant amount of study would be required to find a tradeoff between the power consumption and the receiver sensitivity performance, if we are targeting an very power efficient design. And in particular, we would like to understand the following aspects.

a) In scenarios where the surrounding environment provides devices an opportunity to harvest energy, the received power would be about 1 100 uW depending on different energy sources. For 1- 100 uW power consumption, we think more effort is needed for the wake-up signal design in order to simplify the receiver architecture to save power (currently the IDLE power consumption is tens of mW level which is 100-1000 times higher than that is desired for devices with harvested energy).

b) What is the expected low-power wake-up radio receiver sensitivity and power consumption target?

c) For energy harvesting wake-up radio, it is mentioned that the downlink reachability requirement is relaxed. Do you think it will restrict the deployment scenario and if so what will be the advantage compared to existing technology such as IEEE 802.11ba.

In summary, we are very much interested on introduction of wake-up radio for 5G in 3GPP, however, we believe a dedicated study item is necessary so that an optimal design can be considered, rather than rush in to a work item. In addition, we would like to design the wake-up radio as a generic tool which can be utilized for various UE types and scenarios (not limited to the stationary industrial sensors) and decoupled with the main-radio technology so that it can be used to wake-up NR, LTE, or sidelink in the future. We wonder what is Ericsson's consideration of making it as a general wake-up funtionality.

Having said above, we are supportive for Rel-18 eRedCap WI, however, we suggest to consider the following objectives as the work item scope, with wake-up radio been seperately studied but applicable to Redcap devices.

1) Further cost reduction by

a) RF BW reduction and/or baseband BW reduction (e.g. TBS restriction, RB restriction)

b) Reduced number of HARQ processes

c) UE Processing time relaxation (data, CSI)

d) Lower UE power class (20dBm, 14dBm or lower)

2) Further power saving by serving cell RRM relaxation for stationary devices

3) Coverage recovery, if needed

4) Positioning support for redcap devices

3 – ZTE Corporation

Thanks for the proposals on RedCap evolution. We have following questions for clarification:

- For 'Inter-RAT mobility support', compared with Rel-15 inter-RAT mobility from(to) NR to(from) LTE, is there any enhancement that need to be considered specifically for RedCap UEs? (We think the assumption is that LTE system already supports RedCap access and no need to differentiate RedCap and non-RedCap UEs). In addition, does "enabling efficient transition without interruption between NR and LTE for RedCap devices" means "0ms interruption" should be considered for inter-RAT mobility for RedCap UEs?

- For 'Further bandwidth reduction', could you clarify why Options 2 and 3 can achieve similar cost reduction benefits as Option 1?

4 – Lenovo (Beijing) Ltd

Thanks Ericsson for the nice contribution for enhanced RedCap.

For further BW reduction, we think this feature is beneficial for UE side power saving, which is an objective in your proposal. Besides, we can agree option 2 & 3 have less standard impact than option 1, but our understanding is that option 1 might need more complex UE side options when receiving signals that are transmitted in BW wider than BB BW, e.g., legacy SSB. Could you check if our understand is correct?

5 – Xiaomi Communications

[Xiaomi]

Thanks for the contribution. Regarding the positioning in RedCap, do you think if there is need to define new requirement on the positioning accuracy? Secondly, we think the narrow band feature may have some impact on the positioning accuracy, so some evaluation may be needed and potential enhancement solution is required, which would invovle some RAN1 work. Considering this point, RAN1 should also be involved in the work of RedCap Positioning. We see RAN1 is not included in the Positioning support page, Can you explain your consideration?

6 – Spreadtrum Communications

Thanks for the contribution with attractive points, regarding the UE cost reduction, we have different views. The cost reduction in Rel.17 is related to RF and BB, from these two parts, cost reduction cause by further BW reduction is limited. However, when support for lower bandwidth, the peak data rate is naturally reduced, which means lower memory footprint, then the cost of memory can by reduced significantly.

7 – Spreadtrum Communications

For energy-harvesting devices, we are not sure if it is the zero-power wakeup receiver with power consumption 0. If it is so, we think it seems aggressive to decide to focus on this type of devices. Maybe, we should have a study to align the understandings of wakeup receivers.

8 – Huawei Tech.(UK) Co.. Ltd

1. For improved UE energy efficiency, we'd like to understand where the energy harvesting applies in a RedCap UE and what is the relationship in between the two proposals:

(a) For the proposal of "enable energy efficient UE wake-up radio", is the low power wake-up radio power supplied by energy harvesting? If so, what is the power supply of communication radio?

(b) What much power level (e.g. mW) of energy harvesting can be saved in your estimation, to support a RedCap UE transmitting?

(c) In slide 3, energy harvesting is different to the traditional way of powering legacy UEs. If it is introduced, what use cases beyond the ones mentioned elsewhere on the slide can be further expanded in your view?

2. Given that NR specifications support configuration of UE channel bandwidth down to 5 MHz, why do you think the specification impact of option 1 is large, if the reduction of UE supported bandwidth does not go below 5 MHz? It is well known from commercial deployment of LTE IoT that bandwidths from 180 kHz to 20 MHz do have different costs in reality.

9 – MediaTek Inc.

1. We have introduced wakeup mechanisms for connected and idle modes in Rel-16 and Rel-17 respectively. With this baseline, it is expected that link maintenance mechanisms (RRM in Idle, CSI in connected) will dominate UE power consumption. With the suggested wake-up radio in this TDoc, have you considered the associated power consumption impact of these link maintenance activities? Furthermore what sensitivity levels are targeted by this new WUR? Is it aimed at local (e.g. Sidelink) or wide area operation (e.g. Uu)?

2. What level of coverage do you foresee with energy harvested devices, i.e. is this aimed at Uu or SL interfaces?

3. The analysis on diminishing returns with lower bandwidths is really good.

10 – Sony Europe B.V.

Slide 5: comment: we support enhancements to operate on harvested energy (RWS-210302 and RAN-R18-WS-non-eMBB-SONY)

Slide 5: questions

- Do you envisage using the redcap waveform and current redcap devices with energy harvesting?
- Is the WUR based on DCI, an NR sync signal or some new waveform?

- What are your views on supporting energy harvesting in other IoT technologies, such as eMTC?

Slide 9: Would you consider accuracy enhancements to account for the reduced redcap bandwidth? If not, what accuracy degradation would you consider acceptable?

11 – Intel Corporation (UK) Ltd

Q1 - Would you agree that additional cost/complexity reduction only from BW reduction from 20 to 5 MHz may offer 10% cost/complexity savings? Further, that the overall cost savings from reduced BW could be more than estimated in RWS-210313 since, with BW reduction, e.g., to 5MHz, various other features/capabilities (buffer sizes, processing times, etc.) can/should be further simplified?

Q2 - Does the alternative proposal to only limit max BW @ BB for data channels help meaningfully with cost/complexity savings or even power savings (if PDCCH BW is still ""large"")?

Q3 - For energy harvesting based solutions, has the feasibility for such solutions for cellular connectivity been established? Considering max coverage, data rates, etc. that may be commensurate with a UE supporting 20 MHz max BW for the "main radio" and whether energy harvesting is only limited to separate C-WUR?

Q4- Could you clarify the assumption taken show the power consumption difference w/ and w/o RF, understanding that RF usually plays a dominant factor.

12 – Apple Poland Sp. z.o.o.

[Apple]

Thanks for the nice contribution.

We share the view that it is important to further improve power efficiency for Redcap device in Rel-18 and low-power UE wake-up radio is one attractive candidate to study. On the other hand, wake-up radio increases RF cost. The exact impact depends on the RF sensitivity requirement. What is the targeted RF sensitivity in Ericsson mind for the enhanced Redcap device? In addition, what are the targeted use cases? Is it mainly targeted to Redcap devices due to traffic characteristic (e.g., industry sensor or video surveillances) or is generic design for all types of devices?

On positioning objective, we noticed that Ericsson does not list RAN1 as involved WG. Is it correct understanding that the intended enhancement limits to define requirements in RAN4 for Redcap UEs with reduced #Rx or BW but the positioning measurements accuracy is intended to be reused?

13 – CATT

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

1. We share the same view that there is no much room for further complexity/cost reduction without significant spec impact.
2. For support of energy harvesting, does RAN1 only need to define a Wake-Up signal?
3. For BW reduction only for BB, would there be any impact to RAN1?

14 – Qualcomm Incorporated

1) Could you elaborate the rationale of BW reduction option 2 and option 3 ? Why the cost vs. BW chart on page#11 indicates the cost saving is marginal when BW is reduced from 20 MHz to 10/5/3/1 MHz ?
2) What are the expected upper layer impacts of LP-WUR ?
3) Does LP-WUR require a new WUS waveform different from R16 WUS and R17 PEI?

4) Does LP-WUR have to rely on energy harvesting ? What is the receiver sensitivity expected for LP-WUR ? Can it be used for wearables ?
5) why is RAN1 excluded from R18 positioning for eRedCap UE ?
6) why is RAN1 excluded from the study of low power class UE ?
7) do you expect any change in NW topology when lower power class is introduced ?
8) what are the potential impacts on initial access of low power class UE (before capability signaling of power class) ?

15 – LG Electronics Inc.

Q1) Lower UE power class means smaller coverage. Is the proposed lower UE power class intended for smaller coverage? If yes, can you explain the use case scenarios you have in mind for the lower UE power class? It is also proposed not to introduce new mechanisms for coverage compensation, but we are not sure if we can restrict the use cases of such devices to a small cells only.

Q2) Regarding energy harvesting from the environment, the spec impact from 3GPP perspective is unclear. Can you explain the expected outcome of the study from 3GPP perspective, especially from RAN perspective?

Q3) For the wake-up radio at least in RRC_IDLE, do you have in mind the solution similar to the sequence-based WUS for LTE MTC and NB-IoT?

Q4) The motivations for inter-RAT mobility is unclear to us based on the understanding that RedCap UEs are supposed to be deployed in NR network.

16 – Samsung Electronics Co.

Wake-up signal for low-power wake-up radio at least in RRC_IDLE

Rel-17 paging early indication (PEI) is designed for both eMBB and RedCap UEs. The use case and functionality of wake-up signal for low-power wake-up radio at least in RRC_IDLE proposed in the tdoc seem to overlap with Rel-17 PEI design. Do you consider enhancement on top of Rel-17 design or totally new WUS design or something like zp-WUS?

17 – NTT DOCOMO INC.

Regarding the cost evaluation in Page 11, we would like to ask followings:

- Does it mean Rel-17 RedCap devices and the devices with 1MHz such as LTE Cat.M1 have similar cost reduction gain? It seems strange in terms of their different performance requirements and what we have in LTE devices.
- Is it correct understanding Option 2/3 can receive PDCCH with 20MHz BW?

18 – DOCOMO Communications Lab.

In addition to the above, we would like to ask following questions:
Q1: Is lower UE power class applied only for stationary device?
Q2: What is the assumption on the uses of harvested energy? e.g. power consumption for idle mode.
Q3: Could you provide the details or example of ”L2/L3 protocol optimizations” considering energy havesting devices?

2.1.1 Answers by the moderator

2.1.1.1 Classon Consulting

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

[Reply] Note that the proposals in our RedCap contributions (RWS-210313, RWS-210314) essentially concern RAN4 requirements for existing positioning methods for UEs with reduced number of Rx branches. However, in our positioning contribution (RWS-210315), we propose to study potential positioning enhancements for RedCap UE, which probably require RAN1 involvement.

2.1.1.2 vivo Communication Technology

Thanks Ericsson for the nice proposal on eRedCap, please find our questions and comments as below.

1. For lower UE power class, we are in general supportive. As discussed in our paper RWS-210171, we are considering the power level of 20dBm or 14dBm so that CMOS PA can be utilized rather than GaAs therefore better PA efficiency. We wonder what power level Ericsson is considering for devices with harvested energy?

[Reply] Generally speaking, what transmit power energy harvesting could support depends on the time required for energy harvesting and the characteristics of the employed energy storage technology, so it depends on the combination of the energy harvesting technique and the traffic model. We propose an initial study phase to better understand which UE power class(es) would be suitable for Rel-18 (e.g. 14 dBm and/or something else).

2. Regarding L2/L3 protocol optimizations for devices with harvest energy (P6 of RWS-210313), we wonder what are the potential optimizations does Ericsson have in mind?

[Reply] Energy harvesting devices may be characterized by ability to transmit/receive in an intermittent manner due to potential variations in the amount of harvested energy. Therefore, some L2/L3 protocol enhancements may be beneficial to support such devices, or even needed if the device would become energy depleted. One example of such optimization is extending the set of UE assistance information parameters to support energy harvesting devices.

3. What issue is expected to be solved for inter-RAT mobility from/to LTE?

[Reply] This is for improved coverage for RedCap UE. If there is only NR standalone, and there is lack of coverage, the RedCap UE cannot make cell change to an LTE cell. By introducing this support, the RedCap UE can be operated in much wider coverage scenarios.

4. Regarding the wake-up radio, based our assessment, significant amount of study would be required to find a tradeoff between the power consumption and the receiver sensitivity performance, if we are targeting an very power efficient design. And in particular, we would like to understand the following aspects.

a) In scenarios where the surrounding environment provides devices an opportunity to harvest energy, the received power would be about 1 100 uW depending on different energy sources. For 1- 100 uW power consumption, we think more effort is needed for the wake-up signal design in order to simplify the receiver architecture to save power (currently the IDLE power consumption is tens of mW level which is 100-1000 times higher than that is desired for devices with harvested energy).

[Reply] Note that the combination of WUR and DRX can be very effective in bringing down the overall power

consumption.

b) What is the expected low-power wake-up radio receiver sensitivity and power consumption target?

[Reply] These important aspects (and the possible trade-offs between these aspects) need to be studied in the WGs.

c) For energy harvesting wake-up radio, it is mentioned that the downlink reachability requirement is relaxed. Do you think it will restrict the deployment scenario and if so what will be the advantage compared to existing technology such as IEEE 802.11ba.

[Reply] We are interested in studying WUR for NR for diverse deployment scenarios, including macro scenarios, e.g. for wearables.

In summary, we are very much interested on introduction of wake-up radio for 5G in 3GPP, however, we believe a dedicated study item is necessary so that an optimal design can be considered, rather than rush in to a work item. In addition, we would like to design the wake-up radio as a generic tool which can be utilized for various UE types and scenarios (not limited to the stationary industrial sensors) and decoupled with the main-radio technology so that it can be used to wake-up NR, LTE, or sidelink in the future. We wonder what is Ericsson's consideration of making it as a general wake-up funtionality.

[Reply] We are interested in solutions that can be useful in as many scenarios and use cases as possible, although so far, we have only considered NR, not LTE, and would like to prioritize NR. We think this could be a potential 5G-Advanced signature feature.

Having said above, we are supportive for Rel-18 eRedCap WI, however, we suggest to consider the following objectives as the work item scope, with wake-up radio been separately studied but applicable to Redcap devices:

- Further cost reduction by: 1) RF BW reduction and/or baseband BW reduction (e.g. TBS restriction, RB restriction), 2)Reduced number of HARQ processes , 3) UE Processing time relaxation (data, CSI), 4)Lower UE power class (20dBm, 14dBm or lower).

- Further power saving by serving cell RRM relaxation for stationary devices

- Coverage recovery, if needed

- Positioning support for redcap devices

2.1.1.3 ZTE Corporation

Thanks for the proposals on RedCap evolution. We have following questions for clarification:

For 'Inter-RAT mobility support', compared with Rel-15 inter-RAT mobility from(to) NR to(from) LTE, is there any enhancement that need to be considered specifically for RedCap UEs? (We think the assumption is that LTE system already supports RedCap access and no need to differentiate RedCap and non-RedCap UEs). In addition, does "enabling efficient transition without interruption between NR and LTE for RedCap devices" means "0ms interruption" should be considered for inter-RAT mobility for RedCap UEs?

[Reply] For example, the Rel-15 NR inter-RAT mobility does not have any requirements for 1 Rx NR UE to measure on LTE carriers. The RedCap UE cannot fulfill the Rel-15 inter-RAT mobility requirements which

were developed for more than 1 Rx. The intention is to introduce the basic functionality, no enhancements at the moment. Also, it is not clear if the UE can make cell change from LTE to NR because the current inter-RAT (NR) requirements in NR were developed with respect to Rel-15 NR without considering reduced BW. At this moment, we do know now whether 0 ms interruption can be achieved, but efficient transition can be studied as part of the WI objective.

For 'Further bandwidth reduction', could you clarify why Options 2 and 3 can achieve similar cost reduction benefits as Option 1?

[Reply] These three bandwidth reduction options have several common components (e.g., post FFT buffering, receiver processing, LDPC decoding, HARQ buffer) which contribute to the cost saving. The additional cost saving achieved by Option 1 (RF+BB bandwidth reduction) compared to Options 2 and 3 (BB-only bandwidth reduction) mainly comes from the complexity reduction of ADC/DAC and FFT/IFFT components. Since these components have a small contribution to the overall cost saving, Options 2 and 3 can provide similar cost reduction as Option 1.

2.1.1.4 Lenovo (Beijing) Ltd

Thanks Ericsson for the nice contribution for enhanced RedCap.

For further BW reduction, we think this feature is beneficial for UE side power saving, which is an objective in your proposal.

[Reply] Regarding power saving, our understanding is that the current specifications allow BWP adaptation and power saving by operating on a small BWP. Therefore, the power saving is already possible (by operation on a narrow BWP) without reducing the maximum supported UE RF bandwidth. Also, in general, the potential gain of power saving by bandwidth reduction may not be clear. For specific use cases requiring large TB sizes, reducing the bandwidth and consequently the data rate can prolong the transmission time, thus increasing the UE power consumption. Therefore, the overall impact of reducing the bandwidth on the UE power consumption depends on several factors such as the scenario, traffic, and channel condition.

Besides, we can agree option 2 & 3 have less standard impact than option 1, but our understanding is that option 1 might need more complex UE side options when receiving signals that are transmitted in BW wider than BB BW, e.g., legacy SSB. Could you check if our understand is correct?

[Reply] Regarding UE complexity, we agree with your understanding.

2.1.1.5 Xiaomi Communications

Thanks for the contribution. Regarding the positioning in RedCap, do you think if there is need to define new requirement on the positioning accuracy? Secondly, we think the narrow band feature may have some impact on the positioning accuracy, so some evaluation may be needed and potential enhancement solution is required, which would invovle some RAN1 work. Considering this point, RAN1 should also be involved in the work of RedCap Positioning. We see RAN1 is not included in the Positioning support page, Can you explain your consideration?

[Reply] Note that the proposals in our RedCap contributions (RWS-210313, RWS-210314) essentially concern RAN4 requirements for existing positioning methods for UEs with reduced number of Rx branches. However, in our positioning contribution (RWS-210315), we propose to study potential positioning enhancements for RedCap UE, which probably require RAN1 involvement.

2.1.1.6 Spreadtrum Communications

Thanks for the contribution with attractive points, regarding the UE cost reduction, we have different views. The cost reduction in Rel.17 is related to RF and BB, from these two parts, cost reduction cause by further BW reduction is limited. However, when support for lower bandwidth, the peak data rate is naturally reduced, which means lower memory footprint, then the cost of memory can by reduced significantly.

[Reply] In our cost evaluation, we have followed the established cost evaluation methodology (TR 38.875).

For energy-harvesting devices, we are not sure if it is the zero-power wakeup receiver with power consumption 0. If it is so, we think it seems aggressive to decide to focus on this type of devices. Maybe, we should have a study to align the understandings of wakeup receivers.

[Reply] We are ok to study the achievable power consumption. Note that we did not mention zero power in our RedCap contributions (RWS-210313, RWS-210314).

2.1.1.7 Huawei

1. For improved UE energy efficiency, we'd like to understand where the energy harvesting applies in a RedCap UE and what is the relationship in between the two proposals:

(a) For the proposal of "enable energy efficient UE wake-up radio", is the low power wake-up radio power supplied by energy harvesting? If so, what is the power supply of communication radio?

[Reply] We would like the low-energy wake-up radio to be supported for RedCap UEs, regardless of whether they operate on harvested energy or not. The WUR and the main communication radio may or may not be operating on harvesting energy.

(b) What much power level (e.g. mW) of energy harvesting can be saved in your estimation, to support a RedCap UE transmitting?

[Reply] The power level will depend on several factors, and we need to consider further what assumptions may be reasonable in this context.

(c) In slide 3, energy harvesting is different to the traditional way of powering legacy UEs. If it is introduced, what use cases beyond the ones mentioned elsewhere on the slide can be further expanded in your view?

[Reply] Use cases beyond what we mentioned in our slide set may include e.g. (non-medical) wearables.

2. Given that NR specifications support configuration of UE channel bandwidth down to 5 MHz, why do you think the specification impact of option 1 is large, if the reduction of UE supported bandwidth does not go below 5 MHz?

[Reply] The specification impact for option 1 would be larger because the UE may not be able to receive SSB (for 30 kHz SCS) and most/all of the CORESET#0 configurations (for 15/30 kHz SCS).

It is well known from commercial deployment of LTE IoT that bandwidths from 180 kHz to 20 MHz do have different costs in reality.

[Reply] In our cost evaluation, when comparing 5 MHz and 20 MHz, we have followed the established cost evaluation methodology (TR 38.875).

2.1.1.8 MediaTek

1. We have introduced wakeup mechanisms for connected and idle modes in Rel-16 and Rel-17 respectively. With this baseline, it is expected that link maintenance mechanisms (RRM in Idle, CSI in connected) will dominate UE power consumption. With the suggested wake-up radio in this TDoc, have you considered the associated power consumption impact of these link maintenance activities?

[Reply] Our preference is to enable WUR in RRC_IDLE. We have not yet considered power consumption impact of link maintenance activities. However, we think this is an important aspect to study before specifying WUS for enabling WUR.

Furthermore what sensitivity levels are targeted by this new WUR? Is it aimed at local (e.g. Sidelink) or wide area operation (e.g. Uu)?

[Reply] These important aspects (and the possible trade-offs between these aspects) need to be studied in the WGs.

2. What level of coverage do you foresee with energy harvested devices, i.e. is this aimed at Uu or SL interfaces?

[Reply] We have so far envisioned this for Uu interface. The coverage of energy harvesting devices will depend on maximum output power with which these devices are capable of transmitting. We currently assume that these devices will not need coverage compensation, so we only foresee RAN2/RAN4 impacts (cf. assumptions used for the 14-dBm UE power class in LTE-M/NB-IoT).

3. The analysis on diminishing returns with lower bandwidths is really good.

2.1.1.9 Sony

Slide 5: comment: we support enhancements to operate on harvested energy (RWS-210302 and RAN-R18-WS-non-eMBB-SONY)

Slide 5: questions

- Do you envisage using the redcap waveform and current redcap devices with energy harvesting?

[Reply] Yes, our current assumption is that the enhancements for improved support of operation on harvested energy include new UE power class(es) and L2/L3 enhancements to consider potential variations of amount of harvested energy and traffic.

- Is the WUR based on DCI, an NR sync signal or some new waveform?

[Reply] In our view, WUS based on DCI or existing NR sync signal may not suitable for enabling low-power WUR. We assume that the WUR makes use of a new signal based on the existing NR CP-OFDM waveform.

- What are your views on supporting energy harvesting in other IoT technologies, such as eMTC?

[Reply] We are interested in solutions that can be useful in as many scenarios and use cases as possible, although so far, we have only considered NR, not LTE, and would like to prioritize NR. We think this could be a potential 5G-Advanced signature feature.

Slide 9: Would you consider accuracy enhancements to account for the reduced redcap bandwidth? If not, what accuracy degradation would you consider acceptable?

[Reply] Note that the proposals in our RedCap contributions (RWS-210313, RWS-210314) essentially concern RAN4 requirements for existing positioning methods for UEs with reduced number of Rx branches. However, in our positioning contribution (RWS-210315), we propose to study potential positioning enhancements for RedCap UE, which probably require RAN1 involvement.

2.1.1.10 Intel

Q1 - Would you agree that additional cost/complexity reduction only from BW reduction from 20 to 5 MHz may offer 10% cost/complexity savings? Further, that the overall cost savings from reduced BW could be more than estimated in RWS-210313 since, with BW reduction, e.g., to 5MHz, various other features/capabilities (buffer sizes, processing times, etc.) can/should be further simplified?

[Reply] According to our cost evaluation, which is based on the established cost evaluation methodology (TR 38.875), the cost reduction from UE bandwidth reduction from 20 MHz to 5 MHz (i.e. compared to a Rel-17 RedCap UE) is less than 10%. Reduced UE processing time is a separate cost reduction technique which is not included.

Q2 - Does the alternative proposal to only limit max BW @ BB for data channels help meaningfully with cost/complexity savings or even power savings (if PDCCH BW is still ""large")?

[Reply] The additional cost saving by reducing the UE bandwidth from 20 MHz to 5 MHz is not significant, and there is not much room for further cost reduction compared to Rel-17 RedCap. In general, the potential gain of power saving by hardcoded UE bandwidth reduction may not be clear, compared to simply configuring a smaller UE bandwidth.

Q3 - For energy harvesting based solutions, has the feasibility for such solutions for cellular connectivity been established? Considering max coverage, data rates, etc. that may be commensurate with a UE supporting 20 MHz max BW for the "main radio" and whether energy harvesting is only limited to separate C-WUR?

[Reply] We are interested in solutions that can be useful in as many scenarios and use cases as possible, including cases where the main radio operates on harvested energy, although the feasibility in different cases need further study.

Q4- Could you clarify the assumption taken show the power consumption difference w/ and w/o RF, understanding that RF usually plays a dominant factor.

[Reply] Sorry, we do not understand this question.

2.1.1.11 Apple

Thanks for the nice contribution.

We share the view that it is important to further improve power efficiency for Redcap device in Rel-18 and low-power UE wake-up radio is one attractive candidate to study. On the other hand, wake-up radio increases RF cost. The exact impact depends on the RF sensitivity requirement. What is the targeted RF sensitivity in Ericsson mind for the enhanced Redcap device? In addition, what are the targeted use cases? Is it mainly targeted to Redcap devices due to traffic characteristic (e.g., industry sensor or video surveillances) or is

generic design for all types of devices?

[Reply] In our view, these are important aspects and the possible trade-offs can be studied in the WGs. We are interested in solutions that can be useful in as many scenarios and use cases as possible. In our view, the benefit may be unclear for more advanced devices like smart phones, so we are mainly targeting RedCap devices.

On positioning objective, we noticed that Ericsson does not list RAN1 as involved WG. Is it correct understanding that the intended enhancement limits to define requirements in RAN4 for Redcap UEs with reduced #Rx or BW but the positioning measurements accuracy is intended to be reused?

[Reply] Note that the proposals in our RedCap contributions (RWS-210313, RWS-210314) essentially concern RAN4 requirements for existing positioning methods for UEs with reduced number of Rx branches. However, in our positioning contribution (RWS-210315), we propose to study potential positioning enhancements for RedCap UE, which probably require RAN1 involvement.

2.1.1.12 CATT

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

1. We share the same view that there is no much room for further complexity/cost reduction without significant spec impact.

2. For support of energy harvesting, does RAN1 only need to define a Wake-Up signal?

[Reply] Our current assumption is that the enhancements for improved support of operation on harvested energy include new UE power class(es) and L2/L3 enhancements to consider potential variations of amount of harvested energy and traffic.

3. For BW reduction only for BB, would there be any impact to RAN1?

[Reply] It may at least need to be captured in RAN1 specifications (e.g., in 38.214) that the UE is not expected to transmit/receive data with bandwidth larger than the UE's BB bandwidth for data.

2.1.1.13 Qualcomm

1) Could you elaborate the rationale of BW reduction option 2 and option 3? Why the cost vs. BW chart on page#11 indicates the cost saving is marginal when BW is reduced from 20 MHz to 10/5/3/1 MHz?

[Reply] For options 2 and 3, only the size/complexity of components for data processing is reduced while maintaining components for decoding control channel and SSB (i.e., DL control processing & decoder and synchronization/cell search block). The main intention is to avoid significant design change for SSB and CORESETs and also be able to support configurations with 30 kHz SCS as well. The cost saving results presented on page 11 are based on the agreed methodology in Rel-17 RedCap SI. The additional cost saving by reducing the UE bandwidth from 20 MHz to 5 MHz is not significant and there is not much room for further cost reduction compared to Rel-17 RedCap. Also, since the presented results are relative to normal NR UEs (100 MHz BW), the cost saving become marginal when BW is reduced from 20 MHz to 10/5/3/1 MHz.

2) What are the expected upper layer impacts of LP-WUR?

[Reply] We expect that there may at least be a need for updates to the paging protocol (cf. Rel-15 WUS for

LTE-M/NB-IoT).

3) Does LP-WUR require a new WUS waveform different from R16 WUS and R17 PEI?

[Reply] In our view, WUS based on DCI or existing NR sync signal may not suitable for enabling low-power WUR. We assume that the WUR makes use of a new signal based on the existing NR CP-OFDM waveform.

4) Does LP-WUR have to rely on energy harvesting? What is the receiver sensitivity expected for LP-WUR? Can it be used for wearables?

[Reply] No, WUR would not necessarily require the use of energy harvesting. We are interested in studying WUR for NR for diverse deployment scenarios, including macro scenarios, e.g. for wearables. Receiver sensitivity, coverage and power consumption (and the possible trade-offs between these aspects) are important aspects that need to be studied in the WGs.

5) why is RAN1 excluded from R18 positioning for eRedCap UE?

[Reply] Note that the proposals in our RedCap contributions (RWS-210313, RWS-210314) essentially concern RAN4 requirements for existing positioning methods for UEs with reduced number of Rx branches. However, in our positioning contribution (RWS-210315), we propose to study potential positioning enhancements for RedCap UE, which probably require RAN1 involvement.

6) why is RAN1 excluded from the study of low power class UE?

[Reply] It is because we currently assume that these devices will not need coverage compensation, so we only foresee RAN2/RAN4 impacts (cf. assumptions used for the 14-dBm UE power class in LTE-M/NB-IoT).

7) do you expect any change in NW topology when lower power class is introduced?

[Reply] No, see reply to previous question.

8) what are the potential impacts on initial access of low power class UE (before capability signaling of power class)?

[Reply] E.g. cell (re)selection parameters might be impacted (cf. support for the 14-dBm UE power class in LTE-M/NB-IoT).

2.1.1.14 LG

Q1) Lower UE power class means smaller coverage. Is the proposed lower UE power class intended for smaller coverage? If yes, can you explain the use case scenarios you have in mind for the lower UE power class? It is also proposed not to introduce new mechanisms for coverage compensation, but we are not sure if we can restrict the use cases of such devices to a small cells only.

[Reply] We currently assume that these devices will not need coverage compensation (cf. assumptions used for the 14-dBm UE power class in LTE-M/NB-IoT). Cell (re)selection parameters might be impacted (cf. support for the 14-dBm UE power class in LTE-M/NB-IoT).

Q2) Regarding energy harvesting from the environment, the spec impact from 3GPP perspective is unclear. Can you explain the expected outcome of the study from 3GPP perspective, especially from RAN perspective?

[Reply] Our intention is not to study or specify how the devices harvest and store energy. In our view, 3GPP can enhance the communication protocol to make it possible for devices operating with energy harvesting which may not sustain long continuous reception/transmission due to variations of the amount of harvested energy and traffic to connect to 3GPP network.

Q3) For the wake-up radio at least in RRC_IDLE, do you have in mind the solution similar to the sequence-based WUS for LTE MTC and NB-IoT?

[Reply] We assume that the WUR makes use of a new signal based on the existing NR CP-OFDM waveform (rather than the LTE-M/NB-IoT sequence-based WUS).

Q4) The motivations for inter-RAT mobility is unclear to us based on the understanding that RedCap UEs are supposed to be deployed in NR network

[Reply] This can be for improved coverage for RedCap UE. If there is only NR standalone, and there is lack of coverage, the RedCap UE cannot make cell change to an LTE cell. By introducing this support, the RedCap UE can be operated in much wider coverage scenarios.

2.1.1.15 Samsung

Wake-up signal for low-power wake-up radio at least in RRC_IDLE

Rel-17 paging early indication (PEI) is designed for both eMBB and RedCap UEs. The use case and functionality of wake-up signal for low-power wake-up radio at least in RRC_IDLE proposed in the tdoc seem to overlap with Rel-17 PEI design. Do you consider enhancement on top of Rel-17 design or totally new WUS design or something like zp-WUS?

[Reply] In our view, there may be room for improvement compared to Rel-17 PEI when targeting to enable low-power WUR. We assume that the WUR makes use of a new signal based on the existing NR CP-OFDM waveform.

2.1.1.16 NTT DOCOMO

Regarding the cost evaluation in Page 11, we would like to ask followings:

Does it mean Rel-17 RedCap devices and the devices with 1MHz such as LTE Cat.M1 have similar cost reduction gain? It seems strange in terms of their different performance requirements and what we have in LTE devices.

[Reply] The cost evaluation on slide 11 only concerns UE bandwidth reduction, and it is true that according to the cost evaluation methodology (TR 38.875) there is small additional cost saving from further bandwidth reduction. In comparison, Cat-M1 uses some additional complexity reduction techniques, e.g., a reduced max TBS of 1000 bits, cross-subframe DL scheduling, HD-FDD operation type B, and reduced DL transmission mode support, which are not part of Rel-17 RedCap.

Is it correct understanding Option 2/3 can receive PDCCH with 20MHz BW?

[Reply] Yes, bandwidth reduction Option 2/3 can receive PDCCH with 20 MHz BW.

2.1.1.17 DOCOMO Communications Lab.

In addition to the above, we would like to ask following questions:

Q1: Is lower UE power class applied only for stationary device?

[Reply] Lower UE power class may be applicable for non-stationary UEs as well.

Q2: What is the assumption on the uses of harvested energy? e.g. power consumption for idle mode.

[Reply] We assume that the harvested energy can be used in all RRC states.

Q3: Could you provide the details or example of ”L2/L3 protocol optimizations” considering energy harvesting devices?

[Reply] One example could be extending the set of UE assistance information parameters to support energy harvesting devices.

2.2 2nd round questions to the proposals on RedCap

Please provide your 2nd round questions to RWS-210313 and RWS-210314 in the below feedback form:

Feedback Form 2: 2nd round questions to the proposals on RedCap

1 – vivo Communication Technology

Thanks for the reply. We have following additional questions:

Q1: It is not clear to us what kind of UE assistance information parameters are useful for energy harvesting devices, could you please elaborate more? Thanks.

Q2: We see you mentioned CP-OFDM based waveform for low-power wake-up signal, we would like to further clarify:

1) Does it refer to that gNB (Tx side) can generate the low power wake-up signal (e.g. OOK waveform) by reusing the legacy CP-OFDM signal generation, e.g. similar to IEEE 802.11ba

2) Or it refers to also the receiver side at the UE should use the legacy receiver structure for CP-OFDM which includes A/D, FFT, etc and if so how the UE power consumption for the WUS detection can be significantly reduced compared to Rel-17 PEI?

Q3: what is your view on applying low power wakeup radio to sidelink?

Q4 what is your view on applying lower UE power class to sidelink?

Q4: Could you share your view on the following other potential enhancement areas for Rel-18 eRedCap?

1) Reduced number of HARQ processes

2) UE Processing time relaxation (data, CSI)

3) serving cell RRM relaxation for stationary devices

4) Coverage recovery

Thanks.

2 – Spreadtrum Communications

Thanks for your replay. For further cost reduction, we share views with some other companies that there are a significant number of mid/low-range IoT applications that only require data rates in the order of few Mbps, the current 20MHz BW are overdesigned. Therefore, these applications can benefit from further device cost reduction.

As RF and BB are only a portion of the whole chipset, from our view, the cost evaluation methodology in TR 38.875 is not enough for Rel.18 RedCap.

3 – Huawei Tech.(UK) Co.. Ltd

Thanks for the replies. We are wondering about the calculation of cost saving for your options 2 and 3. Can you explain what are the changes that comprise option 2 and 3, in terms of the cost reduction model in the TR?

4 – ZTE Corporation

Thanks for the replies. We still have some questions.

- For ”the Rel-15 inter-RAT mobility requirements”, we think you are referring to RAN4 requirements(e.g. HO delay, measurement requirement), because higher layer designs (RRC/PDCP/RLC/MAC) seems to be applicable no matter of the number of UE’s Rx branches. So based on your reply, do you think inter-RAT mobility between LTE and NR cannot be supported for RedCap in Rel-17, thus additional work will be needed in Rel-18?

- Regarding cost of three bandwidth reduction options, for baseband, besides ADC/DAC and FFT/IFFT, the cost of post FFT buffering and LDPC decoding for Option 1 would be less than that for Option 2 and Option 3. From our analysis, if we take 100 MHz non-RedCap UE bandwidth as reference, Option 1 would have 3.6% to 4.2% additional cost saving gain compard with Option 2 and Option 3.

5 – Intel Corporation (UK) Ltd

Follow-up comments/questions:

- *For energy harvesting, the practical applicability/feasibility in cellular context still remains a bit unclear, especially if it would be practical beyond some very specific use-cases for which probably existing alternative RATs may be better suited than cellular IoT.*

- *On low power-WUR, similarly, it remains unclear on potential power saving benefits in cellular settings if the main radio would need to be turned on frequently enough. Regarding the design itself, do you have any initial thoughts on the type of waveform/signal to provide adequate detection performance and coverage to justify an ultra-low power WUR in multi-cellular scenarios?*

6 – QUALCOMM JAPAN LLC.

[Qualcomm]

Thanks much for your clarifications/answers for the first round discussion. We have a few follow-up questions for your proposals on BW reduction for R18 eRedCap UE (RWS-210313).

Q1) For options 2 and 3, do you expect any spec change for the DCI carrying DL assignment and/or UL grant ? In our opinion, BB BW reduction for DL/UL data channels can be supported by current NR spec already.

Q2) Could you please clarify if BW reduction for DL data applies to the broadcast PDSCH (e.g. RMSI/msg2/msg4) of R18 eRedCap UE? If so, shall DL coverage enhancement be pursued in R18 to compensate for the potential loss of frequency diversity gain ?

Q3) What is your view on timeline relaxation for R18 eRedCap UE in terms of N1/N2/Z/Z' ?

7 – DOCOMO Communications Lab.

Thanks much for your answers for the first round discussion.
We have a follow up question for your proposals on lower UE power class for R18 eRedCap UE.

In the first round, you answered, 'Lower UE power class may be applicable for non-stationary UEs as well."
In the case, we think coverage compensation is needed because non-stationary UE may move to coverage edge.
On the other hands, according to your contribution, it is assumed that lower class UEs are deployed in good coverage.
Could you clarify why it can be assumed that lower class UEs are deployed in good coverage for non-stationary UEs as well?

8 – Samsung Electronics Polska

Q1: How to ensure low power class UE in always in good coverage?

Q2: What kind of L2/L3 protocol optimizations do you see to support harvested energy?

Q3: Comparing with existing Pos solutions, what pecific to RedCap? Increasing the accuracy in given BW?

9 – China Unicom

Thanks for your contribution and clarification. In your opinion, what is the preference/priority of the potential objective of R18 RedCap?

2.2.1 Answers by the moderator

2.2.1.1 vivo Communication Technology

Thanks for the reply. We have following additional questions:

Q1: It is not clear to us what kind of UE assistance information parameters are useful for energy harvesting devices, could you please elaborate more? Thanks.

[Reply] It could for example be information that is implicitly or explicitly related to the energy profile of the UE such as UE power level, needed harvesting time, UE power storage capability, etc. However, we would

like to clarify that extending the set of UE assistance information parameters, which we mentioned in our previous response, was only intended as an example of a potential enhancement that can be considered. There may also be other optimizations (e.g., including new parameters in capability signaling) that can be considered to support UEs with intermittent energy availability.

Q2: We see you mentioned CP-OFDM based waveform for low-power wake-up signal, we would like to further clarify:

1) Does it refer to that gNB (Tx side) can generate the low power wake-up signal (e.g. OOK waveform) by reusing the legacy CP-OFDM signal generation, e.g. similar to IEEE 802.11ba

2) Or it refers to also the receiver side at the UE should use the legacy receiver structure for CP-OFDM which includes A/D, FFT, etc and if so how the UE power consumption for the WUS detection can be significantly reduced compared to Rel-17 PEI?

[Reply] The details of the WUS would need to be further discussed, but in our current understanding, an OOK signal is a good potential candidate, and an OOK signal can be generated by reusing the OFDM transmitter. The receiver structure could be simplified compared to legacy.

Q3: what is your view on applying low power wakeup radio to sidelink?

[Reply] We are in general not supportive of introducing sidelink based relay for Rel-18 eRedCap. The sidelink support increases the relay cost/complexity, as well as requires considerable specification efforts in RAN4. Furthermore, as mentioned in our contribution (slide 12 in RWS-210313), it is hard to justify the use of licensed spectrum for sidelink based relay, as alternative technologies based on unlicensed band operation exist.Q4 what is your view on applying lower UE power class to sidelink?

[Reply] See answer to Q3 above.

Q4: Could you share your view on the following other potential enhancement areas for Rel-18 eRedCap?

1) Reduced number of HARQ processes

2) UE Processing time relaxation (data, CSI)

3) serving cell RRM relaxation for stationary devices

4) Coverage recovery

Thanks.

[Reply] Regarding reduced number of HARQ processes and UE processing time relaxation, these were considered during the Rel-17 RedCap SI phase. However, the estimated cost reductions were found to be minimal. Therefore, we are not supportive of introducing these cost reduction techniques for Rel-18 eRedCap.

Regarding RRM relaxation for serving cell, we do not foresee any considerable power saving benefit for this feature.

Regarding coverage recovery, we currently do not see a need to specify RedCap-specific coverage recovery techniques even if a lower UE power class would be introduced. In industrial deployments, we assume that sufficient coverage can be guaranteed. In other deployments, we assume that there will be a cell-edge uplink data rate reduction which will depend on the maximum transmission power of the new power class(es). E.g.

according to the link budgets in TR 38.875 clause 9.1, there seems to be room for some reduction of the maximum transmission power without overall coverage loss beside the reduction in achievable cell-edge uplink data rate. Also, if needed, the existing coverage enhancement techniques in Rel-15/16/17 can be considered.

2.2.1.2 Spreadtrum Communications

Thanks for your replay. For further cost reduction, we share views with some other companies that there are a significant number of mid/low-range IoT applications that only require data rates in the order of few Mbps, the current 20MHz BW are overdesigned. Therefore, these applications can benefit from further device cost reduction.

As RF and BB are only a portion of the whole chipset, from our view, the cost evaluation methodology in TR 38.875 is not enough for Rel.18 RedCap.

[Reply] If, as you say, RF and BB are only a portion of the whole chipset, that would seem to imply that further complexity reduction in RF and BB will not help reduce the overall chipset cost significantly.

2.2.1.2.1 Huawei Tech.(UK) Co.. Ltd

Thanks for the replies. We are wondering about the calculation of cost saving for your options 2 and 3. Can you explain what are the changes that comprise option 2 and 3, in terms of the cost reduction model in the TR?

[Reply] The main components which are reduced in terms of cost/complexity by Options 2 and 3 are Post-FFT data buffering, Receiver processing block, LDPC decoding, HARQ buffer, and (for Option 2) UL processing block.

2.2.1.3 ZTE Corporation

Thanks for the replies. We still have some questions.

For ”the Rel-15 inter-RAT mobility requirements”, we think you are referring to RAN4 requirements(e.g. HO delay, measurement requirement), because higher layer designs (RRC/PDCP/RLC/MAC) seems to be applicable no matter of the number of UE’s Rx branches. So based on your reply, do you think inter-RAT mobility between LTE and NR cannot be supported for RedCap in Rel-17, thus additional work will be needed in Rel-18?

[Reply] Yes, we are referring to RAN4 requirements. If the RAN4 requirements for inter-RAT mobility between LTE and RedCap are a leftover from Rel-17 (due to possible down-scoping in RAN4), then we want it to be considered in Rel-18. We would also be fine with supporting it already in Rel-17.

Regarding cost of three bandwidth reduction options, for baseband, besides ADC/DAC and FFT/IFFT, the cost of post FFT buffering and LDPC decoding for Option 1 would be less than that for Option 2 and Option 3. From our analysis, if we take 100 MHz non-RedCap UE bandwidth as reference, Option 1 would have 3.6% to 4.2% additional cost saving gain compard with Option 2 and Option 3.

[Reply] Your results seem to be close to our results. One potential reason that there is a difference could perhaps be that the cost estimates in our RedCap contribution (RWS-210313) are based on Ericsson’s input to the RedCap SI (R1-2009293), not the averages across companies. Although your results indicate slightly

higher cost saving gains, it is in our view still insignificant.

2.2.1.4 Intel Corporation (UK) Ltd

Follow-up comments/questions:

For energy harvesting, the practical applicability/feasibility in cellular context still remains a bit unclear, especially if it would be practical beyond some very specific use-cases for which probably existing alternative RATs may be better suited than cellular IoT.

[Reply] We are interested in support of devices operating on harvested energy (e.g., vibrational energy, photovoltaic energy, thermal-electric generated energy) in Rel-18. However, we believe that a study phase may be needed in Rel-18 to study whether/how such UEs can be supported in a 5G network.

On low power-WUR, similarly, it remains unclear on potential power saving benefits in cellular settings if the main radio would need to be turned on frequently enough. Regarding the design itself, do you have any initial thoughts on the type of waveform/signal to provide adequate detection performance and coverage to justify an ultra-low power WUR in multi-cellular scenarios?

[Reply] We agree that the potential power saving gains from a low-power WUR will mainly be meaningful in scenarios where the main radio does not need to be turned on frequently, and these are the scenarios that we want to target. We believe that WUR can make use of a new signal based on the existing NR CP-OFDM waveform. However, we believe that a study phase is necessary so that an optimal design can be considered.

2.2.1.5 QUALCOMM JAPAN LLC.

Thanks much for your clarifications/answers for the first round discussion. We have a few follow-up questions for your proposals on BW reduction for R18 eRedCap UE (RWS-210313).

Q1) For options 2 and 3, do you expect any spec change for the DCI carrying DL assignment and/or UL grant ? In our opinion, BB BW reduction for DL/UL data channels can be supported by current NR spec already.

[Reply] For Option 2 and 3, we do not expect any spec changes for DCI/PDCCH/CORESET.

Q2) Could you please clarify if BW reduction for DL data applies to the broadcast PDSCH (e.g. RMSI/msg2/msg4) of R18 eRedCap UE? If so, shall DL coverage enhancement be pursued in R18 to compensate for the potential loss of frequency diversity gain ?

[Reply] Regarding DL coverage aspect, the impact on PDSCH should be the same among the different BW reduction options discussed in our contribution (RWS-210313). If needed, existing or new coverage enhancement techniques may need to be considered, unless relaxed acquisition time performance can be accepted. But to be clear, we are not proposing to include any further BW reduction as part of Rel-18 eRedCap.

Q3) What is your view on timeline relaxation for R18 eRedCap UE in terms of N1/N2/Z/Z' ?

[Reply] Regarding the timeline relaxation, it has been extensively studied in the Rel-17 RedCap SI. During the SI, it was mentioned by some companies that any potential power saving gain may be offset by the fact the UE would need to stay active longer. In the end, it was noted in TR 38.875 that the impact on power consumption of relaxed UE processing time depends on implementation and traffic characteristics. Based on above, we

don’t see any strong justification for discussing this again in Rel-18.

2.2.1.6 DOCOMO Communications Lab.

Thanks much for your answers for the first round discussion. We have a follow up question for your proposals on lower UE power class for R18 eRedCap UE.

In the first round, you answered, ’Lower UE power class may be applicable for non-stationary UEs as well.” In the case, we think coverage compensation is needed because non-stationary UE may move to coverage edge. On the other hands, according to your contribution, it is assumed that lower class UEs are deployed in good coverage. Could you clarify why it can be assumed that lower class UEs are deployed in good coverage for non-stationary UEs as well?

[Reply] In industrial deployments, we assume that sufficient coverage can be guaranteed. In other deployments, we assume that there will be a cell-edge uplink data rate reduction which will depend on the maximum transmission power of the new power class(es). E.g. according to the link budgets in TR 38.875 clause 9.1, there seems to be room for some reduction of the maximum transmission power without overall coverage loss beside the reduction in achievable cell-edge uplink data rate. Also, if needed, the existing coverage enhancement techniques in Rel-15/16/17 can be considered.

2.2.1.7 Samsung Electronics Polska

Q1: How to ensure low power class UE in always in good coverage?

[Reply] In industrial deployments, we assume that sufficient coverage can be guaranteed. In other deployments, we assume that there will be a cell-edge uplink data rate reduction which will depend on the maximum transmission power of the new power class(es). E.g. according to the link budgets in TR 38.875 clause 9.1, there seems to be room for some reduction of the maximum transmission power without overall coverage loss beside the reduction in achievable cell-edge uplink data rate. Also, if needed, the existing coverage enhancement techniques in Rel-15/16/17 can be considered.

Q2: What kind of L2/L3 protocol optimizations do you see to support harvested energy?

[Reply] One example could be extending the set of UE assistance information parameters to support energy harvesting devices.

Q3: Comparing with existing Pos solutions, what pecific to RedCap? Increasing the accuracy in given BW?

[Reply] The proposals in our RedCap contributions (RWS-210313, RWS-210314) essentially concern RAN4 requirements for existing positioning methods for UEs with reduced number of Rx branches, but in our positioning contribution (RWS-210315), we propose to study potential positioning enhancements for RedCap UE, which could potentially involve increasing the accuracy in a given bandwidth.

2.2.1.8 China Unicom

Thanks for your contribution and clarification. In your opinion, what is the preference/priority of the potential objective of R18 RedCap?

[Reply] We would like to prioritize UE energy efficiency improvements as outlined in our RedCap

contributions (RWS-210313, RWS-210314). We do not want to prioritize further cost reduction through further UE bandwidth reduction in Rel-18, since we do not expect the further cost reduction to be significant (see our cost analysis on slides 10-11 in RWS-210313, which is based on the established cost evaluation methodology from TR 38.875), while the specification impacts can be expected to be substantial.

3 Unmanned Aerial Vehicles (UAVs)

3.1 1st round questions to the proposals on UAVs

Please provide your 1st round questions to RWS-210189 and RWS-210190 in the below feedback form:

Feedback Form 3: 1st round questions to the proposals on UAVs

1 – Lenovo Mobile Com. Technology

Thanks for the proposals and we have some clarification questions for further understanding consider following objectives:

1. control the amount of measurement for mobility: In LTE, multi-cell measurement was introduced and can reduce the measurement overhead to some extent. Do you think it is not enough and some enhancements are still needed especially for mobility purpose?

2. Ground identification on PC5: we understand communicate UAV identification using which cast type is determined by higher layer, e.g. V2X layer, so wondering how to limit *not unicast* in AS layer.

2 – LG Electronics Inc.

Q: Does ”UAV-to-ground identification using LTE and NR PC5” mean that that UAV sends its ID using LTE and NR PC5? Do you expect that the UAV ID messages are generated from an application which is outside 3GPP scope? If so, what RAN spec update would be needed to support this?

3 – vivo Mobile Communication Co.

Q1: Regarding the first 4 bullets, we wonder whether the intention is to reuse the solution from LTE, or any enhancement could be considered from Ericsson point of view. If reuse could be considered, we think it is better to state it explicitly.

Q2: We would like to check how to use CHO in UAV, i.e. same mechanism as in Rel-16 or some further enhancement e.g. new triggering event?

4 – Intel Corporation (UK) Ltd

For the bullet ””Study the applicability of non-codebook based PUSCH transmission and fast beam switching that are specified in NR up to Release 17 for UAV use case in FR1, and specify enhancements if needed””. Is it assumed that multiple beams are supported by the drone in FR1 (generated in analog domain, e.g. by phase shifters)?”

5 – ZTE Corporation

Thanks for your contribution. And we also prefer to initialize the discussion on this topic in R18. W.r.t your proposal, clarification on following are preferred:

Q1: To mitigate the interference, we understand that optimization on the beam for UL transmission is surely needed. In this way, both analog and digital beamforming based solution can be considered. For the FR1, in order to achieve the performance gain by 'non-codebook based PUSCH', any views on assumption for the UE's antenna configuration?

Q2: For the 'Specify support for UAV-to-ground identification using LTE and NR PC5', do you prefer to initialize the study for both LTE and NR in one WI or separately. And in our views, the NR based solution can be prioritized with more powerful capability to serve this application.

3.1.1 Answers by the moderator

3.1.1.1 Lenovo Mobile Com. Technology

Thanks for the proposals and we have some clarification questions for further understanding consider following objectives:

1. control the amount of measurement for mobility: In LTE, multi-cell measurement was introduced and can reduce the measurement overhead to some extent. Do you think it is not enough and some enhancements are still needed especially for mobility purpose?

[Reply] It was not introduced for mobility but for interference and flying mode detection. One cannot rely on that for mobility, as that will trigger measurements too late. The objective is for mobility measurements to control event triggering (first cell) as multiple "first cells" are expected.

2. Ground identification on PC5: we understand communicate UAV identification using which cast type is determined by higher layer, e.g. V2X layer, so wondering how to limit not unicast in AS layer.

[Reply] The V2X layer should map the service of "ground identification" (or whatever this service will be called) to use only broadcast. This probably should be done by SA2 and some restriction should be captured in their specification. For LTE, we have only broadcast for sidelink and thus there is no particular problem, but in NR since we have three cast types (unicast, broadcast, and groupcast) this restriction on the V2X layer is needed.

3.1.1.2 LG Electronics Inc.

Q: Does "UAV-to-ground identification using LTE and NR PC5" mean that that UAV sends its ID using LTE and NR PC5? Do you expect that the UAV ID messages are generated from an application which is outside 3GPP scope? If so, what RAN spec update would be needed to support this?

[Reply] Yes, the UAV sends its ID by using LTE or NR PC5 (but not both at the same time). Once the application generates the message, the V2X layer chooses whether to use LTE or NR PC5, and in case it chooses NR PC5 it needs to enforce to the AS layer the use of the broadcast cast type. The identity may be a 3GPP identity, but we expect the case with the application outside of 3GPP scope to be more relevant. Overall, the spec impact should be minimal as we can basically reuse what we already have for LTE and NR.

3.1.1.3 vivo Mobile Communication Co.,

Q1: Regarding the first 4 bullets, we wonder whether the intention is to reuse the solution from LTE, or any enhancement could be considered from Ericsson point of view. If reuse could be considered, we think it is better to state it explicitly.

[Reply] Not sure what exactly the "first 4 bullets" are, but in general the approach is to reuse the solutions from LTE as much as possible.

Q2: We would like to check how to use CHO in UAV, i.e. same mechanism as in Rel-16 or some further enhancement e.g. new triggering event?

[Reply] Some enhancements should be considered, e.g. based on location information, UE's airborne status, or height.

3.1.1.4 Intel Corporation (UK) Ltd

For the bullet ""Study the applicability of non-codebook based PUSCH transmission and fast beam switching that are specified in NR up to Release 17 for UAV use case in FR1, and specify enhancements if needed"". Is it assumed that multiple beams are supported by the drone in FR1 (generated in analog domain, e.g. by phase shifters)?"

[Reply] We are open to study such enhancements to improve UL transmission on FR1 to mitigate interference

3.1.1.5 ZTE Corporation

Thanks for your contribution. And we also prefer to initialize the discussion on this topic in R18. W.r.t your proposal, clarification on following are preferred:

Q1: To mitigate the interference, we understand that optimization on the beam for UL transmission is surely needed. In this way, both analog and digital beamforming based solution can be considered. For the FR1, in order to achieve the performance gain by 'non-codebook based PUSCH', any views on assumption for the UE's antenna configuration?

[Reply] no specific view. We are open to study such enhancements to improve UL transmission on FR1 to mitigate interference

Q2: For the 'Specify support for UAV-to-ground identification using LTE and NR PC5', do you prefer to initialize the study for both LTE and NR in one WI or separately. And in our views, the NR based solution can be prioritized with more powerful capability to serve this application.

[Reply] We think LTE and NR PC5 could be done in the same WI. NR gNB can schedule LTE UE and vice versa thus the specification impact is assumed similar. For this reason one WI is preferred as it ensures better unified solutions. Unified solutions would be wishful thinking with separate WIs □

3.2 2nd round questions to the proposals on UAVs

Please provide your 2nd round questions to RWS-210189 and RWS-210190 in the below feedback form:

Feedback Form 4: 2nd round questions to the proposals on UAVs

1 – ZTE Corporation Thanks for your replies. W.r.t the UE to ground identification, we share the views that similar enhancement can be considered for the LTE and NR PC5 linkage among terminal. In this way, do we further consider the case that UAV platoon communication is done by LTE pc5, but the communication between header UE to gNB (e.g., in standalone mode) is by NR-Uu. Moreover, for the UE to ground identification, in my view, it mainly refers to the identification among UAVs or between UAV and authority entity. Is it same views from your side? The identification between UAV and ground BS will still follow the access procedure as normal UE.
2 – LG Electronics Inc. Q1: As a follow-up question on UAV-to-ground identification, can you elaborate on potential frequency bands for the use of LTE and NR PC5 for UAV-to-ground identification? If band 47 is not going to be used for this purpose, do you see some reason to use LTE PC5 instead of NR PC5?

3.2.1 Answers by the moderator

3.2.1.1 ZTE Corporation

Thanks for your replies. W.r.t the UE to ground identification, we share the views that similar enhancement can be considered for the LTE and NR PC5 linkage among terminal. In this way, do we further consider the case that UAV platoon communication is done by LTE pc5, but the communication between header UE to gNB (e.g., in standalone mode) is by NR-Uu. Moreover, for the UE to ground identification, in my view, it mainly refers to the identification among UAVs or between UAV and authority entity. Is it same views from your side? The identification between UAV and ground BS will still follow the access procedure as normal UE.

[Reply] Over the PC5 interface, we only target the broadcast communication between UAVs and authorized entities on the ground for the purpose of remote identification of the UAVs. We do not target UAV platooning use case or use cases requiring direct UAV-to-UAV communication.

For connectivity between the UAV and ground BS over the Uu interface, normal access procedures apply.

3.2.1.2 LG Electronics Inc.

Q1: As a follow-up question on UAV-to-ground identification, can you elaborate on potential frequency bands for the use of LTE and NR PC5 for UAV-to-ground identification? If band 47 is not going to be used for this purpose, do you see some reason to use LTE PC5 instead of NR PC5?

[Reply] In our view, the spectrum for UAV-to-ground identification over PC5 is decided by the regulators outside 3GPP. We believe it is important that both LTE and NR are capable of supporting this service. We expect that RAN2 work is not band-specific.

4 Mission Critical Communication

4.1 1st round questions to the proposals on Mission Critical Communication

Please provide your 1st round questions to RWS-210189 in the below feedback form:

Feedback Form 5: 1st round questions to the proposals on Mission Critical Communication

1 – Classon Consulting

[for FUTUREWEI]

Thanks for the interesting paper. The proposals on Msg 1 differentiation seem mis-aligned with the arguments made by Ericsson against operators desiring early identification of 1RX UEs in Msg 1 in the RedCap discussions this RAN meeting. Can you comment on the apparent discrepancy?

4.1.1 Answers by the moderator

4.1.1.1 Classon Consulting [for FUTUREWEI]

Thanks for the interesting paper. The proposals on Msg 1 differentiation seem mis-aligned with the arguments made by Ericsson against operators desiring early identification of 1RX UEs in Msg 1 in the RedCap discussions this RAN meeting. Can you comment on the apparent discrepancy?

[Reply] Ericsson supports differentiation of RedCap vs non-RedCap users. However, there are only so many ways to split the RA resources. We think it is more important to differentiate between NSPS users and non-NSPS users rather than differentiate between RedCap users with 1 Rx and RedCap users with 2 Rx.

4.1.1.2 Nokia (Question received via email)

MC applications can occur in different contexts. Some of them have very localized and sporadic need of resources, e.g., public safety, others have more frequent (although arguably localized) need, e.g., factory. Which MC applications and contexts would these enhancements be targeting? All or just thsoe related to public safety (and similar)?

2 Objectives out of 3 are related to coverage enhancement. We propose in subsequent phases they are discussed together with general coverage enhancements, assuming such general thread will be defined.

[Reply] We mention public safety as a specific use case for mission critical communications. The proposed enhancements can be used for other mission critical industry use cases when early identification of mission critical users/services and a finer network accessibility differentiation is required. Factory can be a possible use case here, e.g., when both mission critical services and normal services are hosted in the factory network, which has limited capability/resources/spectrum.

4.2 2nd round questions to the proposals on Mission Critical Communication

Please provide your 2nd round questions to RWS-210189 in the below feedback form:

Feedback Form 6: Questions to the proposals on Mission Critical Communication

4.2.1 Answers by the moderator

There were no questions.

5 Multicast Broadcast Services and related spectrum bands

5.1 1st round questions to the proposals on MBS

Please provide your 1st round questions to RWS-210330 in the below feedback form:

Feedback Form 7: 1st round questions to the proposals on MBS

1 – HUAWEI TECHNOLOGIES Co. Ltd.

[Huawei, HiSilicon] "Pre-Rel.18 UEs could then receive the legacy numerology slots as usual, and just ignore the slots with the new extended CP. Rel.18 UEs, on the other hand, could receive both types of slots."

=□ why we can't avoid impact to legacy UE by simply not scheduling legacy UE in ECP slots?

2 – BBC

BBC supports the evolution of NR MBS under Rel-18.

Comments from BBC:

We have the following comments from Proposals 1, 2 and 3 (SFN support) in your contribution:

- Generally, we have concerns that significant changes in UEs may hinder the deployment of the feature. As stated in our contribution [RWS-210133] and being discussed under [RAN-R18-WS-crossFunc-BBC] in NWM we believe widespread feature support in handsets is essential.
- Specially for UEs in RRC_IDLE/INACTIVE that may not be able to signal back to the gNB the capability, enhancements that force significant changes in the UEs may limit the reach of Multicast and Broadcast.
- However, as stated in your contribution, we understand you propose that transmissions signals with larger CP would not affect Rel-17 UEs. Considerations should be taken in whether simulcasting two signals (with different CPs) would be overall beneficial to the system spectral efficiency.

- Another aspect to consider is whether the reference signals frequency sampling (assuming are unchanged) can cope with the additional channel selectivity from deployments with larger ISDs and therefore extended CPs.

- Regarding Proposal 3, we generally agree that enhancements that imply significant changes in the network may also hinder the deployment of the feature, and therefore should be carefully considered.

3 – Guangdong OPPO Mobile Telecom.

For proposal 4 and proposal 5, is is correct understanding that the specification efforts are mainly focus on RAN4?

4 – Intel Corporation (UK) Ltd

1) For ”Proposal 4, in Rel.18, specify support for LTE unicast and NR unicast/multicast/broadcast in the 470-694/698 MHz band..” - this range is planned to be defined as a part of LTE based 5G terrestrial broadcast with the new Rel.17 WI (RP-210907). Is there any market request from the spectrum holders to support NR services, especially unicast mode?

2) For ”Proposal 5 In Rel.18, specify NR support for the 450-470 MHz band.”, is it proposed to specify the band n31 with exactly frequency range as LTE band 31? Also, LTE Band 31 (450MHz) was originally introduced for Brazil. Is the proposal aiming the same market and is there request for NR MBS services from operators?

5 – CATT

CATT support Rel-18 NR MBS enh.

We have a general comment regarding SFN: we need to take into account potentail benefit, spec impact, as well as UE complexity when we discuss SFN aspect as potential obj. in Rel-18. The above comments on legacy UE impact is also very good point to further discuss.

6 – Qualcomm Incorporated

On P1: Could you clarify how you define small vs wide area SFN? Is it in terms of number of cells or the actual geographical area? In terms of geographical area, we are wondering how extended CP and ”small” SFN go together?

On P1/P2: In our understanding, mixed numerologies in one carrier (normal CP for legacy/non-MBS and extended CP for R18 MBS) is proposed. Is this a shared carrier b/w HPHT MBS and cellular on existing/normal NR band? Or is it a dedicated band for MBS with extended CP and SCS 15kHz? If mixed CP in same band, how to keep backward compatibility and/or simultaneous reception of unicast/multicast? Also, doesn’t this degrade tputs of legacy/non-MBS UEs?

On P3: Don’t we need F1 enhancements to sync cells of different DUs (inter-DU intra-CU)? How does it work in case of multi vendor scenario?

On P4: If we extend 470-694/698 MHz bands to Unicast services, is it not limiting broadcast capacity? Is there any regulatory limitation?

7 – LG Electronics Polska

For Proposal 3, would you clarify how to perform synchronization for gNB-DUs within the gNB-CU in the SFN area?

8 – MediaTek Inc.

About P1-P3, when considering the SFN support within one gNB-CU, there may be some CU-DU network signaling needed to ensure the synchronization of one SFN transmission area.

Meanwhile, for backwards-compatibility of pre-Rel.18 UEs, more evaluation may be needed.

9 – ZTE Corporation

We share the same view that:

- SFN shall not bring much impacts to network signaling, i.e., having MBSFN intra DU if SFN is needed eventually.
- Rel-17 is still on-going, however, some of the issues, e.g., Multicast reception for UE in RRC_INACTIVE although de-prioritised in Rel-17 but with strong need shall be part of Rel-18.

One more question:

- Do you consider, and if yes, how to support simultaneous reception of MBSFN and unicast?

5.1.1 Answers by the moderator

Thanks for the interest in our contributions.

To Huawei, HiSilicon: ”Not schedule” is probably a better wording than ”ignore”, and more accurately reflects our intention.

To BBC: Thanks for your comments and the support in evolving NR MBS. We assume the impact of the ECP is small enough not to require any major redesign of UE hardware. It would not constitute a significant change in our opinion.

To Oppo: Yes, the specification efforts related to P4 and P5 would mainly focus RAN4.

To Intel: Regarding the first question: It is a chicken-and-egg problem. The band is currently not defined for LTE unicast and any NR operation, thus there cannot be a specific demand. However, there is always a general demand for more spectrum as this is key to the success of mobile broadband. The current use of the band is for broadcast and changing that would require regulatory changes.

Regarding the second question: We foresee the use of the band in any market where this band allocated to LTE.

To CATT: Thanks for the comments. We agree there are several important aspects to discuss further.

To Qualcomm: On P1: the current CP imposes limits in SFN size by a combination of ISD and number of cells. We are mainly thinking of enabling inter-cell SFN using Macro sites, where the ISD may significantly exceed current c*T_CP. But somewhat larger SFNs may also be supported. We are not considering wide area SFN deployments using HPHTs.

On P1/P2: we are primarily considering shared carriers with a slot-based mix of unicast, multicast and possibly broadcast.

On P3: Similar to Rel.17, we foresee proprietary implementations for Rel.18, where the inter-DU synch can be handled by a single vendor.

On P4: This depends on regulatory decisions.

To LG: Similar to Rel.17, we foresee proprietary implementations for Rel.18, where the inter-DU synch can be handled by a single vendor.

To Mediatek: Similar to Rel.17, we foresee proprietary implementations for Rel.18, where the inter-DU synch can be handled by a single vendor.

To ZTE: It is a broad question and should be considered from both UE and network perspective. For Rel.18 we consider mainly a single carrier with unicast, multicast and potentially broadcast. ECP would be transmitted in dedicated slots.

5.2 2nd round questions to the proposals on MBS

Please provide your 2nd round questions to RWS-210330 in the below feedback form:

Feedback Form 8: 2nd round questions to the proposals on MBS

1 – MediaTek Inc. Should the extended CP be allowed to be configurable for the said dedicated slot? This means in case an SFN area is not a big area, the normal CP can be configured for this slot for the purpose of SFN transmission.
2 – HUAWEI TECHNOLOGIES Co. Ltd. [Huawei, HiSilicon] Thank you for the answers. On SFN, we have the same understanding that if ECP was introduced, the legacy UEs can be configured/scheduled not in ECP slots to avoid impact to legacy UEs.

5.2.1 Answers by the moderator

5.2.1.1 MediaTek Inc.

Should the extended CP be allowed to be configurable for the said dedicated slot? This means in case an SFN area is not a big area, the normal CP can be configured for this slot for the purpose of SFN transmission.

[reply] In our view, the standard should not limit the use of SFN to ECP, which means that SFN may be used either with normal or extended CP, depending on need. From an SFN perspective, the only difference is that with ECP there is better immunity to inter-symbol interference caused by the SFN multi-path channel, which may be very useful in some, but not all cases.

5.2.1.2 HUAWEI TECHNOLOGIES Co. Ltd.

Thank you for the answers. On SFN, we have the same understanding that if ECP was introduced, the legacy UEs can be configured/scheduled not in ECP slots to avoid impact to legacy UEs.

[reply] It is good we have a common understanding.

6 URLLC and IIoT enhancements

6.1 1st round questions to the proposals on URLLC and IIoT enhancements

Please provide your 1st round questions to RWS-210380 in the below feedback form:

Feedback Form 9: 1st round questions to the proposals on URLLC and IIoT enhancements

1 – Sony Europe B.V.

1) We agree that higher data rate URLLC is important and wonder what is E///'s view on the expected data rate. Note: we are considering 160 Mbps (Ref: RWS-210304)
2) What does it means by "replicated data" in your proposal for dynamic LCH multiplexing of multiple reliability targets (slide 4)
3) What assistance information enhancements (slide 4) are you considering, would appreciate an example.

2 – vivo Communication Technology

Thanks Ericsson for the contribution, could you elaborate more details about "Dynamic higher layer LCH multiplexing for different reliability targets"

3 – CATT

Thanks for the proposals. We have the following comment/questions.

1) For re-scheduling of unused configured resources, is the intention to re-schedule the CG resource of UE1 to UE2 and let UE1 knows so that UE1 does not transmit on the CG resource? If so,couldn't that be supported by existing schemes e.g. CI?

2) For multi-slot resource allocation with CG, we need SA2 input on higher and variable data rate requirement, and then consider RAN enhancement if needed.

4 – Nokia Germany

-

On slide 3: Indeed, "high efficiency & capacity with moderate latency bound" overlaps quite a lot with XR use cases/requirements. What do you think should be the right split of technical topics between the potential R18 XR and IIOT work items?

- On slide 3, “Configured grant enhancements for traffic with both periodical and non-periodical components” it has been the assumption since Rel-15 that configured grant can be used for both periodical and non-periodical traffic – what specific problems do you have in mind?

- Slide 4 on CG flexibility: Rel-16 already included per CG configuration repetition factor, and the support of PUSCH repetition type B. So what type of additional ‘flexibility’ for ‘multi-slot CG resource allocation’ is envisioned here?

- Slide 4: In Rel-17 RAN2 already concluded that burst end time is not needed on top of available TSCAI, what’s the motivation to bring it back? In case any new QoS parameter needed, should the discussion start in SA2 first?

5 – Intel Corporation (UK) Ltd

Q1: Could you elaborate a bit more on re-scheduling of unused configured grant resources, what are the benefits?

6 – Intel Corporation (UK) Ltd

Continuation of the Intel questions

Q2: Can re-scheduling of unused configured resources be handled by gNB implementation?

Q3: Regarding “dynamic scheduling of LCHs multiplexes”, is there impact on QoS of URLLC?

7 – Apple Italia S.R.L.

Q1: Can you elaborate on ”re-scheduling of configured resources”?

Q2: Can you elaborate on “Flexibility in using features like multi-slot resource allocation with Configured Grant”? Is it related to the re-scheduling of configured resources?

Q3: Can you elaborate on “Dynamic scheduling of LCHs multiplexes (new eMBB data + replicated URLLC data, if needed)”? What does “replicated URLLC data” mean?

8 – Qualcomm Incorporated

Question for clarification regarding the burst time variability. Can you elaborate on use-cases where burst-time variability is required. Is this for motion control use-cases, or covers more broad set of applications?

9 – Samsung Electronics Co.

1. The proposal for multi-slot transmission is motivated by higher data rates. What are such data rates for URLLC? What would the difference be from XR or eMBB and why isn’t a similar proposal made for those applications?

2. If a traffic has an aperiodic component, what is the benefit of CG enhancements over dynamic scheduling?

3. What is the difference between dynamic scheduling of LCH multiplexes and reception of 2 PDSCHs over the same resources?

10 – Lenovo Mobile Com. Technology Thanks for the good proposals! we have few questions in the below: Could you elaborate a bit more on the difference between "Configured grant enhancements for traffic with both periodical and non-periodical components" and the existing configured grant configuration? If non-periodical components is needed to enhance CG, whether TSC assistance information needs to includes such information? Could you elaborate a bit more on "Dynamic LCH multiplexing"?
11 – HUAWEI TECHNOLOGIES Co. Ltd. Thanks for the contribution. Can you explain more on "Flexibility in using features like multi-slot resource allocation with Configured Grant"?
12 – Qualcomm Incorporated Multi-slot transmission efficiency enhancements: what type of improvements are targeted?
13 – Qualcomm Incorporated ... continuation Configured grant enhancements for traffic with periodic and non-periodic components: what type of functionality is considered? Which is the traffic scenario? variable data rates?

6.1.1 Answers by the moderator

6.1.1.1 Sony Europe B.V.

1) We agree that higher data rate URLLC is important and wonder what is E///'s view on the expected data rate. Note: we are considering 160 Mbps (Ref: RWS-210304)

Answer: We are thinking of optimization which makes URLLC features applicable to data rates that go beyond use-cases were in focus of Rel-15/16, e.g. XR.

2) What does it means by "replicated data" in your proposal for dynamic LCH multiplexing of multiple reliability targets (slide 4)

Answer: With this enhancement, the scheduler gets the flexibility to dynamically handle multiplexing of different LCH data on the same TB, such as new/different MBB data + duplicated URLLC data, if needed. This way one could for example schedule new MBB data + new URLLC data on a first TB (e.g. on TRP1) and then schedule more/new MBB data + the same URLLC data i.e. duplicated URLLC data on a second TB (e.g. on TRP2), if needed for meeting the reliability target. This does not depend on Rel-16/17 features, i.e. no intra-UE multiplexing enhancements.

3) What assistance information enhancements (slide 4) are you considering, would appreciate an example.

Answer: For TSC assistance information enhancements we consider burst end time and variable burst components, like mean/min/max of burst size. The network can benefit by more efficient resource scheduling.

6.1.1.2 vivo Communication Technology

Thanks Ericsson for the contribution, could you elaborate more details about ”Dynamic higher layer LCH multiplexing for different reliability targets”

Answer: With this enhancement, the scheduler gets the flexibility to dynamically handle multiplexing of different LCH data on the same TB, such as new/different MBB data + duplicated URLLC data, if needed. This way one could for example schedule new MBB data + new URLLC data on a first TB (e.g. on TRP1) and then schedule more/new MBB data + the same URLLC data i.e. duplicated URLLC data on a second TB (e.g. on TRP2), if needed for meeting the reliability target. This does not depend on Rel-16/17 features, i.e. no intra-UE multiplexing enhancements.

6.1.1.3 CATT

Thanks for the proposals. We have the following comment/questions.

1) For re-scheduling of unused configured resources, is the intention to re-schedule the CG resource of UE1 to UE2 and let UE1 knows so that UE1 does not transmit on the CG resource? If so,couldn’t that be supported by existing schemes e.g. CI?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. We expect that CI cannot be used in this “reactive” manner. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

2) For multi-slot resource allocation with CG, we need SA2 input on higher and variable data rate requirement, and then consider RAN enhancement if needed.

Answer: For URLLC traffic with non-periodical and periodical components, it is beneficial to inform RAN about the traffic profile (if known in CN), e.g. minimum, average and maximum burst size expected could be indicated to RAN, in order to enable RAN to more efficiently schedule dynamic and configured grant resources to the user. Furthermore, for these kind of traffic types, beside burst arrival time, also burst end time information would be beneficial to be known in RAN for timely scheduling. We think that since motivation for these enhancements come from RAN point of view, while standardization of this signaling would happen in SA2, it could still be RAN working groups starting the discussion by considering the enhancement in a RAN work item.

6.1.1.4 Nokia

On slide 3: Indeed, “high efficiency & capacity with moderate latency bound” overlaps quite a lot with XR use cases/requirements. What do you think should be the right split of technical topics between the potential R18 XR and IIOT work items?

Answer: We see URLLC features and further enhancements to be applicable to a wide range of time-critical communication use-cases, such as XR. One possibility is to have scheduling enhancements framework in URLLC and keep other XR specific related enhancements apart. We are open to discuss how to best split those enhancements between Rel-18 work items.

On slide 3, “Configured grant enhancements for traffic with both periodical and non-periodical components” it has been the assumption since Rel-15 that configured grant can be used for both periodical and non-periodical traffic – what specific problems do you have in mind?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

Slide 4 on CG flexibility: Rel-16 already included per CG configuration repetition factor, and the support of PUSCH repetition type B. So what type of additional ‘flexibility’ for ‘multi-slot CG resource allocation’ is envisioned here?

Answer: We consider multi-slot allocations per CG period for different data (not repetitions) as beneficial for the URLLC traffic with periodical and non-periodical components.

Slide 4: In Rel-17 RAN2 already concluded that burst end time is not needed on top of available TSCAI, what’s the motivation to bring it back? In case any new QoS parameter needed, should the discussion start in SA2 first?

Answer: For URLLC traffic with non-periodical and periodical components, it is beneficial to inform RAN about the traffic profile (if known in CN), e.g. minimum, average and maximum burst size expected could be indicated to RAN, in order to enable RAN to more efficiently schedule dynamic and configured grant resources to the user. Furthermore, for these kind of traffic types, beside burst arrival time, also burst end time information would be beneficial to be known in RAN for timely scheduling. We think that since motivation for these enhancements come from RAN point of view, while standardization of this signaling would happen in SA2, it could still be RAN working groups starting the discussion by considering the enhancement in a RAN work item.

6.1.1.5 Intel Corporation (UK) Ltd

Q1: Could you elaborate a bit more on re-scheduling of unused configured grant resources, what are the benefits?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

6.1.1.6 Intel Corporation (UK) Ltd

Continuation of the Intel questions

Q2: Can re-scheduling of unused configured resources be handled by gNB implementation?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered, as they are faster than handling the re-scheduling by gNB implementation.

Q3: Regarding "dynamic scheduling of LCHs multiplexes", is there impact on QoS of URLLC?

Answer: There is no direct impact on QoS from our point of view. With this enhancement, the scheduler gets the flexibility to dynamically handle multiplexing of different LCH data on the same TB, such as new/different MBB data + duplicated URLLC data, if needed. This way one could for example schedule new MBB data + new URLLC data on a first TB (e.g. on TRP1) and then schedule more/new MBB data + the same URLLC data i.e. duplicated URLLC data on a second TB (e.g. on TRP2), if needed for meeting the reliability target (i.e. the QoS target). This does not depend on Rel-16/17 features, i.e. no intra-UE multiplexing enhancements.

6.1.1.7 Apple Italia S.R.L.

Q1: Can you elaborate on "re-scheduling of configured resources"?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

Q2: Can you elaborate on "Flexibility in using features like multi-slot resource allocation with Configured Grant"? Is it related to the re-scheduling of configured resources?

Answer: Yes, we see the enhancements for multi-slot scheduling applicable for CG, where re-scheduling is seen beneficial as commented above.

Since we want to broad scope of requirements to high-data rates, multi-TB scheduling becomes essential. We are open to discuss enhancements targeting more efficient multi-TB PUSCH resource allocation to schedule variable packet sizes.

Q3: Can you elaborate on "Dynamic scheduling of LCHs multiplexes (new eMBB data + replicated URLLC data, if needed)"? What does "replicated URLLC data" mean?

Answer: With this enhancement, the scheduler gets the flexibility to dynamically handle multiplexing of different LCH data on the same TB, such as new/different MBB data + duplicated URLLC data, if needed. This way one could for example schedule new MBB data + new URLLC data on a first TB (e.g. on TRP1) and then schedule more/new MBB data + the same URLLC data i.e. duplicated URLLC data on a second TB (e.g. on TRP2), if needed for meeting the reliability target. This does not depend on Rel-16/17 features, i.e. no intra-UE multiplexing enhancements.

6.1.1.8 Qualcomm Incorporated

Question for clarification regarding the burst time variability. Can you elaborate on use-cases where bursttime variability is required. Is this for motion control use-cases, or covers more broad set of applications?

Answer: For URLLC traffic with non-periodical and periodical components, it is beneficial to inform RAN about the traffic profile (if known in CN), e.g. minimum, average and maximum burst size expected could be indicated to RAN, in order to enable RAN to more efficiently schedule dynamic and configured grant resources to the user. Furthermore, for these kind of traffic types, beside burst arrival time, also burst end time information would be beneficial to be known in RAN for timely scheduling. We think that since motivation for these enhancements come from RAN point of view, while standardization of this signaling would happen in SA2, it could still be RAN working groups starting the discussion by considering the enhancement in a RAN work item. The use-cases would include for example real-time media.

6.1.1.9 Samsung Electronics Co.

1. The proposal for multi-slot transmission is motivated by higher data rates. What are such data rates for URLLC? What would the difference be from XR or eMBB and why isn't a similar proposal made for those applications?

Answer: We see URLLC features and further enhancements to be applicable to a wide range of time-critical communication use-cases, such as XR. We are open to discuss how to best split those enhancements between Rel-18 work items.

2. If a traffic has an aperiodic component, what is the benefit of CG enhancements over dynamic scheduling?

Answer: We consider traffic types with both periodical and non-periodical components, and for control channel overhead saving and reliability for the periodical part, one would consider CG. The question is then how to consider the a-periodic part on top of that, i.e. when CG is configured. In this case, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered, as they are faster than handling the re-scheduling by gNB implementation.

3. What is the difference between dynamic scheduling of LCH multiplexes and reception of 2 PDSCHs over the same resources?

Answer: With this enhancement, the scheduler gets the flexibility to dynamically handle multiplexing of different LCH data on the same TB, such as new/different MBB data + duplicated URLLC data, if needed. This way one could for example schedule new MBB data + new URLLC data on a first TB (e.g. on TRP1) and then schedule more/new MBB data + the same URLLC data i.e. duplicated URLLC data on a second TB (e.g. on TRP2), if needed for meeting the reliability target. This does not depend on Rel-16/17 features, i.e. no intra-UE multiplexing enhancements.

6.1.1.10 Lenovo Mobile Com. Technology

Thanks for the good proposals! we have few questions in the below:

Could you elaborate a bit more on the difference between "Configured grant enhancements for traffic with both periodical and non-periodical components" and the existing configured grant configuration? If non-periodical components is needed to enhance CG, whether TSC assistance information needs to includes such information?

Answer: We considered enhancements to efficiently schedule high data rate periodic traffic when packet arrival time varying and packet size also varying, e.g. video. TCSAI can be enhanced for this purpose.

For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

For URLLC traffic with non-periodical and periodical components, it is beneficial to inform RAN about the traffic profile (if known in CN), e.g. minimum, average and maximum burst size expected could be indicated to RAN, in order to enable RAN to more efficiently schedule dynamic and configured grant resources to the user. Furthermore, for these kind of traffic types, beside burst arrival time, also burst end time information would be beneficial to be known in RAN for timely scheduling. We think that since motivation for these enhancements come from RAN point of view, while standardization of this signaling would happen in SA2, it could still be RAN working groups starting the discussion by considering the enhancement in a RAN work item.

Could you elaborate a bit more on "Dynamic LCH multiplexing"?

Answer: With this enhancement, the scheduler gets the flexibility to dynamically handle multiplexing of different LCH data on the same TB, such as new/different MBB data + duplicated URLLC data, if needed. This way one could for example schedule new MBB data + new URLLC data on a first TB (e.g. on TRP1) and then schedule more/new MBB data + the same URLLC data i.e. duplicated URLLC data on a second TB (e.g. on TRP2), if needed for meeting the reliability target. This does not depend on Rel-16/17 features, i.e. no intra-UE multiplexing enhancements.

6.1.1.11 HUAWEI TECHNOLOGIES Co. Ltd.

Thanks for the contribution. Can you explain more on "Flexibility in using features like multi-slot resource allocation with Configured Grant"?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

6.1.1.12 Qualcomm Incorporated

Multi-slot transmission efficiency enhancements: what type of improvements are targeted?

Answer: For high-data rate URLLC traffic with periodical and non-periodical components, CG with multi-slot allocations per period is beneficial, when being able to re-schedule CG resources (slots) to other users, if otherwise unused. To support this better, UE procedure (e.g. cancelling unused CG slots) and signaling enhancements should be considered.

6.1.1.13 Qualcomm Incorporated

Configured grant enhancements for traffic with periodic and non-periodic components: what type of functionality is considered? Which is the traffic scenario? variable data rates?

Answer: See comment above

6.2 2nd round questions to the proposals on URLLC and IIoT enhancements

Please provide your 2nd round questions to RWS-210380 in the below feedback form:

Feedback Form 10: 2nd round questions to the proposals on URLLC and IIoT enhancements

1 – Nokia Germany Thanks for the detailed 1st round answers. Some small follow-up from our side: Could you please elaborate a bit more on the motivation for multi-slot allocations per CG period? What are the gain mechanisms you envision compared to what is supported already (so what is beneficial there)? And couldn't this be realized based on Rel-16 URLLC specifications using multiple configured grant configurations already?
2 – Intel Corporation (UK) Ltd Further Q: For "UE procedure and signaling" of the re-scheduling of CG resources, do you consider sidelink transmission to other UEs announcing unused resources?

6.2.1 Answers by the moderator

6.2.1.1 Nokia Germany

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

Could you please elaborate a bit more on the motivation for multi-slot allocations per CG period? What are the gain mechanisms you envision compared to what is supported already (so what is beneficial there)? And couldn't this be realized based on Rel-16 URLLC specifications using multiple configured grant configurations already?

[Reply] Main motivation for multi-slot allocations per CG period is to better serve packet bursts for high-data rate URLLC. We see at least gain in decreasing of signaling when setting up and handling one CG

configuration instead of multiple in particular for variable burst sizes per period.

Moreover, overprovisioning of CG resources (e.g. by multiple CG configurations) to minimize latency and account for packet bursts will lead to blind decoding burden at gNB side. We believe that this can be improved also by better combined handling of CG and DG.

6.2.1.2 Intel Corporation (UK) Ltd

Further Q: For "UE procedure and signaling" of the re-scheduling of CG resources, do you consider sidelink transmission to other UEs announcing unused resources?

[Reply] We do not consider sidelink for URLLC.

7 eXtended Reality (XR)

7.1 1st round questions to the proposals on XR

Please provide your 1st round questions to RWS-210381 in the below feedback form:

Feedback Form 11: 1st round questions to the proposals on XR

1 – CATT Thanks for the proposal of additional study Rel-18 study first to identify the area of NR enhancement and specification impact in the area of RAN traffic characteristics awareness i.e. the type of traffic characteristic and its use case for improving efficient dropping of unnecessary delayed packets, enhanced efficient signalling mechanisms for scheduling and link adaptations for high rate services with bounded latencies, power saving for XR and mobility enhancement. We agree that the study of XR enhancement should be completed at working group first. Do you think that XR study in Rel-17 could not be completed with conclusions of NR enhancement for XR after evaluation?
2 – HuaWei Technologies Co. Do you think the RAN awareness requires an E2E mechanism involving CN to get useful information from the APP?
3 – vivo Communication Technology Thanks Ericsson for the contribution. Regarding proposal 3, could you elaborate more on how to conduct the dropping of unnecessary delayed packets by RAN and which layer/functionality will the packet dropping be applied to?
4 – LG Electronics Inc. We agree that traffic awareness and efficient handling is important to support XR traffic. Some questions on this: 1. It is not clear from the paper whether the traffic awareness is performed by UE or network or both. Could you clarify? 2. We think packet dropping is performed only in network side. For UE side, PDCP discard timer will be

used for this purpose. Is our understanding correct? If you also consider packet dropping in the UE side, could you clarify the difference between PDCP discard and packet dropping?

5 – Samsung Research America

Section 3.1.: Could you please elaborate on "(…) studying 1) the type of traffic characteristic information which may be useful in RAN to be obtained e.g. from the application, core network, or by other means, and 2) how this information may be useful to improve the scheduling mechanisms e.g. packet dropping." We also think that traffic/packet-awareness at the gNB scheduler when dealing with XR packet bursts is of great benefit, e.g. dropping or TDM. However, propagating traffic characteristics through the U-plane stack is an exceedingly complex tasks with potentially very high impact and requirements on inter-operability of network nodes. For the SI part, do you have in mind to evaluate simply additions like more XR-specific 5QIs, possibility/flexibility for multiple stream handling per XR user, or are you proposing to study a fully optimized U-plane XR protocol with in-band signaling?

Section 3.2: Thank you for the nice discussion of dynamic grant-based vs. CG/SPS allocations. Regarding dynamic grant based, you propose "Investigating efficient signaling for fast multiple resource allocations would be beneficial." R17 NR-U defines multi-PDSCH/PUSCH scheduling and R17 CovEnh defines TBs over multiple slots (at least for the UL, but this could be extended to the DL). Did you mean to propose "multi-TB scheduling (per grant)" for the SI or something else altogether? Could you elaborate on this part of your proposal?

Section 3.2: Could you please provide more background to the proposal "improved link adaptation may be beneficial for increased capacity for XR" (e.g. interference variations due to short-term scheduling decisions) When compared to the ongoing R17 eURLLC, what additional improvements do you consider of benefit when dealing with quasi-periodic traffic such as XR (and that would not be captured through R17 eURLCC work)?

Section 3.4 & Mobility for XR: Could you provide more background as to why it would be critical to include XR mobility enhancements right away into the R18 SI/WI (as opposed to consider this an optimization for a later Release)? For example, is there anything XR-specific about mobility handling (incl. interruption times during HO) which wouldn't also apply to generic URLCC? For example, do you anticipate that he likelihood of mobility events for XR applications would be higher than typically expected for URLCC/factory-floor IIOT services such that there would be a scaled benefit of considering XR related mobility enhancements through (e)DAPS in a SI? It is not obvious to us to include XR mobility in a SI, so any insight you could provide here would be greatly appreciated.

6 – Sony Europe B.V.

Could you possibly elaborate on the rational to start with a study. Is to continue from the RAN1 XR study, that is not ready until end of Rel-17, and therefor has not yet giving and conclusive input for further XR work, and/or to add other topics to evaluate in order to enhance XR performance, e.g. traffic awareness , which would be one such feature, where packet prioritization can be made, in order to avoid dropping of packets.

7 – Nokia Corporation

Thank you for the interesting contribution. 1) You suggest starting a new SI in Rel'18. Should we rather consider using the remaining allocated time in Rel-17 SI to discuss enhancements to the standard instead of setting a new Rel-18 SI? 2) Regarding LA, what type of enhanced signaling do you have in mind? A few HARQ retranmissions can still be performed since XR PDB (10-15ms) is relatively high compared to IIoT.

8 – Lenovo Information Technology

3.1. Traffic characteristic knowledge in the RAN: could you please explain whether the traffic characteristic knowledge is provided by CN or UE application layer and what traffic characteristic knowledge means, a new QCI for XR? which layer perfom packet dropping, something as PDCP discard function?

9 – 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?
- For CSI enhancements, given less stringent reliability requirement than URLLC and it has already studied in R17 URLLC WI, would the need of further/new CSI enhancements be justified first?
- For mobility enhancement with CA/DC/M-TRP, whether this extension of DAPS HO can be used for other use cases other than XR?

10 – Apple Europe Limited

Thanks for the nice paper. Could you explain more on ”To deal with a varying frame size, for example, the dynamic scheduling may be the most flexible and best solution. However, dynamic scheduling comes at the costs of overhead control signalling (PDCCH, SR), and potentially increased latency. Considering the large application PDU size, the network will usually need to allocate several slots to deliver all the packets associated with one application PDU. Investigating efficient signalling for fast multiple resource allocations would be beneficial.”? It is for uplink transmission using CG-UCI like design?

11 – LG Electronics Inc.

Regarding SI objectives, we have the following additional questions.

Q) For the objective on mobility enhancements, is it your preference to study the mobility enhancements in the XR SI/WI? If so, can you explain the XR-specific enhancements that can be better handled in XR rather than other mobility enhancement SI/WI which should strive to reduce the latency anyway as it is kind of a generic objective for mobility enhancement?

12 – Samsung Electronics Co.

1. What is the likelihood of mobility events for XR applications and what would be the scaled benefit of enhanced DAPS vs. no eDAPS in such scenarios? What about mobility is XR-specific and was not e.g. URLLC-specific?

2. Rel-17 NR-U defines multi-PDSCH/PUSCH scheduling and CovEnh define TB over multiple slots (for UL, but can be extended for DL). What else is needed for ”efficient signaling for fast multiple resource allocations”?

3. For link adaptation, what is needed specifically for XR (that also has periodic traffic) compared to Rel-17 URLLC/eMBB?

4. Section 3.1.: Could you please elaborate on “(…) studying 1) the type of traffic characteristic information which may be useful in RAN to be obtained e.g. from the application, core network, or by other means, and 2) how this information may be useful to improve the scheduling mechanisms e.g. packet dropping.” We also think that traffic/packet-awareness at the gNB scheduler when dealing with XR packet bursts is of great benefit, e.g. dropping or TDM. However, propagating traffic characteristics through the U-plane stack is an exceedingly complex tasks with potentially very high impact and requirements on inter-operability of network nodes. For the SI part, do you have in mind to evaluate simply additions like more XR-specific 5QIs, possibility/flexibility for multiple stream handling per XR user, or are you proposing to study a fully optimized U-plane XR protocol with in-band signaling?

5. Section 3.2: Thank you for the nice discussion of dynamic grant-based vs. CG/SPS allocations. Regarding dynamic grant based, you propose “Investigating efficient signaling for fast multiple resource allocations would be beneficial.” R17 NR-U defines multi-PDSCH/PUSCH scheduling and R17 CovEnh defines TBs over multiple slots (at least for the UL, but this could be extended to the DL). Did you mean to propose “multi-TB scheduling (per grant)” for the SI or something else altogether? Could you elaborate on this part of your proposal?

6. Section 3.2: Could you please provide more background to the proposal “improved link adaptation may be beneficial for increased capacity for XR” (e.g. interference variations due to short-term scheduling decisions) When compared to the ongoing R17 eURLLC, what additional improvements do you consider of benefit when dealing with quasi-periodic traffic such as XR (and that would not be captured through R17 eURLCC work)?

7. Section 3.4 & Mobility for XR: Could you provide more background as to why it would be critical to include XR mobility enhancements right away into the R18 SI/WI (as opposed to consider this an optimization for a later Release)? For example, is there anything XR-specific about mobility handling (incl. interruption times during HO) which wouldn’t also apply to generic URLCC? For example, do you anticipate that he likelihood of mobility events for XR applications would be higher than typically expected for URLCC/factory-floor IIOT services such that there would be a scaled benefit of considering XR related mobility enhancements through (e)DAPS in a SI? It is not obvious to us to include XR mobility in a SI, so any insight you could provide here would be greatly appreciated.

7.1.1 Answers by the moderator

7.1.1.1 CATT

Thanks for the proposal of additional study Rel-18 study first to identify the area of NR enhancement and specification impact in the area of RAN traffic characteristics awareness i.e. the type of traffic characteristic and its use case for improving efficient dropping of unnecessary delayed packets, enhanced efficient signalling mechanisms for scheduling and link adaptations for high rate services with bounded latencies, power saving for XR and mobility enhancement. We agree that the study of XR enhancement should be completed at working group first. Do you think that XR study in Rel-17 could not be completed with conclusions of NR

enhancement for XR after evaluation?

[Reply]

The conclusions of the Release 17 SI should definitely be used to set the direction of what RAN WGs should do moving on. On the other hand, the goal of the Rel-17 SI is to perform evaluations but its goal is neither to find protocol limitations nor study solutions. Therefore, a new Study Item to study these limitations, possible solutions to address them and their gains should be done first. In a second phase, a work item, should narrow down the solutions and specify the best options.

7.1.1.2 HuaWei Technologies Co., Ltd

Do you think the RAN awareness requires an E2E mechanism involving CN to get useful information from the APP?

[Reply]

We are unclear what 'E2E mechanism' really means but we believe RAN awareness of traffic/application characteristics can be achieved by different means. So our idea is that the network gets information from the application/traffic. For example, it would be useful if CN gets or retrieves useful information from the application and this information is passed to the RAN. How this can be achieved is outside the scope of RAN WGs and SA groups may need to be involved too. In some cases, machine learning or artificial intelligence could be used. The important aspect is to identify the relevant traffic/application characteristics for RAN to meet the E2E QoS. Since different application may have different characteristics, it is also important to find a subset of characteristics which are somewhat common to most of these apps and give most value to the networks. Otherwise, complexity will not be manageable and acceptance among developers may also be limited.

7.1.1.3 vivo Communication Technology

Thanks Ericsson for the contribution. Regarding proposal 3, could you elaborate more on how to conduct the dropping of unnecessary delayed packets by RAN and which layer/functionality will the packet dropping be applied to?

[Reply]

From our point of view, capacity is one of the bottlenecks for XR. Maximizing the network resources and reducing wasting resources are, therefore, key. As an example, a application data PDU such as a video frame may be transmitted over multiple IP packets. If any of these IP packets is delivered late or is lost, all the other packets may become obsolete as the application data PDU may not be reconstructed. Taking into consideration that these IP packets may be large, they will have a considerable impact in the capacity and resource utilization. Thus, transmitting all these packets may result in a waste of resources. Dropping all these packets which belong to the same application data PDU may make sense. The first thought may be to use the PDCP discard timer; however, we think it does not serve the purpose. This issue applies to both DL and UL.

We think this type of functionality needs to be further studied to see the impact in capacity considering the complexity too as any other feature proposed during the SI/WI.

7.1.1.4 LG Electronics Inc.

We agree that traffic awareness and efficient handling is important to support XR traffic. Some questions on this:

1. It is not clear from the paper whether the traffic awareness is performed by UE or network or both. Could you clarify?

[Reply] We think that the NW should be aware of the traffic/application characteristics rather than the inverse. The main reason is that the application/UE have a very limited view of what is happening at the NW and how the NW behaves, while the network has the full view and, ultimately, has to manage the network resources and is the NW responsibility to deliver on the agreed QoS for each connected device.

2. We think packet dropping is performed only in network side. For UE side, PDCP discard timer will be used for this purpose. Is our understanding correct? If you also consider packet dropping in the UE side, could you clarify the difference between PDCP discard and packet dropping?

[Reply] Similar question is addressed above (vivo).

7.1.1.5 Samsung Research America

Section 3.1.: Could you please elaborate on "(…) studying 1) the type of traffic characteristic information which may be useful in RAN to be obtained e.g. from the application, core network, or by other means, and 2) how this information may be useful to improve the scheduling mechanisms e.g. packet dropping." We also think that traffic/packet-awareness at the gNB scheduler when dealing with XR packet bursts is of great benefit, e.g. dropping or TDM. However, propagating traffic characteristics through the U-plane stack is an exceedingly complex tasks with potentially very high impact and requirements on inter-operability of network nodes. For the SI part, do you have in mind to evaluate simply additions like more XR-specific 5QIs, possibility/flexibility for multiple stream handling per XR user, or are you proposing to study a fully optimized U-plane XR protocol with in-band signaling?

[Reply]

To the first two questions 1) and 2), please refer to above responses (Huawei) and (vivo). We also share concerns about complexity and we mentioned this above (CATT).

About changing in the 5QI, that could be an option to evaluate and discuss. We are not proposing a fully optimized U-place due to the impact and complexity this may bring. Yet, additions which bring benefits with a reasonable impact should be considered in 3GPP.

All these are good questions and the reason why we think 3GPP needs to first start with a study item to understand options, feasibility, and benefits.

Section 3.2: Thank you for the nice discussion of dynamic grant-based vs. CG/SPS allocations. Regarding dynamic grant based, you propose "Investigating efficient signaling for fast multiple resource allocations would be beneficial." R17 NR-U defines multi-PDSCH/PUSCH scheduling and R17 CovEnh defines TBs over multiple slots (at least for the UL, but this could be extended to the DL). Did you mean to propose

“multi-TB scheduling (per grant)” for the SI or something else altogether? Could you elaborate on this part of your proposal?

[Reply] We consider multi-TB scheduling per grant is useful to avoid repeated control signaling for multiple slot allocations which would be needed to deliver one video frame. It would be beneficial to study the possible extension of the existing framework of multi-slot scheduling in Rel-17, e.g., support of multi-slot scheduling across multiple cells in the same band

Section 3.2: Could you please provide more background to the proposal “improved link adaptation may be beneficial for increased capacity for XR” (e.g. interference variations due to short-term scheduling decisions) When compared to the ongoing R17 eURLLC, what additional improvements do you consider of benefit when dealing with quasi-periodic traffic such as XR (and that would not be captured through R17 eURLCC work)?

[Reply] Any improvements for XR would be on top of what is finally specified for eURLLC in Rel-17, but it is unclear what will be specified in the end. The characteristics of XR traffic are somewhat different to the traffic characteristics considered so far in the eURLLC work, regarding data rates and latency requirements. It is thus not obvious that solutions specified for eURLLC will be suitable for XR traffic.

Section 3.4 & Mobility for XR: Could you provide more background as to why it would be critical to include XR mobility enhancements right away into the R18 SI/WI (as opposed to consider this an optimization for a later Release)? For example, is there anything XR-specific about mobility handling (incl. interruption times during HO) which wouldn’t also apply to generic URLCC? For example, do you anticipate that he likelihood of mobility events for XR applications would be higher than typically expected for URLCC/factory-floor IIOT services such that there would be a scaled benefit of considering XR related mobility enhancements through (e)DAPS in a SI? It is not obvious to us to include XR mobility in a SI, so any insight you could provide here would be greatly appreciated.

[Reply] There are limitations for DAPS. It cannot be used in FR2, and it cannot be used together with CA. Since XR may benefit from the high data rates of CA and FR2, these two limitations are quite restrictive for XR. It is also so that XR will most likely be deployed over wider areas, and for users that are mobile. Mobility related aspects could also be discussed in a separate Work Item too. We are open for how to address this aspect.

7.1.1.6 Sony Europe B.V.

Could you possibly elaborate on the rational to start with a study. Is to continue from the RAN1 XR study, that is not ready until end of Rel-17, and therefor has not yet giving and conclusive input for further XR work, and/or to add other topics to evaluate in order to enhance XR performance, e.g. traffic awareness , which would be one such feature, where packet prioritization can be made, in order to avoid dropping of packets.

[Reply] Similar question is addressed above in (CATT) and (Samsung). In overall, continuing with a study item has the purpose to start discussing about specific problems, how they contribute to the bottlenecks, and discuss solutions for them as well as their benefits and complexity. The current Study Item does not include these goals and we do not think this can be done in a couple of meetings. Thus, we think it is reasonable to dedicate some period of time to allow WGs to bring the problems which may be causing e.g. low capacity, and study together solutions. After all that is settled, the WGs can enter the work item phase to specify the best

solutions.

7.1.1.7 Nokia Corporation

Thank you for the interesting contribution. 1) You suggest starting a new SI in Rel'18. Should we rather consider using the remaining allocated time in Rel-17 SI to discuss enhancements to the standard instead of setting a new Rel-18 SI? 2) Regarding LA, what type of enhanced signaling do you have in mind? A few HARQ retransmissions can still be performed since XR PDB (10-15ms) is relatively high compared to IIoT.

[Reply]

1) There are a couple of meetings left and the simulation work is not really in a shape to be concluded. RAN1 should also spend time finding conclusions about the evaluations. Further, the goals of the current SI are limited and RAN1 should deliver on those. Whether further work is required is something RAN1 can conclude and to be discussed at the plenary. We are open to discuss different options but we think we need a period to discuss detail problems and solutions. Similar question is answered above (CATT), (Samsung), (Sony).

2) The number of HARQ retransmissions that can be handled depends heavily on the TDD pattern. It is important to extend the use also to other TDD patterns. Furthermore, we would like to be able to handle larger interference variations than those that can be captured using a small number of HARQ retransmissions.

7.1.1.8 Lenovo Information Technology

3.1. Traffic characteristic knowledge in the RAN: could you please explain whether the traffic characteristic knowledge is provided by CN or UE application layer and what traffic characteristic knowledge means, a new QCI for XR? which layer perform packet dropping, something as PDCP discard function?

[Reply] Similar question has been responded above (Huawei), (vivo), (LG), (Samsung).

7.1.1.9 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?

[Reply]

This is a question 3GPP needs to answer in the next phase. There are many proposals suggesting to study CG enhancements. We think that for large packet sizes which transmission may span over several slots, the dynamic grant (DL and UL) may be more effective as also outlined in the question. Yet, we should study whether configure grants (DL/UL) can play a role too, and whether it is and how is possible to combine these mechanisms in a better way than it is possible today. It also needs to be considered that there will be both large packets (e.g. video) and small packets (e.g. pose) some with tight latency requirements some without tight latency requirements. We need to discuss how these mechanisms fit to handle the distinct traffic with its requirements.

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?

[Reply] DRX maching the XR pattern is not only about reducing PDCCH monitoring. It is about ensuring the UE is awake when traffic arrives to the network. There are two consequences of the mismatch: UE is wasting power as no data arrived yet, increased the delay due to the fact that data may arrive when UE is sleeping. We are not sure previous enhancements can address this in a good way.

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?

[Reply] Similar question has been responded above (Huawei), (vivo), (LG), (Samsung), (Lenovo).

There is a good point in the question with regards SA4. How to plan the work is a good topic also for this workshop. We are quite open to discuss different options. Nonetheless, it is key that there is a good communication between SA and RAN groups to achieve the best output.

For CSI enhancements, given less stringent reliability requirement than URLLC and it has already studied in R17 URLLC WI, would the need of further/new CSI enhancements be justified first?

[Reply] Any improvements for XR would be on top of what is finally specified for eURLLC in Rel-17, but it is unclear what will be specified in the end. The characteristics of XR traffic are somewhat different to the traffic characteristics considered so far in the eURLLC work, regarding data rates and latency requirements. It is thus not obvious that solutions specified for eURLLC will be suitable for XR traffic. This should be clarified as part of the initial SI.

For mobility enhancement with CA/DC/M-TRP, whether this extension of DAPS HO can be used for other use cases other than XR?

[Reply] Extensions of DAPS HO could potentially be used for other applications, but since XR needs both high data rates and bounded latency, improvements or alternatives to DAPS HO would be of particular interest for XR.

7.1.1.10 Apple Europe Limited

Thanks for the nice paper. Could you explain more on ”To deal with a varying frame size, for example, the dynamic scheduling may be the most flexible and best solution. However, dynamic scheduling comes at the costs of overhead control signalling (PDCCH, SR), and potentially increased latency. Considering the large application PDU size, the network will usually need to allocate several slots to deliver all the packets associated with one application PDU. Investigating efficient signalling for fast multiple resource allocations

would be beneficial.”? It is for uplink transmission using CG-UCI like design?

[Reply] It is rather for enhancement of dynamic grant, e.g., multi-slot scheduling.

7.1.1.11 LG Electronics Inc.

Regarding SI objectives, we have the following additional questions.

Q) For the objective on mobility enhancements, is it your preference to study the mobility enhancements in the XR SI/WI? If so, can you explain the XR-specific enhancements that can be better handled in XR rather than other mobility enhancement SI/WI which should strive to reduce the latency anyway as it is kind of a generic objective for mobility enhancement?

[Reply] XR is expected to be a service for users on the move. The end-user experience of an XR service relies heavily on good mobility performance, and XR is thus a strong motivator for mobility enhancements in Rel-18. To us, it is not clear that there will be a mobility WI in Rel-18, and if there is, it is crucial that XR-specific requirements are considered, regarding latency, drop rates and data rates.

7.1.1.12 Samsung Electronics Co., Ltd

1. What is the likelihood of mobility events for XR applications and what would be the scaled benefit of enhanced DAPS vs. no eDAPS in such scenarios? What about mobility is XR-specific and was not e.g. URLLC-specific?

[Reply]

Since XR is a service for users on the move, and is used for an extended period, the likelihood of mobility events is high. The shortcomings of DAPS are the lack of DC/CA support and the lack of support for FR2, as well as high UE complexity.

Compared to factory-floor IIoT applications, XR can tolerate a slightly higher latency, but requires higher data rates, also during mobility events.

2. Rel-17 NR-U defines multi-PDSCH/PUSCH scheduling and CovEnh define TB over multiple slots (for UL, but can be extended for DL). What else is needed for ”efficient signaling for fast multiple resource allocations”?

[Reply] please see answer above (the other Samsung question).

3. For link adaptation, what is needed specifically for XR (that also has periodic traffic) compared to Rel-17 URLLC/eMBB?

[Reply] Any improvements for XR would be on top of what is finally specified for eURLLC in Rel-17, but it is unclear what will be specified in the end. The characteristics of XR traffic are somewhat different to the

traffic characteristics considered so far in the eURLLC work, regarding data rates and latency requirements.

4. Section 3.1.: Could you please elaborate on "(…) studying 1) the type of traffic characteristic information which may be useful in RAN to be obtained e.g. from the application, core network, or by other means, and 2) how this information may be useful to improve the scheduling mechanisms e.g. packet dropping." We also think that traffic/packet-awareness at the gNB scheduler when dealing with XR packet bursts is of great benefit, e.g. dropping or TDM. However, propagating traffic characteristics through the U-plane stack is an exceedingly complex tasks with potentially very high impact and requirements on inter-operability of network nodes. For the SI part, do you have in mind to evaluate simply additions like more XR-specific 5QIs, possibility/flexibility for multiple stream handling per XR user, or are you proposing to study a fully optimized U-plane XR protocol with in-band signaling?

[Reply] Similar question has been responded in (Huawei), (vivo), (LG), (Samsung), (Lenovo), (MediaTek).

5. Section 3.2: Thank you for the nice discussion of dynamic grant-based vs. CG/SPS allocations. Regarding dynamic grant based, you propose "Investigating efficient signaling for fast multiple resource allocations would be beneficial." R17 NR-U defines multi-PDSCH/PUSCH scheduling and R17 CovEnh defines TBs over multiple slots (at least for the UL, but this could be extended to the DL). Did you mean to propose "multi-TB scheduling (per grant)" for the SI or something else altogether? Could you elaborate on this part of your proposal?

[Reply] see answers above (the other Samsung question)

6. Section 3.2: Could you please provide more background to the proposal "improved link adaptation may be beneficial for increased capacity for XR" (e.g. interference variations due to short-term scheduling decisions) When compared to the ongoing R17 eURLLC, what additional improvements do you consider of benefit when dealing with quasi-periodic traffic such as XR (and that would not be captured through R17 eURLCC work)?

[Reply] Any improvements for XR would be on top of what is finally specified for eURLLC in Rel-17, but it is unclear what will be specified in the end. The characteristics of XR traffic are somewhat different to the traffic characteristics considered so far in the eURLLC work, regarding data rates and latency requirements. It is thus not obvious that solutions specified for eURLLC will be suitable for XR traffic. This should be clarified as part of the initial SI.

7. Section 3.4 & Mobility for XR: Could you provide more background as to why it would be critical to include XR mobility enhancements right away into the R18 SI/WI (as opposed to consider this an optimization for a later Release)? For example, is there anything XR-specific about mobility handling (incl. interruption times during HO) which wouldn't also apply to generic URLCC? For example, do you anticipate that he likelihood of mobility events for XR applications would be higher than typically expected for URLCC/factory-floor IIOT services such that there would be a scaled benefit of considering XR related mobility enhancements through (e)DAPS in a SI? It is not obvious to us to include XR mobility in a SI, so any insight you could provide here would be greatly appreciated.

[Reply] XR is expected to be a service for users on the move. The end-user experience of an XR service relies heavily on good mobility performance, and XR is thus a strong motivator for mobility enhancements in Rel-18. Compared to factory-floor applications commonly considered in the eURLLC work, the latency

requirements are somewhat relaxed, but the required data rates are higher. A mobility solution that is suitable for factory-floor applications may be unsuitable or overly complex for XR.

Yes, we expect that the likelihood of mobility events will be higher at least for some types of XR applications.

7.2 2nd round questions to the proposals on XR

Please provide your 2nd round questions to RWS-210381 in the below feedback form:

Feedback Form 12: 2nd round questions to the proposals on XR

1 – Fujitsu Limited

Thank you for the contribution.

We have one question on Section 3.2 on inaccuracy of the channel estimation. PDCP duplication has been already specified from Rel-15 with 2 legs and enhanced in Rel-16 with 4 legs. Given that precious exact channel estimation is infeasible in real world, the effectiveness of enhanced link adaptation is unclear to us. Do you have more accurate channel estimation in mind in this proposal?

2 – HuaWei Technologies Co.

Thanks for the reply. Regarding to the machine learning or artificial intelligence, it maybe useful for XR. Can you please clarify where the ML/AI will be used, CN or RAN, and is it specific to XR or it is rather a general consideration on AI?

3 – Samsung Electronics Co.

Q1: Could you quantify the "high likelihood" of a mobility event for a given XR application? Also, could you quantify the impact that a mobility event would have on the overall experience for that XR application compared to error events during "regular" operation?

Is a FR2 a primary operating scenario to optimize for XR and, if so, what additional enhancements to the Rel-17 beam management and inter-cell M-TRP support are needed?

Q2: Multi-cell scheduling by a single DCI was considered in Rel-17 and was not found to be beneficial even for single-slot scheduling. What are the benefits envisioned in case of multi-slot scheduling? If any, shouldn't "multi-cell + multi-slot" scheduling be considered as a general CA enhancement?

Q3: XR traffic is quasi-periodic. Why are CSI enhancements motivated more than for the dynamic traffic of eMBB/URLLC? What is a new CSI metric that would be required specifically for XR and was not required for eMBB/URLLC?

4 – MediaTek Inc.

Thanks for the detailed reply.

For DRX marching the XR pattern, to our understanding NW should be able to know the timing when a new frame arrives from application. Hence, would setting a proper PDCCH skipping period from NW considering frame arrival time be a possible solution? Or the intention is to ensure UE reside in DRX_OFF to save more UE power?

7.2.1 Answers by the moderator

7.2.1.1 Fujitsu Limited

Thank you for the contribution.

We have one question on Section 3.2 on inaccuracy of the channel estimation. PDCP duplication has been already specified from Rel-15 with 2 legs and enhanced in Rel-16 with 4 legs. Given that precious exact channel estimation is infeasible in real world, the effectiveness of enhanced link adaptation is unclear to us. Do you have more accurate channel estimation in mind in this proposal?

[Answer]:

We think that PDCP duplication might not be, in general, a suitable tool for XR type of traffic. Rel-17 simulations show an already low capacity even without duplication….

We were not thinking of increasing the requirements on the channel estimation accuracy. The main idea is that the UE provides additional information that would aid the link adaption. Examples like the statistical CSI discussed in URLLC is one example, additional interference measurements could also be relevant.

7.2.1.2 HuaWei Technologies Co., Ltd

Thanks for the reply. Regarding to the machine learning or artificial intelligence, it maybe useful for XR. Can you please clarify where the ML/AI will be used, CN or RAN, and is it specific to XR or it is rather a general consideration on AI?

[Answer]:

We think ML/AI is a general tool which can be used in different part of the network. These are possible mechanisms which could assist the network (CN or/and RAN) to learn about the traffic characteristics, for example. Though, it would be better to get more accurate information by the application if that was possible.

7.2.1.3 Samsung Electronics Co., Ltd

Q1: Could you quantify the “high likelihood” of a mobility event for a given XR application? Also, could you quantify the impact that a mobility event would have on the overall experience for that XR application compared to error events during “regular” operation?

[Answer]:

Different XR applications will involve different levels of mobility. VR is an example with less mobility, whereas CG and AR may imply more mobility. We are hoping that we will have time to evaluate mobility performance in the Rel-17 SI. As far as we see, a mobility event will lead to the loss of a few packets, and it may also lead to degraded performance due to “slow start” in the target cell, e.g., due to link adaptation. The frequency of mobility events may impact the overall experience, of course. The

mobility challenge for XR is that the handover should be completed within the inter-arrival time of two packets which means that the completion of the procedure should be done between 5-30 ms.

Is a FR2 a primary operating scenario to optimize for XR and, if so, what additional enhancements to the Rel-17 beam management and inter-cell M-TRP support are needed?

[Answer]:

FR2 is an important operating scenario for XR services that require a high bandwidth. The main additional beam management enhancement would be the full support of "scenario 2" in inter-cell beam management.

Q2: Multi-cell scheduling by a single DCI was considered in Rel-17 and was not found to be beneficial even for single-slot scheduling. What are the benefits envisioned in case of multi-slot scheduling? If any, shouldn't "multi-cell + multi-slot" scheduling be considered as a general CA enhancement?

[Answer]:

We think that multi-slot scheduling could be beneficial given that XR traffic may need to be transmitted over several slots. Thus, there are obvious benefits of multi-slot scheduling on the PDCCH load. We also think that multi-cell intra-band is beneficial.

Whether a certain functionality was not seen beneficial under certain assumptions, does not mean it is not beneficial under a different set of assumptions. XR traffic characteristics are quite different from eMBB and IIoT. Thus, we think there are merits to study the benefits of multi-slot and multi-cell intra-band scheduling for these cases.

In overall, we think this and many of the previous questions indicate that there is a need of RAN WGs to have an open discussion about problems and solutions. Those answers need to come during a Study Item phase before RAN WG decide to specify something.

Q3: XR traffic is quasi-periodic. Why are CSI enhancements motivated more than for the dynamic traffic of eMBB/URLLC? What is a new CSI metric that would be required specifically for XR and was not required for eMBB/URLLC?

[Answer]:

It is not the quasi-periodic traffic that motivates the enhancements, it is the bounded latency requirement. With bounded latency, HARQ becomes less efficient, and more accurate link adaptation becomes beneficial. Just using a larger backoff will reduce the spectral efficiency, which is undesirable for high bitrate applications like XR

7.2.1.4 MediaTek Inc.

Thanks for the detailed reply.

For DRX marching the XR pattern, to our understanding NW should be able to know the timing when a new frame arrives from application. Hence, would setting a proper PDCCH skipping period from NW considering frame arrival time be a possible solution? Or the intention is to ensure UE reside in DRX_OFF to save more UE power?

[Answer]:

To set proper DRX parameters, the NW should have knowledge about the traffic characteristics. This may be provided by the application or learned by ML/AI.

Whether PDCCH skipping is a good solution is something RAN2 should study as any other solution. If it is concluded that PDCCH skipping is a good solution, then it is already available. We think, however, that PDCCH skipping does not fully address the issue. PDCCH will help to keep the UE sleeping. However, it does not address the extra latency which will be added due to the fact that the UE is sleeping in wrong period when it should be awake if the DRX period would have follow the periodicity of the data arrival.

In overall, we think this and many of the previous questions indicate that there is a need of RAN WGs to have an open discussion about problems and solutions. Those answers need to come during a Study Item phase before RAN WG decide to specify something.

8 Non-terrestrial Networks

8.1 1st round questions to the proposals on NTN

Please provide your 1st round questions to RWS-210394 in the below feedback form:

Feedback Form 13: 1st round questions to the proposals on NTN

1 – Asia Pacific Telecom co. Ltd We share the same view that mobility shall be enhanced. However, we wonder what is the priority for the following HO schemes: Reduction of User Data Interruption (RUDI) HO, DAPS or RACH-less HO.
2 – MediaTek Inc. We are generally supportive of proposals. What would be the scope of enhancements for regenerative architecture with full gNB on board and which working group – i.e. RAN1, RAN2, RAN3? What would be the use case and scope for RUDI HO with enhanced make-before-break for mobility enhancement if not already part of Rel-17 and which working group – i.e. RAN2?
3 – HUAWEI TECHNOLOGIES Co. Ltd. Q1: RUDI is the old name of DAPS handover. Do you see any showstopper to apply DAPS handover in NTN?
4 – CATT On Regenerative architecture, we fully agree with you to consider full gNB on board in Rel-18, CU-DU split case could be further considered in the future release. Here, we would to ask two questions for clarification: 1. What's your view on supporting of the ISL? We assume it's beneficial to coordinate the radio resources between gNBs on board, which could further reduce the handover interruption. However, the ISL could be

out of 3GPP, we just need to focus on the Xn/NG interfaces carried on the ISL.

2. On TN-NTN coordination,what kind of behavior are expected, RUDI handover between TN and NTN ? What do you think of DC like coordination?

5 – Lenovo (Beijing) Ltd

We support to study regenerative arch and wonder if you consider ISL as well.

We share the view that mobility enhancement should be studied, including DAPS and RACH-less HO.

6 – Guangdong OPPO Mobile Telecom.

Slide 4: For regenerative payload, does Ericsson consider the case of Xn over SRI and its impact?

Slide 5: For regenerative architecture, Ericsson only supports the case of full gNB on board, instead of other cases such as gNB-DU on board. Is this true?

7 – THALES

Mobility enhancement can be a candidate feature but can you clarify the enhancements you have in mind ?

As per regenerative payload, what architecture would you prioritise among gNB on board, gNB-DU on board, IAB node on board and why ?

8 – China Unicom

Thanks for thisi contribution.

We have concerns on “No showstoppers” in page 4. Would you please provide some detail information on that part?

8.1.1 Answers by the moderator

8.1.1.1 Asia Pacific Telecom co. Ltd

We share the same view that mobility shall be enhanced. However, we wonder what is the priority for the following HO schemes: Reduction of User Data Interruption (RUDI) HO, DAPS or RACH-less HO.

[Reply] According our information on RAN2 status, in Rel-16 the focus for reduction of user data interruption (RUDI) was a solution for a dual Tx/Rx enabled UE, and make-before-break assumes single Tx/Rx and was not considered (even if it was sometimes referred to as ”enhanced” make-before-break in the context of a dual Tx/Rx UE, which caused some confusion). RAN2 agreed that RACH-less will not be introduced in NR given that CFRA 2-step RA for HO is introduced in Rel-16. Then in Rel-16 it turned out that DAPS did not work FR2-FR2 and RAN2 agreed to not solve the FR2 HO interruption problem in Rel-16 (even if the make-before-break was one possibility). Long story short, if this is correct it seems we are left with RUDI with enhanced make-before-break by exclusion. In any case, I don’t think we should worry too much about prioritization at this stage.

8.1.1.2 MediaTek Inc.

We are generally supportive of proposals. What would be the scope of enhancements for regenerative architecture with full gNB on board and which working group – i.e. RAN1, RAN2, RAN3? What would be

the use case and scope for RUDI HO with enhanced make-before-break for mobility enhancement if not already part of Rel-17 and which working group – i.e. RAN2?

[Reply] The scope should be mostly RAN2 (as this was the scope from our original proposal (see the reference to the R2-1914724 document). Some minor RAN3 impact might be possible due to the necessary coordination between source and target.

8.1.1.3 HUAWEI TECHNOLOGIES co. Ltd

Q1: RUDI is the old name of DAPS handover. Do you see any showstopper to apply DAPS handover in NTN?

[Reply] Not at the moment.

8.1.1.4 CATT

On Regenerative architecture, we fully agree with you to consider full gNB on board in Rel-18, CU-DU split case could be further considered in the future release.

Here, we would to ask two questions for clarification:

1. What's your view on supporting of the ISL? We assume it's beneficial to coordinate the radio resources between gNBs on board, which could further reduce the handover interruption. However, the ISL could be out of 3GPP, we just need to focus on the Xn/NG interfaces carried on the ISL.

2. On TN-NTN coordination,what kind of behavior are expected, RUDI handover between TN and NTN ? What do you think of DC like coordination?

[Reply] 1. We envisage the ISL as a transport link, which in the "full gNB on board" architecture option, transports the inter-satellite Xn interface. Of course 3GPP would concern itself with the Xn interface, not the ISL itself. 2. TN-NTN coordination was discussed during both the Rel-16 SI (and some problems were found with e.g. a potential TN-NTN DC, think of UP buffering requirements between the 2 "legs" which are so unbalanced) and the Rel-17 WI (and so far nothing in was found as needed for TN-NTN coordination). For this reason, we don't believe TN-NTN tight coordination will be necessary. On the other hand, intra-NTN coordination through inter-satellite Xn seems feasible and beneficial (think inter-satellite DC, load balancing, etc., which in principle could be specified reusing currently specified Xn functionality as baseline).

8.1.1.5 Lenovo (Beijing) Ltd

We support to study regenerative arch and wonder if you consider ISL as well.

We share the view that mobility enhancement should be studied, including DAPS and RACH-less HO.

[Reply] Indeed, we believe the full gNB on board option is the most beneficial precisely because it allows for an ISL with Xn, opening up to e.g. inter-satellite DC and load balancing. Such an option was already studied in Rel-16 and was considered ready for normative work, so there is no need to study it further. With respect to the different mobility enhancements, it seems RUDI is the only option that might be feasible according to the RAN2 status; but it should be OK to keep considering other options (i.e. prioritization at this stage seems premature).

8.1.1.6 Guangdong OPPO Mobile Telecom.

Slide 4: For regenerative payload, does Ericsson consider the case of Xn over SRI and its impact?

Slide 5: For regenerative architecture, Ericsson only supports the case of full gNB on board, instead of other cases such as gNB-DU on board. Is this true?

[Reply] Xn over SRI was studied in Rel-16 and discussed in the Rel-17 WI. Although it's not precluded, so far no particular functionality was found needed for TN-NTN Xn, so nothing was specified on top of what is already available. For the regenerative architecture, we would only support the full gNB on board because, according to the conclusions of TR 38.821, it's the only one that would have "no showstoppers". The CU-DU split one, in particular, would require (according to the SI conclusions) some adaptations of the F1 interface, and it would preclude an inter-satellite interface. On the contrary, with a full gNB on board it would be possible to consider reusing current Xn functions if desired.

8.1.1.7 THALES

Mobility enhancement can be a candidate feature but can you clarify the enhancements you have in mind ?

As per regenerative payload, what architecture would you prioritise among gNB on board, gNB-DU on board, IAB node on board and why ?

[Reply] According to the RAN2 discussion status, the RUDI (aka "make before break") enhancement seemed to be the only one applicable (the scenario would be UE mobility with LEO satellites, which is characterized by shorter connection time and more frequent handovers). But we would not oppose discussing other enhancements if they are proven feasible. On the regenerative payload, we would like to be consistent with the conclusions of TR 38.821: "no showstoppers" for the full gNB on board (which offers the benefit of an inter-satellite Xn, enabling e.g. inter-satellite DC and load balancing). According to TR 38.821 the CU-DU split option would require revisiting the F1 interface (and that option would not offer the benefit of an inter-satellite Xn); we do not favor impacting the F1 interface for NTN, considering that in any case the current NG-RAN architecture does not allow an inter-gNB-DU interface so the benefit of an inter-satellite interface in this case is lost. IAB would require a dedicated study (the IAB architecture was not mature at the time of the Rel-16 NTN SI so it was not considered) and also in this case there would be no possibility of an inter-satellite interface (an IAB node includes a gNB-DU).

8.1.1.8 China Unicom

Thanks for this contribution.

We have concerns on "No showstoppers" in page 4. Would you please provide some detail information on that part?

[Reply] It's copied word for word from the conclusions section of TR 38.821, the result of the Rel-16 NTN SI. According to the study, it's the only regenerative option that can be adopted for normative work without major work to existing interfaces (unlike e.g. the CU-DU split option which requires modifying F1).

8.2 2nd round questions to the proposals on NTN

Please provide your 2nd round questions to RWS-210394 in the below feedback form:

Feedback Form 14: 2nd round questions to the proposals on NTN

8.2.1 Answers by the moderator

There were no questions.